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Sampling and Analysis Plan for the Interim Remedial Design at Solid Waste Management Unit 2 of Waste Area Grouping 22 at the Paducah Gaseous Diffusion Plant Paducah, Kentucky

DEPARTMENT OF ENERGY • UNITED STATES OF AMERICA

I-00314-0003

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

February 16, 1996

Mr. Tony Able
Remedial Project Manager
United States Environmental Protection Agency
Region IV
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Division of Waste Management
Kentucky Department for Environmental Protection
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Frankfort, Kentucky 40601

SAMPLING AND ANALYSIS PLAN FOR THE INTERIM REMEDIAL DESIGN AT SOLID WASTE MANAGEMENT UNIT (SWMU) 2 OF WASTE AREA GROUPING (WAG) 22 AT THE PADUCAH GASEOUS DIFFUSION PLANT (PGDP)

Dear Mr. Able and Ms. Haight:

Enclosed for your review is the D2 *Sampling and Analysis Plan for the Interim Remedial Design at Solid Waste Management Unit 2 of Waste Area Grouping 22 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*. This document is being submitted in accordance with work done under Resource Conservation and Recovery Act (RCRA) Permit Number KY-890-008-982.

If you have any questions or require additional information, please call David W. Dollins at (502) 441-6819.

Sincerely,

Jimmie C Hodges

Jimmie C. Hodges, Site Manager
Paducah Site Office

EF-22:Dollins

Enclosure

cc: J. Stickney, KDEP/Frankfort
T. Taylor, KDEP/Frankfort

DOE/OR/07-1374&D2
KY/EM-82&D2

Sampling and Analysis Plan for the Interim Remedial Design at Solid Waste Management Unit 2 of Waste Area Grouping 22 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky

Date Issued—February 1996

Prepared by the
WAG 22 SWMU 2 Team
Lockheed Martin Energy Systems, Inc

Prepared for
Environmental Restoration and Waste Management
Paducah, Kentucky 42002
managed by
LOCKHEED MARTIN ENERGY SYSTEMS, INC.
for the
U.S. DEPARTMENT OF ENERGY
under Contract No. DE-AC05-76OR00001

CERTIFICATION

Document Identification: **Sampling and Analysis Plan for the Interim Remedial Design at Solid Waste Management Unit 2 of Waste Area Grouping 22 at the Paducah Gaseous Diffusion Plant, Paducah Kentucky (DOE/OR/07-1374&D2, KY/EM-82&D2)**

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this application and all attachments and that, based on my inquiry of those persons immediately responsible for obtaining the information contained in the application, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

U. S. Department of Energy
Owner and Operator

Jimmie C. Hodges — 2-9-96

Jimmie C. Hodges, Paducah Site Manager — Date Signed
Paducah Site Office
U. S. Department of Energy

The Department of Energy has signed as "owner and operator" and Lockheed Martin Energy Systems, Inc., has signed as "co-operator" this application for the permitted facility. The Department has determined that dual signatures best reflect the actual apportionment of responsibility under which the Department's RCRA responsibilities are for policy, programmatic, funding, and scheduling decisions, as well as general oversight, and the contractor's RCRA responsibilities are for day-to-day operations (in accordance with general directions given by the Department of Energy as part of its general oversight responsibility), including but not limited to, the following responsibilities: waste analyses and handling, monitoring, record keeping, reporting, and contingency planning. For purposes of the certification required by 40 CFR Section 270.11(d), the Department of Energy's representatives certify, to the best of their knowledge and belief, the truth, accuracy, and completeness of the application for their respective areas of responsibility.

CERTIFICATION

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Lockheed Martin Energy Systems, Inc.
Co-Operator

Lockheed Martin Energy Systems, Inc.

2/9/96
Date Signed

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PREFACE

This Sampling and Analysis Plan for the Interim Remedial Design at Solid Waste Management Unit (SWMU) 2 of Waste Area Grouping (WAG) 22 at the Paducah Gaseous Diffusion Plant (PGDP) (DOE/OR/07-1374&D1, KY/EM-82&D1) was prepared in accordance with requirements under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Resource Conservation and Recovery Act (RCRA) for investigating areas of concern. This document was prepared under Work Breakdown Structure 1.4.12.7.1.02.11.01 (Activity Data Sheet 5302, "Offsite Groundwater Contamination").

CONTENTS

FIGURES

TABLES

ACRONYMS

ACO	Administrative Order by Consent
AKGWA	Assembled Kentucky Groundwater Database
AnalLIS	Analytical Laboratory Information System
AOC	Area of Concern
ARARs	Applicable or Relevant and Appropriate Requirements
ASTM	American Society of Testing and Materials
BRA	baseline risk assessment
BTEX	Benzene, Toluene, Ethylbenzene, and Xylene
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
COC	chemical of concern
COPC	chemical of potential concern
CRQLs	contract-required quantification limits
CWA	Clean Water Act
DNAPL	dense nonaqueous phase liquid
DOE	U.S. Department of Energy
DOT	Department of Transportation
DQOs	Data Quality Objectives
Energy Systems	Lockheed Martin Energy Systems, Inc.
EPA	U.S. Environmental Protection Agency
ER	Environmental Restoration
FCO	Field Change Order
FFA	Federal Facilities Agreement
FOP	Field Operation Procedure
FS	Feasibility Study
FSP	Field Sampling Plan
GDT	Geophysical Diffraction Tomography
GPR	Ground Penetrating Radar
HI	hazard index
HRS	Hazard Ranking System
HSP	Health and Safety Plan
HSWA	Hazardous and Solid Waste Amendments
HU	Hydrogeological Unit
HWMP	Hazardous Waste Management Permit
IDW	investigation-derived waste
IRIS	Integrated Risk Information System
KDEP	Kentucky Department for Environmental Protection
KPDES	Kentucky Pollutant Discharge Elimination System
LCS	Laboratory Control Sample
LMUS	Lockheed Martin Utilities Services
M&TE	Measuring and Test Equipment
MS	matrix spike
MSD	matrix spike duplicate
NCP	National Contingency Plan

NEPA	National Environmental Policy Act
NPL	National Priorities List
NRC	Nuclear Regulatory Commission
OU	operable unit
PAH	polyaromatic hydrocarbon
PARCC	Precision, Accuracy, Representativeness, Completeness, and Comparability
PCB	polychlorinated biphenyl
PGDP	Paducah Gaseous Diffusion Plant
PRG	Preliminary Remediation Goal
QA	quality assurance
QAPjP	Quality Assurance Project Plan
QC	quality control
RA	risk assessment
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RGA	Regional Gravel Aquifer
RGOs	Remedial Goal Options
RI	Remedial Investigation
ROD	Record of Decision
RPD	relative percent difference
SAFER	Streamlined Approach for Environmental Restoration
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act
SMP	Site Management Plan
SRM	standard reference material
SVOC	semivolatile organic compound
SWMU	Solid Waste Management Unit
TAL	Target Analyte List
TCL	Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure
TOC	total organic carbon
TSCA	Toxic Substances Control Act
UCRS	upper continental recharge system
USEC	United States Enrichment Corporation
VOC	volatile organic compound
WAG	Waste Area Grouping
WMP	Waste Management Plan
%C	percent completeness
%R	percent recovery

EXECUTIVE SUMMARY

The Paducah Gaseous Diffusion Plant (PGDP), located within the Jackson Purchase region of western Kentucky, is an active uranium enrichment facility that is owned by the U.S. Department of Energy (DOE). Effective July 1, 1993, DOE leased the PGDP production operations to the United States Enrichment Corporation (USEC), which in turn contracted with Lockheed Martin Utility Services, Inc. (LMUS) to provide operations and maintenance services. Lockheed Martin Energy Systems, Inc. (Energy Systems) manages the Environmental Restoration and Enrichment Facility activities at PGDP for DOE.

The U.S. Environmental Protection Agency (EPA), DOE, and Kentucky Department for Environmental Protection (KDEP) are negotiating a Federal Facilities Agreement (FFA) pursuant to the final listing of PGDP on the National Priorities List (NPL) of Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites, which occurred on May 31, 1994 (the effective date of placement on the NPL was June 30, 1994). The primary purpose of an FFA is to establish a procedural framework and schedule to investigate and remediate contaminant releases at sites that pose a threat to human health and welfare and the environment. The FFA for PGDP will incorporate the site investigation process, as initiated in accordance with the CERCLA Administrative Order by Consent (ACO) and the requirements of the EPA Hazardous and Solid Waste Amendments (HSWA) and Kentucky Hazardous Waste Management Permit (HWMP). An important aspect of the FFA is effective integration of the PGDP Resource Conservation and Recovery Act (RCRA) Corrective Action Program and the CERCLA Remedial Action Program. The draft Site Management Plan (SMP) developed for PGDP has been designed to integrate the RCRA and CERCLA activities at the site to reflect a consolidated program.

This document represents a Sampling and Analysis Plan (SAP) for the Interim Remedial Design (referred to as SAP in this document) for Solid Waste Management Unit (SWMU) 2 (the C-749 Uranium Burial Ground) located in Waste Area Grouping (WAG) 22. The scope of this SAP is to conduct a field sampling investigation at SWMU 2 and report the results. The goal of the SAP is to fill data gaps not addressed by previous investigations to support a final action as well as collect the necessary data to support the interim remedial design. Filling these data gaps is required to conduct the RI, risk assessment (RA), and Feasibility Study (FS) needed to complete the final Record of Decision (ROD) for SWMU 2. The approach for the SAP consists of two general steps: (1) site characterization, which includes a field investigation and (2) RI report, which includes a baseline risk assessment (BRA).

To facilitate the environmental restoration process at PGDP and focus investigations toward the most effective and efficient remedial actions, PGDP has defined two operable units (OUs): source control units (units that are sources of contamination) and integrator units (units that "collect" contamination from source control units). SWMU 2 is defined as a source control unit.

All existing data, potential final remedial action alternatives, and final FS data requirements were identified and were evaluated to focus the sampling strategy on specific media, contamination, and migration pathways. Based on the results of this evaluation, specific Data Quality Objectives (DQOs) were identified and subsequently were used to focus sampling and data collection requirements for an optimized sample design for SWMU 2.

The sampling strategy focuses on surface soils, subsurface soils, and groundwater within the upper continental recharge system (UCRS) and Regional Gravel Aquifer (RGA). This strategy also addresses ditch sediments west and south of SWMU 2.

The field investigation will focus primarily on the following elements:

- collection of waste characterization samples (soils and water) if the sampling can be accomplished without endangering the health and safety of the workers (see Sect. 5.2),
- collection of surface soils and ditch sediment samples for analysis of contaminants,
- collection of subsurface soil samples for analysis of chemical (i.e., sorption capacity) and physical (i.e., permeability and grain size distribution) characteristics,
- collection of groundwater samples from the upper continental recharge system (UCRS) along site boundaries and at existing monitoring wells for analysis of contaminants,
- collection of groundwater samples from the Regional Gravel Aquifer (RGA) at existing monitoring wells or at temporary well points for the analysis of contaminants,
- collection of McNairy Formation samples for analysis of contaminants if the RGA is determined to be contaminated with trichloroethene concentrations greater than 10 ppm, and
- collection of geophysical data.

In addition, groundwater sampling results from the RGA will be submitted to the PGDP Groundwater Protection Program for evaluation and inclusion in the Groundwater Integrator Unit RI report in accordance with the requirements defined in the *Groundwater Strategy Document for the Paducah Gaseous Diffusion Plant* report (DOE 1994a).

A combination of the current monitoring wells onsite and the monitoring wells presented in this SAP will constitute the monitoring system specified in the final ROD for an interim action for SWMU 2. The monitoring system for the site (the number of wells and their placement) will be based on the results of the additional sampling presented in Chapter 5. The final monitoring system and analytical sampling will be provided in an Operations and Maintenance report following the investigation.

1. INTRODUCTION

The Paducah Gaseous Diffusion Plant (PGDP), located within the Jackson Purchase region of western Kentucky, is an active uranium enrichment facility that is owned by the U.S. Department of Energy (DOE). Effective July 1, 1993, DOE leased the PGDP production operations facilities to the United States Enrichment Corporation (USEC), which in turn contracted with Lockheed Martin Utility Services, Inc. (LMUS) to provide operations and maintenance services. Lockheed Martin Energy Systems, Inc. (Energy Systems) manages the Environmental Restoration and Enrichment Facility activities at PGDP for DOE.

The U.S. Environmental Protection Agency (EPA), DOE, and the Kentucky Department for Environmental Protection (KDEP) are negotiating a Federal Facilities Agreement (FFA) in conjunction with the final listing of PGDP on the National Priorities List (NPL) of Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites. The FFA will set forth the mechanism to integrate CERCLA and the Resource Conservation and Recovery Act (RCRA). A common goal of the FFA participants is to ensure that past releases from operations and waste management at PGDP are investigated and that appropriate remedial action is taken for the protection of human health and the environment.

Following CERCLA guidelines, sites under investigation require a Remedial Investigation (RI) to define the nature and extent of contamination, evaluate the risks to public health and the environment, and determine the available alternatives for a Feasibility Study (FS). This document represents an Sampling and Analysis Plan (SAP) for Solid Waste Management Unit (SWMU) 2 (the C-749 Uranium Burial Ground) which is located within Waste Area Grouping (WAG) 22. The location of the unit at the PGDP facility is illustrated in Fig. 1.1.

To facilitate the environmental restoration process at PGDP and to focus investigations toward the most effective and efficient remedial actions, PGDP has defined two types of operable units (OUs): source control units (units that are sources of contamination) and integrator units (units that "collect" contamination from source control units). SWMU 2 has been defined as a source control unit.

Previous investigations, which included collection and analysis of environmental samples, have been conducted near and within the unit boundary. A summary of these investigations is presented in Chapter 3 of this document. The results of the Phases I and II Site Investigations were previously summarized in the *Remedial Investigation Addendum for Waste Area Grouping 22 Burial Grounds, Solid Waste Management Units 2 and 3, at the Paducah Gaseous Diffusion Plant* (CH2M Hill 1994) and the *Feasibility Study for Solid Waste Management Units 2 and 3 of Waste Area Grouping 22 at the Paducah Gaseous Diffusion Plant* (DOE 1995). An evaluation of all existing data collected at and in the vicinity of SWMU 2 using the Data Quality Objectives (DQOs) process was conducted as part of the preparation of this SAP. Based on this evaluation, it was determined that a limited amount of information needs to be collected to fulfill the data requirements needed for the final RI, risk assessment (RA), and FS for the unit. Implementation of the SAP is required to address the identified data gaps.

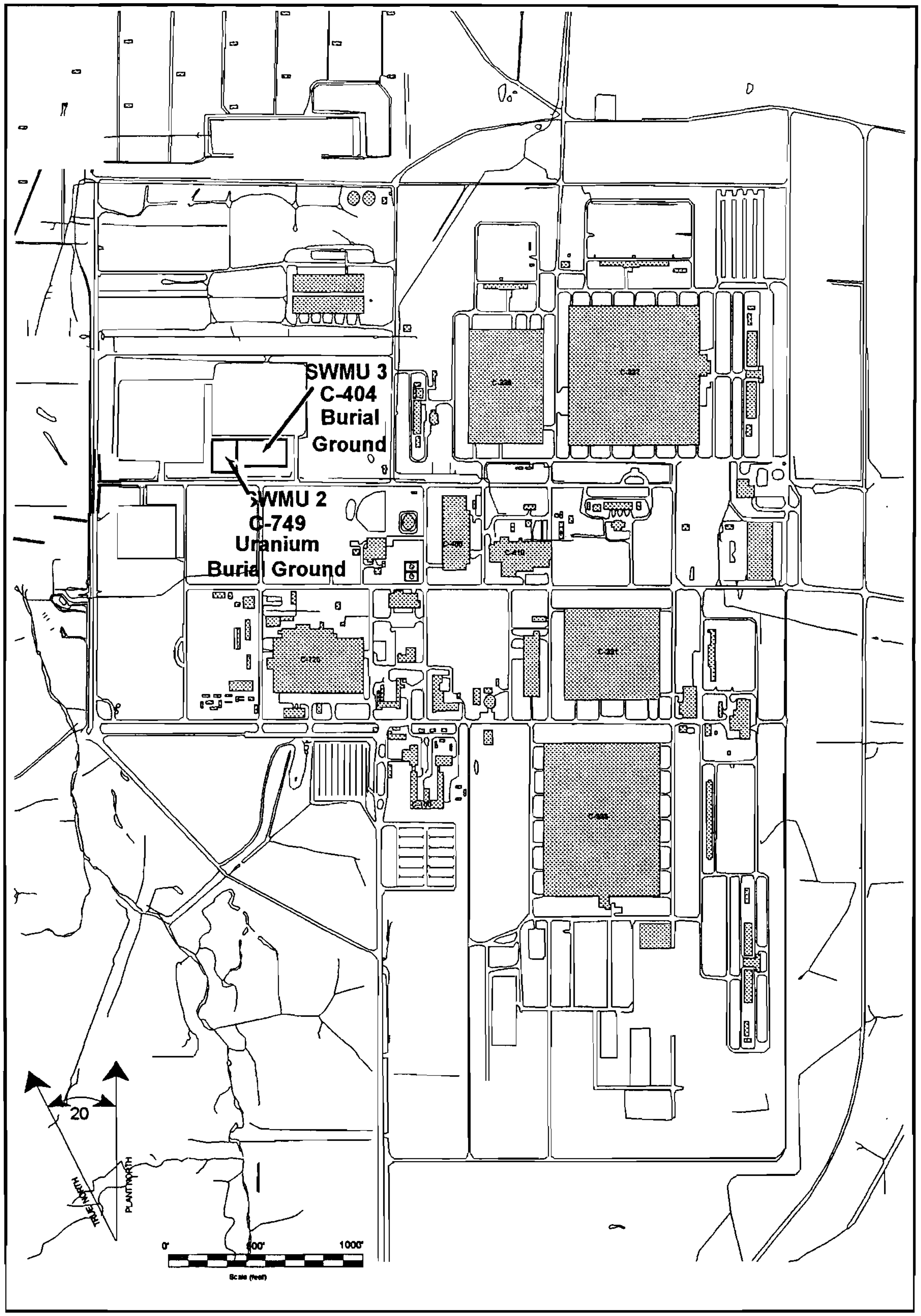

Fig 1.1. PGDP site map.

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Name/Org: SST/PGDP
Date: 1-18-11

The remainder of this chapter discusses the scope and objectives of the SAP and the approach for the field investigation. The other chapters that comprise the SAP address the following topics:

- **Chapter 2: Project Management Plan**. This section addresses the project organization and management plan approach, which details how the project will be organized and managed to ensure that defensible data are collected within project schedules and budgets. An integrated schedule is also included for the SAP preparation and fieldwork.

- **Chapter 3: Characterization Summary**. This chapter presents a characterization summary of SWMU 2, including a description, background information, and waste handling practices, and a brief summary of the previous investigations conducted near or at the unit.

- **Chapter 4: Remedial Investigation Objectives**. This chapter presents the conceptual hydrogeological and contaminant transport models for the unit based on existing data and probable exposure pathways. This chapter also presents the DQOs for the SAP investigations.

- **Chapter 5: Field Sampling Plan**. This chapter summarizes the field sampling strategy to be used for the SAP investigation and details the specific types of sampling to be conducted at the unit. This chapter also correlates each sample with the data need(s) which it fulfills, as defined by the DQOs.

- **Chapter 6: Field Sampling Procedures**. This chapter presents a summary of the field procedures to be used during the SAP sampling activities; documentation procedures for sample collection and transport; and procedures for decontamination, waste management, and data management.

- **Chapter 7: Risk Assessment Plan**. This chapter presents an overview of the scope and objectives for the human health and ecological risk assessments. In addition, a summary of the approaches to be used for the human health risk assessment regarding identification of chemicals of potential concern (COPCs), exposure, toxicity, risk characterization, and Remedial Goal Options (RGOs) is presented.

1.1 PROJECT SCOPE AND APPROACH

The scope of the SAP is to conduct a field sampling investigation at SWMU 2 at PGDP. The goal of the SAP is to fill existing data gaps, not addressed by previous investigations, that are required to complete the final RI, baseline risk assessment (BRA), and FS as well as collect the necessary information to support the interim remedial design.

The approach for the SAP consists of two general steps: (1) site characterization, which includes a field investigation and (2) RI report, which includes a BRA. The outline for the RI report can be found in the draft *Site Management Plan* (Energy Systems 1995). The field investigation will focus primarily on the following elements:

- collection of waste characterization samples (soils and water) if the sampling can be accomplished without endangering the health and safety of the workers (see Sect. 5.2),

- collection of surface soils and ditch sediment samples for analysis of contaminants,

- collection of subsurface soil samples for analysis of chemical (i.e., sorption capacity) and physical (i.e., permeability and grain size distribution) characteristics,

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- collection of McNairy Formation samples for analysis of contaminants if the RGA is determined to be contaminated with trichloroethene concentrations greater than 10 ppm, and

- collection of geophysical data.

In addition, groundwater sampling results from the RGA will be submitted to the PGDP Groundwater Protection Program for evaluation and inclusion in the Groundwater Integrator Unit RI report in accordance with the requirements defined in *Groundwater Strategy Document for the Paducah Gaseous Diffusion Plant* (DOE 1994a).

A combination of the current monitoring wells onsite and the monitoring wells presented in this SAP will constitute the monitoring system specified in the final Record of Decision (ROD) for an interim action for SWMU 2. The monitoring system for the site (the number of wells and their placement) will be based on the results of the additional sampling presented in Chapter 5. The final monitoring system and analytical sampling will be provided in an Operations and Maintenance report following the investigation.

The goal of the SAP investigation is to fill identified data gaps to complete final characterization of the unit and perform a BRA. An RI report will be developed using data derived from the this field investigation, as well as existing data collected during previous investigations or monitoring activities conducted near or at the unit.

1.2 PROJECT OBJECTIVES

The project objectives are consistent with those established in the FFA that is currently being negotiated between DOE, EPA, and KDEP. The FFA will require PGDP to identify, investigate, and remediate all SWMUs and Areas of Concern (AOCs) that could potentially pose a threat to human health and the environment. The objectives of this SAP are to provide the following SWMU-specific data:

1. description of the site physiography, geology, and hydrogeology with emphasis on identification of contaminant pathways and environmental receptors;

2. characterization within SWMU-boundaries of the nature, extent, and magnitude of groundwater contamination within the UCRS, RGA, and McNairy Formation in coordination with other integrator unit investigations;

3. characterization within SWMU-boundaries of the nature, extent, and magnitude of soil and groundwater contamination;

4. determination of risk to human health and the environment posed by wastes and environmental contamination; and

5. collection of geotechnical and environmental data required for preparation of the FS.

After all the data have been collected, reduced, validated, and evaluated, the results will be presented in an RI report. The results of the RI report will be used in an FS to determine the appropriate action for remediation of the unit. Potential actions are:

1. no further action,

2. implementation of a removal action if contamination presents an immediate and adverse impact to human health and welfare or to the environment, or

3. implementation of remedial design/remedial action activities if contamination could present an adverse impact to human health and the environment.

The data collected are designed to be of sufficient quality and quantity to justify a final remedial action decision. To achieve this goal, definitive data (i.e., data obtained by fixed-based laboratory analysis) and screening data will be collected. All fixed-based laboratories will be licensed by the Nuclear Regulatory Commission (NRC) or an agreement state and will meet Contract Laboratory Program (CLP) guidelines for data quality. Appropriate quality assurance/quality control (QA/QC) procedures as defined in the Quality Assurance Project Plan (QAPjP) presented in Appendix A will be followed to ensure proper collection and handling of samples. At least two fixed-base laboratories will be procured so that a second laboratory can be quickly accessed to provide backup analytical capabilities in the event that the primary laboratory is unable to analyze all of the samples within specified holding and data turnaround times.

Data collected during the field investigation will be incorporated directly into the remedial studies for the two integrator units (Groundwater OU and Surface Water OU) identified at PGDP. For groundwater, contaminant concentration data collected from the UCRS, RGA, and McNairy Formation (if applicable) will be used in the development of the facility-wide groundwater flow and solute transport models. Incorporation of these data will ensure that significant sources of groundwater contamination are considered in the human health risk assessment for the Groundwater Integrator Unit. For surface water, data collected during the investigation will be used in the development of the surface water transport model needed for the ecological and human health risk assessments for the Surface Water Integrator Unit.

1.3 PROJECT PLANNING

DOE has a program, termed the Streamlined Approach for Environmental Restoration (SAFER), that incorporates the EPA DQO process to help plan and implement efficient and effective remediation investigations and actions. The process defines the problem at a unit and directs the selection of the types and quality of data needed to understand and correct the problem. Central to this process is a framework for managing uncertainty and decision making. The overall objectives of the process include:

- enhancing focus on planning/scoping,
- linking decision-making needs directly to data collection,
- recognizing and managing uncertainty explicitly,
- learning as planning and remediation proceed and applying what is learned directly and efficiently,
- converging early on a remedy (bias for action), and
- ensuring participation and consensus by all key stakeholders.

The basic framework consists of three major activities: (1) planning, (2) assessment and selection, and (3) implementation. Individual elements, which comprise each of the three major activities and their relationships, are illustrated in Fig. 1.2. The SAP focuses on the planning activity. The planning activity is divided into four individual elements and a comprehensive integrating element. A summary of the planning activity elements are discussed in the following text; additional details are discussed in Chapter 4.

The first element of planning is to develop and refine a conceptual model for the site with the objective of creating a summary "picture" of the site to frame and guide remediation. The second element is to focus on the problem and reasonable deviations with the objective of identifying those probable conditions likely to drive the remedial process and other site conditions that may arise and change the view of the problem. The third element is to develop and refine remedial objectives for the site problem with the objectives of validating assumptions about the site and creating clean-up goals associated with the problem(s) of concern. The final element of planning is to develop and refine initial decision roles with the objective of ensuring that site decisions are properly framed and that data collection is aligned with decision-making needs.

All four of these planning elements interact with and ultimately flow into a comprehensive integrating, planning element to pursue early action opportunities and preliminary data needs. The purpose of pursuing early action opportunities is to reduce risk to human health or the environment through early or interim actions whenever appropriate. Activities conducted to pursue early action opportunities include prioritization of site risk, identification and implementation of early/interim actions to reduce risk, and revision of remedial objectives based on early/remedial results. The purpose of pursuing preliminary data needs is to obtain key data needed to define the problem, remedial objectives, or decision rules. Activities conducted to pursue preliminary data needs include assessment of site uncertainties, collection of focused data from limited field investigations, and refinement of planning outputs based on field study results.

1.4 REGULATORY OVERVIEW

The Environmental Restoration (ER) Program at PGDP is driven by several laws and regulations. In general, these laws include the National Environmental Policy Act (NEPA), RCRA, CERCLA, the Clean Water Act (CWA), the Toxic Substances Control Act (TSCA), the Endangered Species Act, and KDEP statutes. Although all of these regulations impact the ER Program, CERCLA and RCRA are considered to be the primary laws and regulations driving the investigation and remediation activities at the PGDP site. Site-specific Applicable or Relevant and Appropriate Requirements (ARARs), as identified in the ROD for interim remedial action at SWMUs 2 and 3 of WAG 22, were considered in the preparation of this SAP; only those ARARs invoked by sampling and analysis activities were considered.

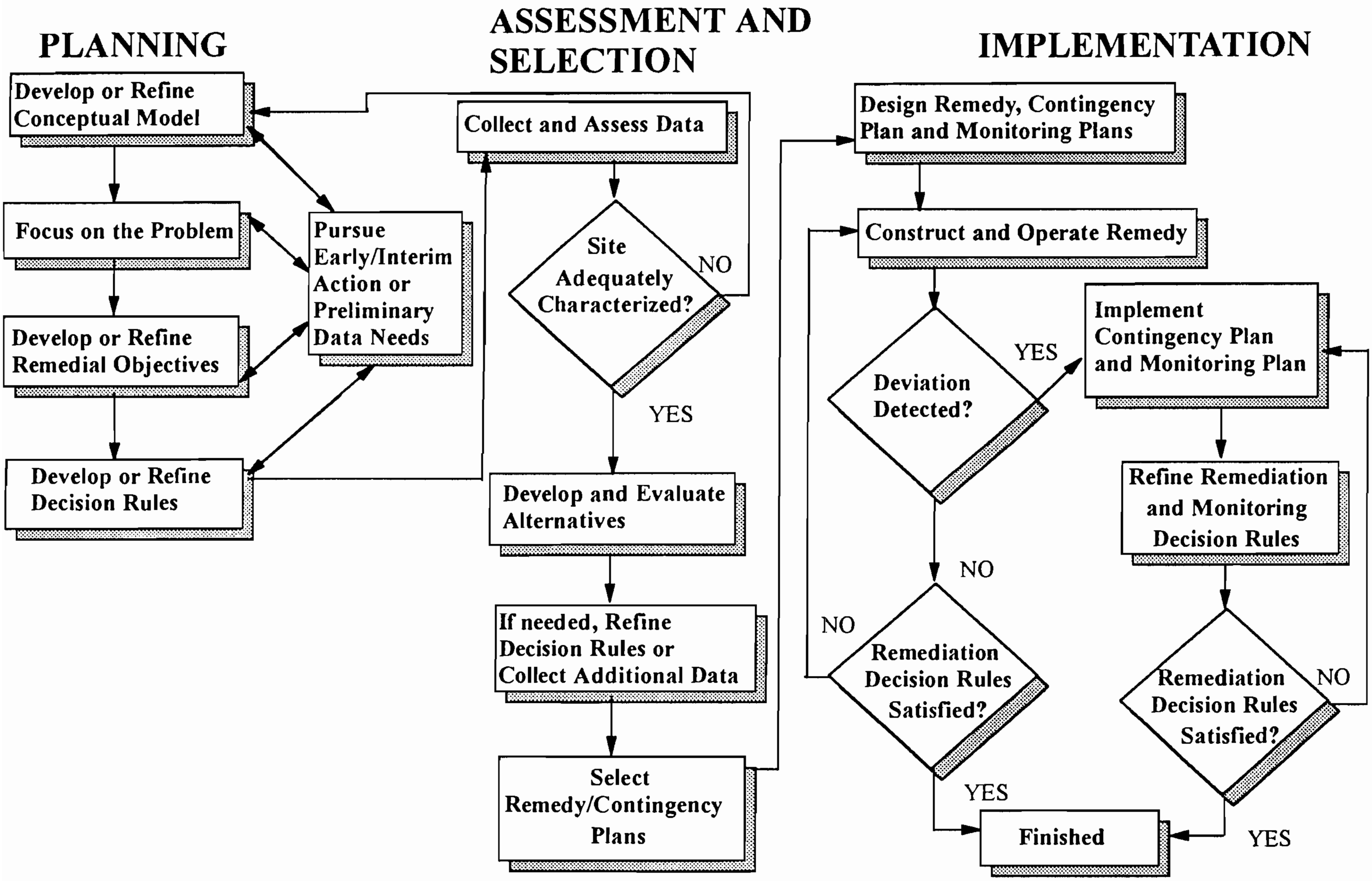


Fig 1.2. Project planning activities and relationships.

2. PROJECT MANAGEMENT PLAN

This chapter presents the Project Management Plan. Topics addressed in this chapter include project organization and schedule.

2.1 PROJECT ORGANIZATION

The responsibilities of key personnel are described as follows:

- The DOE Program Manager will provide technical and management oversight for the SAP and will be the primary interface between the regulatory agencies and Energy Systems.

- The Energy Systems Project Manager will have overall responsibility for the SAP implementation process and will interface with DOE program management and regulatory agencies. Additional programmatic responsibilities include staffing; contracting; and technical, financial, and scheduling matters.

2.2 PROJECT SCHEDULE

Figure 2.1 provides a listing of individual tasks and a schedule for the activities proposed in this SAP. The following assumptions were used to develop the project schedule. Delays in or changes to any of these assumptions could result in individual task or overall project schedule changes.

- Deliverable dates are met by all parties.

- No extended delays due to inclement weather, equipment breakdown, and other unforeseeable circumstances occur.

- PGDP will provide security escorts and passes for all field personnel along with excavation, health and safety, and radiation permits before implementation of field activities.

- The subcontractor will submit requests for permits and additional passes at least 2 weeks before the start of field activities.

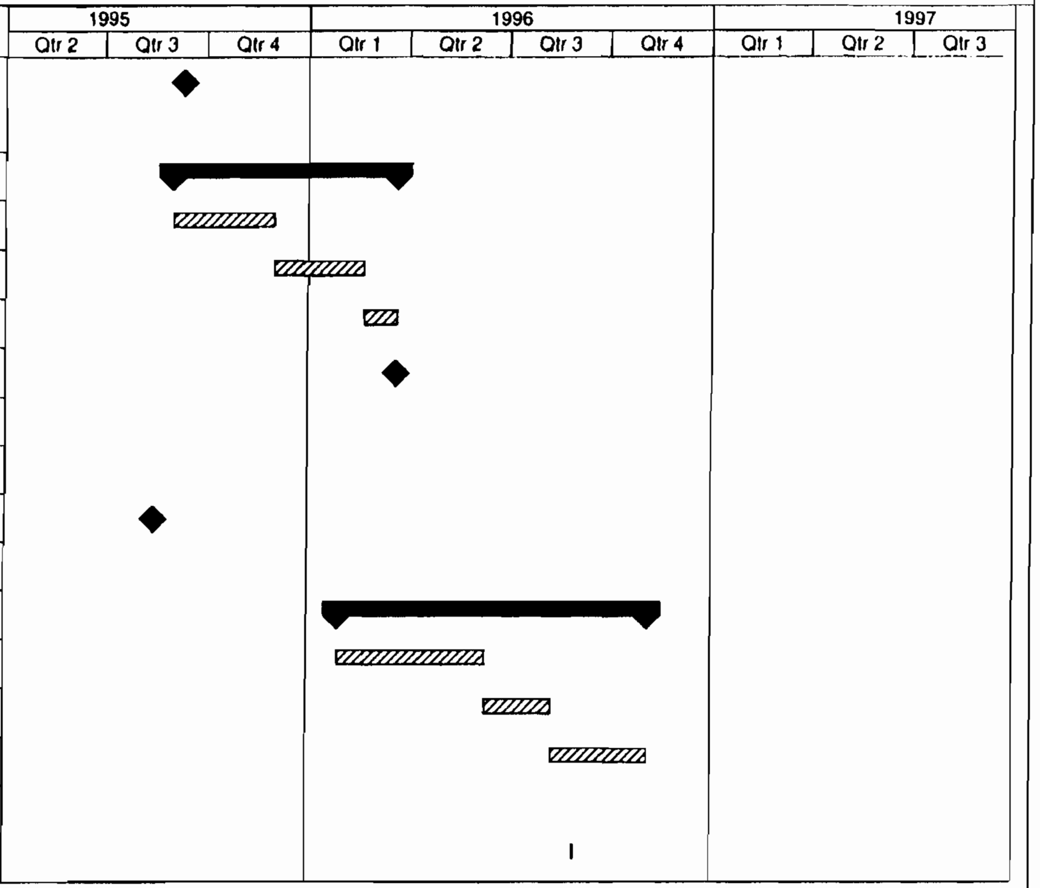
- PGDP will arrange all electrical power and plumbing hookups for required field support facilities prior to mobilization.

- Laboratory analysis reports will be received within 60 days after sample collection.

- All validated data will be available within 90 days after receipt of final laboratory analysis reports.

Remedial Design Schedule for Interim Action at SWMU 2 of WAG 22

ID	Task Name	Duration	Start	Finish
1	EPA ROD signature & KDEP letter of concurrence	0d	9/11/95	9/11/95
2				
3	Sampling and Analysis Plan (SAP) Development	203d	9/1/95	3/21/96
4	EPA & KDEP review D1 SAP	91d	9/1/95	11/30/95
5	DOE incorporate EPA & KDEP comments	82d	12/1/95	2/20/96
6	EPA & KDEP review D2 SAP	30d	2/21/96	3/21/96
7	EPA & KDEP approve SAP	0d	3/21/96	3/21/96
8				
9	Remedial design (RD) phase: Wells	0d	8/15/95	8/15/95
10	Design completed by DOE	0d	8/15/95	8/15/95
11				
12	Sampling activities and Remedial action phase: Wells	281d	1/29/96	11/4/96
13	Procurement	134d	1/29/96	6/10/96
14	Mobilization	60d	6/11/96	8/9/96
15	Install wells/soil sampling/geophysics	87d	8/10/96	11/4/96
16				
17	Waste/ground water interaction meeting	1d	8/30/96	8/30/96



Revised: February 8, 1996

Task ▨ Summary ▬ Milestone ◆

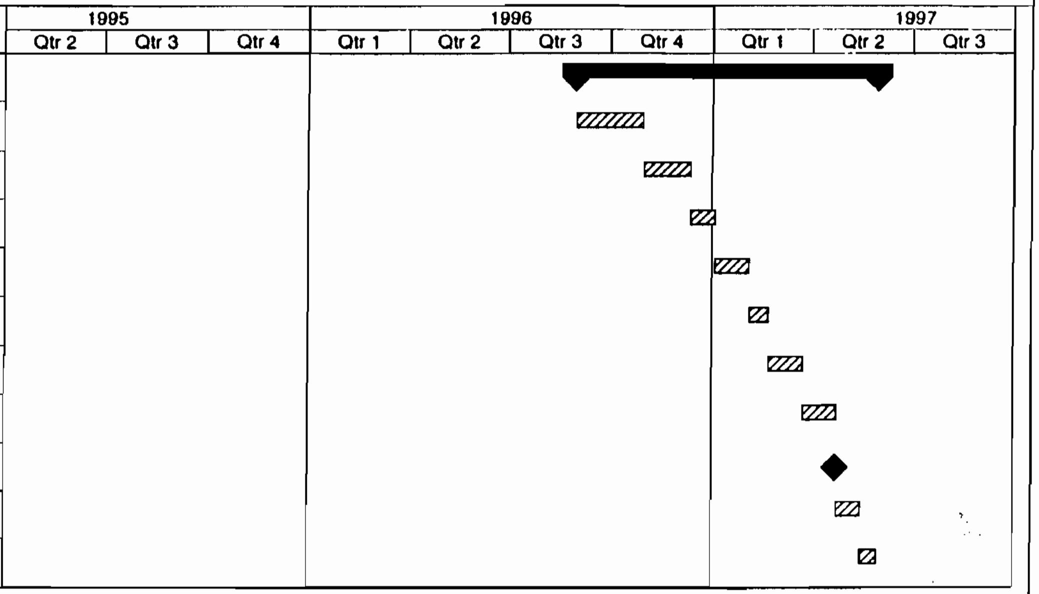
Durations presented in calendar days.

Page 1 of 2

Fig. 2.1. Project schedule.

Remedial Design Schedule for Interim Action at SWMU 2 of WAG 22

ID	Task Name	Duration	Start	Finish
18	Remedial design (RD) phase: Low permeability, multilayered cap	273d	8/31/96	5/30/97
19	Design procurement	61d	8/31/96	10/30/96
20	DOE develop 30% design [See footnote A]	43d	10/31/96	12/12/96
21	EPA & KDEP review 30% design	22d	12/13/96	1/3/97
22	DOE develop 60% design	31d	1/4/97	2/3/97
23	EPA & KDEP review 60% design	17d	2/4/97	2/20/97
24	DOE develop 90% design and construction schedule	31d	2/21/97	3/23/97
25	EPA & KDEP review 90% design and construction sched.	31d	3/24/97	4/23/97
26	EPA & KDEP approve 90% design and construction sched.	0d	4/23/97	4/23/97
27	Complete design	22d	4/24/97	5/15/97
28	Design certified for construction (CFC)	15d	5/16/97	5/30/97



Revised: February 8, 1996
Footnote A: Design activities contingent upon DOE, EPA, and KDEP concurrence to proceed with a definite strategy by 8/30/96.

Task ▨ Summary ▬

Milestone ●

Durations presented in calendar days.

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Fig. 2.1. (continued)

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3. CHARACTERIZATION SUMMARY

This chapter describes SWMU 2 and summarizes previous characterization activities completed at or near the SWMU. A summary of the analytical results from the previous characterization activities and conclusions regarding the nature and extent of soil and groundwater contamination is presented in Chapter 4 as part of the conceptual site model.

3.1 SWMU 2 DESCRIPTION

The C-749 Uranium Burial Ground (SWMU 2) is located in the west-central portion of the plant north of Virginia Avenue (Fig. 3.1). The monitoring wells and sample points in Fig. 3.1 are the result of previous investigations described in Sect. 3.2. SWMU 2 is located on the western edge of the C-404 Low-Level Radioactive/Hazardous Waste Burial Ground. The unit encompasses an area of approximately 32,000 ft^2 with approximate dimensions of 160 by 200 ft and is composed of 20 by 20 ft sections (Fig. 3.2).

SWMU 2 was used from approximately 1951 to 1977 for the disposal of uranium and uranium-contaminated wastes. The burial records for SWMU 2 are provided in the FS for WAG 22, SWMUs 2 and 3 (DOE 1995). The exact depth of the wastes is not known. However, wastes were reportedly placed in trenches excavated to a total depth of approximately 7 to 17 ft and then covered with 2 to 4 ft of soil. In 1982, the unit was covered with a 6-in. clay layer and an 18-in. vegetative cover. It has been estimated that 270 tons of uranium, 59,000 gal. of oils, and 450 gal. of trichloroethene were buried in SWMU 2.

Most of the waste in the unit is believed to consist of pyrophoric uranium metal in the form of machine shop turnings, shavings, and sawdust. Pyrophoric uranium metal usually was placed in 20-, 30-, or 55-gallon drums, and petroleum-based or synthetic oils were used to stabilize the metal. Occasionally, fires were reported as a result of oxidation of pyrophoric (easily ignitable in air) uranium metal, but no subsidence has been observed as a result of volume reductions due to the fires. It is possible that the oils may have included some polychlorinated biphenyl (PCB)-contaminated oils. Other forms of uranium, including oxides of uranium (solid and dissolved in aqueous solutions), uranyl fluoride solutions, uranium-zirconium alloy, slag, and UF_4 were buried in smaller quantities.

No documentation of ^{99}Tc disposal at SWMU 2 exists. However, during the years of feed plant operation, from 1953 to 1964 and from 1968 intermittently through 1977, partially depleted reactor tails were reprocessed through the feed plant resulting in the introduction of reactor-produced radioactive impurities, such as ^{99}Tc, into the enrichment process. It is likely that a portion of the uranium-contaminated wastes disposed in burial grounds at the PGDP contains ^{99}Tc from this source. This assumption is supported by the detection of ^{99}Tc in groundwater samples taken from monitoring wells near the SWMU.

Materials contaminated with trichloroethene are also known to have been disposed of at SWMU 2. In August 1984, Area 9 of SWMU 2 was excavated due to concern about the integrity of trichloroethene-containing drums (fifteen 30-gal. drums) reportedly disposed of in this area. Little documentation is available concerning this excavation. However, it is reported that during excavation, four 30-gal. drums and thirty-five 55-gal. drums (30 of these drums contained uranium sludge, not trichloroethene) were recovered; some of these drums were in poor condition, while others were not recorded as being buried in that area. Results of drum residues and surrounding soils is summarized in Table 3.1.

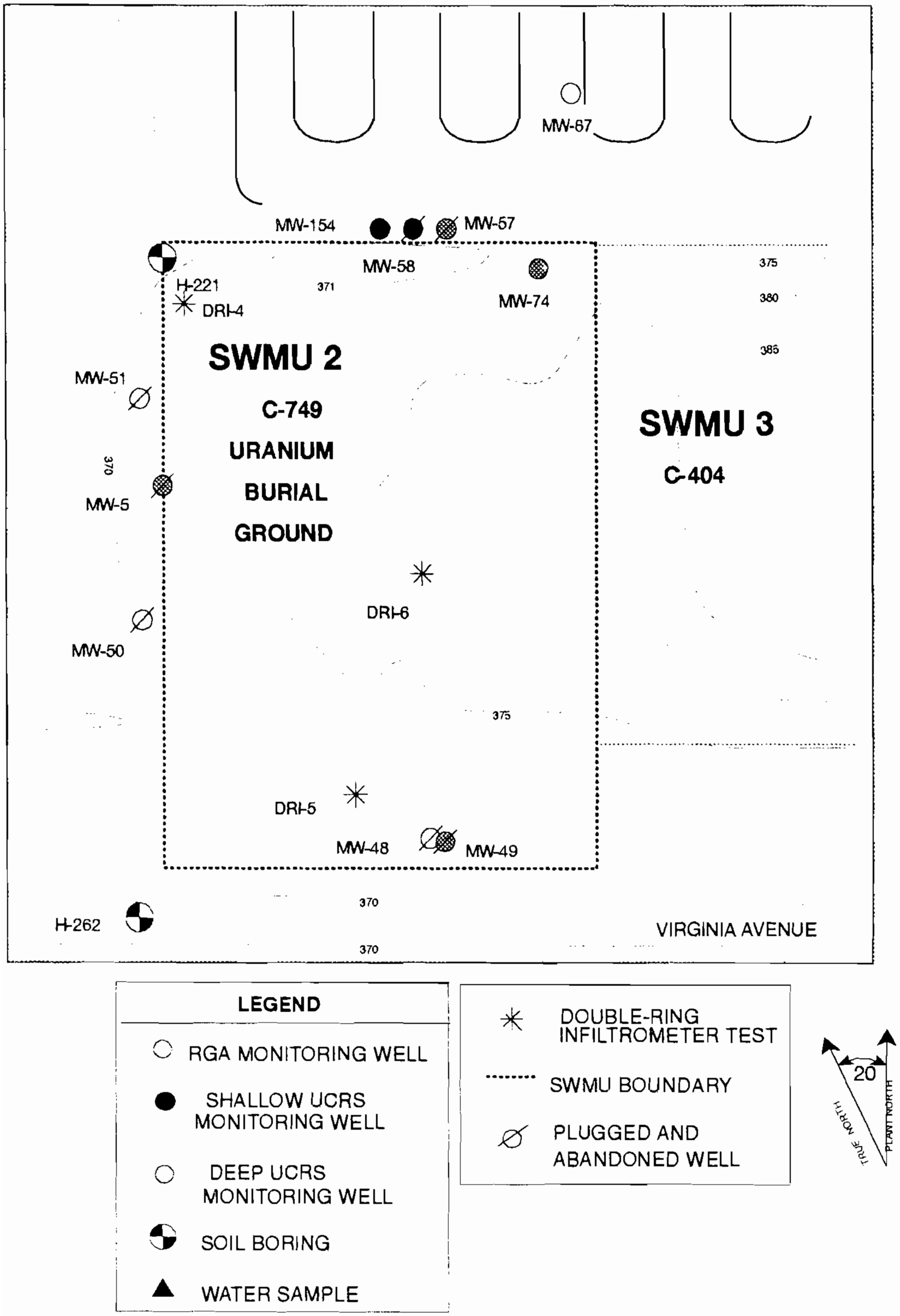

Fig. 3.1. Location of SWMU 2 and previous sampling.

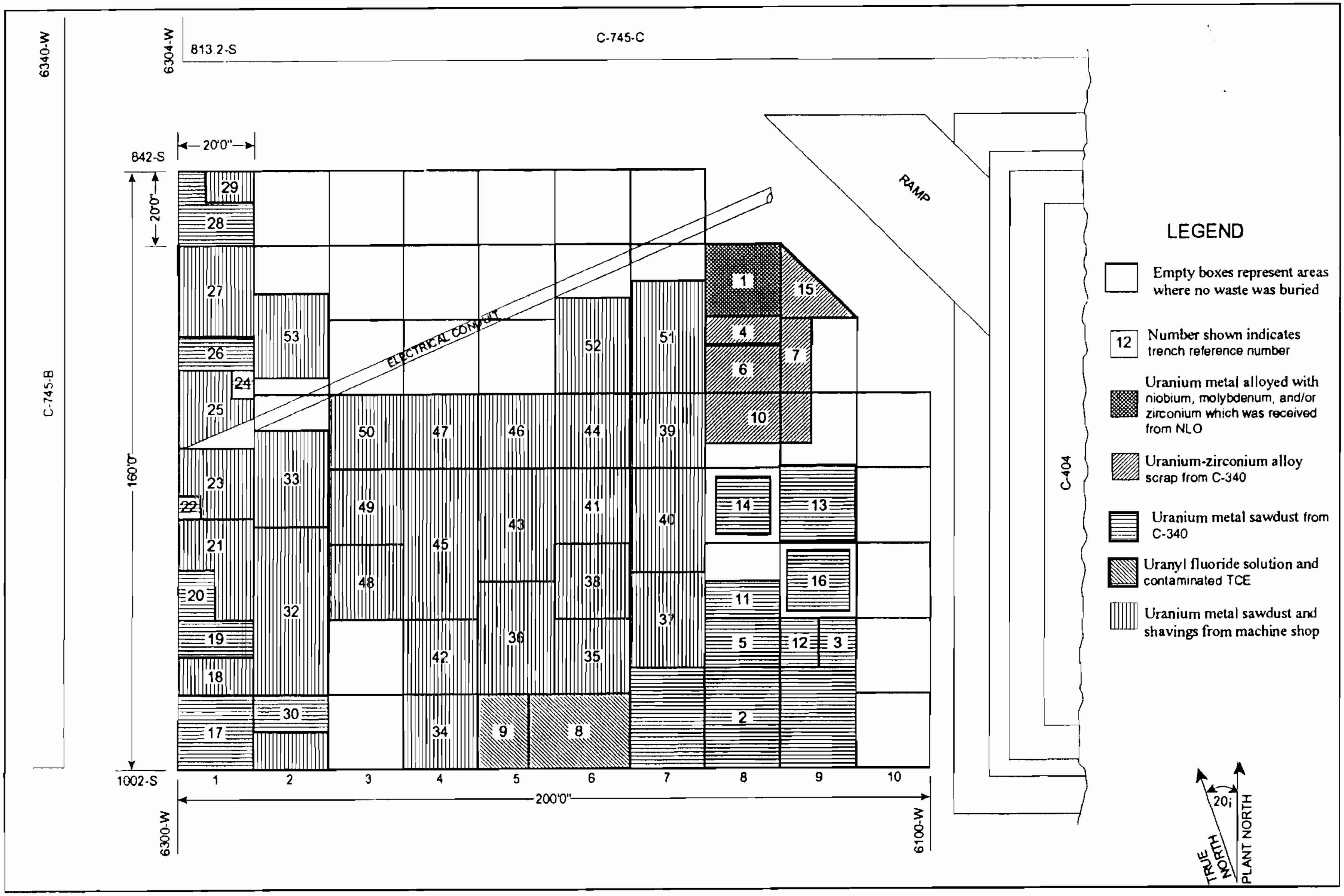

Fig. 3.2. SWMU 2 sections and trenches.

Table 3.1. 1984 excavation sampling results

Soils surrounding excavated drums	<0.1% trichloroethene <0.1% perchloroethylene (tetrachloroethene) <5 ppm PCBs 0.01% MFL oil maximum 0.21% uranium
Mud and sludge in excavated drums	4.5% trichloroethene 20% Uranium

MFL = A brand name of oil.

3.2 PREVIOUS INVESTIGATION OVERVIEW

The nature and extent of soil and groundwater contamination within or in the vicinity of SWMU 2 have been addressed by two previous investigations, the Phases I and II Site Investigations (CH2M Hill 1991 and 1992) which were conducted from 1989 through mid-1991. Phase I of the Site Investigation was conducted between 1989 and 1990 to identify the contaminants of concern (COCs), identify SWMUs possibly contributing to off-site contamination, describe the physical characteristics of the site, and provide a preliminary description of the nature and extent of contamination and risk associated with the off-site contamination. The results of the Phase I investigation were reported in the *Results of the Site Investigation, Phase I, Paducah Gaseous Diffusion Plant* (CH2M Hill 1991), which received final EPA approval in June 1991.

Phase II of the Site Investigation was conducted between 1990 and 1991 to further assess the nature and extent of contamination and risk associated with the off-site and on-site contamination, characterize SWMUs possibly contributing to off-site contaminations, and identify contaminant migration pathways contributing to off-site contamination. The results of the Phase II investigation were reported in the *Results of the Site Investigation, Phase II, Paducah Gaseous Diffusion Plant* (CH2M Hill 1992).

The findings of the Phases I and II Site Investigations were used as the basis for a remedial alternatives evaluation and a health and ecological risk assessment. The results of the evaluation and assessment were submitted to EPA and KDEP in December 1991.

Field activities at SWMU 2 during the investigations included soil borings (surface and subsurface soil sampling), monitoring well installation (surface and subsurface soil sampling and groundwater sampling), double-ring infiltrometer testing, and surface radiation walkover surveys. Environmental samples collected during the Phases I and II Site Investigations underwent analysis for various analytes including Target Compound List (TCL) volatile and semivolatile organic compounds (VOCs and SVOCs), PCBs, Target Analyte List (TAL) metals, and radionuclides (^{237}Np, ^{239}Pu, ^{230}Th, ^{234}U, ^{235}U, and ^{238}U). The sampling results of the field activities are provided in the Phases I and II Site Investigations (CH2M Hill 1991, 1992). Figure 3.1 illustrates the locations where samples were collected during the investigations.

4. REMEDIAL INVESTIGATION OBJECTIVES

4.1 PROJECT OBJECTIVES

SWMU 2 was identified as a high priority waste unit for cleanup in the Phase II Site Investigation report (CH2M Hill 1992). In this report, SWMU 2 was identified as being a major source of metal contamination and a likely source of uranium contamination to off-site areas. However, review of the Phase II Site Investigation report indicated that data may have been insufficient to support this contention. To clarify this matter, DOE prepared an RI addendum to the Phase II Site Investigation (DOE 1994b) that summarized all information about SWMU 2 contained in the Phases I and II Site Investigation reports (CH2M Hill 1991 and 1992). This report, in turn, supported the production of an FS for SWMU 2 (DOE 1995).

While final remedial action was believed possible when the FS was initiated, several important uncertainties, or data gaps, were identified during the production of the FS that precluded the selection of a final action for remediation of SWMU 2. These data gaps were primarily concerned with the relationship of the depth of the waste pits and the water table at SWMU 2, the nature of the buried waste, and the potential for contaminant migration from the unit. However, even with these uncertainties, DOE, with the agreement of the regulatory agencies, completed the FS and proposed an interim action to decrease the potential for contaminant migration at SWMU 2, provided sufficient data could be collected to verify its usefulness. This interim action includes a low permeability cap to reduce infiltration and a monitoring network to determine if the SWMU is contributing to RGA contamination.

Although an interim action may be implemented at SWMU 2, the unit requires further investigation due to the pyrophoric uranium contained within the unit and the identified data gaps. Until these data gaps are satisfied, a final action for remediation of SWMU 2 is not possible. Filling these data gaps for SWMU 2 and collecting information to support the interim remedial design are the project objectives for the SAP.

4.2 DATA QUALITY OBJECTIVES

The EPA's DQOs (EPA 1993) are qualitative and quantitative criteria used to establish requirements for sample collection and analysis and are based on the needs and intended uses of the data. The overall intent of the DQOs is to emphasize and identify project objectives during project planning to collect the most useful data for supporting decision making. The DQO process places strong emphasis on identifying those conditions at a site that greatly affect the ability to make cost-effective remediation decisions. Figure 4.1 summarizes the process that was used for the SAP. It is important to note that the DQO process followed in the preparation of this SAP encouraged active participation by and communication among all team members (i.e., regulators, decision makers, managers, field personnel, and laboratory personnel).

Since the uncertainties concerning the site and data gaps have different levels of importance (e.g., some contaminant migration pathways are more important than others), the approach of the SAP focused on the relevant problems at the site. In the following discussion, the relevant problems are referred to as probable conditions. Less likely conditions are referred to as reasonable deviations from probable conditions. This use of terms simply allows the SAP to clearly present why some

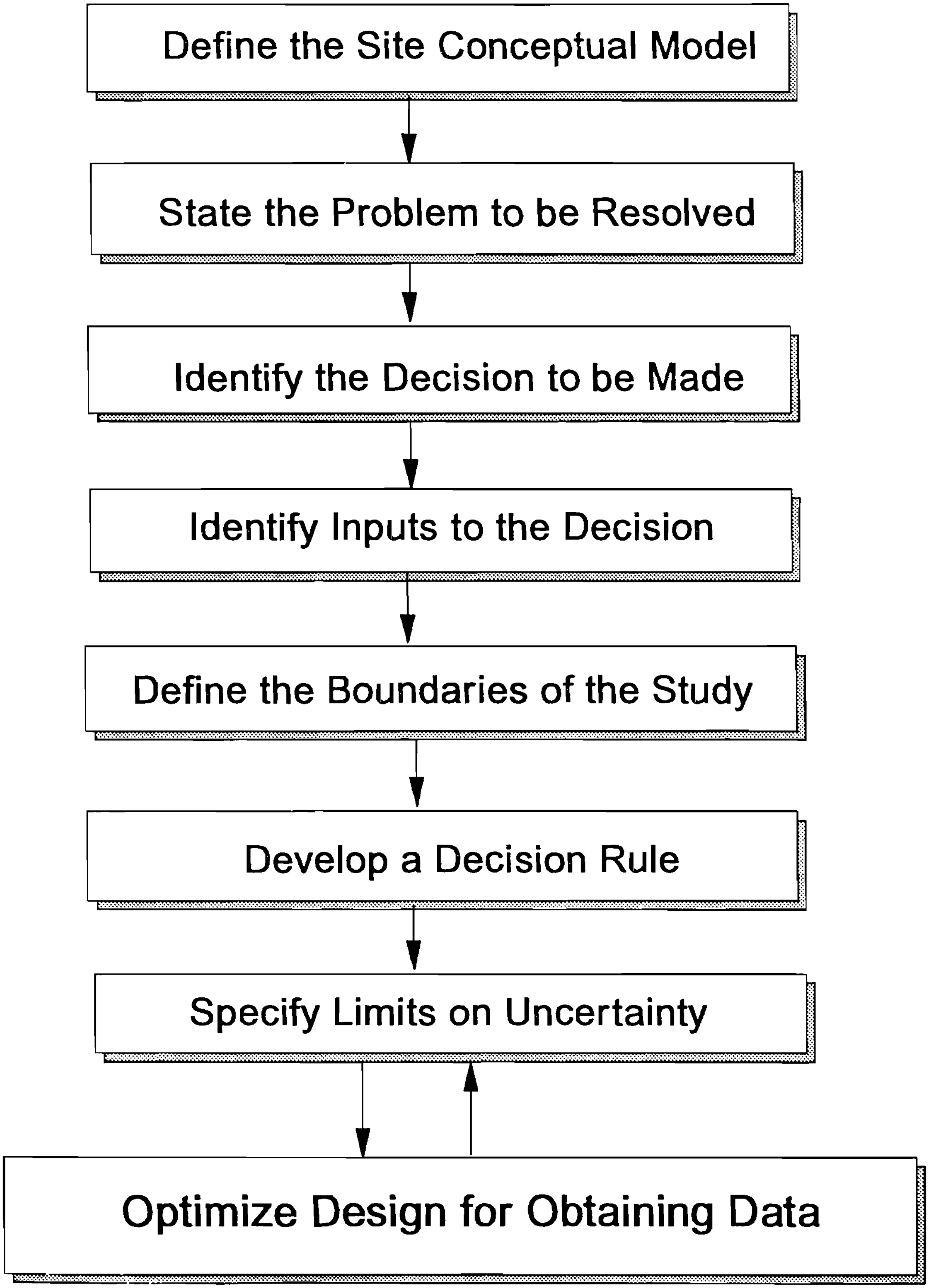

Fig. 4.1. DQO process chart.

activities are of greater importance than others. Generally, more resources will be spent on confirming probable conditions.

The approach followed also stresses that not all uncertainties about a site must be addressed to make cost-effective remedial decisions. Generally, the following discussion focuses on those uncertainties that could prevent selecting and implementing the best and final remedial option.

4.2.1 Define the Conceptual Site Model

The first step in the DQO process is to define the conceptual model for the site to be investigated (Fig. 4.2). The conceptual model presented in Fig. 4.2 is slightly different from the model used during the DQO process due to additional DOE, EPA, and KDEP agreements on the clean-up strategy for PGDP and due to regulator comments on the Record of Decision for the interim action at SWMU 2. A conceptual site model is a statement of probable site conditions and their reasonable deviations that serves as a paradigm against which new observations can be compared. Through the DQOs for the site, the conceptual site model spawns the decisions that need to be made regarding contaminants at the site and their transport to potential receptors. Investigations of the site are conducted within the framework of the DQO process to provide information that will help make these decisions and, in essence, verify the conceptual site model or identify deviations from it. The net result is that, at the end of any particular investigation, a new or modified conceptual model is produced that describes the probable site conditions.

The following discussion presents the conceptual site model for SWMU 2. This discussion is divided into four parts, with each part corresponding to a primary component of the conceptual site model. The four parts to be discussed are a physical description of the source area, probable mechanisms of contaminant transport, probable site-related contaminants, and uncertainties related to each of the previous three parts (i.e., identification of reasonable deviations).

4.2.1.1 Source area

Waste pits. SWMU 2 encompasses an area of approximately 32,000 ft^2 with approximate dimensions of 160 by 200 ft. In turn, waste disposal records allow this area to be divided into 20 by 20 ft sections (Fig. 3.2).

Surface features. The land surface at SWMU 2 is relatively flat with surface elevations ranging from 370 to 375 ft above sea level. SWMU 2 is bounded by drainage ditches on the south and north; water is present in these ditches after rainfall events only. To the east is SWMU 3, which is a capped unit with a significant surface mound. The area to the west of SWMU 2 is flat and at the same approximate elevation as the SWMU 2 surface; however, after rainy periods, water does have a tendency to pond in the area. SWMU 2 is grass covered.

Subsurface features. The stratigraphy at SWMU 2 is similar to that elsewhere at PGDP. The stratigraphy consists of Cretaceous, Tertiary, and Quaternary sediments which overlie Paleozoic bedrock. Pleistocene sediments are divided into two main facies: the lower continental deposits and the upper continental deposits. The lower continental deposits consist of chert gravel in a matrix of poorly sorted sand and silt. This unit forms the uppermost aquifer at the plant site and is referred to as the Regional Gravel Aquifer (RGA). Overlying the lower continental deposits are the upper continental deposits which consist of clayey silt interspersed with discrete lenses of sand and,

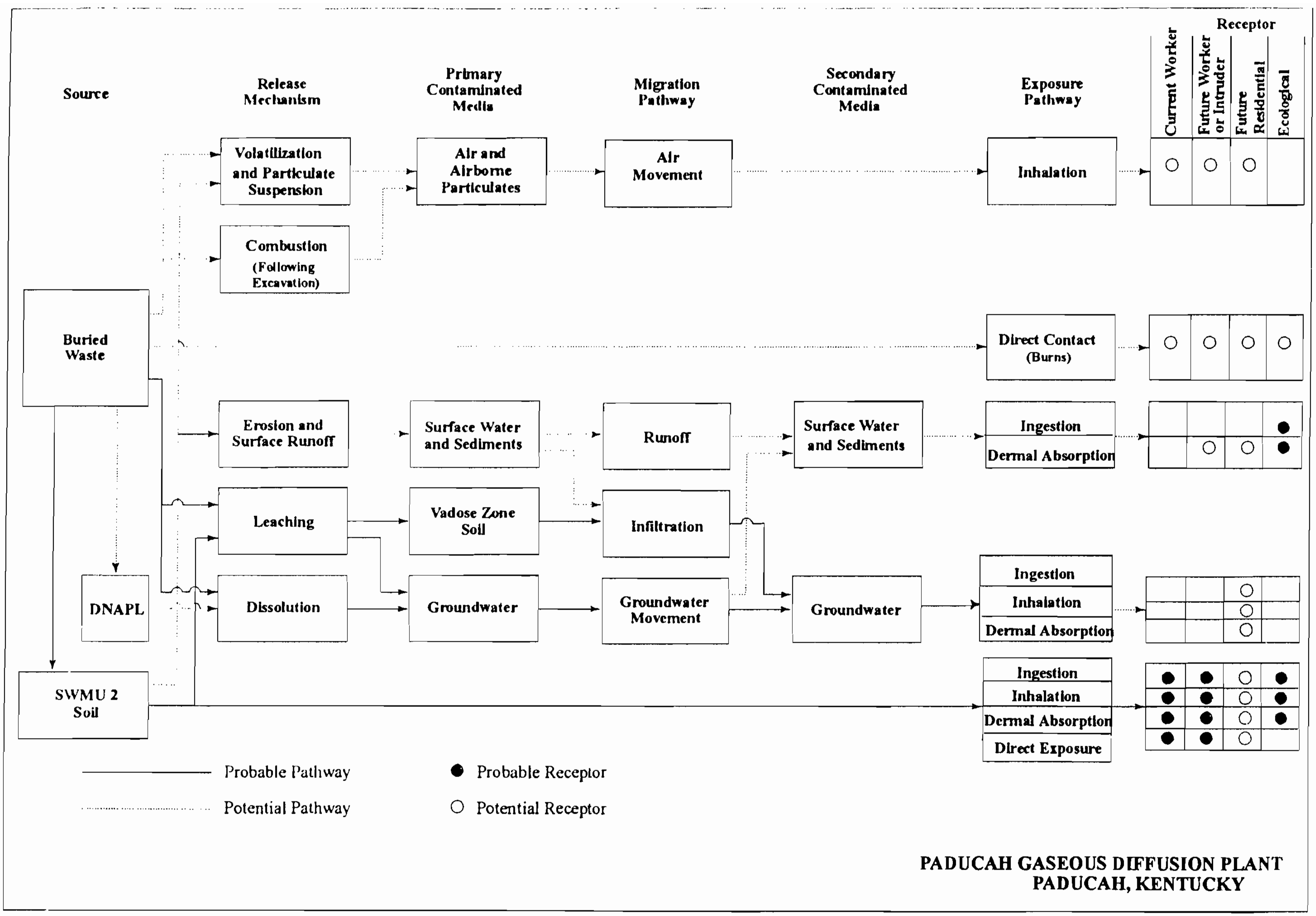

Fig. 4.2. Conceptual site model for SWMU 2.

occasionally, gravel. The units overlying the RGA are collectively referred to as the UCRS. The UCRS beneath SWMU 2 is approximately 60 ft thick.

Hydrogeology. The following text describes the hydrogeologic features in the vicinity of SWMU 2.

- Surface hydrology. The surface hydrology at SWMU 2 is controlled by topography. As noted previously, SWMU 2 and the surrounding area are relatively flat with a drainage ditch to the south of the unit and the mounded topographical high (SWMU 3) to the east. As a consequence of this topography, some surface water flow from SWMU 3 occurs. At SWMU 2 surface drainage is controlled by topography and infiltration. The present topography is the result of a 6-in. clay cap that was placed on the unit. Hydraulic conductivities measured on the cap during the Phase II Site Investigation were relatively low (ranging from 2E-6 and 5E-6 cm/s), indicating that infiltration of precipitation through the cap is minimal.

Surface drainage is primarily by sheet flow to the drainage ditches to the south and north. The ditch to the north is a closed ditch and does not provide a pathway for contaminants to leave the plant property. The southern ditch drains to the west and ultimately discharges to Big Bayou Creek through Outfall 015.

- Subsurface Hydrogeology. The hydrogeology at SWMU 2 is similar to that elsewhere at PGDP. This has been previously described in a report by Douthitt and Phillips (1991). A summary of this material as it is related to SWMU 2 is presented in the following text.

Five hydrostratigraphic units (HUs) were proposed by Douthitt and Phillips (1991) to explain groundwater flow at the PGDP site. In descending order, the HUs are:

- Upper Continental Deposits
  - HU 1 (UCRS): loess that covers the entire site.
  - HU 2 (UCRS): discontinuous, but correlatable, sand and gravel lenses in a clayey silt matrix.
  - HU 3 (UCRS): relatively impermeable clay layer that acts as the upper confining layer for the RGA. The lithologic composition of this unit varies from clay to sand but is predominantly clay or silt.
  - HU 4 (RGA): predominantly continuous sand unit with a clayey silt matrix which directly overlies the RGA. This unit is in hydraulic connection with HU 5 and is included as part of the RGA.
- Lower Continental Deposits
  - HU 5 (RGA): gravel, sand, and silt.

The upper McNairy Formation resides beneath HU 5 and is in hydraulic connection with this unit. As a consequence, the top portion of the McNairy Formation is included in discussions of the RGA.

The HUs present a vertical profile of alternating hydraulic conductivities. The hydraulic conductivities of the sand comprising the HU 2 and HU 4 are typically two orders of magnitude or more than the conductivities of the clays and silts that make up HU 1 and HU 3 (Clausen et al. 1992). Lateral heterogeneity also exists. Although the sand lenses within the UCRS are laterally extensive, they are not always continuous beneath SWMU 2. On a larger scale, the sand lenses within the UCRS decrease in frequency towards the Ohio River.

4.2.1.2 Contaminant transport

The description of the source area can be used to define the probable contaminant transport paths at SWMU 2. Generally, this description indicates that subsurface infiltration and underflow through the source area are the only probable transport mechanisms at SWMU 2. The airborne pathway is not a probable mechanism at the site since current site conditions (i.e., buried waste in a grass-covered unit) do not allow for sufficient volatilization or particulate resuspension to result in significant migration and, ultimately, exposure.

Subsurface infiltrations can result in two probable transport paths: contaminant movement to the ditch to the south of SWMU 2 and contaminant movement to the underlying aquifers (i.e., RGA and upper McNairy Formation). Each of these pathways is discussed in the following text.

Surface water pathways. As noted previously, surface water from SWMU 2 drains toward the north and south to drainage ditches which then carry the water away to the west. Drainage within SWMU 2 is predominantly by sheet flow. Since these drainage ditches are dry except during precipitation events, surface flow provides a minimal contribution to contaminant transport.

Groundwater pathways. Groundwater flow through the UCRS to the RGA is primarily vertical due to extreme differences in the hydraulic conductivities of these two units (Clausen et al. 1992). A pump test within the HU2 gravel at SWMU 91 yielded a hydraulic conductivity of 10^{-6} cm/s, and permeameter testing of HU3 clay yielded a conductivity less than 10^{-7} cm/s. In contrast, RGA hydraulic conductivity is estimated within the 10^{1} to 10^{-2} cm/s range. Based on an analysis of flow at SWMU 3 (Clausen et al. 1992), a horizontal flow component may exist to the southwest. However, the potentiometric maps developed were based on monitoring wells screened at different depths in sand lenses that may or may not be hydraulically connected to each other.

The RGA behaves as a semiconfined aquifer, which is under recharge conditions, except near the Ohio River into which it discharges. Groundwater flow in the RGA is lateral and generally directed north.

4.2.1.3 Site-related contaminants

The following section discusses the COCs in soil and groundwater in the vicinity of SWMU 2 and assesses the extent of contamination at the unit. More detailed information concerning the nature and extent of contamination identified at SWMU 2 is presented in the RI Addendum (CH2M Hill 1994). Table 4.1 presents the state Assembled Kentucky Groundwater Database (AKGWA) number for each monitoring well that will be discussed in the remainder of this SAP. Some wells were abandoned before AKGWA numbers became requirements and were not assigned an AKGWA number.

Table 4.1. AKWGA numbers for monitoring wells associated with SWMU 2

Monitoring Well Number	AKWGA Number	Monitoring Well Number	AKWGA Number
48	8000-5204	67	8000-5216
49	8000-5205	74	8000-5223
50	8000-5206	85	8000-5234
51	8000-5207	94	8000-5103
58	NA	154	8000-5148
57	NA	160	8000-5154

NA = Not Assigned

During the Phase II Site Investigation, reference samples were taken in sediments, soils, surface water, and groundwater at locations judged to be unaffected by PGDP activities. These reference, or background, samples are considered representative of naturally occurring conditions or conditions unrelated to activities at the PGDP. The differences between the reference concentration levels and the concentrations at the SWMU are used to identify the COCs and assist in the evaluation of the nature and extent of contamination at each unit.

Sources of contamination. SWMU 2 contains buried waste materials that are contaminated with radionuclides, metals, VOCs, SVOCs, and possibly PCBs. These waste materials are considered likely sources of contamination in the surface and subsurface soils and in the UCRS groundwater at this unit. Since SWMU 2 is covered with a 6-in. clay cap, much of the observed surface contamination at SWMU 2 is likely due to past waste transportation activities conducted in the area. As noted previously, groundwater flow in the UCRS to the RGA is ultimately vertical, and groundwater flow in the RGA is lateral and generally directed north. Contamination present in the RGA groundwater beneath the unit is probably due to leaching from the burial grounds or from other contaminant sources on the plant located upgradient of SWMU 2.

Due to the inherent danger of pyrophoric uranium, no sampling of the wastes in SWMU 2 was performed during the site remedial investigation, but sufficient data exist to estimate the likely extent of the buried material at this SWMU. The limits are defined by surface topography, and the quantities and types of the buried waste materials within SWMU 2 have been documented in PGDP records. It should be noted that some uncertainty concerning the completeness and accuracy of the disposal records for SWMU 2 exists. The 1984 excavation of Area 9 in SWMU 2 revealed the presence of 36 plastic-lined, 55-gal. drums, which had not been documented in any available disposal records for the area, and recovered only four of the fifteen 30-gallon drums of trichloroethene reportedly present in the area. However, the existing records are sufficient to estimate the horizontal extent of the wastes in the unit. The exact depth of burial of the wastes in SWMU 2 is not known; however, it has been estimated that the wastes may have been buried to a maximum depth of 17 ft.

The following text is taken directly (unedited) from the FS for WAG 22 (DOE 1995).

Organic contamination. The following discussion describes the nature and extent of organic contamination at the site.

- Surface. Trace concentrations of PCBs and dioxins have been detected in surface soils near SWMU 2. Specifically, Aroclor 1248 (210 μg/kg), Aroclor 1260 (130J μg/kg), and dioxins/furans (3.3 μg/kg) were detected in the surface soil samples from borings H 221 and H 262 located at the perimeter of SWMU 2. (The "J" qualifier designates an estimated concentration.) Dioxin and PCBs have also been detected in the ditch south of SWMU 2, though not at KPDES Outfall 015. The source of these contaminants in the ditch could be due to SWMU 2 or other waste management units at the PGDP; the exact source is unknown.

  PCBs have not been detected at depths greater than 6 ft below land surface in the vicinity of SWMU 2. Pentachlorophenol was detected at concentrations of 100J μg/kg in the 0- to 1-ft soil sample from boring H 262 located at the southwest corner of SWMU 2.

- Subsurface. Several organic compounds have been detected in subsurface soil samples at depths greater than 5 ft from boring H 221, located north of SWMU 2. These compounds include trichloroethene (0.8J μg/kg), pentachlorophenol (200J μg/kg), and 1,2-dichlorobenzene (42J μg/kg).

  The principal organic contaminant detected in the groundwater at SWMU 2 is trichloroethene. The trichloroethene contamination is found primarily in the upper UCRS. Trichloroethene was detected in the shallow gravel unit (HU2A) in the upper UCRS in MW58 (20 μg/L) and in MW154 (3400 ug/L). It has been detected in the lower UCRS (MW57, MW74, and MW49) at levels up to 10 μg/L. Trichloroethene also has been detected in the upper RGA at levels less than 5 μg/L. Higher levels of trichloroethene (up to 98 μg/L) have been detected in the RGA wells downgradient of the adjacent unit, SWMU 3. The trichloroethene degradation product 1,2-dichloroethene has been detected in the UCRS and the RGA in two monitoring wells located at the perimeter of SWMU 2: MW49 (UCRS) and MW50 (RGA). Concentrations of SVOCs detected in groundwater during the Phase II Investigation were near the detection limits or the compounds were not detected in more than one groundwater sampling event. Three SVOCs [pentachlorophenol (67 μg/L), n-nitroso-di-n-propylamine (35 μg/L), and 2,4-dinitrotoluene (28 μg/L)] were detected above reference values in one RGA monitoring well (MW93) in the vicinity of SWMU 2.

Metal contamination. The following text describes the nature and extent of metal contamination at the site.

- Surface. Copper (27,100 μg/kg), zinc (60,100J μg/kg), arsenic (15,200J μg/kg), mercury (150 μg/kg), and silver (6300 μg/kg) were detected above reference levels [defined in Sect. 4 of *Results of the Site Investigation, Phase II* (CH2M Hill 1992)] in near surface soil samples taken from two soil borings (H 221 and H 262) located at the perimeter of SWMU 2.

- Subsurface. Silver (from 2100 to 7600 μg/kg) has been detected above reference levels in soil samples taken between depths of 5 and 40 ft from boring H 221 located at the northwest corner of SWMU 2.

  Beryllium (up to 20.8 μg/L), chromium (up to 279 μg/L), lead (up to 113J μg/L), and nickel (up to 239 μg/L) were detected in total (unfiltered) metals analysis in two UCRS wells (MW74, MW49) located near SWMU 2. Arsenic (8.9J μg/L), barium (1200 μg/L), cobalt (191 μg/L), manganese (2910 μg/L), silver (46 μg/L), and vanadium (805 μg/L) were detected in total unfiltered analysis at levels above reference values in these two wells. Cadmium (6.8 µg/L) and thallium (10.4 µg/L) were detected in MW49 (UCRS) and MW92 (RGA), respectively.

Radiological contamination. The following text describes the nature and extent of radiological contamination at the site.

- Surface. Two radiation walk-over surveys of SWMU were conducted in August 1994. The first, conducted August 1, 1994, used a beta gamma probe held at a height of 18 in. above ground level. No areas above the 0.2 millirem per hour (mrem/hr) lower limit of detection for the instrument were found. The second survey, conducted August 10, 1994, used a microroentgen meter and measured between 80 and 260 microR per hour (µR/hr), with an arithmetic average of 150 µR/hr. Although no background measurements were reported, typical readings with microroentgen meters are likely to be on the order of 10 µR/hr for uncontaminated areas in the vicinity of SWMU 2. These survey results indicate that a generalized, low-level gamma field exists across SWMU 2 and is likely attributable to the large quantities of uranium metal buried at the site. In addition, during the Phase II Site Investigation, a radiation walk-over survey was conducted over the ditch located south of SWMU 2. The baseline criterion of three times background was used to indicate the presence of radiological contamination. Three times background does not represent a regulatory guidance but serves to show a significant elevation above naturally occurring levels and also accounts for background variation. The results of this survey indicate that beta and gamma emitters are present at the surface of the ditch at levels exceeding three times background (CH2M Hill 1992). The contamination appears to be distributed throughout the length of the ditch (approximately 1000 ft), with the elevated readings located predominantly at the center (bottom) of the ditch.

  Radiological contamination has been detected in shallow soil samples from borings located at the perimeter of SWMU 2, primarily at H 221 northwest of SWMU 2 and at H 262 southwest of SWMU 2. The radionuclides ^{99}Tc [up to 58 pCi/g (picocuries per gram)] and total uranium (up to 89 pCi/g) have been detected in surface soils and in the ditch southwest of the unit to a depth of approximately 6 ft. Other radionuclides present in the surface soil include ^{239}Pu, ^{237}Np, and ^{230}Th at values of 7.9 pCi/g, 0.32 pCi/g, and 14 pCi/g, respectively. The extent of surface radiological contamination likely extends from H 221 in the swale west of SWMU 2 and from H 262 in the ditch south of SWMU 2 to Outfall 015. It is not possible to determine the depth of radiological contamination for SWMU 2 based on only these two soil borings located outside the SWMU boundaries (CH2M Hill 1991). The levels of radionuclides observed in shallow soil borings generally decrease with depth.

- Subsurface. Radiological analyses of subsurface soil samples indicate no contamination above gross alpha or gross beta screening levels (15 and 50 pCi/g, respectively) in the deep soil boring (H 221, completed to a depth of 40 ft bgs) located at the northwest edge of SWMU 2 (CH2M Hill 1994). Since these soil samples had radioactivity below the screening values, the samples were not subjected to more extensive analyses for radionuclide species.

  Groundwater sampling indicates radiological contamination is present in the UCRS near the burial ground. The principal radiological contaminants are ^{99}Tc and, at lower levels, uranium. In four UCRS wells adjacent to the unit (MW49, -58, -74, and -154), ^{99}Tc was detected at levels ranging from less than 25 to 1000J picocuries per liter (pCi/L), with the highest values reported for MW58 and its replacement MW154, which were both screened in the shallow gravel layer (HU 2A). Since near surface contamination was believed to be migrating down the casing annulus, MW58 was abandoned in 1990 and replaced with MW154. Uranium has been detected at varying levels in UCRS wells; the maximum values (in the dissolved fraction) detected in MW58 were 360 pCi/L for ^{234}U, 63 pCi/L for ^{235}U, and 2700 pCi/L for ^{238}U. Other radionuclides detected above reference levels in the surrounding UCRS wells include ^{230}Th and ^{239}Pu.

In general, less radiological contamination exists in the RGA than in the UCRS in the vicinity of SWMU 2. ^{99}Tc was detected at low levels (<25 pCi/L) in the upper RGA in MW48 and MW50 located at the perimeter of SWMU 2. These two wells are located at the southern and southwestern edges of the unit and probably reflect contaminant levels due to sources upgradient of SWMU 2. Two downgradient wells in the area (MW51 and MW67) have reported ^{99}Tc values of up to 53.2 pCi/L in the upper RGA. Much higher levels of ^{99}Tc (up to 1000 pCi/L) can be found in the RGA wells downgradient of the adjacent unit, SWMU 3. At present, only one RGA monitoring well, MW67, is sampled immediately downgradient of SWMU 2.

4.2.1.4 Conceptual model uncertainties

Three uncertainties concerning the conceptual site model that were identified by DOE (1995) prevented final remediation action at SWMU 2. These uncertainties are:

- source term compositions of the SWMU (i.e., nature of the waste),
- the extent of surface soil contamination, and
- the extent of lateral contaminant transport from the SWMU.

4.2.2 Define the Problem

Based on the conceptual framework for the site, the problem at SWMU 2 is:

> In the past, uranium and multiple COCs were disposed of at SWMU 2. These contaminants have been shown by previous work to be migrating (vertically and horizontally) from the waste cells and show the potential for subsurface migration from the SWMU to the RGA at concentrations or activities that may pose risk to human health and environment. In addition, characteristics of the waste are such that they may pose an imminent hazard. However, critical information about contaminated media and sources is not sufficient to design or select an appropriate or final remedy. An interim action is currently proposed. Specific information shown to be lacking and which must be determined before a final remedy is reached includes:
>
> - the boundaries of contamination,
> - the physical form of waste (volume, depth, and containerization),
> - the chemical form of the waste,
> - geotechnical/geochemical properties of surrounding media,
> - effectiveness of interim measure, and
> - preferential pathways.

4.2.3 Define Objectives and Potential Response Actions

4.2.3.1 Remedial action objectives

Remedial action objectives (RAOs) are used in the FS to aid the alternative development and selection process. RAOs are site-specific goals that establish the primary objectives and extent of cleanup required by a CERCLA remediation (EPA 1988). RAOs address COCs, media of concern, and potential exposure pathways, which in turn help to determine preliminary remediation levels, referred to as Remedial Goal Options (RGOs). Although RAOs cannot be finalized until completion of the RI, preliminary goals and potential response actions can be identified with input from stakeholders. These preliminary goals and potential response actions can, in turn, be used to direct data collection to ensure that a final remedy can be selected for SWMU 2 after the completion of the RI. The preliminary RAOs for this unit are presented in the following list. (Final RAOs can be developed only during the selection of alternatives in the FS).

- Prevent transport of contamination to RGA
- Prevent exposure to contaminated groundwater posing a risk of greater than 1×10^{-6} excess lifetime cancer risk or having a hazard index (HI) of greater than or equal to 1 (noncancer)
- Prevent direct contact, ingestion, and inhalation of contaminated soil which may pose an excess lifetime cancer risk greater than 1×10^{-6} or an HI greater than or equal to 1
- Prevent exposure by ecological receptors to contaminated media at the unit or to contaminants migrating from the unit that would have a deleterious effect on survival or reproduction

4.2.3.2 Potential response actions

Potential response actions for addressing SWMU 2 include:

- no action,
- limited action (e.g., access control),
- hydrologic containment [dewatering system, cap, subsurface barriers, interceptor trench (french drain)],
- in situ treatment/stabilization,
- excavation, treatment/stabilization, disposal/storage, and
- any combination of one or more of these actions.

4.2.4 Identify Decisions

Table 4.2 lists the questions that must be addressed to make decisions. The questions posed in Table 4.2 serve as the basis for identifying data needs throughout the remainder of the DQO process.

Table 4.2. SWMU 2 primary questions to be answered

Number	Specific components of decision
1	Will the contaminants migrate (and how) to the RGA at unacceptable concentrations?
2	Is there lateral/vertical contaminant movement in the UCRS?
3	Is waste saturated and to what extent?
4	How effective will the interim measure be?
5	What are the chemical characteristics of the waste?
6	Under what conditions could uranium combustion occur?
7	Is there migration to surface water bodies?
8	What are current RGA contaminant levels underneath the unit (upgradient/downgradient)?

4.2.5 Identify Study Boundaries

Samples are collected during characterization studies to determine the characteristics of the entire population of contaminated media from which the samples were taken. The problem statement (Sect. 4.2.2) helps define the spatial and temporal characteristics of the population for the study.

4.2.5.1 Spatial boundaries

The spatial boundaries for the population are divided into three areas: waste pits, soils, and groundwater (both UCRS and RGA).

Waste pits. Waste is defined as any material placed in the pits that came from plant processes. The volume of waste in the pits is defined by a combination of the areal extent and the depths of the pits. The areal extent of the waste will be determined by sampling. The depth of the waste is unknown and believed to be between 7 and 17 ft below ground surface.

Soils. Soils are divided into three areas: surface soils, subsurface soils, and deep soils. These areas, which define the vertical spatial boundary, are explained in the following list. (Note: soils inside the unit that may be covered by the proposed cap are defined separately because cap material will be composed of clean soil.)

- Surface soils in areas that are to be covered by the cap (part of the interim action) are defined as that soil located from 0 to 1 ft below ground surface after the cap is installed. In areas that may not be capped as part of the interim action (i.e., the drainage ditches), surface soils are defined as that soil located from 0 to 1 ft below the current ground surface.

- Subsurface soils in areas that are to be covered by the cap are any soils located from 1 ft to 10 ft below ground surface after the cap is installed. In areas that may not be capped as part of the interim action, subsurface soils are defined as that soil located from 1 to 10 ft below the current ground surface.

- Deep soils in areas that are to be covered by the cap are any soils located more than 10 ft below ground surface after the cap is installed. In areas that may not be capped as part of the interim action, deep soils are defined as that soil located below 10 ft below current ground surface.

The horizontal boundaries for soils are as follows:

- East— boundary of SWMU 2 is SWMU 3
- North—sample immediately to the north within 5 ft of the proposed cap
- South—between the proposed cap and the ditch
- West—sample within 5 ft of the proposed cap
- Ditch samples will be taken upgradient (at most 5 ft east of SWMU 2 boundary) and downgradient (at most 10 ft west of SWMU 2 boundary).
- The low area west of the SWMU boundary that holds water during wet times of the year must be included due to the surface water pathway of concern.

Groundwater. The groundwater region includes both the UCRS and RGA waters. The investigative unit goes down to the top of the RGA unless trichloroethene contamination is found at the base of the RGA. Then the McNairy Formation may be investigated at 10-ft intervals until the concentration falls below 10,000 ppb. UCRS horizontal boundaries are the same as the soil horizontal boundaries unless trichloroethene is discovered. If trichloroethene is found in the UCRS or RGA at a concentration greater than 10,000 ppb, then the horizontal boundary may be expanded to determine the presence and/or magnitude of the dense nonaqueous phase liquid (DNAPL) source.

4.2.5.2 Temporal boundaries

The temporal boundaries of the population and the sample study are vastly different. Since the half-life of the primary radiological constituent, ^{238}U, is 4.6×10^9 years, the temporal boundaries over which waste sources may pose an unacceptable risk are almost unbounded. Therefore, the timeframe used in the models is important. For a one-dimensional model (for uranium), the timeframe needs to be 10,000 years. The other constituents of concern need to be modeled in the best available two- or three-dimensional model at a timeframe of 30 years.

A second temporal consideration that must be factored into the sample design is the seasonal variation in site conditions. The interaction between the water level in the waste pits and the water level in the drainage ditch is information that is critical to reaching a final remedial decision for SWMU 2; therefore, the sample data must represent wet weather conditions at the site.

The final temporal consideration is the construction start date for the SWMU 2 ROD. Sampling activities will be conducted in conjunction with the installation of the SWMU 2 ROD monitoring system. Therefore, construction of the monitoring system must start by December 1996 (15 months after ROD signature).

4.2.6 Identify Decision Rules

A decision rule has been identified for many of the questions identified in Table 4.2. Question #4 cannot be answered during this sampling activity since the interim action (low-permeability cap) is not in place; Question #6 is a research question that must be considered to perform sampling in the safest manner possible. Decision rules are "if/then" statements that establish triggers for determining what courses of action should be taken once data have been collected and evaluated. Previously constructed decision rules provide a critical basis for data collection activities and help establish specific data needs (e.g., enough data to estimate the 95% upper confidence limit). Decision rules for all questions listed in Table 4.2 are presented in Table 4.3.

4.2.7 Identify Inputs to the Decision

Specific data requirements are functions of the data use. Therefore, decision inputs have been identified for each decision that must be made concerning the area. These inputs are driven by the decision rule requirements and are shown on Table 4.3 along with the pertinent decision rules. Some data needs have been filled by previous investigation; these data needs are shown in a separate column from the data needs yet to be filled.

4.2.8 Specify Limits on Decision Errors

Response action decisions eventually must be made based on the results of the data assessment and BRA that will be presented in the RI Report. Controlling the potential for making a wrong decision begins in the DQO process by identifying what types of errors may occur while collecting and using data and attempting to limit those errors. Although DQO guidance provides some methods for attempting to limit errors by designing statistically based sampling plans (EPA 1993, 1994a), most practitioners have found that the methods generally account for only single factors (e.g., how a single contaminant is distributed in a single medium), while response action decisions are based on understanding multiple factors (multimedia distribution and partitioning, multiple chemicals of varying degrees of toxicity, and predictive modeling output and the various parameters required for that effort).

EPA specifies two components of decision errors: sampling errors and measurement errors (EPA 1993). A third component of error results from the fact that current sampling data do not represent potential future contaminant distribution conditions. Therefore, modeling error is an important consideration. A summary of errors that may be present after data collection and the approach for preventing those errors are provided in the following sections.

Two types of decision errors exist: false negative errors and false positive errors. The initial assumption (i.e., null hypothesis) is that the site is unclean. A false negative error is one which would lead to the decision that no contamination exists at SWMU 2 when, in fact, the contamination does exist. A false positive error is one which would lead to the decision that contamination exists at SWMU 2 when, in fact, the contamination does not exist.

Table 4.3. SWMU 2 decision rules and decision rule inputs

Decision Rules	Evaluation Method	Evaluation Data Needs	Existing Data	Potential Data Needs
D1. If any of the constituents shown in Table 5.2 are migrating or could migrate (based on RESRAD for uranium and ^{99}Tc and best available 2- or 3-D model for other constituents) from the burial pits, soil matrix, and/or UCRS to the RGA in the future and are found to pose a risk greater than 1×10^{-6} (excess lifetime cancer) or an HI = 1 (noncancer) in the RGA, then an action to control the migration will be evaluated.	Evaluate leaching using SESOIL and/or RESRAD modeling including sensitivity analyses EPA risk assessment exposure and risk models (EPA 1989b) Draft state guidance (risk assessment, remedial options, and site characterization)	Chemical -specific exposure point concentrations in soil Land use assumptions Exposure pathways/parameters SESOIL inputs: source term of each pit(contaminant concentrations and mass or volume of waste)	Phases I and II Site Investigation Data (soils and groundwater) Currently installed monitoring well data Process knowledge of contaminants Previous Summers Modeling and RESRAD modeling Regulatory comments on the WAG 22 RI Addendum, FS, Proposed Plan, and ROD EPA (1989b) recommended pathways: Area-specific demographic data Draft state guidance (risk assessment, remedial options, and site characterization)	Soils - Additional analytical data from pits to confirm constituents and concentrations Soils - Additional analytical data from pits to confirm the transport characteristics of the constituents Water - Additional analytical data from pits to confirm constituents and concentrations

Table 4.3. (continued)

Decision Rules	Evaluation Method	Evaluation Data Needs	Existing Data	Potential Data Needs
D2. If any part of the waste is below the water table any time of the year, determine the impact on migration and include the information in Decision Rule #1. Otherwise, model waste as unsaturated and include in Decision Rule # 1.	Geophysical Defraction Tomography (GDT) Piezometer located in the waste pits Transport modeling Evaluate leaching using SESOIL and/or RESRAD modeling including sensitivity analyses EPA risk assessment exposure and risk models (EPA 1989b) Draft state guidance (risk assessment, remedial options, and site characterization)	Water and waste interaction defined (depth of waste and height of water) Physical and chemical evidences to confirm the pathways for transport are probable SESOIL inputs: source term of each pit(contaminant concentrations and mass or volume of waste)	Current monitoring well water level data Burial records Phases I and II Site Investigation groundwater level data	Water - Water level data to determine the elevation of water in the buried waste cells. Determine the maximum depth of the buried waste.

Table 4.3. (continued)

Decision Rules	Evaluation Method	Evaluation Data Needs	Existing Data	Potential Data Needs
D3. If any of the constituents shown in Table 5.2 could migrate to the surface water integrator unit and could pose a human health risk greater than 10^{-6} (excess lifetime cancer), an HI = 1 (noncancer), or an ecological effect that could be deleterious to nonhuman receptors, then actions to control contaminant migration will be evaluated. Otherwise, disregard control of contaminant migration to the surface water integrator unit when actions for the site are evaluated. (For an explanation of how ecological effects will be measured, see Sect. 4 of *Management Strategy for the Surface Water Integrator Unit at the Paducah Gaseous Diffusion Plant*, DOE 1993).	Determine contaminant flux to surface water drainages: Combine water balance estimates for stormwater analytical results EPA risk assessment exposure and risk models (EPA 1989b) Draft state guidance (risk assessment, remedial options, and site characterization)	Chemical -specific exposure point concentrations in sediments Land use assumptions Exposure pathways/parameters Water balance: meteorological data, including evapotranspiration, rainfall; recharge data	Phases I and II Site Investigation Data (soils, sediments, and groundwater) Currently installed monitoring well data Process knowledge of contaminants Regulatory comments on the WAG 22 RI Addendum, FS, Proposed Plan, and ROD EPA (1989b) recommended pathways: Area-specific demographic data Existing reports, available rainfall data Draft state guidance (risk assessment, remedial options, and site characterization)	Sediments - Additional analytical data upgradient and downgradient to confirm constituents and concentrations Water - Additional analytical data from UCRS to confirm constituents and concentrations Interaction between the water level in the buried waste cells and water level in the drainage ditch.

Table 4.3. (continued)

Decision Rules	Evaluation Method	Evaluation Data Needs	Existing Data	Potential Data Needs
D4. If trichloroethene groundwater concentrations are greater than 10,000 ppb in the UCRS or RGA, then evaluate DNAPL source remediation alternatives. Otherwise, declare no DNAPL associated with SWMU 2.	Evaluate leaching using SESOIL and/or RESRAD modeling including sensitivity analyses EPA risk assessment exposure and risk models (EPA 1989b) Draft state guidance (risk assessment, remedial options, and site characterization)	groundwater concentrations in UCRS and RGA Land use assumptions Exposure pathways/parameters	Phases I and II Site Investigation Data (groundwater) Currently installed monitoring well data Process knowledge of contaminants Regulatory comments on the WAG 22 RI Addendum, FS, Proposed Plan, and ROD	Water - Additional analytical data from UCRS and RGA to confirm constituents and concentrations

Table 4.3. (continued)

Decision Rules	Evaluation Method	Evaluation Data Needs	Existing Data	Potential Data Needs
D5. If trichloroethene, ^{99}Tc, or uranium from units surrounding SWMU 2 (SWMU 3, SWMU 91, PCB oil landfarm) migrate through the UCRS or surface water pathways to SWMU 2, then consider the magnitude when designing the action.	Evaluate leaching using SESOIL and/or RESRAD modeling including sensitivity analyses EPA risk assessment exposure and risk models (EPA 1989b) Draft state guidance (risk assessment, remedial options, and site characterization) Determine contaminant flux to surface water drainages: Combine water balance estimates for stormwater analytical results	Chemical -specific exposure point concentrations in soil Land use assumptions Exposure pathways/parameters Water balance: meteorological data, including evapotranspiration, rainfall; recharge data	Phases I and II Site Investigation Data (soils and groundwater) Currently installed monitoring well data Process knowledge of contaminants Previous Summers Modeling and RESRAD modeling Regulatory comments on the WAG 22 RI Addendum, FS, Proposed Plan, and ROD EPA (1989b) recommended pathways: Area-specific demographic data Existing reports, available rainfall data Draft state guidance (risk assessment, remedial options, and site characterization)	Soils - Additional analytical data from surface and subsurface soils to confirm constituents and concentrations Sediments - Additional analytical data from ditch to confirm constituents and concentrations Water - Additional analytical data from UCRS to confirm constituents and concentrations

For this SAP, the potential for both false negative and false positive sampling errors was evaluated qualitatively when developing the sampling plan. A qualitative analysis was performed because results of previous investigations indicate that at least one contaminant (uranium) at the unit is found or will be found in the future in all media at activities that pose an unacceptable risk to human health. Therefore, the potential for both a false positive or false negative error is minimal.

4.2.8.1 Sampling errors

Sampling errors are those errors generated due to observing only a limited number of the total possible values that make up the population being studied. Random sampling error arises because of environmental uncertainty. Sampling errors are reduced by increasing the number of samples taken. In addition, sampling plans may be deliberately biased around locations where the population is expected to be more uniform, such as suspected contaminant source areas, to further minimize the effect of this error. Sampling plan design must balance the cost of increasing the sampling and thereby the sampling error, with the degree of uncertainty contributed to the overall decision error. The SAP sampling strategy presented in Chapter 5 was designed to bias the sampling toward the suspected contaminant source areas.

4.2.8.2 Measurement errors

A measurement error is one that is related to either misidentification of sample locations or samples, inappropriate or inadequate laboratory analysis of samples, or inaccurate reporting of the results of the laboratory analysis. Measurement errors historically have been controlled through the use of the CLP analytical methods and validation procedures. Many of the quality control features of this program have been set up to avoid the potential for false positive and negative errors and ensure that certain detection limits are met with a high degree of certainty. CLP detection limits are sufficient for SVOCs, PCBs, and metals (OLM1.8, ILM1.8); detection limits for volatiles are specified in the appropriate SW-846 method.

In general, a validation will be made in accordance with *Requirements for Quality Control of Analytical Data for the Environmental Restoration Program* (ES/EM/TM-16) (Energy Systems 1992). A subset of data validation criteria listed in ES/EM/TM-16 have been identified as criteria that contribute the most to uncertainty in the reported values. This subset allows for the identification of false positive and negative errors. Data validation criteria that have been identified for this project are discussed in detail in the QAPjP (Appendix A).

4.2.8.3 Modeling errors

Modeling error is a function of two primary components of a model: the many parameters that go into a predictive model and the mathematical algorithms and relationships used to simulate the natural system. The effect of modeling error on decision making can be controlled by performing a sensitivity analysis on the model equations to determine which parameters drive potential model error. The results of the sensitivity analysis can be used to determine which model parameters need to be investigated further. The sensitivity analysis for the various leaching models to be used in the SAP report was performed as part of the FS for SWMUs 2 and 3 of WAG 22 at PGDP (DOE/OR/06-1246&D2). The sensitive parameters were defined as precipitation recharge and the vertical hydraulic conductivity of the clay layer separating HU2B and the RGA. Modeling error was controlled in the development of the SAP by considering the results of the sensitivity analysis in the FS and targeting the sensitive parameters for additional data collection, if necessary. This consideration was completed when defining analyses for the subsurface soil samples to be taken from each HU as defined in Sect. 5.4.

4.2.9 Optimize Sample Design

A proposed sampling strategy has been defined based on the data needs defined in the DQO process and the stakeholders input during the DQO process related to the approximate location of each sample point and analytes to be sampled. This strategy is summarized in Table 5.1 and presented in Sect. 5.1. The major aspects of the sampling strategy are:

- The source terms for the burial ground will be defined through the use of Geoprobe/Terraprobe sampling technique or other conventional drilling methods that may be more cost-effective. Both soil and water samples will be obtained. The water sample will serve as the source leachate for the modeling effort.

- Transport pathways will be better understood by biased sampling of the RGA groundwater upgradient and downgradient of the site. This sampling will also serve to address the data needs for the integrator unit.

- Targeted laboratory analyses for the COCs (as presented in Table 5.2) at SWMU 2 will be performed. CLP Target Analyte List/Target Compound List analyses will be performed on sediment samples only.

- Most sampling is biased toward locations of known contamination or in areas downgradient or downstream of known contamination. Upgradient/upstream sample locations are proposed to understand whether surrounding SWMUs are contributing to the contamination seen at SWMU 2.

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5. FIELD SAMPLING PLAN

The Field Sampling Plan (FSP) details the sampling strategy and design that will be employed for the SAP investigation. This FSP includes a general discussion of the project-specific sampling strategy and a description of the various sampling and analysis activities that will comprise the SAP. The FSP has been organized according to sampling activity.

5.1 FIELD SAMPLING STRATEGY AND DESIGN

The sampling strategy is focused on specific media, contamination, and migration pathways. All existing information and data, potential remedial action alternatives, and FS data requirements were identified, gathered, and evaluated during the DQO process (Chapter 4) to guide the development of this strategy. Based on the results of this evaluation, specific data needs were identified and subsequently were used to focus sampling and data collection requirements within an optimized sample design. All of the samples to be collected are designed to provide the data required to complete the final RI and FS. To ensure that the data collected are adequate for completing the final RI and FS and that the sampling personnel can react to unanticipated conditions, field screening will be used during the investigation. Field screening techniques to be used include on-site analysis of all samples for volatile constituents using a field gas chromatograph and on-site screening of all samples of radiological constituents using portable alpha, beta, and gamma survey instruments.

The sampling strategy for SWMU 2 will focus on collecting samples from surface soils, subsurface soils, and groundwater within the UCRS, RGA, and McNairy Formation and determining if samples can be safely collected from areas near the buried waste. Sediment samples will be collected from only the ditch to the south of SWMU 2 and the low area to the west of SWMU 2. Subsurface soil samples will be collected from within the unit, if these can be taken safely, and from potential migration routes leading from the unit. Groundwater samples will be collected from the UCRS, RGA, and possibly McNairy Formation to determine rate of or potential for migration of contaminants from the unit. The reader should note that collection of groundwater samples from the McNairy Formation will be dependent upon the results of the analysis of water samples taken from the base of the RGA. A McNairy Formation groundwater sample will be collected only if trichloroethene is detected at a concentration equal to or greater than 10,000 ppb. Lack of contamination at the base of the RGA will allow termination of further sampling at a given location.

Waste burial pit sampling will take place if it is determined that these samples can be taken safely; this decision will be based on the outcome of the geophysical survey of SWMU 2. The primary criterion that will be used to determine if these samples can be taken safely is if the extent of the waste cells can be determined using geophysical methods. If the extent of the waste cells can be delineated, then soil and leachate samples from around some waste cells will be collected. Otherwise, samples within the waste pits will not be collected.

Because validated data from previous investigations are available for SWMU 2, the determination was made that data validation for this SAP did not need to be extensive. The data validation strategy is described in the following list:

- Samples will be screened in the field for volatile organic and radiological contamination. Samples for laboratory analysis will be collected as described in Table 5.1. Radiological

Table 5.1. Summary of sampling and analysis activities to be performed during the SWMU 2 area investigation

Sample Type	Sample Points	Sample Depth	Analyses	DQO Decisions
Near-Waste Cell Soil	SWMU2-1, SWMU2-2, SWMU2-4, SWMU2-8, SWMU2-12	5, 10, 15, 20 ft BGS	See Table 5.2	D1 & D3
Near-Waste Cell Water	SWMU2-1, SWMU2-2, SWMU2-4, SWMU2-8, SWMU2-12	2 ft below local water table up to maximum of 20 ft BGS	See Table 5.2	D1, D2, & D3
Surface Soil	SWMU2-7, SWMU2-10, SWMU2-14, SWMU2-17	0 to 1 ft BGS	Rad Screen (Sect. 5.3)	D3
Drainage Ditch Sediment	SWMU2-6, SWMU2-11, SWMU2-15	Surface	TAL/TCL	D3 & D5
Perimeter Subsurface and Deep Soil	SWMU2-3, SWMU2-5 SWMU2-9, SWMU2-10 SWMU2-13, SWMU2-16, SWMU2-17	HU1, HU2, HU3, HU4, HU5, McNairy	See Table 5.2	D1
Existing Monitoring Well Groundwater	MW67, MW74, MW154		See Table 5.2	D1, D4, & D5
Perimeter Groundwater	SWMU2-3, SWMU2-5 SWMU2-9, SWMU2-13, SWMU 2-17	HU2A, HU2B, RGA*	See Table 5.2	D1, D4, & D5
Simultaneous Water Level	SWMU2-3, SWMU2-4, SWMU2-5, SWMU2-8, SWMU2-10, SWMU2-13, SWMU2-16, SWMU 2-17, SWMU2-18, SWMU2-19, SWMU2-20	HU2A or HU2B, wherever water is encountered first	NA	D1, D3, D4, & D5
Geophysical Methods	SWMU2-2, SWMU2-5 SWMU2-8, SWMU2-10 SWMU2-12, SWMU2-15 SWMU2-16, SWMU2-17	NA	NA	D1 & D2

NA - not applicable
BGS - below the ground surface
TBD - too be determined in the field
HU - hydrogeologic unit
RGA* - samples will be collected at the top of the HU5 and then on 10 ft intervals thereafter, with one sample collected at the base of HU5/McNairy contact. If the concentration of trichloroethene is equal to or greater than 10,000 ppb in the sample taken at the base of HU5, additional samples may be collected from the McNairy Formation on 10-ft intervals until trichloroethene concentrations fall below 10,000 ppb.

Note: Upon completion of sampling at SWMU2-9, SWMU2-16, and SWMU2-17, groundwater monitoring wells will be installed within the borings drilled at these locations with the screened interval dependent upon the characterization data.

samples will undergo laboratory analysis if field screening results exceed a maximum value to be determined by all parties prior to the start of fieldwork.

- 10 percent of all laboratory data will be randomly validated (i.e., 10% of sediments, 10% of soils, and 10% of water); therefore, 90% of the data will be screening level and 10% definitive.

Laboratory analyses of samples will focus on the COCs identified in the risk analysis and ARARs sections of earlier reports and contaminants believed to be important because they are degradation products of the COCs. The reports evaluated to focus the laboratory analyses were *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 1994b) and *Feasibility Study for Solid Waste Management Units 2 and 3 of Waste Area Group 22 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1995). Table 5.2 summarizes, by medium, the analytes identified as COCs in these reports.

Table 5.2. COCs identified by medium for SWMUs 2 and 3 as presented by DOE (1994 and 1995)

Analyte	Medium		
	Surface Soil	Subsurface Soil	Groundwater
Inorganic analytes			
Arsenic[a]	X	X	X
Barium[a]			X
Beryllium			X
Cadmium[a]			X
Chromium[a]			X
Manganese			X
Nickel[a]			X
Silver[a]			X
Thallium[a]			X
Uranium	X	X	X
Vanadium			X
Organic Analytes			
2,4-Dinitrotoluene[b]			X
N-nitroso-di-n-propylamine[b]			X
Pentachlorophenol[b]			X

Table 5.2. (continued)

Analyte	Medium		
	Surface Soil	Subsurface Soil	Groundwater
Polychlorinated Biphenyls			X
Trichloroethene	X	X	X
Radionuclide Analytes			
^{99}Tc			X
^{234}U	X	X	X
^{238}U	X	X	X

[a] Removed from the SAP analyte list because the maximum detected concentration of the COC in all media is less than recently determined background concentrations for the COC in all media. (Background concentrations for soil from Bonczek et al. 1995; background concentrations for groundwater from Dolislager et al. 1994.) Because this is a draft document, tables comparing the maximum detected concentrations to threshold values and industrial use preliminary remediation goals for all media are included in Appendix B.

[b] Removed from SAP analyte list because the sample in which the COC was detected was associated with a SWMU 3 sample and not a SWMU 2 sample

The list was examined during the DQO meetings, and a final analyte list by medium was developed (Table 5.3). Because more recent information was available concerning some potential analytes, the project team removed some analytes listed as COCs in earlier reports from the final analyte list for the SAP. In addition, some analytes that had not been listed as COCs in earlier reports were added to the SAP analytes list. Tables comparing the maximum detected concentrations to threshold values and industrial use preliminary remediation goals for analytes in all media are included in Appendix B.

Specific reasons for removing a previously identified COC from the SAP analyte list were:

- the maximum detected concentration of the COC in all media is less than recently determined background concentrations (Bonczek et al. 1995 and Dolislager et al. 1994, Table 5.17) for the COC in all media and

- the sample in which the COC was detected was associated with a SWMU 3 sample and not a SWMU 2 sample.

Specific reasons for adding a chemical not previously identified as a COC to the SAP analytes list were:

- sampling performed during previous investigations was deemed inadequate to determine the nature of the contamination,

- results of previous investigations indicate that the chemical may be present as a degradation product of a current COC, and

- the analyte is considered to be a plant-wide contaminant.

Table 5.3. Final SAP analyte list by medium

Analyte	Media			
	Drainage Ditch Sediment [1]	Subsurface and Deep Soil	Groundwater	Near-waste Cell Soil and Water
Inorganic analytes				
Arsenic				X[2]
Barium				X[2]
Beryllium			X	X[2]
Cadmium				X[2]
Chromium				X[2]
Manganese			X	X[2]
Nickel				X[2]
Silver				X[2]
Thallium				X[2]
Uranium	X	X	X	X
Vanadium			X	X[2]
Organic Analytes				
cis-1,2-Dichloroethylene[3]			X	X
trans-1,2-Dichlororehylene[3]			X	X
Polychlorinated Biphenyls				X
Trichloroethene	X	X	X	X
Vinyl Chloride[3]			X	X

Table 5.3. (continued)

Analyte	Media			
	Drainage Ditch Sediment [1]	Subsurface and Deep Soil	Groundwater	Near-waste Cell Soil and Water
Radionuclide Analytes[5]				
^{99}Tc	X[4]	X[4]	X	X
^{234}U	X	X	X	X
^{235}U[2]	X	X	X	X
^{238}U	X	X	X	X
^{234}Th	X	X	X	X
^{234}Pa	X	X	X	X
^{230}Th	X	X	X	X
^{241}Am	X	X	X	X
^{237}Np	X	X	X	X
^{239}Pu	X	X	X	X

[1] The final analytes list for samples collected from the ditch to the south of and the low area to the west of SWMU 2 will be the Total Analyte List/Total Compound List included in CERCLA, radionuclides, polychlorinated biphenyls, and pesticides. This analyte list was expanded from that presented in this table because the project team believed that the characterization of the ditch in past investigations was inadequate. The analytes contained on this list are presented in Table 5.4.

[2] Added to the SAP analytes list because the sampling performed during previous investigations was deemed inadequate to determine the nature of contamination.

[3] Added to the SAP analytes list since the results of previous investigations indicate that the chemical may be present because it is a degradation product of a COC.

[4] Added to the SAP analytes list for drainage ditch sediment and subsurface and deep soils since ^{99}Tc is considered a plant-wide contaminant.

[5] Radionuclide analyses will be based on the results of radiological field screening as defined in Sect. 6.1.8.

5.2 NEAR-WASTE CELL SAMPLING

Sampling immediately adjacent to the waste burial cells is contingent upon locating areas of disturbed and undisturbed soils using the geophysical methods outlined in Sect. 5.7. A concern is that drums of trichloroethene are known to be buried at the unit. Penetration of these drums is undesirable because this could result in free product escaping into the subsurface soil. Another significant health and safety concern is the potential of driving through pyrophoric uranium material and causing the material to burn. Therefore, if the geophysical methods outlined in Sect. 5.7 cannot delineate the location of individual waste cells, soil and water sampling within SWMU 2 waste cell areas will not be attempted.

5.2.1 Soil Sampling

Five soil samples will be collected from an undisturbed area immediately adjacent to cells containing buried material within SWMU 2. These samples should be representative of the types of contamination that may migrate from uranium material disposal at SWMU 2. The exact location of these samples will be dependent upon the surface geophysical results and will be determined by Energy Systems, DOE, EPA, and KDEP prior to sampling. Figure 2.1 provides the proposed schedule. However, sampling points (SWMU2-1, SWMU2-2, SWMU2-4, SWMU2-8, SWMU2-12) have been arbitrarily defined on Fig. 5.1 to show the five waste cell soil samples. Samples will be collected at four depth intervals: 5, 10, 15, and 20 ft below the ground surface. A summary of the sampling points for the SWMU 2 investigation is presented in Table 5.1, and the analyte list for these samples is presented in Table 5.3.

Soil samples will be collected using rotary hollow stem auger drilling coupled with Shelby tube, Rotary-Sonic, or dual wall drilling techniques. Alternate methods such as Geoprobe/Terraprobe sampling technology may be used if the method is deemed cost-effective. The center portion of the sample core collected at each location will be designated for VOCs analysis and will be placed in appropriate sample containers immediately upon retrieval. The remainder of the core will be composited, and portions needed for other required analyses will be collected. In the event the soil core collected at a given location contains insufficient volume for all required analyses, additional core(s) will be collected within 5 ft of the primary location at the same depth interval. Except for VOCs analyses, the additional core(s) will be combined with the primary core and composited.

Results obtained from analyses of these soil samples will be used to fulfill data evaluation needs as identified for the investigation during the DQO development stage (specifically, the contamination migration from the waste cells to the UCRS and RGA). This will allow the selection of the preferred response action(s) to address the risk from the waste cells.

5.2.2 Water Sampling

Water samples will be collected from the same locations as were the soil samples specified in Sect. 5.2.1 (Fig. 5.1). The samples will be analyzed for the COCs identified in Table 5.3. Water will be collected at 4-ft intervals for field screening. The water sample to be submitted for laboratory analysis will be collected from a depth equivalent to the bottom of the waste cell based on the Geophysical Diffraction Tomography (GDT) results or a maximum depth of 20 ft bgs. If the GDT method proves unsuccessful in determining the depth of the waste, and no water is encountered to a depth of 20 ft, no water sample will be collected from that location. A temporary piezometer will be installed at location SWMU2-4 to evaluate water levels within the waste cells (see Sect. 5.6.3 for further discussion on water levels).

Water samples will be collected using either a Hydropunch sampler in conjunction with rotary augers, a dual wall drilling method, or a Geoprobe/Terraprobe sampling technology. Results obtained from analyses of these water samples will be used to fulfill data evaluation needs as identified for the investigation during the DQO development stage (specifically, contaminant migration from the waste cells to the UCRS and RGA). This will allow the selection of the preferred response action(s) to address the risk from the waste cells.

5.3 SURFACE SOIL SAMPLING

Surface soil samples from the SWMU 2 area are required to augment previous soil data collected during the Phases I and II Site Investigations. Surface soil samples will be collected from

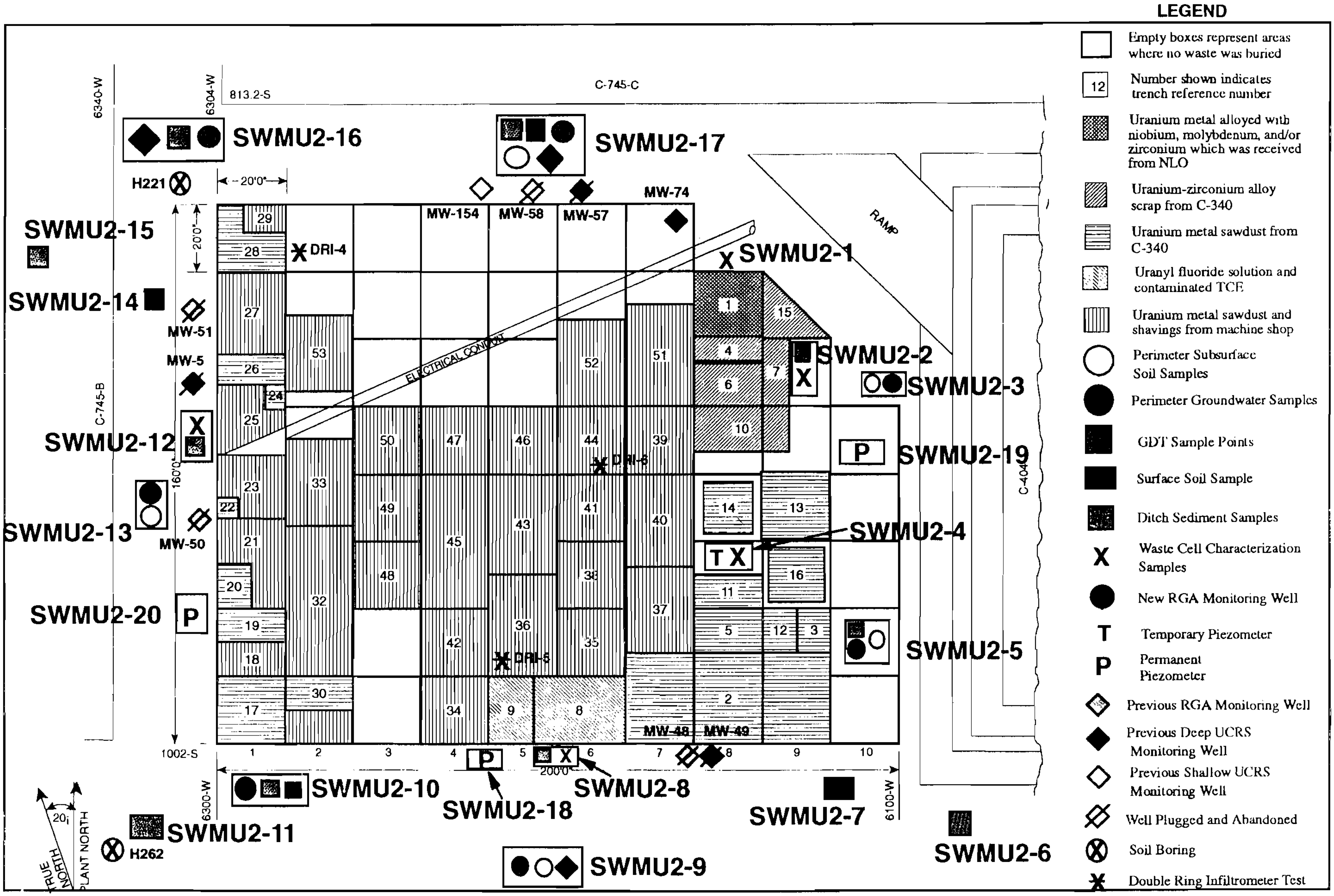

Fig. 5.1. SWMU 2 Previous and Proposed Sampling Points.

four locations (SWMU2-7, SWMU2-10, SWMU 2-14, and SWMU 2-17) located outside of the boundary for the proposed cap. These samples will be collected from a depth of 0 to 1 ft below ground surface and will be screened for radioactivity with field instrumentation as defined in Sect. 6.1.8. If the results of the field screening exceed a maximum value to be determined by all parties prior to fieldwork, samples will undergo laboratory analysis for the radionuclide analytes in Table 5.3. These samples will provide information to ensure that the proposed cap covers the horizontal boundaries for the soils that were identified during the DQO process (see Sect. 4.2.5). Samples will be collected using a bucket hand auger collection device.

5.4 SUBSURFACE AND DEEP SOIL SAMPLING

Soil samples from the SWMU 2 perimeter will be collected to characterize physical (i.e., permeability, grain size distribution, and sorption capacity) and chemical parameters (i.e., COCs) associated with the various HUs. Samples will be collected from each HU, HU1 through HU 5, at sampling points SWMU2-3, SWMU2-5, SWMU2-9, SWMU2-13, and SWMU2-17 (Fig. 5.1). If trichloroethene is found at the base of the RGA in amounts greater than 10,000 ppb in the water analyses, as discussed in Sect. 5.6.2, then a soil sample will be collected from the McNairy Formation. Sampling depths will be determined in the field based on observations during drilling but will correspond to the HUs. Soil samples collected from each boring will undergo analysis for the following geotechnical-geochemical parameters: (1) hydraulic conductivity, grain-size distribution, cation exchange capacity, and uranium sorption capacity for soils from all five HUs; (2) soil moisture content from HU3; and (3) total organic carbon from soils in HU3 and HU5. All samples will undergo analyses for the COCs as outlined in Table 5.2.

Results obtained from analysis of the subsurface and deep soils will be used to fulfill data evaluation needs identified for the investigation DQO decisions regarding possible contaminant migration from the buried uranium cells to the UCRS and RGA and surrounding soils. This information will be used to select the best response(s) action to address risk from SWMU 2.

5.5 DRAINAGE DITCH SEDIMENT SAMPLING

Surface drainage ditch samples from an area south of SWMU 2 and samples from the low area west of SWMU 2 will be collected to assess contaminant migration from SWMU 2 to the Surface Water Integrator Unit via Kentucky Pollutant Discharge Elimination System (KPDES) Outfall 015. One upgradient (10 ft east of SWMU 2) and one downgradient (10 ft west of SWMU 2) sample will be collected. The sample locations are identified on Fig. 5.1 as SWMU2-6 and SWMU2-11 for the drainage ditch samples and SWMU2-15 for the low area west of the unit. Samples will be collected from the surface using a hand trowel, bucket hand auger, or similar collection device. The samples will be analyzed for Target Analyte List/Target Compound List (TAL/TCL) analytes, radionuclides (based on field screening results), and pesticides (see Table 5.4).

5.6 GROUNDWATER SAMPLING

5.6.1 Existing Monitoring Wells

Groundwater samples from existing monitoring wells (MW67, MW74, and MW154), as shown on Fig. 3.1, are required to augment previous data collected during the Phases I and II Site Investigations. Prior to sample collection, various field parameters will be measured within each well including water level, pH, temperature, specific conductance, and dissolved oxygen to determine stabilization during purging. Once stabilized, these parameters will be recorded into the field log book. Samples will be obtained from the wells using low-flow purging sampling methods and collected directly into the appropriate sampling containers. This activity will be coordinated with the PGDP sampling activities. The analyses will include the analytes presented in Table 5.3 as well as calcium, sodium, magnesium, potassium, nitrate-nitrogen, sulfate, fluoride, bicarbonate, and chloride.

Results obtained from analyses of these groundwater samples will be used to fulfill data needs as identified for the investigation during the DQO process. These data needs include the decisions of contaminant migration from the waste cells to the UCRS and RGA and to surrounding soils, selection of the best response action to address the waste cells, and support of the Groundwater Integrator Unit requirements.

5.6.2 Perimeter Locations

Groundwater samples from locations adjacent to the perimeter of SWMU 2 are required to augment previous groundwater data collected during the Phases I and II Site Investigations, characterize upgradient water quality, and provide data required by the Groundwater Integrator Unit. The sampling locations are the same as those discussed in Sect. 5.4 (SWMU2-3, SWMU2-5, SWMU2-9, SWMU2-13, and SWMU2-17) with two additional locations SWMU2-10 and SWMU2-16. The upgradient locations for the RGA SWMU2-9 and SWMU2-10 are to be placed as far from the SWMU 2 boundary as is possible within the confines of the ditch and the road; this placement is to provide the best possibility that the RGA samples reflect upgradient conditions and are not affected from contaminants from SWMU 2.

Groundwater samples will be collected at two depths corresponding to HU2A and HU2B within the UCRS. Within the RGA, samples will be collected at the top of HU5 and then at 10-ft intervals thereafter with another sample collected at the HU5/McNairy Formation contact. If trichloroethene concentrations are observed to be greater than 10,000 ppb at the HU5/McNairy Formation contact, then samples will be collected at 10-ft intervals within the McNairy Formation until the trichloroethene concentration drops below 10,000 ppb. This will result in collection of three to five samples from the RGA. Potentially, one to five samples could be collected from the McNairy Formation. Sampling depths will be determined in the field based on lithologic observations made during drilling.

The method of sample collection will consist of drilling a boring with rotary augers, dual wall reverse circulation drilling, or some other suitable drilling method which will allow the use of a hydropunch sampler or a packer and bladder pump to be inserted into the borehole. Whatever drilling method is chosen should allow for the installation of a 2-in monitoring well. Any monitoring wells installed will be fitted with a packer and bladder pump upon installation.

Table 5.4. TAL/TCL constituents list

Volatile organics	Semivolatile organics	Pesticides and PCBs	Metals	Other	Radiological analyses	Field parameters	Major ions
Acetone	Acenapthene	Aldrin	Aluminum	Cyanide	~~Gross alpha~~	Oxidation-reduction potential	Alkalinity
Benzene	Acenapththylene	alpha-BHC	Antimony		~~Gross beta~~	pH	Bicarbonate (from alkalinity)
Bromodichloromethane	Anthracene	beta-BHC	Arsenic		Technetium-99	Specific electrical conductance	Carbonate (from alkalinity)
Bromoform	Benzo(a)anthracene	delta-BHC	Barium		Uranium-234	Temperature	Calcium
Bromomethane	Benzo(b)fluoranthene	gamma-BHC (Lindane)	Beryllium		Uranium-238		Chloride
2-Butanone	Benzo(k)fluoranthene	Aroclor-1016	Cadmium		Thorium-230		Magnesium
Carbon disulfide	Benzo(a)pyrene	Aroclor-1221	Calcium		Neptunium-237		Nitrate
Carbon tetrachloride	Benzo(g,h,i)perylene	Aroclor-1232	Chromium		Plutonium-239		Potassium
Chlorobenzene	Benzoic acid	Aroclor-1242	Cobalt		Uranium-235		Sodium
Chloroethane	Benzyl alcohol	Aroclor-1248	Copper		Thorium-234		Sulfate
Chloroform	Bis(2-chloroisopropyl)ether	Aroclor-1254	Iron		Protactinium-234		Sulfide
Chloromethane	Bis(2-chloroethoxy)methane	Aroclor-1260	Lead		Americium-241		
Dibromochloromethane	Bis(2-chloroethyl)ether	alpha-Chlordane	Magnesium		Neptunium-237		
1,1-Dichloroethane	Bis(2-ethylhexyl)phthalate	gamma-Chlordane	Manganese				
1,2-dichloroethane	4-Bromophenyl-phenylether	4,4'-DDD	Mercury				
1,1-Dichloroethene	Butylbenzylphthalate	4,4'-DDE	Nickel				
1,2-Dichloroethene (total)	4-Chloro-3-methylphenol	4,4'-DDT	Potassium				
1,2-Dichloropropane	4-Chloroanaline	Dieldrin	Selenium				
cis-1,3-Dichloropropene	2-Chloronaphthalate	Endosulfan I	Silver				
trans-1,3-Dichloropropene	2-Chlorophenol	Endosulfan II	Sodium				
Ethyl benzene	4-Chlorophenyl-phenylether	Endosulfan sulfate	Thallium				
2-Hexanone	Chrysene	Endrin	Vanadium				
4-Methyl-2-pentanone	Di-N-butylphthalate	Endrin ketone	Zinc				
Methylene chloride	Di-N-octylphthalate	Heptachlor					
Styrene	Dibenzo(a,h)anthracene	Heptachlor epoxide					
1,1,2,2-Tetrachloroethane	Dibenzofuran	Methychlor					
Tetrachloroethane	1,2-Dichlorobenzene	Toxaphene					
Toluene	1,3-Dichlorobenzene						
1,1,1-Trichloroethane	1,4-Dichlorobenzene						
1,1,2-Trichloroethane	3,3-Dichlorobenzidine						
Trichloroethene	2,4-Dichlorophenol						
Vinyl acetate	Diethylphthalate						
Vinyl chloride	2,4-Dimethylphenol						
Xylenes (total)	Dimethylphthalate						
	4,6-Dinitro-2-methylphenol						

Table 5.4. (continued)

Volatile organics	Semivolatile organics	Pesticides and PCBs	Metals	Other	Radiological analyses	Field parameters	Major ions
	2,4-Dinitrophenol						
	2,4-Dinitrotoluene						
	2,6-Dinitrotoluene						
	Fluoranthene						
	Fluorene						
	Hexachlorobenzene						
	Hexachlorobutadiene						
	Hexachlorocyclopentadiene						
	Hexachlorethane						
	Indeno(1,2,3-cd)pyrene						
	Isophorone						
	2-Methylnaphthalene						
	2-Methylphenol						
	4-Methylphenol						
	Naphthalene						
	2-Nitroanaline						
	3-Nitroanaline						
	4-Nitroanaline						
	Nitrobenzene						
	2-Nitrophenol						
	4-Nitrophenol						
	N-Nitroso-di-n-dipropylamine						
	N-Nitrosodiphenylamine						
	Pentachlorophenol						
	Phenanthrene						
	Phenol						
	Pyrene						
	1,2,4-Trichlorobenzene						
	2,4,5-Trichlorophenol						
	2,4,6-Trichlorophenol						

Upon completion of groundwater sampling, a monitoring well, MW280, will be installed at the top of the RGA at the SWMU2-9 location; this well will serve as an upgradient monitoring point. Two downgradient RGA monitoring wells, MW282 and MW283, screened at the top of the RGA will be installed at the SWMU2-16 and SWMU2-17 locations.

If trichloroethene is detected at a concentration of 10,000 ppb or more in groundwater at the base of the RGA at location SWMU2-9, monitoring well MW281 will be installed in the bottom of the RGA at location SWMU2-9, and monitoring well MW284 will be installed in the bottom of the RGA at location SWMU2-17. If trichloroethene is detected at a concentration of 10,000 ppb or more in groundwater at the base of the RGA at location SWMU2-17, but not at location SWMU 2-9, only monitoring well MW284 will be installed in the bottom of the RGA. If it can be determined from the sampling results that some of the current monitoring wells at the SWMU (MW74 or MW154) could be used as part of the monitoring system, the number of new monitoring wells will be reduced.

Results obtained from analyses of these groundwater samples will be used to answer data needs identified during the DQO decision process. These decisions include (1) determination of contaminant migration from the waste cells to the UCRS and RGA, (2) determination of contaminant migration from the UCRS to the RGA, (3) selection of the best response action to address waste cells, and (4) support of the Groundwater Integrator Unit requirements.

5.6.3 Simultaneous Water Level Determination

Determination of simultaneous water levels within and around SWMU 2 is required to assess the possibility of elevated water levels within waste cells during periods of high local water table. Additionally, water levels are needed to determine if any of the waste is saturated during any time of the year; this determination can be made only if the GDT method proves successful. In the event the GDT proves ineffective for determining the depth of the waste, the simultaneous water level measurements will still be collected. One round of simultaneous water level measurements will be collected from the UCRS at SWMU2-3, SWMU2-4, SWMU2-5, SWMU2-8, SWMU2-10, SWMU2-13, SWMU2-16, and SWMU2-17 (Fig. 5.1). At a minimum, this information will allow for an evaluation of the component of horizontal flow within the UCRS.

Upon completion of groundwater sampling, three permanent piezometers (PZ279, PZ280, and PZ281) will be installed at the SWMU2-18, SWMU2-19, and SWMU2-20 locations in the UCRS to evaluate changes in shallow water levels. The precise placement of the permanent piezometers will be determined based on an evaluation of data from preliminary GDT results and the near-waste cell borings; their locations as identified on Fig. 5.1 are for demonstration purposes only. The water fluctuations in these piezometers will be compared with PZ278 (temporary piezometer) installed in a waste cell (SWMU2-4) to evaluate water levels for the duration of the field investigation. PZ278 will only be installed if the surface geophysical methods clearly delineate areas of disturbed and undisturbed waste cells. A data logger system will be set up at PZ279, PZ280, and PZ281 to monitor shallow water levels for temporal fluctuations. This information, coupled with existing shallow water measurements from UCRS wells in the area (MW154, MW85, MW94, and MW160), will allow for determining the degree of water level fluctuations and if any part of the waste is saturated during the year. Water level measurments will be collected on a quarterly basis through construction of the interim remedial action cap and will continue for a duration after cap construction (not to exceed one year).

Results obtained from measurements of simultaneous water levels will be used to fulfill data needs identified during the DQO process. These decision rules include (1) determination of contaminant migration from the waste cells to the UCRS and surface water drainages, (2) determination of contaminant migration from the UCRS to surface water drainages, and (3) selection of the best response action(s) to address buried waste cell risk.

5.7 GEOPHYSICAL METHODS

A geophysical survey of the SWMU 2 area using several methods will be conducted prior to all sampling activities. Because the unit is a collection of pits of various depths that are filled with a heterogeneous collection of wastes and backfill soils, the burial ground represents a difficult target for geophysical characterization. Magnetic properties of the metal drums and buried metal scrap offer the best contrast with the native soils for imaging.

First, an EM-61 magnetometer survey will be conducted at the surface of the SWMU 2 area to locate the cells where waste material has been buried and identify any undisturbed cells. Additionally, the geophysical survey should be able to accurately delineate the location of the buried electrical conduit that crosses the northern part of the unit. If undisturbed cells can be found within SWMU 2, these will be candidate areas for the collection of soil and leachate samples. The EM-61 survey will be implemented along continuous lines spaced 4 to 5 ft apart covering an area that will extend 10 ft beyond the SWMU boundary. A data logger or USRAD system will be employed for data acquisition.

If the EM-61 method proves ineffective for delineating areas of disturbed and undisturbed cells, a high frequency Ground Penetrating Radar (GPR) survey will be conducted in the SWMU 2 area. Soils to the west of C-749 at the C-745-B Cylinder Drop Test site have been found to significantly attenuate the resolution of GPR. With GPR, a high frequency antenna maximizes the depth of investigation but reduces the quality of response. From previous use of GPR onsite, a resolution of 4–6 ft bgs is expected, which is adequate to delineate the top of the waste cells. The GPR will be implemented using a towed array system over an area extending 10 ft beyond the SWMU 2 boundary.

In addition to the surface geophysical methods, Geophysical Diffraction Tomography (GDT) will be employed to determine the depth of waste burial and whether or not the waste is saturated. GDT images seismic velocities of soils from both surface and downhole locations, generating a 3-D model of seismic anomaly. The complex nature of the burial ground may inhibit the modeling from producing an accurate 3-D image of the base of the entire burial ground; however, imaging of the burial cells adjacent to the geophysical boreholes will provide sufficient resolution to determine the depth of those waste cells. GDT will be implemented in eight boreholes completed to a depth of approximately 30 ft bgs around the perimeter of the unit. The borehole will be cased and filled with chlorinated water, and the GDT tool will be lowered into the hole. Eight locations that largely correspond with planned boreholes for subsurface soil and groundwater sampling have been selected. The borehole locations are depicted in Fig. 5.1 and include sample locations SWMU2-2, SWMU2-5, SWMU2-8, SWMU2-10, SWMU2-12, SWMU2-15, SWMU2-16, and SWMU2-17. Upon completion of the geophysical evaluation, the chlorinated water will be pumped out of the borehole, and the hole will be used for installation of a piezometer or grouted.

5.8 QUALITY ASSURANCE/QUALITY CONTROL SAMPLING

Quality control (QC) sampling will take place both in the field and in the laboratory. The types and numbers of laboratory QC samples to be analyzed are outlined in the SWMU 2 QAPjP, Appendix A, Section A.8.

Field QC sampling will be conducted to check sampling analytical accuracy and precision for both laboratory and field analyses of collected samples. In the event contaminants are found in QC blank samples, an attempt will be made to identify the source of contamination, and corrective action will be initiated in accordance with procedures described in the SAP QAPjP (Appendix A). The laboratory contracted to perform sample analyses will also develop QC samples in accordance with the analytical method and with the *Requirements for Quality Control of Analytical Data for the Environmental Restoration Program* (ES/ER/TM-16) (Energy Systems 1992).

Four different types of field QC samples will be collected during implementation of the SWMU 2 investigation: trip blanks, equipment rinseates, field blanks, and field duplicates. A trip blank consists of a sealed container of ASTM Type II water that travels with the samples collected in the field and transported to the laboratory for VOCs analysis. The trip blank is used to identify contamination, specifically VOCs, that may have originated during transport of the samples from the field. One trip sample will be placed in each cooler containing field samples and analyzed for VOCs.

An equipment rinseate is collected in the field from the final ASTM Type II decontamination rinse water from the field sampling equipment. The equipment rinseate determines effectiveness of the decontamination process and identifies carryover of contamination from one sampling location to another. One equipment rinseate will be collected from each type of sampling equipment used during each sampling event. All samples of this type will be analyzed for the same analytes associated with the medium being collected.

A field blank consists of a sealed container of ASTM Type II water that travels with the sample bottles into the field. The sample bottle is cracked open in the field and then closed and transported with the samples. The field blank is used to identify contamination that may have originated during transport of the samples from the field. One trip sample will be placed in each cooler containing field samples and analyzed for the same analytes associated with the medium being collected.

A field duplicate is collected along with a field sample at the same sampling location and is placed into a separate set of containers labeled with a different sample number. Field duplicates are submitted as "blind" to the contract laboratory and are used to indicate whether the field sampling technique is reproducible and ensure the accuracy of reported laboratory results. A field duplicate will be collected for every 20 samples collected for the same medium.

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6. FIELD SAMPLING PROCEDURES

All sampling to be performed will be conducted in accordance with medium-specific procedures provided in the PGDP Environmental Restoration and Enrichment Facilities Field Operations Procedures (FOPs) Manual (Energy Systems 1993). The PGDP FOPs are consistent with the Energy Systems Environmental Surveillance Procedures (Kimbrough et al. 1990) and the EPA Region IV Standard Operating Procedures. Any deviations from the PGDP FOPs during the investigation will be addressed using the field variance system described the SAP QAPjP for the investigation (Appendix A). Table 6.1 provides a listing of all PGDP FOPs that will provide procedural guidance for field activities conducted during the investigation.

6.1 SAMPLING ACTIVITIES

6.1.1 Near-waste Cell Soil Samples

Soil samples adjacent to the waste cells will be collected using rotary augering, Rotary-Sonic, or reverse air rotary coupled with a Shelby tube or Geoprobe/Terraprobe sampling, whichever is more cost effective. All borings will undergo continuous field screening. The continuous core from the soil collection device will first be screened with a photo-ionization detector for volatile organic contamination. The core will then be screened for radiological contamination; first, with a sodium iodide detector for gamma radiation followed by an alpha/beta scalar ratemeter for discrimination of alpha/beta radiation. LMES Health Physics procedures (CP4-HP-RP2101, CP4-HP-IO2200, CP4-HP-IO2203, and CP4-HP-IO2211) will be used to govern the radiological field screening. Samples will be collected for laboratory analysis as defined in Sect. 5.2.1 and Table 5.1.

For the laboratory samples, the center portion of the sample core collected at each location will be designated for VOCs analysis and will be placed in appropriate sample containers immediately upon retrieval. VOCs analysis will be performed in a field laboratory equipped with a GC using an Electron Capture Detector (ECD). The remainder of the core will be composited and portions needed for other required analyses will be collected. In the event the soil core collected at a given location contains insufficient volume for all required analyses, additional core(s) will be collected within 5 ft of the primary location at the same depth interval. The additional core(s) will be combined with the primary core and composited. Additional information related to near-waste cell sampling is presented in Sect. 5.2.

6.1.2 Surface Soil Samples

Surface soil samples will be collected using a hand auger in accordance with PGDP FOP CP4-ER-SAM4201. These samples will be screened for radioactivity only with field instrumentation. LMES Health Physics procedures (CP4-HP-RP2101, CP4-HP-IO2200, CP4-HP-IO2203, and CP4-HP-IO2211) will be used to govern the radiological field screening. Additional information related to surface soil sampling is presented in Sect. 5.3.

6.1.3 Subsurface Soil Sampling

Subsurface soil samples will be collected using split-spoon devices in accordance with PGDP FOP CP4-ER-SAM4202. Split-spoon samples will be collected over the entire depth of the borings for the purpose of developing lithology logs in accordance with PGDP FOP CP4-ER-A1103.

The borings will be drilled and sampled using a hollow-stem auger drill rig. The internal diameter of each boring will be 4 in. The drill rig should have the capability to reach a depth of 100 ft. Additional information related to the subsurface soil sampling is presented in Sect. 5.4.

6.1.4 Drainage Ditch Sediment Sampling

Sediment samples from the drainage ditches will be collected in accordance with PGDP FOP CP4-ER-SAM4101. Additional information related to drainage ditch sediment sampling is presented in Sect. 5.5.

Table 6.1. Summary of PGDP FOPs

Procedure Identification	Procedure Title
CP4-ER-A1101	Site and Field Logbook Content and Control
CP4-ER-A1103	Lithologic Logging
CP4-ER-SAM2001	Sample Identification
CP4-ER-SAM2002	Sample Chain of Custody
CP4-ER-SAM2003	Sample Packaging and Shipment
CP4-ER-SAM2004	Sample Preservation, Container Selection, and Determination of Holding Times
CP4-ER-SAM2006	Radiation Screening
CP4-ER-SAM4001	Surface Water Sample Collection
CP4-ER-SAM4101	Collection of Sediment/Sludge Samples
CP4-ER-SAM4201	Surface Soil Sampling
CP4-ER-SAM4202	Subsurface Soil Sampling
CP4-ER-SAM4203	Geoprobe/Terraprobe Surveys
CP4-ER-SAM4204	Composite Sample Preparation
CP4-ER-SAM4301	Water Level Measurements
CP4-ER-SAM4303	Groundwater Sampling
CP4-ER-SAM4501	Field Measurements: Temperature
CP4-ER-SAM4502	Field Measurements: pH
CP4-ER-SAM4503	Field Measurements: Dissolved Oxygen
CP4-ER-SAM4506	Field Measurements: Specific Conductance
CP4-ER-SAM4508	Field Gas Chromatography
CP4-ER-SAM4601	Drum and Special Container Staging and Sampling
CP4-ER-SAM4602	Manual Drum Opening
CP4-ER-SAM4603	Drum and Special Waste Handling
CP4-ER-SRV4001	Monitoring Well Filter Pack an Screen Selection
CP4-ER-SRV4002	Monitoring Well Installation
CP4-ER-SRV4004	Monitoring Well Development
CP4-ER-WM2001	Handling of Investigation-Derived Waste

Table 6.1. (continued)

Procedure Identification	Procedure Title
CP4-ER-Q1001	Data Management
CP4-ER-Q1002	Sample tracking and Laboratory Coordination
CP4-ER-Q4001	Preparation of Field Quality Control Samples
CP4-ER-DCN4001	Decontamination of Drilling-Related Equipment
CP4-ER-DCN4002	Decontamination of Field Equipment

6.1.5 Groundwater Sampling

Groundwater samples will be collected from existing monitoring wells and adjacent perimeter locations. Field measurements performed on the groundwater samples collected from monitoring wells and sampling locations will be conducted in accordance with the following PGDP FOPs:

- CP4-ER-SAM4501 (temperature),
- CP4-ER-SAM4502 (pH),
- CP4-ER-SAM4503 (dissolved oxygen), and
- CP4-ER-SAM4506 (specific conductance).

Prior to the collection of groundwater samples from existing monitoring wells, the level of water within each well will be measured in accordance with PGDP FOP CP4-ER-SAM4301. Additional information related to groundwater sampling is presented in Sect. 5.6.

6.1.5.1 Existing monitoring wells

Groundwater samples from the existing monitoring wells will be collected using low-flow purging and sampling techniques. This technique will be used to minimize well purge water investigation-derived waste (IDW). All existing monitoring wells will undergo low-flow purging during which the pH of the purge water will be measured at regular intervals. Purging will continue until the groundwater dissolved oxygen measurements have stabilized to within +/- 10% or until one of the two following criteria are met: (1) four continuous hours of purging have been completed or (2) three well volumes of groundwater have been purged. Additional information related to groundwater sampling at existing monitoring wells is presented is Section 5.6.1.

6.1.5.2 Near-waste cell locations

Groundwater samples will be collected using a Hydropunch sampler in conjunction with rotary augers or a Geoprobe/Terraprobe sampling technology in accordance with PGDP FOP CP4-ER-SAM4203. The groundwater sampling device will be placed at the appropriate depth, as directed by the Energy Systems Hydrologist, and the required volume of sample will be extracted. In the event that all or part of the required groundwater sample volume cannot be extracted in a timely fashion at any location due to lack of sufficient saturation, the sampling device assembly will be sealed at the ground surface and will remain in the ground for a period of 24 hours. If an apparently permeable zone is encountered and sufficient sample is not collected in the initial borehole, additional sampling device assemblies may be installed within 5 ft of the primary location over the same depth interval to augment the volume of groundwater available for sampling.

Collection of the groundwater samples will then be completed assuming that sufficient groundwater has recharged into the sampling device(s). Groundwater sampling will be abandoned at the location if a sufficient volume of groundwater cannot be collected after a 24-hour period. Field measurement of groundwater characteristics will not be conducted on samples that cannot be collected in a timely fashion because the entire volume of extracted groundwater will be needed to complete the required sampling. Additional information related to groundwater sampling at near-waste cell locations is presented in Sect. 5.2.2.

6.1.5.3 Perimeter locations

Groundwater samples from locations adjacent to the perimeters of the unit will be collected using Hydropunch sampling technology or another suitable technique. The groundwater sampling device will be driven to the defined sampling depths, and the required volume of sample will be extracted. In the event that all or part of the required groundwater sample volume cannot be extracted in a timely fashion at any location due to lack of sufficient saturation, the sampling device assembly will be sealed at the ground surface and will remain in the ground for a period of 24 hours.

Collection of groundwater samples will then be completed assuming that sufficient groundwater has recharged into the sampling device. Groundwater sampling will be abandoned at the location if a sufficient volume of groundwater cannot be collected after a 24-hour period. Field measurements of groundwater characteristics will not be conducted on samples that cannot be collected in a timely fashion because the entire volume of extracted groundwater will be needed to complete the required sampling. Additional information related to groundwater sampling at adjacent perimeter locations is presented in Sect. 5.6.2.

6.1.5.4 Monitoring well installation and development

Up to five groundwater monitoring wells may be installed in the perimeter borings augered during the investigation in accordance with PGDP FOPs CP4-ER-SRV4002, CP4-ER-SRV4001, and CP4-ER-SRV4004. Installation of the monitoring wells is dependent upon the groundwater sampling results from SWMU2-3, SWMU2-5, SWMU2-9, SWMU2-10, SWMU2-14, SWMU2-17, and SWMU2-18. If no contaminants are detected at the base of the RGA at these locations, only upper RGA wells will be installed at selected locations. All RGA monitoring wells will be installed as double-cased monitoring wells having 12-in. outer diameter steel isolation casings and 2-in. inner diameter stainless steel well casings and screens. Screen size and placement in all of the wells will be based on the sampling results and professional judgment of the hydrogeologist. The well construction diagram is shown in Fig. 6.1.

6.1.5.5 Simultaneous water level determination

Simultaneous water level measurements will be obtained in accordance with PGDP FOP CP4-ER-SAM4301. Measurements at one of these locations (SWMU2-4) will be made within a temporary piezometer installed in accordance with PGDP FOP CP4-ER-SAM4203. Additional information related to simultaneous water level determination is presented in Sect. 5.6.3.

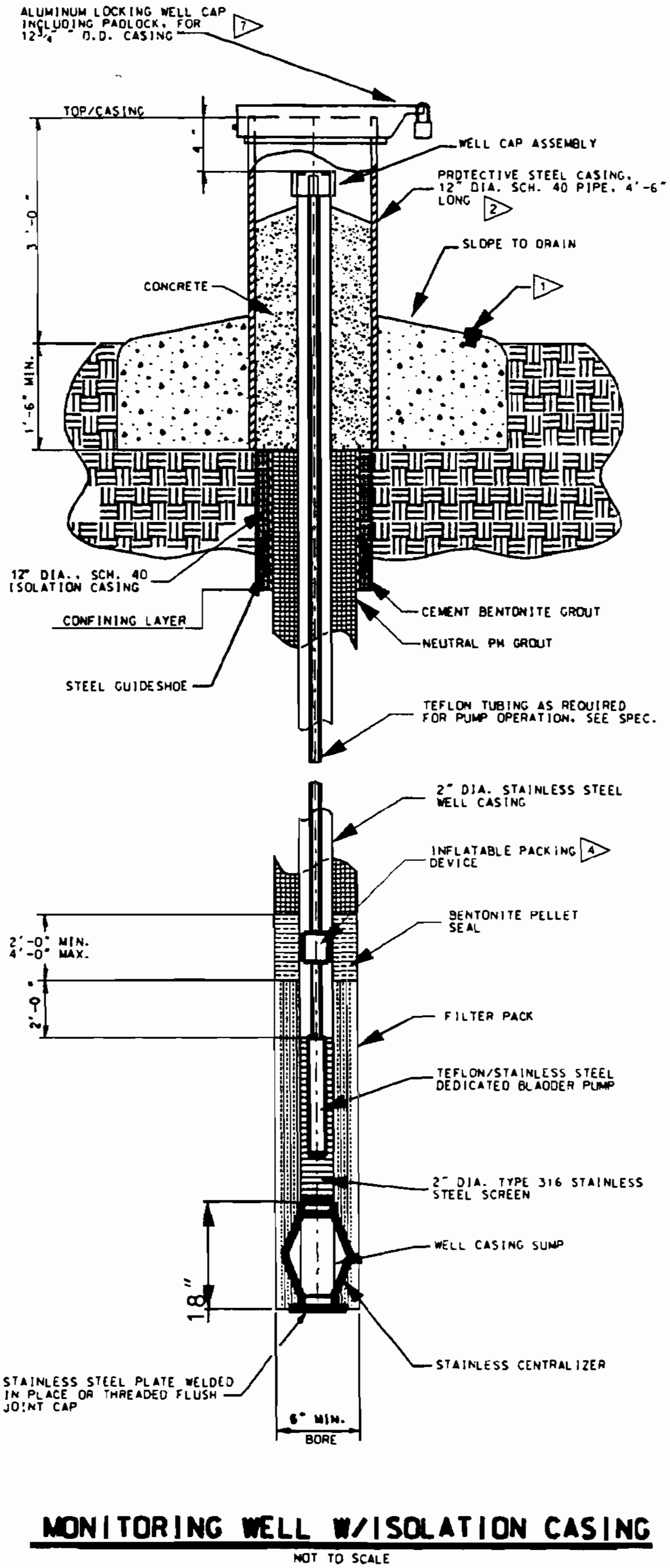

Fig. 6.1. Well construction diagram.

6.1.6 Sample Collection

Collection of soil and groundwater samples will be performed in accordance with PGDP FOPs CP4-ER-SAM4201, CP4-ER-SAM4202, and CP4-ER-SAM4202. Related QA/QC procedures and sampling requirements are discussed in the SAP QAPjP (Appendix A). Waste management requirements for IDW generated during sample collection will be presented in the project-specific Waste Management Plan that will be developed for the investigation.

6.1.7 QA/QC Sampling

Field QC samples will be collected and will include trip blanks, equipment rinseates, field blanks, and field duplicates. Descriptions of these sample types are presented in Sect. 5.8. These samples will be collected in accordance with PGDP FOP CP4-ER-Q4001.

6.1.8 Field Screening

Field screening of soil and groundwater samples will include on-site analyses of all samples for volatile constituents using a field gas chromatograph equipped with an EDC and for radiological constituents using portable alpha, beta, and gamma survey instruments. Radiological field screening of samples will consist of a gamma screen using a Ludlum Model 2350 with a 2×2 sodium iodide detector followed by an alpha/beta scalar rate meter (i.e., a Ludlum 2224 with a 14389 a/b scintillator) for alpha/beta discrimination. If the radiological field screening results exceed a maximum value (to be determined by all parties prior to the commencement of field activities), the sample will undergo laboratory analysis for the radionuclide analytes defined in Table 5.3. Only a certain percentage of these samples (to be determined prior to field activities) will be analyzed for ^{241}Am, ^{23}Np, and ^{239}Pu. LMES Health Physics procedures CP4-HP-RP2101, CP4-HP-IO2200, CP4-HP-IO2203, and CP4-HP-IO2211 will be used to govern the radiological field screening.

6.1.9 Field Location Surveying

Sample location surveys will be performed to provide a horizontal and vertical reference for characterizing a location. Sampling locations will be measured to within the nearest 0.1 ft horizontally and 0.01 ft vertically. The site surveys will be tied to the PGDP coordinate system and to U.S. Coast and Geodetic Survey monuments. All benchmarks, reference points, and associated elevations and coordinates will be approved by Energy Systems Site Engineering Design Department.

Surveying of the sampling locations will be conducted upon completion of all field activities. Where possible, markers consisting of flagging or of wooden stakes will be used to mark all sample locations. Flagging and wooden stakes will be removed once the area/locations have been surveyed and the data have been checked by the Energy Systems Site Engineering Design Department. A thorough description of each sampling location will be made during field sampling activities and documented using field maps and/or photographs. This documentation will be used for the survey effort if sampling-location markers are disturbed or if permanent markers cannot be placed at the time of sampling. A member of the field sampling team will accompany the survey crew to provide information regarding the location of sampling points.

6.2 DOCUMENTATION

Field documentation will be maintained throughout the SAP investigation in various types of documents and formats, including the site logbook, field logbook, sample labels, sample tags, chain-of-custody forms, and field data sheets. In addition to the requirements of PGDP FOP CP4-ER-A1101, the following general guidelines for maintaining field documentation will be implemented.

- Blank lines are prohibited. Information should be recorded on each line or the line should be lined out, initialed, and dated.
- No documents will be altered, destroyed, or discarded even if they are illegible or contain inaccuracies that require correction.
- All information blocks on field data forms will be completed or a line will be drawn through the unused section, and the area will be dated and initialed.
- Photocopies of all logbooks, field data sheets, and chain-of-custody forms will be made weekly and sent to the project file.

6.2.1 Site and Field Logbooks

Site and field logbooks will be used for the maintenance of field records and for documenting any information pertinent to field activities. These data will be obtained from exploration, observation, and sampling activities and entered in the field logbook by site and field personnel. Field documentation will conform to PGDP CP4-ER-A1101.

6.2.2 Field Data Sheets

Field data sheets will be maintained as appropriate for the following types of data:

- water level measurements,
- soil boring logs,
- monitoring well construction logs,
- sample log sheets,
- well development logs,
- well purging logs,
- groundwater sampling logs,
- chain-of-custody,
- instrument calibration logs,

- sample log sheets, and
- temperature monitoring sheets.

Data to be recorded will include such information as the location, sampling depth, sampling station, and applicable sample analysis to be conducted. Field-generated data forms will be prepared, if necessary, based on field sampling plan requirements. This information will be documented or referenced in the field logbooks.

6.2.3 Sample Identification, Numbering, and Labeling

Sample identification, numbering, and labeling will be performed in accordance with PGDP FOP CP4-ER-SAM2001. This procedure identifies each environmental sample obtained using an overall project identification number and a unique sample number. All sample information will be entered in the appropriate site and field logbooks and will include the time of sample collection, sample matrix type, and analyses requested. Labels will be securely attached to selected sample containers (Sect. 6.1.6). Field QC samples, as listed in Sect. 6.1.7, will also receive unique sample numbers to facilitate tracking of these samples.

6.2.4 Sample Handling

Sample chain of custody will be accomplished in accordance with PGDP FOP CP4-ER-SAM2002. This procedure outlines documentation requirements for sample possession through all transfers of custody from time of collection, transport to and receipt at the laboratory, and subsequent analysis. Chain-of-custody records will accompany each packaged shipping container of samples; the laboratory will not accept a sample for analysis without a correctly prepared chain-of-custody record. The chain-of-custody form will also contain a sample request form for the laboratory's use. Internal laboratory records will document the custody of the sample through its final disposition in accordance with PGDP FOP CP4-ER-Q1001.

6.2.5 Sample Shipment

If environmental and hazardous samples are shipped offsite, the shipment will be performed in accordance with PGDP FOP CP4-ER-SAM2003. Environmental and hazardous samples will be defined according to U.S. Department of Transportation (DOT) regulations defined in 49 CFR 172. In general, sample containers will be packed in the following manner:

- Custody tape will be wrapped around each end of the cooler two times, and custody seals will be placed on each end of the cooler.
- Glass sample containers will be placed in plastic bags and sealed to prevent contact with other sample containers or the inner walls of the container. Vermiculite will be placed between the sealed sample containers inside the cooler.
- Logbook entries, sample tags and labels, and chain-of-custody forms will be completed with sample data collection information and names of all persons handling the sample in the field before packaging.
- Samples, temperature blanks, and trip blanks will be placed in a thermally insulated cooler along with ice packed in sealed plastic bags. After the cooler is filled, the appropriate

chain-of-custody form will be placed in the cooler in a sealed plastic bag attached to the inside of the cooler lid.

- The temperature of the temperature blank will be recorded before the cooler is sealed.

- Samples will be classified according to DOT regulations pursuant to 49 CFR 172. All samples will be screened for radioactivity so that DOT limits of 2.0 nCi/mL for liquid waste and 2.0 nCi/mg for solid waste are not exceeded. PGDP will supply an on-site screening laboratory for investigative samples before their shipment to an off-site laboratory.

6.2.6 Field Planning Meeting

A field planning meeting will occur before work begins so that all involved personnel will be informed of the requirements of the field work associated with the project. Additional field planning meetings will be held whenever new personnel join the field team or if the scope of work changes significantly. These meetings will discuss the following briefly:

- objectives and scope of the field work,
- project and site-specific health and safety,
- equipment and training needs,
- field operating procedures,
- required QA/QC measures, and
- documents governing on-site field work.

Each meeting will have a written agenda that will be reviewed by the subcontractor's QA/QC Officer or designee before the meeting. This agenda will be used for any field personnel joining the field team after the initial field planning meeting. Each attendee must sign an attendance sheet, and copies of the agenda and attendance sheet will be maintained in the project files and on site. Depending on conditions and schedules, this meeting may take place at the field office or at another convenient location. If necessary, the agenda may be mailed or a telefacsimile transmitted to field personnel and then discussed over the telephone.

6.2.7 Readiness Checklist

Before initiation of the field investigation, the SAP will be reviewed to identify all field activities and materials required to complete the activities. A readiness checklist, which summarizes the status of the following information, will be prepared and maintained for the task:

- task deliverables;
- required approvals and permits;
- procurement of laboratories, drillers, surveyors, etc.;
- personnel availability;

- training and indoctrination;
- field equipment (including all calibration and maintenance equipment);
- sampling equipment;
- site facilities and equipment; and
- health and safety equipment (including all calibration and maintenance equipment).

This readiness checklist and accompanying documentation will be prepared and submitted to the appropriate Energy Systems ER Program personnel for review before field work is initiated.

6.3 DECONTAMINATION

Sampling equipment will be decontaminated in accordance with PGDP FOPs CP4-ER-DCN4002 and CP4-ER-DCN4001. The decontamination site to be used for the investigation will be one of the five existing decontamination sites located at PGDP and will be determined by the PGDP ER Program based on availability at the time of investigation implementation. In addition, the operating procedures for the chosen decontamination site will be followed.

6.4 WASTE MANAGEMENT

The following PGDP Environmental Restoration and Enrichment Facility waste management procedures will be used during the implementation of the investigation for management of IDW:

- CP4-ER-SAM4601,
- CP4-ER-SAM4602,
- CP4-ER-SAM4603,
- CP4-ER-WM2001,
- ERWM/PA-11762,
- ERWM/ER-P2103, and
- PTWM-2002.

Soils generated through sampling and well and piezometer installation will be drummed and stored pending waste characterization results. In the event that a low-permeability cap is placed on the unit, soils generated within the SWMU boundaries may be placed on the unit as below cap fill. All waste from outside the SWMU boundary will be stored and disposed of based on characterization results.

The waste streams expected from the sampling include personal protective equipment (PPE), plastics, sanitary waste (packing material), and water generated from the borings, well purging, and decontamination of the equipment. Table 6.2 presents the standard parameters that are requested from Energy Systems Waste Management to characterize waste for waste treatment and disposal. Some parameters may be eliminated due to documented process knowledge.

Table 6.2. Energy Systems Waste Management sampling parameters for waste characterization

TCLP metals and nickel, Tl, and Sb
TCLP volatiles and semivolatile organics
Uranium
^{235}U
^{237}Np
^{230}Th
^{239}Pu
^{99}Tc
^{241}Am
^{60}Co (solids only)
^{137}Cs (solids only)
PCBs
pH (if applicable)

A detailed description of waste management procedures and practices will be presented in the WMP that will be developed for this investigation.

6.5 DATA MANAGEMENT

Sampling activities to be conducted will result in the collection of several types of data to be used for multiple purposes. Data collection will include field measurements and laboratory analyses of soil and groundwater (site characterization data). The specific data types to be generated will include physical, chemical, and radiological parameters. In addition, other information will be generated to describe the sampling location, well, or boring that is being characterized.

The steps necessary for proper handling of field data are detailed in the PGDP FOP CP4-ER-Q1001. Appropriate field forms containing relevant information (including sample identification, sample locations, depths, media, equipment, analysis types, etc.) and all analytical data reported by the analytical laboratory will be transferred as required to the Energy Systems Environmental Information Management System.

All contract deliverables will be transmitted to Energy Systems for storage in the Energy Systems ER Document Management Center. Additional information regarding data management for the investigation will be presented in the Data Management Plan that will be developed for this investigation.

6.6 HEALTH AND SAFETY

Health and safety information, requirements, and procedures to be used during the implementation of this investigation will be defined in the project Health and Safety Plan that will be developed for this investigation.

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7. RISK ASSESSMENT

7.1 RISK ASSESSMENT SCOPE AND OBJECTIVES

A BRA consisting of a human health risk evaluation and an ecological risk evaluation will be developed for SWMU 2. This BRA will use all previous data as well as those data collected following this SAP. The human health evaluation will be consistent with the assessment strategy for source units to be presented in the forthcoming human health risk assessment strategy appendix to the PGDP Site Management Plan. The ecological risk evaluation will follow the strategy for source units outlined in the *Management Strategy for the Surface Water Integrator Unit at the Paducah Gaseous Diffusion Plant* (DOE 1993b). The objectives of the risk assessment will be to:

- provide an evaluation of the potential threat to human health in the absence of any action,
- provide a preliminary evaluation of harm to ecological resources in the absence of any action,
- provide a basis for determining whether or not remedial action is necessary and the justification for performing remedial action,
- provide the information needed to determine to what level the concentrations and activities of chemicals and radionuclides must be reduced to protect human health and the environment, and
- provide a baseline for comparing the level of protection from various remedial alternatives relative to potential human health and ecological effects.

To attain these objectives, the risk assessment will identify and characterize:

- levels of hazardous substances present in relevant media, including a review of relevant biological and chemical information and the potential changes in concentrations and activities of hazardous substances in relevant media over time and within the boundary of the study area;
- potential exposure pathways and routes and the extent of actual or predicted exposure;
- potential human receptors by defining the size, characteristics, and location of human populations which may be exposed to contaminants originating at the site;
- extent of potential impact by quantifying potential carcinogenic risk and systemic toxicity;
- potential ecological harm within the site's watershed from exposure to contaminants at or originating from the site; and
- levels of uncertainty associated with the assessment, including a summary of the strengths and weaknesses of site characterization, toxicity assessment, exposure assessment, and health risk characterization (this summary will include discussion of the effect of the major assumptions made during risk characterization upon the resulting risk values; uncertainty analysis may include sensitivity or other quantitative analyses if these are deemed necessary for decision making in the FS).

7.2 HUMAN HEALTH RISK ASSESSMENT

7.2.1 Identification of Contaminants of Potential Concern

This section of the assessment will describe the site characterization regime and will use relevant historical information and analytical data from all sampling activities conducted at SWMU 2. The results gathered from site characterization activities will be evaluated for appropriateness of use in the risk assessment. The following data evaluation steps will be applied, in accordance with EPA guidance (EPA 1989a), to identify COPCs from site media and gather the subset of data which will be used to quantify exposure:

- evaluation of sampling (sample locations will be examined to ensure that resulting data are adequate to allow for the determination of current and future risk),

- evaluation of analytical methods (data qualifiers and codes, results of blank analyses, sample quantification limits, and frequency of detection will be evaluated to determine the quality of the sampling data),

- comparison of analyte concentrations in environmental samples from the site to analyte concentrations in background,

- comparison of analyte concentrations in environmental samples to residential preliminary remediation goals or other suitable screening criteria (e.g., ARARs), and

- comparison of analyte concentrations of essential nutrients (e.g., iron and calcium) in environmental media to potentially toxic concentrations.

A discussion of uncertainties associated with each of the aforementioned evaluations or comparisons will be included in the summary for this section of the assessment.

7.2.2 Exposure Assessment

The exposure assessment will be performed in accordance with EPA guidance (e.g., EPA 1989a, 1989b, 1991a, 1991b) and will be consistent with the risk characterization strategy for source units to be presented in the forthcoming human health risk assessment strategy document for the PGDP. The exposure assessment will include a description of the exposure setting, or physical environment, land use, and demography, for the area near SWMU 2. This assessment will also include a discussion of the location of potentially exposed populations under both current and alternative future land uses (e.g., industrial, rural residential, and recreational). Potential human exposure pathways will be identified on the basis of the following factors:

- the locations of contaminated source areas, types of contaminants found at SWMU 2, and potential release mechanisms for contaminants from the area;

- the likely fate and transport of contaminants within or between environmental media, estimated concentration of contaminants at points of potential human contact (i.e., exposure points), and the associated probable routes of human exposure; and

- the completeness of each exposure pathway (i.e., consideration of the integration of the presence of a source, a mechanism for release and transport, a point of exposure, and a route of human exposure at that exposure point).

The conceptual site model that is presented in Chapter 4, including potential and probable exposure pathways, will be revised, if sampling results necessitate, for each current and potential future land use through consideration of the aforementioned factors. This model will be used subsequently to determine which pathways should be quantitatively assessed. The reason for including or excluding any pathway from the quantitative assessment will be presented in the risk assessment.

Exposure point contaminant concentrations and activities at the unit under current conditions will be calculated using the lesser of the maximum detected analyte concentrations or activity and the 95% upper confidence limit on the arithmetic mean of the appropriate distribution. Contaminant concentrations and activities will be assumed to be log normally distributed unless a statistical evaluation indicates that this is inappropriate. Exposure point contaminant concentrations and activities both at the unit and at compliance points will use modeled values for all future scenarios except for the scenario which represents loss of institutional control in the immediate future. This scenario will use the current exposure point contaminant concentrations discussed earlier.

All models used to calculate future concentrations will be selected at the time the risk assessment is performed and will be discussed completely. This discussion will include references for each model, a general description of each model, and a presentation of parameters used in each model, including sensitivity analysis. Sensitivity analyses will consider both the parameters that may affect rate of migration of contaminants and the parameters that define the source term. Parameters defining the source term will be considered in the sensitivity analysis because near waste and not waste samples will be collected during the investigation. This analysis will focus on reducing the uncertainty in migration and recognize that considerable uncertainty will remain after the investigation is completed regarding the rate of source term depletion.

The exposure point concentrations and activities and the conceptual site model will be integrated to calculate the average chronic daily intakes of COPCs at each exposure point. All parameter values, such as those used to estimate the rate of contact and the physical characteristics of the receptor, and exposure models will be taken from EPA guidance (EPA 1989a, 1989b, 1991b) unless site-specific information, including information offered by the Commonwealth of Kentucky is available. All departures from the use of values or models recommended in EPA guidance will be documented and justified.

The exposure assessment will conclude with a summary of the effects of uncertainties upon estimates of average chronic daily intake. Uncertainties that will be discussed include those associated with land use, receptors, pathways included or excluded, parameter values, and models.

7.2.3 Toxicity Assessment

A summary of the toxicity of the COPCs will be presented in this section of the risk assessment. Toxicity parameters will be taken from *Toxicity Values for Use in Hazardous Waste Risk Assessment and Remediation* (Energy Systems 1994a) as derived from the EPA's Integrated Risk Information System (IRIS) and Health Effects Assessment Summary Table unless more recent values are available. Updates from the IRIS data base will be used to determine if any toxicity values have been added, withdrawn, or changed since the last quarterly publication of the Energy Systems report (1994a). Toxicity profiles for contaminants of potential concern will be taken from *Toxicity Profiles for Use in Hazardous Waste Risk Assessment and Remediation*, Volumes I and II (Energy Systems 1994b). COPCs that do not have a toxicity profile in this publication will be profiled using information drawn from other available sources.

All analytes that are COPCs but do not have EPA-approved toxicity values will be discussed qualitatively in the risk assessment. These contaminants will be considered to be COCs in the risk characterization of the risk assessment. Uncertainties related to toxicity information will be discussed in the summary of the toxicity assessment.

7.2.4 Risk Characterization

The chemical and radiological health risks resulting from exposure to contamination at SWMU 2 will be presented in this section of the assessment. Potential carcinogenic risks and systemic toxicity will be calculated integrating the chronic daily intake of COPCs and toxicity information. These calculations will be consistent with EPA guidance (EPA 1989a).

Carcinogenic risk will be presented as the increased probability that an individual may develop cancer over the course of a lifetime and will assume that risk from exposure to COPCs are additive over chemicals and over pathways and routes of exposure. In calculating total risk, risks presented by each COPC within each pathway of exposure will be summed within each pathway to determine pathway risk. Pathway risks will then be summed over all pathways to calculate total risk.

For those contaminants that can be quantitatively assessed, COCs for carcinogenicity will be determined by examining the total risk for each scenario, pathway risks within each scenario, and individual chemical or radiological risks within each pathway. Consistent with EPA guidance (EPA 1994b), COCs for carcinogenicity will be selected for those use scenarios with a total excess lifetime cancer risk equal to or greater than 1×10^{-4}. COCs will be those COPCs that display an individual chemical or radiological excess lifetime cancer risk equal to or greater than 1×10^{-6} over all pathways of exposure.

Systemic toxicity will be presented as the potential for the development of a health related effect in a receptor over the term of exposure. System toxicity for a single toxicant [i.e., hazard quotient (HQ)] will be determined by dividing the average chronic daily intake by the toxicant's reference dose. In calculating total systemic toxicity, the HQ for each COPC within each pathway of exposure will be summed within each pathway to determine a pathway HI. Pathway HIs will then be summed over all pathways to calculate a total HI.

For those contaminants that can be assessed quantitatively, COCs for systemic toxicity will be determined by examining the total HI for each scenario, pathway HIs within each scenario, and individual chemical HQs within each pathway. Consistent with EPA guidance (EPA 1994b), COCs for systemic toxicity will be selected for those use scenarios with a total HI equal to or greater than unity (1). COCs will be those COPCs that display an HQ equal to or greater than 0.1 over all pathways of exposure.

The risk characterization section of the risk assessment will conclude with summaries of the contaminants and pathways of concern and the major uncertainties affecting the selection of these contaminants and pathways. In discussing the COPCs, those contaminants that lack EPA-approved toxicity values will be identified as COCs. In discussing the uncertainties, the magnitude of effect of each uncertainty upon the risk values will be qualitatively discussed. In addition, a quantitative uncertainty analysis may be presented if this type of analysis is deemed to be required for decision making in the FS.

7.2.5 Summary

This section of the assessment will include a brief summary of each of the previous sections of the risk assessment, including major uncertainties.

7.2.6 Remedial Goal Options

Consistent with *Development of Health Based Preliminary Remediation Goals, Remedial Goal Options, and Remediation Levels* (EPA 1994b), remedial goal options (RGOs) will be presented for the chemicals and media of concern in this section of the risk assessment. This presentation will include RGOs based upon both ARARs and human health risk values. Generally, this section will explain how the RGOs were calculated, present tables with media-specific RGOs for each chemical or radionuclide of concern in each land use scenario evaluated in the risk assessment, and discuss the limitations of the RGOs. RGOs will be calculated by combining the intake levels of each chemical by a receptor from all appropriate routes of exposure and pathways of concern within a scenario and rearranging the site-specific risk equations used in the risk assessment to solve for the concentration term. Target risks to be used in these calculations will be 1×10^{-4}, 1×10^{-5}, and 1×10^{-6}. Target HIs to be used will be 0.1, 1.0, and 10.0. Concentrations for each of these target risks and HIs and any available chemical-specific ARARs will be presented in tables segregated by land use scenario and receptor type. RGOs for subsurface and surface soil for protection of groundwater and surface water will be presented in this section.

7.3 ECOLOGICAL RISK ASSESSMENT

Because of the limited amount of information that can be collected during the investigation of a small site, the ecological risk assessment for the SWMU 2 area will qualitatively evaluate potential ecological risks. The approach for this evaluation will be consistent with that used for other source areas at the PGDP and will include the following:

- identification of ecological units that may be impacted by contaminants migrating from the source unit (i.e., location of the unit within the watershed),
- discussion of ecological communities that may be affected by contamination at or migrating from the source unit (i.e., preliminary identification of receptor populations),
- summary of those threatened and endangered species known to be present at or near PGDP that may be adversely impacted by contaminants at or from the SWMU 2 area, and
- comparison of medium-specific analyte concentrations and activities found at the site with ecological-toxicity benchmark values.

In the summary of the ecological assessment, the aforementioned information will be integrated, and a list of contaminants of potential ecological concern for the SWMU 2 area will be formulated. Ultimately, this information will be incorporated into a facility-wide baseline ecological risk assessment for the PGDP. The method to be used to develop the facility-wide assessment is presented in more detail in the *Management Strategy for the Surface Water Integrator Unit at the Paducah Gaseous Diffusion Plant* (DOE 1993b).

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8. REFERENCES

Bonczek, R. R., J. Davidson, A. F. Diefendorf, F. G. Dolislager, N. E. Korte, C. J. Marshall, G. R. Miller, and W. L. Richards. 1995. *Background Concentrations and Human Health Risk-based Screening Criteria for Metals in Soil at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, KY/EM-77.

CH2M Hill Southeast, Inc. 1991. *Results of the Site Investigation, Phase I, Paducah Gaseous Diffusion Plant,* KY/ER-4, March.

CH2M Hill Southeast, Inc. 1992. *Results of the Site Investigation, Phase II, Paducah Gaseous Diffusion Plant,* KY/SUB/13B-97777C P-03/1991/1, April.

CH2M Hill Southeast, Inc. 1994. *Remedial Investigation Addendum for Waste Area Grouping 22, Burial Ground, at the Paducah Gaseous Diffusion Plant, Paducah Kentucky, (Draft),* DOE/OR/07-1141&D2, KY/ER-26&D2, September.

Clausen, J.L., J.W. Douthitt, K.R. Davis, and B.E. Phillips. 1992. *Report of the Paducah Gaseous Diffusion Plant Groundwater Investigation Phase III,* KY/E-150, Martin Marietta Energy Systems, Inc.

DOE (U.S. Department of Energy). 1993. *Management Strategy for the Surface Water Integrator Unit at the Paducah Gaseous Diffusion Plant* (Draft), DOE/OR/07-1130&D0, April.

DOE. 1994a. *Groundwater Strategy Document for the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/OR/07-1145/R1, KY/ER-27/R1, August.

DOE. 1994b. *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. 1995. *Feasibility Study for Solid Waste Management Units 2 and 3 of Waste Area Grouping 22, Burial Ground, at the Paducah Gaseous Diffusion Plant, Paducah Kentucky,* DOE/OR/06-1246&D2, February.

Dolislager, F. G., D.S. Jones, G.W. Suter II, and R.R. Bonczek. 1994. *Baseline Risk Assessment and Technical Investigation Report for the Northwest Dissolved Phase Plume, Paducah Gaseous Diffusion Plant*, DOE/OR/07-1286&D1.

Douthitt, J.W. and B.E. Phillips. 1991. *Stratigraphic Controls on Contaminant Migration in Fluvio-Lacustrine Sediments near Paducah, Kentucky,* Geologic Society of America, Southeast-Northeast Meeting, Baltimore, Maryland, March 14-16.

Energy Systems (Martin Marietta Energy Systems, Inc.). 1992a. *Requirements for Quality Control of Analytical Data for the Environmental Restoration Program,* ES/ER/TM-16, Oak Ridge National Laboratory, Oak Ridge, Tennessee, December.

Energy Systems. 1993. *Paducah Gaseous Diffusion Plant Environmental Restoration and Waste Management Field Operations Procedure Manual,* November.

Energy Systems. 1994a. *Toxicity Values for Use in Hazardous Waste Risk Assessments and Remediation, Volumes I and II,* Chemical Hazard Evaluation Group, Biomedical and Environmental Information Analysis Section, Health Sciences Research Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Energy Systems. 1994b. *Toxicity Values from the U.S. Environmental Protection Agency, Integrated Risk Information System and Health Effects Assessment Summary Table,* ES/ER/TM-76, Chemical Hazard Evaluation Group, Health Sciences Research Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee, September.

Energy Systems. 1995. *Site Management Plan, Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (Draft), KY/ER-17, August.

EPA (U.S. Environmental Protection Agency). 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA,* EPA/540/G-89/004, Office of Emergency and Remedial Response, Washington, D.C.

EPA. 1989a. *Risk Assessment Guidance for Superfund: Human Health Evaluation Manual, Part A* (Interim Final), EPA/540/1-89/002, Office of Emergency and Remedial Response, Washington, D.C., September.

EPA 1989b. *Exposure Factors Handbook,* EPA/600/8-89/043, Office of Health and Environmental Assessment, Washington, D.C., July.

EPA. 1991a. *Standard Operating Procedures and Quality Assurance Manual,* EPA Region IV, February.

EPA. 1991b. *Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors,* OSWER Directive 9285-6.03, Office of Solid Waste and Emergency Response, Washington, D.C.

EPA. 1993. *Guidance for Planning for Data Collection in Support of Environmental Decision Making Using the Data Quality Objectives Process* (Interim Final), EPA QA-G-4, Office of Research and Development, Washington, D.C.

EPA. 1994a. *Data Quality Objectives Decision Error Feasibility Trials: User's Guide,* Quality Assurance Management Staff (QAMS), Washington, D.C., August.

EPA. 1994b. *Development of Health Based Preliminary Remediation Goals, Remedial Goal Options, and Remediation Levels (Draft),* Supplemental Guidance to RAGS: Region IV Bulletin, Vol. 1, No. 3, October 12.

Geotrans, Inc. 1992. *Groundwater Modeling and Offsite Pump and Treat Evaluation at the Paducah Gaseous Diffusion Plant, Phase II.- Model Development, Calibration, and Assessment.*

Kimbrough, C.W., L.W. Long, and L.W. McMahon. 1990. *Environmental Surveillance Procedures,* ES/ESH/INT-14, Quality Control Program, Martin Marietta Energy Systems, Inc., January.

Appendix A

QUALITY ASSURANCE PROJECT PLAN
FOR THE
SWMU 2 AREA INVESTIGATION

A. SWMU 2 AREA REMEDIAL INVESTIGATION QUALITY ASSURANCE PROJECT PLAN

Approvals

Prepared by:	________________________ Jennifer R. Blewett Lockheed Martin Energy Systems, Inc. ER Program QA Specialist	Date:	______
Approved by:	________________________ Robert Pratt Lockheed Martin Energy Systems, Inc. ER Program Project Manager	Date:	______
Approved by:	________________________ Donnie Chumbler Lockheed Martin Energy Systems, Inc. ER QA Program Manager	Date:	______
Approved by:	________________________ Myrna Redfield U. S. Department of Energy DOE QA Representative	Date:	______

CONTENTS

A. QUALITY ASSURANCE PROJECT PLAN

This QAPjP has been developed for use in the sample collection and analysis activities during the SWMU 2 SAP investigation to ensure that appropriate levels of QA/QC are achieved. This QAPjP defines procedures that will be followed in the collection, custody, and handling of data used for the investigation. These procedures are intended to define the methods applied to achieve the QA/QC goals established for the SAP investigation.

This plan further establishes QA requirements and responsibilities applicable to investigation participants and establishes methods through which investigation participants implement the requirements of the investigation. Where no appropriate procedure exists, this QAPjP requires that one be developed by a cognizant individual(s) or organization(s).

All QA/QC procedures will be in accordance with applicable professional technical standards, EPA requirements, government regulations, DOE Orders, Energy Systems procedures and guidelines, and reassessment goals and requirements. This plan has been prepared to meet the requirements of the guidance document, *Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans,* EPA-600/4-83-004, QAMS-005/80 (Stanley and Verner 1983). Table A.1 lists the location of the elements required by QAMS-005/80 in this QAPjP or in the SWMU 2 SAP. Individuals receiving copies of the QAPjP and its subsequent revisions are included on the distribution list for this SAP.

A.1 PROJECT ORGANIZATION AND RESPONSIBILITIES

The SAP investigation will be funded, managed, and operated by the PGDP ER Program. The investigation will provide data to be used by the PGDP ER Program, DOE, EPA, and the KDEP. Organization of the investigation with regard to QA/QC is depicted in Fig. A.1. Control of sampling activities affecting quality will be implemented throughout the life of the investigation to the degree necessary to ensure that quality objectives are met. All participating personnel will be responsible for QA/QC processes during implementation of the investigation.

A.1.1 Energy Systems Personnel

- **ER Program Project Manager** will report investigation progress and results to the DOE Program Manager and is responsible for the following: ensuring that appropriate QA/QC requirements are included in subcontracts and that subcontractor technical commitments are met; incorporating the appropriate QA requirements for the investigation into all sampling and analytical activities; consulting with the ER Program QA Specialist on all quality-related matters; investigating quality problems during sampling operations, determining their root cause, proposing solutions, implementing corrective actions, and obtaining the concurrence of the QA Specialist on the appropriateness of the corrective action; initiating stop-work actions when conditions or procedures adverse to quality warrant immediate action; and conducting operational readiness reviews according to Energy Systems procedure ER/C-P1610.

Table A.1. Cross reference of EPA QAMS 005/80 elements with the SWMU 2 Remedial Investigation Quality Assurance Project Plan

EPA QAMS 005/80	Location
1. Title page	Title page (QAPjP)
2. Table of Contents	Table of Contents (SAP)
3. Project Description	1. Introduction (SAP)
4. Project Organization and Responsibility	A.1 Project Organization and Responsibilities (QAPjP)
5. QA Objectives	A.2 QA Objectives for Data Measurement (QAPjP)
6. Sampling Procedure	6.0 Field Sampling Procedures (SAP)
7. Sample Custody	6.2.4 Sample Handling (SAP)
8. Calibration Procedures and Frequency	A.5 Calibration Procedures and Frequency (QAPjP)
9. Analytical Procedures	A.6 Analytical Procedures (QAPjP)
10. Data Reduction, Validation and Reporting	A.7 Data Reduction, Verification/Validation, and Reporting (QAPjP)
11. Internal QC Checks	6.2.3 Sample Identification, Numbering, and Labeling (SAP)
12. Performance and System Audits	A.9 Audits and Surveillances (QAPjP)
13. Preventive Maintenance	A.10 Preventive Maintenance Procedures/Schedules (QAPjP)
14. Specific Routine Procedures Used to Assess Data Precision, Accuracy, Representativeness, Completeness, and Comparability	A.11 Specific Routine Procedures (QAPjP)
15. Corrective Actions	A.12 Corrective Action (QAPjP)
16. QA Reports to Management	A.13 QA Reports to Management (QAPjP)

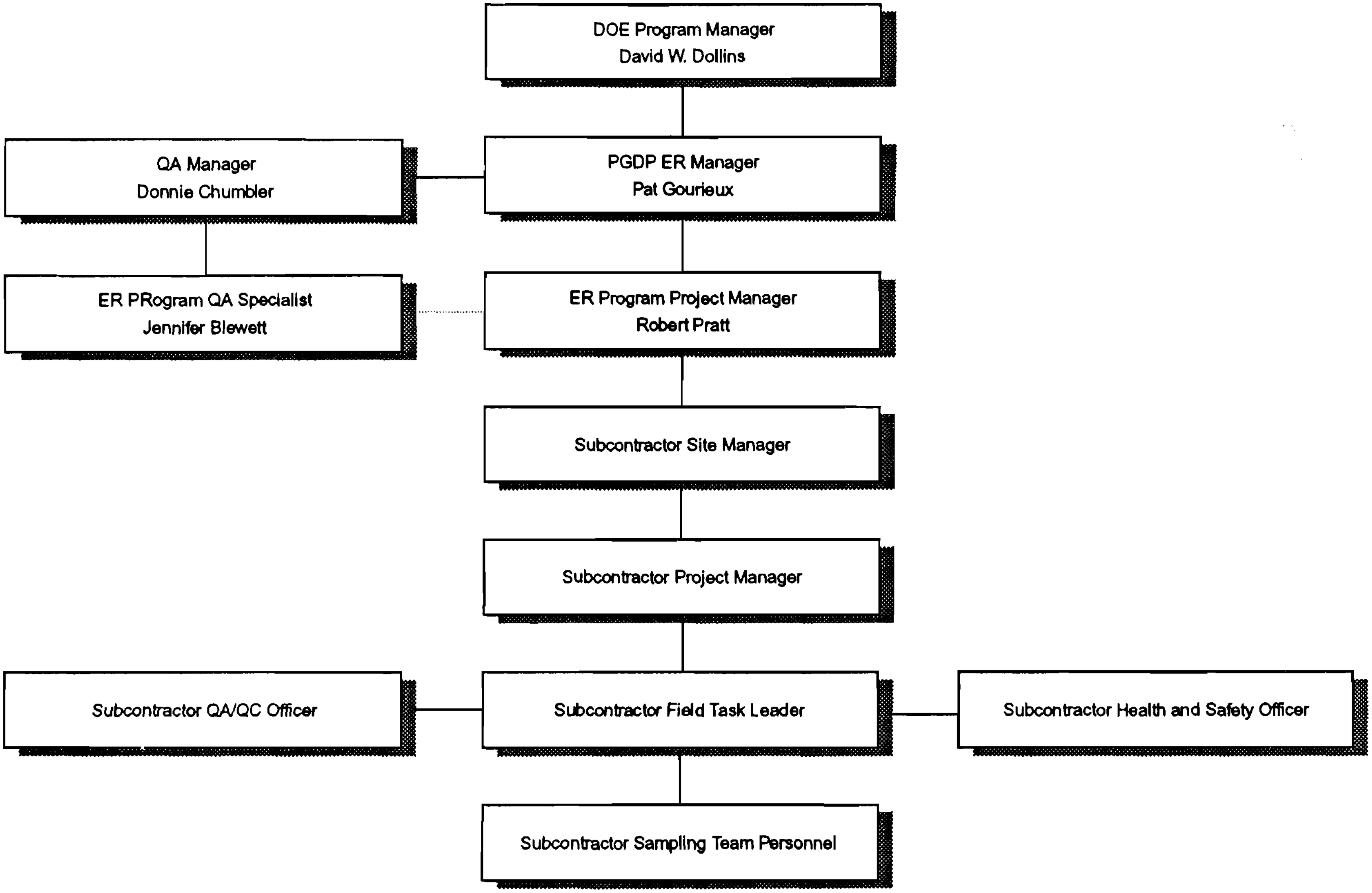

Fig. A.1. QAPjP organizational chart for the C-749 Area.

- **ER Program QA Specialist** reports to the Energy Systems Quality Program Manager and is responsible for assisting the Project Manager with establishing and implementing the QA measures outlined in the C-749 SAP and QAPjP; evaluating the effectiveness of QA activities through audits and surveillances and reporting results to the Project Manager; providing guidance to resolve quality problems encountered during sampling and/or decontamination operations and ensuring that corrective action is taken and appropriately documented; participating in the operational readiness review; and initiating stop-work actions when the severity of conditions adverse to quality warrants immediate action.

A.1.2 Energy Systems Subcontractor

- **Project Manager** will oversee environmental sampling and will be responsible for site accessibility, safety, and QA measures as well as delegating specific responsibilities in areas to other members of the sampling team, specifically the Field Task Leader.

- **QA/QC Officer** is responsible for ensuring and assessing the implementation of the Subcontractor QA program; reviewing, identifying and solving problems.

- **Field Task Leader** will report to the Subcontractor Project Manager and will be responsible for ensuring the QA requirements as outlined in the investigation SAP and QAPjP are followed; ensuring that sampling and decontamination procedures are effectively implemented; ensuring that appropriate QA/QC requirements and technical commitments as outlined in subcontractor contracts are met; ensuring that all applicable state and federal codes, standards, and regulations are appropriately specified and effectively implemented; interfacing with the assigned ER Program QA Specialist on all quality-related matters; and initiating stop-work actions when conditions or procedures adverse to quality warrant immediate action.

- **Sampling Team Personnel** responsibilities include ensuring the QA requirements as outlined in the investigation SAP and QAPjP are followed, ensuring that appropriate QA/QC requirements and technical commitments as outlined in subcontractor contracts are met, interfacing with the Field Task Leader on all quality-related matters, and initiating stop-work actions when conditions or procedures adverse to quality warrant immediate action.

A.2 QA OBJECTIVES FOR DATA MEASUREMENT

QA objectives for data collection are developed from the DQOs for the SAP investigation (see Chapter 4). The QA/QC analytical data program develops information that can be used to:

- evaluate the accuracy and precision of analytical data,

- identify COPCs and indicator parameters for long-term monitoring, and

- support development of a data set for subsequent trend or modeling analyses.

The QA objectives for all analytical data are to obtain reproducible, precise, and accurate measurements consistent with the intended use of the data and the limitations of the sampling and analytical procedures. The purpose of QC is (1) to screen out data of unacceptable precision or accuracy and (2) to obtain data that will accomplish the objectives of the investigation. All analyses for the SAP investigation will use QC data deliverables.

Goals for data precision, accuracy, representativeness, completeness, and comparability (PARCC) as well as sensitivity are presented in Sect. A.11 of this QAPjP.

A.3 SAMPLING PROCEDURES

A.3.1 Procedures

Procedures to be used during implementation of the Area SAP investigation regarding sampling activities, documentation, and equipment decontamination are presented in Chapter 6 of the SAP.

A.3.2 Field Variance System

Procedures cannot fully encompass all conditions encountered during a field investigation. Variances from the operating procedures, Field Sampling Plan, and/or Health and Safety Plan likely will occur and must be documented on an FCO form or a Nonconformance Report and be noted in the appropriate logbooks. The approach to controlling and documenting field changes will follow Energy Systems procedure ER/C-P1719. If a variance is anticipated (e.g., due to a change in the field instrumentation), the applicable procedure should be modified and the change noted in the field logbooks. Field changes fall into three categories: (1) minor, (2) major, and (3) other, which are described in the following text.

A.3.2.1 Minor field change

A minor field change is one that does not affect the objectives of the field sampling plan and may be approved by the Field Task Leader by noting the change in the field logbook. An example of a minor field change would be movement of a sampling point several feet from the originally defined location due to subsurface obstruction.

Routine (minor) FCOs will be completed in the field, noted on the FCO log, and then routed to the ER Program Project Manager and QA Specialist for signature approval. A verbal approval from the ER Program Project Manager or designee will be noted in the field logbook.

A.3.2.2 Major field change

A major field change is one that affects the field sampling objectives and/or schedule and will require DOE, EPA, and/or KDEP approval. The major field change must be approved by the subcontractor and ER Project Manager. These changes may require alteration of the Field Sampling Plan. An example of a major field change would be a decision to eliminate sampling points from the field investigation.

A.3.2.3 Other field change

An other field change falls between the minor and major field change definitions in that it significantly affects the Field Sampling Plan without requiring a change to the plan. It is approved by the Subcontractor Project Manager and may require DOE, EPA, and/or KDEP approval. An example of an other field change would be a decision to change the number of samples collected at a given sampling point.

As appropriate, regulatory agencies will be notified of any variances that significantly affect the scope and/or objectives of the SAP investigation, and approval from the agencies will be obtained as necessary. Any variances from the health and safety plan must be approved by the PGDP Health and Safety Officer. Copies of the FCO form will be maintained by the Field Task Leader or designee until the field work is complete and will then be forwarded to the Subcontractor Project Manager for inclusion in the project file and the Subcontractor Central Records Facility. The ER Project Manager must also approve these forms.

A.4 SAMPLE CUSTODY

Procedures to be used during implementation of the SAP investigation regarding sample chain of custody are presented in Section 6 of the SAP.

A.5 CALIBRATION PROCEDURES AND FREQUENCY

All measuring and test equipment (M&TE) will be calibrated against certified equipment and/or standards having known valid traceability to nationally recognized standards. M&TE shall be calibrated, adjusted, and maintained at prescribed intervals or before use. If no nationally recognized standards exist, the basis for calibration will be documented.

A.5.1 Field Instrument Calibration Procedures and Frequency

Field instrumentation will be calibrated according to the procedures specified in the manufacturer's operating manual or more frequently should the conditions dictate it for the particular instrument. Table A.2 lists all M&TE to be used for the investigation, the detection limits, and a schedule for calibration. Instrument logbooks or notebooks will be established and maintained by the cognizant field team members, the Field Task Leader, or the PGDP Health and Safety Officer, as appropriate.

All instruments will be maintained within factory calibration, in accordance with applicable manufacturer's recommendations and specifications described in the manufacturer's operation manuals. Daily calibration will be recorded in the field logbook in a section dedicated to calibration and vital information about the instruments.

A.5.2 Laboratory Instrument Calibration Procedures and Frequency

Laboratory equipment will be calibrated according to the procedures specified in the analytical methods and in the operating manual for the particular instrument. Calibration frequency will be based on the analytical methods employed, type of equipment, inherent stability, manufacturer's recommendations, values given in national standards, intended use, and experience. For laboratory equipment, Class A volumetric glassware shall be used to prepare calibration standards, bench standards, samples for analysis, etc. Class A glassware may be purchased with known accuracy per federal and American Society of Testing and Materials (ASTM) specifications.

Table A.2. Field instrument uses, detection limits, and calibration

Instrument	Uses	Detection limits	Calibration	Comments
Total organic vapor meters	Sample screening for VOCs	PID - 0.2 ppm benzene	1 point - PID benzene daily	Action level must be stated in Health and Safety Plan
Field Gas Chromograph with Electron Capture Detector	Level II screening for VOCs	TCE, DCE - 1 ppb VC - 5 ppb	5 point	
Alpha Meter	Screening for alpha	100 cpm	every six months	
Gamma, Beta Meter	Screening for gamma and beta	100 cpm	every six months	

It should be noted that other nonanalytical instrumentation (such as thermometers) must be properly maintained and calibrated. The temperatures of ovens and refrigerators used in sample handling shall be recorded and the control limits shall also be defined. If these limits are not met, corrective action will be required. All calibration and maintenance records will be kept with the equipment if practicable. Otherwise, they will be maintained by the laboratory QA personnel.

A.5.3 Equipment Categories

Calibrated equipment will be uniquely identified by using either the manufacturer's serial number or by other means. All equipment shall be categorized as one of the following:

- Category A—casual devices and systems (rulers, tape measures, graduated cylinders, etc.) that are not to be calibrated in service (i.e., not calibrated other than by the manufacturer).
- Category B—routine devices and systems (balances, spectrophotometers, etc.) that are to be included in a regular calibration recall program.
- Category C—field experiment devices and systems (pH meters, conductivity meters, etc.) that are to be calibrated before use.

The appropriate category decal with the identification number and the due date of the next calibration will be attached to the equipment. If this identification is not possible, records traceable to the equipment will be readily available for reference.

A.5.4 Calibration Failures

Scheduled periodic calibration of equipment will not relieve personnel of the responsibility of employing properly functioning equipment. If an individual suspects an equipment malfunction, he/she should remove the device from service, initiate a Nonconformance Report, tag the piece of equipment to prevent inadvertent use, and notify project management. If equipment is found to be out of calibration, the appropriate project management personnel shall evaluate and document (in the instrument logbook) the validity of previous inspection or test results and the acceptability of similar equipment previously inspected or tested.

The Field Task Leader shall ensure that devices that are out of calibration are (1) tagged or segregated from other equipment and (2) disposed of or not used until they are calibrated. Any equipment that is consistently found to be out of calibration shall be repaired or replaced. Any such action should be recorded in the instrument logbook or notebook.

All standards used for equipment calibration will be traceable to the EPA, the National Institute of Standards and Technology, or a commercially available certified standard. The source of the standard used must be documented in a calibration logbook.

A.5.5 Calibration Records

Calibration data will be recorded in the instrument logbook or notebook. The information shall include the date, operator, signature, standard that was used, and its source. Records will be prepared and maintained for each piece of calibrated equipment to indicate that established calibration procedures have been followed. Records shall be kept that demonstrate traceability of all calibration standards used in full or daily calibrations to the certified source. The appropriate project management personnel will ensure that records of calibration data are kept current. Records for field equipment used will be maintained by the Field Task Leader and the PGDP Health and Safety Officer and kept in the project files. Records for laboratory equipment used will be maintained by the laboratory supervisor and kept in the project files.

A.6 ANALYTICAL PROCEDURES

Procedures to be used during implementation of the SAP investigation regarding field screening of collected samples are presented in Chapter 6 of the SAP.

All laboratories performing analyses for this task will be required to hold a current NRC license for handling radioactive materials. In addition, all laboratories will be audited and accepted by the Energy Systems, if applicable.

When available and appropriate for the sample matrix, EPA methods will be used. When not available, other nationally recognized methods such as EPA, DOE, and ASTM methods will be used. Table A.3 summarizes the analytical methods and sample requirements for laboratory analytical parameters. Note that SW-846 methods will be used for the analysis of TAL/TCL compounds, as appropriate. For a listing of these compounds, see Table 5.4.

The method detection limit is defined as the minimum concentration of a substance that can be measured and reported with 99% confidence that the value is greater than zero. The method detection limit actually achieved in a given analysis varies depending on instrument sensitivity and interferences. Contracts will be established with analytical laboratories to analyze environmental samples collected during the investigation. Each contract laboratory that analyzes samples will provide quantification limits for each constituent analyzed.

Specific chemical analytical methods, parameters, and quantification level goals for samples collected during the SAP investigation are presented in Table A.4; specific geotechnical-geochemical analytical methods for investigation samples are presented in Table A.5.

A.7 DATA REDUCTION, VERIFICATION/VALIDATION, AND REPORTING

The data reduction will follow guidelines of CLP organic and inorganic protocols and EPA SW-846, *Test Methods for Evaluating Solid Waste, Physical Chemical Methods* (EPA 1990). Generally, results must be expressed to two significant figures. Results of aqueous samples must be expressed in milligrams per liter, micrograms per liter, or picocuries per liter, while soil sample results must be expressed in milligrams per kilogram, micrograms per kilogram, or picocuries per gram.

Data reduction, verification/validation, and reporting will be in accordance with the *Requirements* for Quality Control of Analytical Data for the Environmental Restoration Program (Energy Systems 1992). Data will be entered into common standardized formats. In addition to following field and laboratory documentation and QA/QC procedures, data may be verified using a variety of computerized checks for reasonableness. These procedures will ensure that data are entered, encoded, manipulated in a consistent way, and available in a usable format.

Table A.3. Analytical methods and sample requirements for environmental samples

Parameter	Method No.	Matrix	Holding Time (from time of collection)	Sample Container	Preservative
Volatile Organics	SW-846^{a}, 8240	Water	14 d	Two 40 mL vials with Teflon-lined caps	HCl to pH <2^{b} Cool to 4°C
	Prep 5030	Soil	14 d	4 oz. widemouth glass jar with Teflon-lined closure or brass liner	Cool to 4°C
Aromatic volatile organics	SW-846, 8020	Water	14 d	Two 40 mL vials with Teflon-lined caps	HCl to pH <2 Cool to 4°C
	Prep 5030	Soil	14 d	4 oz. widemouth glass jar with Teflon-lined closure or brass liner	Cool to 4°C
Semivolatile organics	SW-846, 8270 Water Prep, 3510/3520	Water	7 d - extn. 40 d - anly.	Two 1-L amber glass jars with Teflon liner	Cool to 4°C
	Soil Prep 3540/3550	Soil	14 d - extn. 40 d - anly.	8 oz. widemouth glass jar with Teflon lined closure	Cool to 4°C
Metals^{c} (other than Hg)	SW-846, 6010 Arsenic-7060, Lead-7421, Selenium-7740, Thallium-7841, Water Prep 3010	Water	180 d	1-L polyethylene with polyethylene closure	HNO_3 to pH < 2
	Soil Prep 3050	Soil	180 d	8-oz. widemouth glass jar with Teflon-lined closure	Cool to 4°C
Mercury^{c}	SW-846, 7470	Water	28 d	2-L polyethylene with polyethylene closure	HNO_3 to pH < 2
	SW-846, 7471	Soil	28 d	8-pz. widemouth glass jar with Teflon-lined closure	Cool to 4°C
Pesticides/PCBs	SW-846, 8080 Water Prep 3510/3520	Water	7 d - extn. 40 d - anly.	Two 1-L glass jars with Teflon lined closure	Cool to 4°C
	Soil Prep 3540/3550	Soil	14 d - extn. 40 d - anly.	8 oz. widemouth glass jar with Teflon lined closure	Cool to 4°C

Table A.3. (continued)

Parameter	Method No.	Matrix	Holding Time (from time of collection)	Sample Container	Preservative
Cyanide	SW-846, 9010	Water	14 d	1-L polyethylene with polyethylene closure	NaOH to pH >12 Cool to 4°C
		Soil	14 d	4-oz. widemouth glass jar with Teflon-lined closure	Cool to 4°C
Gross Alpha and Beta	SW-846, 9310	Water	6 months	Two 1-gal. polyethylene with polythylene closure	HNO_3 to pH < 2
		Soil	6 months	8-oz. widemouth glass jar with Teflon-lined closure	
Other Radionuclides		Water	6 months	Two 1-gal. polyethylene with polythylene closure	HNO_3 to pH < 2
U-234	TIMS-3[d], Rev. 0				
U-238	TIMS-3, Rev. 0				
Tc-99	MEK Extraction	Soil	6 months	8-oz. widemouth glass jar with Teflon-lined closure	None
Np-237	Method, R-46				
Pu-239	Alpha Spectroscopy				
Th-230	Method R-54, Rev. 0				
	Alpha Spectroscopy				
	Method R-54, Rev. 0				
	Alpha Spectroscopy				
	Method R-54, Rev. 0				
Total Lead	SW-846, 7421 Water Prep. 3020	Water	6 months	1-L polyethylene with polyethylene closure	HNO_3 to pH < 2
	Soil Prep 3050	Soil	6 months	8-oz. widemouth glass jar with Teflon-lined closure	None

Table A.3. (continued)

Parameter	Method No.	Matrix	Holding Time (from time of collection)	Sample Container	Preservative
Oxidation-reduction potential	ASTM D 1498	Water	48 hours	16-oz. widemouth glass jar with Teflon-lined closure	Cool to 4°C
pH	SW-846, 9045	Water	At collection	2-L polyethylene with polyethylene closure	None
Specific conductance	SW-846, 9050, EPA 120.1	Water	At collection	2-L polyethylene with polyethylene closure	None
Temperature	EPA 170.1	Water	At collection	2-L polyethylene with polyethylene closure	None
Alkalinity	EPA Method 2320, W-12	Water	14 d	Polyethylene or glass	Cool to 4°C
Bicarbonate	EPA Method 2320, W-12	Water	14 d	Polyethylene or glass	Cool to 4°C
Carbonate	EPA Method 2320, W-12	Water	14 d	Polyethylene or glass	Cool to 4°C
Calcium	SW-846, 6010, 7140	Water	180 d	1-L polyethylene with polyethylene closure	HNO_3 to pH < 2 Cool to 4°C
Chloride	SW-846, 9250-9252	Water Soil	28 days 28 days	1-L polyethylene with polyethylene closure 8-oz. widemouth glass jar with Teflon-lined closure	Cool to 4°C Cool to 4°C
Magnesium	SW-846, 6010	Water	180 d	1-L polyethylene with polyethylene closure	HNO_3 to pH < 2 Cool to 4°C
Nitrate	SW-846, 9200	Water	24 hr	2-L polyethylene with polyethylene closure	Cool to 4°C
Potassium	SW-846, 6010	Water	180 d	1-L polyethylene with polyethylene closure	HNO_3 to pH < 2 Cool to 4°C
Sodium	SW-846, 6010, 7710	Water	180 d	1-L polyethylene with polyethylene closure	HNO_3 to pH < 2 Cool to 4°C
Sulfate	SW-846, 9035 - 9038	Soil	28 days	16 ox. widemouth glass jar with Teflon-lined closure	Cool to 4°C
Sulfide	SW-846, 9030	Soil	28 days	16 ox. widemouth glass jar with Teflon-lined closure	Cool to 4°C

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[a] U. S. Environmental Protection Agency. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, SW-846, Third Ed., November 1986b.

[b] The first sample for volatile analysis will be tested for pH by first adding four drops of Hcl to a spare 40-mL vial, adding the water sample, and testing with pH paper. If pH > 2, additional acid will be added until pH < 2 is achieved. Once this determination has been mnade, remaining VOA vials will be pre-preserved before sample collection.

[c] Samples for these parameters can occupy the same sample containers.

[d] Thermal Ionization Mass Spectrometer (TIMS-3) Rev. 0

Table A.4. Method Detection limits for NRC-licensed laboratory analyses

Water (µg/L)	Soil (µg/kg)	Volatile Organic Compounds[a] SW-846,[b] 8240		
5	5	Benzene Bromodichloromethane Bromoform Carbon disulfide Carbon Tetrachloride Chlorobenzene Chloroform Chloroprene (10) Cis-1,3-dichloropropene Dibromochloromethane Dibromomethane 1,2-Dibromomethane Dichlorodifluoromethane (50) 1,1-Dichloroethane	1,2-Dichloroethane 1,1-Dichlorethene 1,2-Dichloroethene(Total) 1,2-Dichloropropane Ethyl methacrylate Ethyl benzene Lodomethane Methacrylonitrile (100) Methyl methacrylate Methylene chloride Pentachloroethane (10) Styrene 1,1,2,2,-Tetrachoroethane	1,1,1,2-Tetrachloroethane Tetrachloroethene Toluene Trans-1,2-dichloropropene Trans-1,4-dichloro-2-butene (100) 1,1,1-Trichloroethane 1,1,2-Trichloroethane Trichloroethene Tri chlorofluoromethane 1,2,3-Trichloropropane Xylenes (Total)
10	10	Bromomethane Chloroethane	2-Chloroethyl vinyl ether	Chloromethane Vinyl chloride
50	50	2-Hexanone	4-Methyl-2-pentanone	Vinyl acetate
100	100	Acetone Acrolein	Acrylonitrile Butanone	Poprionitrile

Water (µg/L)	Soil (µg/kg)	Aromatic Volatile Organic Compounds SW-846, 8020		
2	2	Benzene Chlorobenzene	Ethyl benzene Toluene	Xylenes (Total)
3	3	1,4-Dichlorobenzene		
4	4	1,2-Dichlorobenzene	1,3-Dichlorobenzene	

Table A.4. (continued)

Water (µg/L)	Soil (µg/kg)	Semivolatile Organic Compounds SW-846, 8270		
10	660	Acenapthene Acenaphthylene Anthracene Benzo(a)anthracene Benzo(b)fluoranthene Benzo(k)fluoroanthene Benzo(a)pyrene Benzo(g,h,i)perylene Bis(2-chloroisopropyl)ether Bis(2-chloroethoxy)methane Bis(2-chloroethyl)ether Bis(2-ethylhexyl)phthalate 4-Bromophenyl-phenylether Butylbenzylphthalate 2-Chloronaphthalate 2-Chlorophenol 4-Chlorophenyl-phenylether Chrysene	Di-N-butylphthalate Di-N-octylphthalate Dibenzo(a,h)anthracene Dibenzofuran 1,2-Dichlorobenzene 1,3-Dichlorobenzene 1,4-Dichlorobenzene 2,4-Dichlorophenol Diethylphthalate 2,4-Dimethylphenol Dimethylphthalate 2,4-Dinitrotoluene 2,6-Dinitrotoluene Fluoranthene Fluorene Hexachlorobenzene Hexachlorobutadiene Hexachlorocyclopentadiene	Hexachlorethane Indeno(1,2,3-cd)pyrene Isophorone 2-Methylnaphthalene 2-Methylphenol 4-Methylphenol Naphthalene Nitrobenzene 2-Nitrophenol N-Nitroso-di-n-dipropylamine N-Nitrosodiphenylamine Phenanthrene Phenol Pyrene 1,2,4-Trichlorobenzene 2,4,5-Trichlorophenol 2,4,6-Trichlorophenol
20	1300	Benzyl alcohol 4-Chloro-3-methylphenol	4-Chloroanaline	3,3-Dichlorobenzidine
50	3300	Benzoic acid 4,6-Dinitro-2-methylphenol 2,4-Dinitrophenol	2-Nitroanaline 3-Nitroanaline 4-Nitroanaline	4-Nitrophenol Pentachlorophenol

Water (µg/L)	Soil (µg/kg)	Pesticides and PCBs SW-846, 8080	
0.02	1.32	Dieldrin	
0.03	2.0	Alpha-BHC	Heptachlor
0.04	2.7	Aldrin 4,4'-DDE	Endosulfan II Gamma-BHC (Lindane)
0.06	4.0	Beta-BHC	Endrin
0.09	6.0	Delta-BHC	
0.11	7.4	4,4'-DDD	
0.12	8.0	4-4'-DDT	
0.14	9.4	Chlordane	Endosulfan
0.23	15.4	Endrin aldehyde	
0.65	43.5	Aroclor 1242	

Table A.4. (continued)

Water (µg/L)	Soil (µg/kg)	Pesticides and PCBs SW-846, 8080		
0.66	44.2	Endosulfan sulfate		
0.83	55.6	Heptachlor epoxide		
1.76	117.9	Methoxychlor		
2.4	160.8	Toxaphene		
0.1	0.1	Aroclor 1016 Aroclor 1221 Aroclor 1232	Aroclor 1248 Aroclor 1253	Aroclor 1260

Water (µg/L)	Soil (µg/kg)	Metals[c] SW-846, 6010 and 7000 series
45	40	Aluminum
32	4	Antimony
53	1	Arsenic
2	10	Barium
0.3	1	Beryllium
4	1	Cadmium
10	50	Calcium
7	2	Chromium
7	2	Cobalt
6	2	Copper
7	20	Iron
42	1	Lead
30	10	Magnesium
2	3	Manganese
0.2	0.1	Mercury
15	3	Nickel
N[d]	12	Potassium
75	1	Selenium
7	2	Silver
29	50	Sodium
40	1	Thallium
8	1	Vanadium

Table A.4. (continued)

Water (µg/L)	Soil (mg/kg)	Metals[c] SW-846, 6010 and 7000 series	
2	4	Zinc	
20	5	Cyanide--SW-846, 9010	
Water (pCi/L)	Soil (pCi/g)	Radionuclides	Method
3	10	Gross Alpha and Beta	SW-846, 9310
0.4	0.4	Uranium-234	TIMS-3[e] Rev. 0
0.4	0.4	Uranium-238	TIMS-3, Rev. 0
1	1	Technetium-99	MEK Extraction Method R-46
0.4	0.4	Thorium-230	Alpha Spectroscopy Method R-54, Rev.0
0.5	0.5	Neptumium-237	Alpha Spectroscopy Method R-54, Rev.0
0.4	0.4	Plutonium-239	Alpha Spectroscopy Method R-54, Rev.0

[a] Values in parentheses are compound-special MDLs for soil.

[b] U. S. Environmental Protection Agency. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, SW-846, Third Ed., November 1986b. Values shown in this table are taken from this document and presented therein as both method detection limits and practical quantitation limits.

[c] SW-846 Methods 7470 and 7471 will be used to analyuze for mercury in water and soil, respectively. Otheral metal analytes will be analyzed by SW-846, Method 6010, except for arsenic (Method 7060), lead (method 78421), selenium (method 7740, and thallium (method 7841).

[d] N denotes a parameter highly dependent on operating conditions and plasma conditions.

[e] Thermal Ionization Mass Spectrometers (TIMS-3) Rev. 0

Table A.5. Geotechnical-geochemical analytical methods for investigation samples

Parameter Description	Analytical Method[a]	
Grain size (sieve)	Standard practice for dry preparation of soil samples for particle-size analysis and determination of soil constants	ASTM D 421-85
	Standard test method for particle-size analysis of soils	ASTM D 422-63
Hydraulic conductivity[b]	Standard test method for measurement of hydraulic conductivity of saturated porous materials using a flexible permeameter	ASTM D 5084-90[c]
Sorptive capacity	Standard test method for determination of 24-hour batch -type distribution ratio	ASTM ES10
Cation exchange capacity	Cation exchange capacity of soils ammonium acetate	EPA SW846[d] Method 9081
Total Organic Carbon	Total Organic Carbon	EPA SW846[d] Method 9081
Moisture Content	Standard test method for laboratory determination of water (moisture) content of soil and rock	ASTM D 2216-92

[a] Except where noted, all ASTM procedures are referenced from *ASTM* Annual *Book of Standards*, Section 4: Construction, Vol. 4.08, 1994.

[b] Test also requires use of ASTM Methods D 421-85 and D 422-63.

[c] *ASTM Annual Book of Standards*, Section 4: Construction, Vol. 4.08, 1993.

[d] EPA 1990.

A.7.1 Field Data Reduction and Evaluation

Data collected during field activities will be evaluated by checking the procedures used and comparing the data to previous measurements in accordance with Energy Systems procedure ER/KI1604. The Subcontractor QA/QC Officer, or designee, and appropriate field personnel, will be responsible for checking field QC sample results to ensure that field measurement and sampling protocols have been observed. These reviews will check date and time sampled, preservation, standard operating procedures, calibration method and frequency, and chain-of-custody documentation.

Reviewers are responsible for ensuring that data reduction calculations are documented and checked by qualified personnel. Written reports including reduced and summarized data may include the raw data in appendixes. Specific calculations used for data reduction may also be included.

A.7.2 Analytical Laboratory Data Reduction and Evaluation

In general, the analyst will process the data, either manually or by inputting the data into a computer. For manually processed data, all the steps in the computation must be provided, including equations used and the source of input parameters such as response factors, dilution factors, and calibration constants. If calculations are not performed directly on the data sheet or chromatogram, the calculations must be provided on company letterhead paper and attached to the data sheets. All pages of the calculations must be signed and dated by the analyst performing the calculations.

For data input by an analyst and processed using a computer, a copy of the input must be kept and uniquely identified with the project number and other pertinent information as necessary. The samples to which the data processing refers must be clearly stated, and the input must be signed and dated by the analyst performing the input.

When processing data acquired from instrumentation, the analyst must verify that the correct project, sample numbers, calibration constants, response factors, units, and numerical values used for detection limits are present. The laboratory will be responsible for deliverables as defined by ES/ER/TM-16 and identified in Table A.6. Upon completion of required chemical analyses, the samples will be maintained at a temperature of 4°C (± 2°C) for at least 2 weeks after expiration of the appropriate holding time.

Reviewers are responsible for ensuring that data reduction calculations follow data calculation procedures, are documented, and are checked by qualified personnel. Written reports, including reduced and summarized data, may include the raw data in appendixes. Specific calculations used for data reduction will also be included.

A.7.3 Data Validation Approach

Data validation will be consistent with the specifications a outlined in ES/ER/TM-16 and Energy Systems procedure ER/C-2201. All project data will be evaluated to ensure a complete, consistent, and usable investigation data set.

Data validation will be performed to ensure that the precision and accuracy of the analytical data are adequate for their intended use. Because the greatest uncertainty in a measurement is often a result of the sampling process and inherent variability in the environmental media rather than the

Table A.6. Data set deliverables for investigation samples

Method requirements	Deliverables
Requirements for all methods	
- Holding time information and methods	Signed chain-of-custody forms requested
- Discussion of laboratory analysis, including any laboratory problems	Case narratives
- Laboratory Control Sample Analysis	Results and Acceptance Criteria
Organics: GC/MS analysis	
- Sample results, including TICs	CLP Form 1 or equivalent
- Surrogate recoveries	CLP Form 2 or equivalent
- Matrix spike/spike duplicate data	CLP Form 3 or equivalent
- Method blank data	CLP Form 4 or equivalent
- GC/MS tune	CLP Form 5 or equivalent
- GC/MS initial calibration data	CLP Form 6 or equivalent
- GC/MS continuing calibration data	CLP Form 7 or equivalent
- GC/MS internal standard area data	CLP Form 8 or equivalent
- Complete raw data	All chromatograms, preparation logs, run logs, calculations, etc.
- Sample results	CLP Form 1 or equivalent
- Surrogate recoveries	CLP Form 2 or equivalent
- Matrix spike/spike duplicate data	CLP Form 3 or equivalent
- Method blank data	CLP Form 4 or equivalent
- Initial calibration data	CLP Form 6 or equivalent
If calibration factors are used	A form listing each analyte, the concentration of each standard, the relative calibration factor, the mean calibration factor, and the%RSD
- Calibration curve if used	Calibration curve and correlation coefficient
- Continuing calibration data	CLP Form 9 or equivalent
- Positive identification (second column confirmation)	CLP Form 10 or equivalent
- Complete raw data	All chromatograms, preparation logs, run logs, calculations, etc.
Metals	
- Sample results	CLP Form 1 or equivalent
- Initial and continuing calibration	CLP Form 2 or equivalent, dates of analyses and calibration curve, and the correlation coefficient factor
- Method blank	CLP Form 3 or equivalent and dates of analyses
- ICP interference check sample	CLP Form 4 or equivalent and dates of analyses
- Spike sample recovery	CLP Form 5A or equivalent
- Postdigestion spike sample recovery for ICP metals	CLP Form 5B or equivalent
- Duplicates	CLP Form 6 or equivalent
- Postdigestion spike for GFAA	CLP Form 5B or equivalent
- Laboratory Control Sample (LCS)	CLP Form 7 or equivalent
- Standard additions (when implemented)	CLP Form 8 or equivalent
- Holding times	CLP Form 13 or equivalent

Table A.6. (continued)

Method requirements	Deliverables
- Run log	CLP Form 14 or equivalent
- Complete Raw Data	All preparation logs, run logs, instrument output, calculations, etc.
Wet chemistry	
- Sample results	Report result
- Matrix spike recovery	%Recovery
- Matrix spike duplicate or duplicate	%Recovery and %RPD
- Method blank	Report results
- Initial calibration	Calibration curve and correlation coefficient
- Continuing calibration check	Recovery and % difference
- LCS	LCS result and control criteria
- Run log	Copy of run log
- Complete Raw Data	All preparation logs, run logs, instrument output calculations, etc.
Radiochemical analysis	
- Sample results	Report results
- Initial calibration	Efficiency determination
- Efficiency check	% difference from calibration
- Background determinations	Report results
- Minimum detectable activity (MDA)	Report results
- Method blank	Report results
- Spike recovery results	Spike added and %Recovery
- Internal standard results (tracers or carriers)	Standard added and %Recovery
- Duplicate results	Report results and %RPD
- Self absorption factors (alpha)	Report factors
- Cross-talk factors (ap)	Report factors and control criteria
- LCS	LCS result and control criteria
- Run log	Copy of run log
- Complete raw data	All preparation logs, run logs, instrument output, calculations, etc.
Geotechnical analysis	
- Sample results	Report results
- Complete raw data	All preparation logs, run logs, instrument output, calculations, etc.

CLP = Contract Laboratory Program
GC = gas chromatography
GFAA = graphite furnace atomic absorption
ICP = inductively coupled plasma
MS = mass spectrometry
RPD = relative percent difference
RSD = relative standard deviation
TIC = tentatively identified compound

to ensure accurate identification of detected versus nondetected compounds). This approach is consistent with the DQOs for the investigation.

A.7.3.1 Data validation rationale

The data validation criteria listed in Table A.7 have been determined as critical in the evaluation of analytical data useability. These are a subset of the comprehensive ES/ER/TM-16 data validation criteria that, based on analytical process knowledge, contribute significantly to the qualification and associated uncertainty of the reported results. Evaluation of this subset will allow identification of potential false positive or negative results. Because these criteria are associated with random rather than systematic error, they require evaluation throughout the analytical measurement process. They cannot be comprehensively determined by reviewing only a portion of the data. Consistent with the data quality requirements as defined in the DQOs and based on the previous rationale, all project data and associated QC must be evaluated on these criteria and qualified as per the outcome of the review. The criteria by which the data will be evaluated are discussed in the following subsection.

A.7.3.2 Data validation criteria

Holding Times. Evaluation of holding times ascertains the validity of results based on the length of time from sample collection to sample preparation or sample analysis. Verification of sample preservation must be confirmed and accounted for in the evaluation of sample holding times. The evaluation of holding times is essential to establishing sample integrity and representativeness. Concerns regarding physical, chemical, or biochemical alteration of analyte concentrations can be eliminated or qualified through this evaluation.

Blanks. The assessment of blank analyses is performed to determine the existence and magnitude of contamination problems. The criteria for evaluation of blanks applies to any blank associated with the samples, including field, trip, equipment, and method blanks. Contamination during sampling or analysis, if not discovered, results in false positive data.

Surrogate recovery. System monitoring compounds are added to every sample, blank, matrix spike, matrix spike duplicate, and standard. They are used to evaluate extraction, cleanup, and analytical efficiency by measuring recovery on a sample-specific basis. Poor system performance as indicated by low surrogate recoveries is one of the most common reasons for data qualification. Evaluation of surrogate recovery is critical to the provision of reliable sample-specific analytical results.

Calibration. The purpose of initial and continuing calibration verification analyses is to verify the linear dynamic range and stability of instrument response. Relative instrument response is used to quantify the analyte results. If the relative response factor is outside acceptable limits, the data quantification is uncertain and requires appropriate qualification.

Internal standards. Internal standards are used to evaluate and compensate for sample-specific influences on the analyte quantification. They are evaluated to determine whether data require qualification due to excessive variation in acceptable internal standard quantitative or qualitative performance measures. For example, a decrease or increase in internal standard area counts for organics may reflect a change in sensitivity that can be attributed to the sample matrix. Because

Table A.7. Data validation criteria

Organics	Inorganics	Radiochemistry	Geotechnical/geochemical
Holding times	Holding times	Holding times	
Blanks	Blanks	Blanks	
Surrogate recovery	Laboratory control sample	Laboratory control sample	
Internal Standards	Furnace atomic absorption QC	Sample-specific chemical or tracer recovery	
Calibration	Calibration	Calibration	Calibration
Sample reanalysis			Sample reanalysis
Secondary dilutions			
Case narrative	Case narrative	Case narrative	Case narrative

quantitative determination of analytes is based on the use of internal standards, evaluation is critical to the provision of reliable analytical results.

Sample Reanalysis. When instrument performance–monitoring standards indicate an out-of-control analysis, the laboratory is required to reanalyze the sample. If the reanalysis does not solve the problem (i.e., surrogate compound recoveries are outside the limits of both analyses), the laboratory is required to submit data from both analyses. An independent review is required to determine which is the appropriate sample result.

Secondary Dilutions. When the concentration of any analyte in any sample exceeds the initial calibration range, a new aliquot of that sample must be diluted and reanalyzed. The laboratory is required to report data from both analyses. When this occurs, an independent review of the data is required to determine the appropriate results to be used for that sample. An evaluation of each analyte exceeding the calibration range must be made, including a review of the dilution analysis performed. Results chosen in this situation may be a combination of both the original results (i.e., analytes within initial calibration range) and the secondary dilution results.

Laboratory Control Samples. The laboratory control sample serves as a monitor of the overall performance of the analytical process, including sample preparation, for a given set of samples. Evaluation of this standard provides confidence in or allows qualification of results based on a measurement of process control during each sample analysis.

Furnace Atomic Absorption QC. Duplicate injections and furnace post-digestion spikes are evaluated to establish precision and accuracy of individual analytical determinations. Because of the nature of the furnace atomic absorption technique and because of the detailed decision tree and analysis scheme required for quantification of the elements, evaluation of QC is critical to ensuring reliable analytical results.

Sample Specific Chemical or Tracer Recovery. Laboratory performance on individual samples subject to chemical process and separation is established by means of spiking with tracer quantities of other radioisotopes of the same element or carrier quantities of an inactive isotope of the same or a chemically similar element. This process is analogous to surrogate or internal standard recovery, dependent on the analyte and method being evaluated, and a common reason for data qualification.

A.7.4 Project Data Quality Assessment

The data quality indicator parameters (PARCC) will be used to evaluate data quality and quantity. Reviewers are responsible for ensuring that data reduction calculations follow appropriate data calculation procedures, are documented, and are checked by qualified personnel. Written reports, including reduced and summarized data, will include the raw data in appendixes.

Both qualitative and quantitative criteria are used as indicators of the quality of the data. In determining data usability, especially in the decision-making process, the integrity and authenticity of the data must be evaluated and the analytical uncertainty must be determined. Parameters used to assess data quality for the SAP investigation are precision, accuracy, representativeness, comparability, completeness, and sensitivity. These parameters will be evaluated for the entire investigation data set.

A.8 QC CHECKS

A.8.1 Field QC Sampling

The types and numbers of field QC samples to be collected during implementation of the SAP investigation are discussed in Sect. 5.8 of the SAP.

A.8.2 Laboratory QC Procedures

A number of laboratory QC samples will be analyzed to check and monitor laboratory performance, precision, and accuracy. Laboratory QC is necessary to assess potential impacts of interferences and contaminants during the analytical process. A summary of the laboratory QC samples to be used during sample analyses is presented in the following text.

A.8.2.1 Laboratory duplicates

Laboratory duplicates are separate aliquots of a single sample that are prepared and analyzed concurrently at the laboratory. This duplicate sample should not be a method blank, trip blank, or field blank. The primary purpose of the laboratory duplicate is to check the precision of the laboratory analyst, the sample preparation methodology, and the analytical methodology. If there are significant differences between the duplicates, the affected analytical results will be re-examined. One in 20 samples will be laboratory duplicates, with fractions rounded to the next whole number.

A.8.2.2 Method blanks

A method blank is a sample made up of a pure, noncontaminated substance of the matrix of interest (usually distilled/de-ionized water or silica sand) that is then subjected to all of the sample preparation (digestion, distillation, extraction) and analytical methodology applied to the samples. The purpose of the method blank is to check for contamination from within the laboratory that might be introduced during sample preparation and analysis that would adversely affect analytical results. One in 20 samples will be method blanks with fractions rounded to the next whole number.

A.8.2.3 Surrogate spikes

A surrogate spike is prepared by adding a pure compound to a sample before extraction. The compound in the surrogate spike should be of a similar type to that being assayed in the sample. The purpose of a surrogate spike is to determine the efficiency of recovery of analytes in the sample preparation and analysis. The percent of recovery of the surrogate spike is then used to gauge the total accuracy of the analytical method for that sample.

A.8.2.4 Laboratory control samples

The laboratory control sample (LCS) contains known concentrations of analytes representative of the contaminants to be determined or are added to laboratory ASTM Type II water and carried through the entire preparation and analysis process. Commercially available LCSs or those from EPA may be used. LCS standards that are prepared in-house must be made from a source independent of that of the calibration standards. For methods using surrogates, the method blank may be used as the LCS. Each LCS analyte must be plotted on a control chart. The primary purpose of the LCS is to establish and monitor the laboratory's analytical process control. An LCS must be analyzed with each analytical sample batch.

A.8.2.5 Matrix spikes and matrix spike duplicates

A matrix spike (MS) is an aliquot of a sample spiked with known quantities of analytes and subjected to the entire analytical procedure. It is used to indicate the appropriateness of the method for the matrix by measuring recovery or accuracy. Accuracy is the nearness of a result or the mean of a set of results to the true or accepted value. A matrix spike duplicate (MSD) is a second aliquot of the same sample as the MS with known quantities of compounds added. The purpose of the MSD, when compared to the MS, is to determine method precision. Precision is the measure of the reproducibility of a set of replicate results among themselves or the agreement among repeat observations made under the same conditions. MSs and MSDs are performed per 20 samples of similar matrix.

A.8.2.6 Method-specific QC

The laboratory must follow specific quality processes as defined by the method. These will include measures such as calibration verification samples, instrument blank analysis, surrogate determinations, internal standards, tracer analysis, etc.

A.9 AUDITS AND SURVEILLANCES

A.9.1 Audits

Audits are performed to review and evaluate the adequacy of field and laboratory performance and ascertain whether the QAPjP is being completely and uniformly implemented. Planned and scheduled audits may be performed to verify compliance with all aspects of the QA program and determine the program's effectiveness. These audits shall be conducted in accordance with written procedures and checklists and shall be performed by personnel who do not have direct responsibility for performing the activities being audited. Energy Systems audits will be conducted in accordance with site-specific procedure ERWM/PAI-1052.

The QA/QC Officer is responsible for audits and may perform them according to a schedule that coincides with appropriate activities on the investigation schedule. Table A.8 provides the tentative schedule of audits and surveillances.

Table A.8. Schedule of audits and surveillances

Type of audits/surveillance	Frequency
Surveillance of field QC	At least once during the beginning of each type of field sampling activity
Audits	As requested by the Project Manager
Laboratory surveillance/audit	As requested by the Project Manager

A.9.2 Surveillances

Surveillance activities include monitoring and observing documents and work activities to provide an effective real-time means of evaluating the adequacy and effectiveness of methods for achieving quality and for assessing the quality of final results. A minimum of one field surveillance will be performed to verify QC of the project. Field surveillances will be conducted early for each phase of the project. A field surveillance is required for a major change in personnel or change in type of sampling and may be required periodically during long periods of sampling. Energy Systems surveillances will be conducted in accordance with Energy Systems procedure ER/C-P1600 and site-specific procedure ERWM/PAI-1054.

A.10 PREVENTIVE MAINTENANCE PROCEDURES/SCHEDULES

Any equipment (an inclusive term for tools, gauges, instruments, and other items that have specific preventive maintenance) will be serviced and documented as specified by manufacturer's recommended schedule. All service will be performed by qualified and trained individuals. The operators are responsible for seeing that the equipment is scheduled for service, serviced, and properly maintained. Properly maintained equipment helps reduce unnecessary “downtime.” A complete list of equipment will be developed by the operator and the parts replacement equipment will be immediately available (either from the supplier/manufacturer on site). Having replacement equipment or critical spare parts available also minimizes “downtime.”

The implementation of a preventive maintenance program depends on the specific instruments and equipment used for the field investigation. The subcontractor will ensure a preventive maintenance program that includes the following:

- a listing of the instruments and equipment that are included in the program;

- the frequency of maintenance considering manufacturer's recommendations and/or previous experience with equipment (the listing and maintenance frequency should provided on a schedule; frequency should be stated in terms of monthly, quarterly, etc.); and

- for each instrument in the program provide external service contracts, items to be checked and/or serviced during maintenance, and directions for performing maintenance (if external service is not provided, or if not stated in the manufacturer's instrument manuals).

Preventive maintenance will be documented. A file will be maintained for each instrument. The instrument file should include, at a minimum:

- external service contracts;

- checklist of items to be serviced and directions for maintenance or manufacturer's instrument manuals;

- record of periodic maintenance; and

- comments noting any replacement of parts, observed deterioration, etc.

Analytical laboratories performing sample analyses also will be responsible for implementing preventive maintenance procedures, schedules, and record keeping similar to those described previously for field equipment.

A.11 SPECIFIC ROUTINE PROCEDURES

The analytical data assessment objectives for laboratory analysis will produce data of known and sufficient quality to support the investigation and its resulting decisions. This subsection defines the goals for PARCC parameters for measurement data. Appropriate procedures and QC checks will be employed to assess the level of acceptance of these parameters. All QC data will be reported for the investigation, along with the sample results, when the analytical sample set is completed. QC data generated will be reviewed and evaluated to validate the information. Acceptance criteria and evaluation of laboratory analytical results for the PARCC parameters will be determined according to the following outline.

Field procedures for the collection of samples are discussed in Chapter 6 of the SAP and will be provided in a separate procedures manual. The equipment and techniques that will be employed to obtain representative samples will be in accordance with approved procedures.

Procedures to attain sensitivity objectives include (1) uniform training and certification for staff; (2) standard provisions for inspection, maintenance, and repair; (3) provision of standard operating procedures to technical staff; (4) reference to standard operating procedures in the field and laboratory QAPjP; and (5) field/laboratory QA inspections to determine compliance with the items specified in the support plans.

A.11.1 Precision

Precision is defined as the reproducibility or degree of agreement among duplicate measurements under a given set of conditions. The closer the measurements approach each other, the more precise the measurement. The level of precision is determined by calculating the relative percent difference (RPD) between the two measurements, using the following formula:

$$RPD = \frac{S - D}{(S + D)/2} \times 100\%,$$

where

S = analyte concentration of the original sample,
D = analyte concentration of the duplicate sample.

Precision is determined using MS/MSD analyses conducted on samples collected. The laboratory will select one sample in 20 to split into three aliquots. The first aliquot will be analyzed routinely for the parameters of interest, while the other two aliquots will be spiked with known quantities of the parameters of interest before analysis. The RPD between the two spike results will be calculated and used as an indication of the precision of the analyses performed.

When the analyte of interest provides a measurable quantity, these precision determinations can be obtained through duplicate analysis comparisons. Analytical precision goals for the proposed metals, radiochemical, and other inorganic parameters will be < 20 RPD. Goals for analytical precision for organic parameters will be those identified in the analytical methods for specific analytes. In general, these range up to 25 RPD (volatile organics) and 50 RPD (semivolatile organics) in soils and water. In the event analytical precision goals are exceeded, a determination will be made through the data validation process relative to the useability of that information.

A.11.2 Accuracy

Accuracy is defined as the degree of difference between measured values and the true values. Sampling accuracy will be maximized by adhering to the QA program presented in the QAPjP. Accuracy will be assessed by splitting a sample into two portions, spiking (i.e., adding known quantity of the constituents of interest to one of the portions), and then analyzing both portions for these parameters. The difference in the concentration levels of the constituents of interest should be equal to the quantity of the spike added to one of the two portions. The following equation will be used to calculate percent recovery (%R):

$$\% R = \frac{A_r - A_o}{A_f} \times 100\%,$$

where

A^r = total compound or element concentration detected in the spiked sample,
A^o = concentration of the compound or element detected in the unspiked sample,
A^f = concentration of the compound or element added to the sample.

For laboratory samples, 100% recovery is equivalent to 100% accuracy. Values < 100% may indicate a sample matrix effect and a false reading. For situations in which a standard reference material (SRM) is used rather than or in addition to MSs, the following formula is used:

$$\%R = \frac{C_m}{C_{srm}} \times 100\%,$$

where

C^m = measured concentration of SRM,
C^{srm} = actual concentration of SRM.

A.11.3 Representativeness

Representativeness expresses the relative degree to which the data depict the characteristics of a population, parameter, sampling point, process condition, or environmental condition. The objective of the investigation is to accurately represent the concentrations of target analytes.

Representative samples for the investigation will be acquired through implementation of approved sampling and analytical procedures that will generate data representative of the sampling point location. Sampling procedures are designed to minimally impact the sample obtained so that conditions representative of the sampling location will be maintained. Analytical methods will be selected that most accurately represent the true concentration of the parameter of interest. The accumulation of QC procedures and information (i.e., RPD values, blank QC concentrations, MS percent recoveries, etc.) employed for a given analysis combine to exhibit the representativeness of the data generated.

The goal for representative sample data will therefore be met through the proper documentation of field and analytical protocols. If these procedures and methods cannot be implemented, the appropriate corrective action documentation will encompass the impact on the representativeness of the information. When review of the data and documentation determines that the data are nonrepresentative, the information will be implemented to further define sample population, parameter, or process characteristics relative to representativeness.

A.11.4 Completeness

Completeness is defined as the percentage of valid data obtained from a measurement system. For data to be considered valid, they must have met all acceptance criteria, including accuracy and precision, as well as any other criteria specified by the analytical methods used.

$$\%C = \frac{V}{n} \times 100\%,$$

where

V = the actual number of valid measurements obtained,
n = the number of sample points planned.

Completeness goals established for investigation sample collection and field measurements are 95%. If this percentage is not met, the necessity for resampling will be determined on case-by-case basis. The completeness goal for laboratory analysis for the investigation is 90 overall. For the critical data points, which consist of the sampling points representative of groundwater background for SWMU 2 (i.e., points SWMU2-9 and SWMU2-10), the completeness goal for sample collection, field measurements, and laboratory analysis is 100%. When review of the data and documentation determines the data to be incomplete, the impact relative to the investigation objectives will be assessed and documented.

To meet the objectives of the investigation, all data will be validated against the data validation criteria (Sect. A.7.3) to determine its useability. For determination of completeness, all data not flagged as rejected by the validation process will be considered valid.

A.11.5 Comparability

Comparability expresses the confidence with which one data set can be compared with another. Comparability of the data generated by the investigation will be obtained through implementation of the identified protocols for sampling and analysis of samples. Use of traceable reference materials as laboratory standards, expression of results in standard concentration units, and successful participation by the laboratories in external performance evaluation programs will enable the data produced through the investigation to be compared with future historical sampling data sets.

A.12 CORRECTIVE ACTION

Energy Systems corrective actions to audit/surveillance findings and nonconformances will be managed in accordance with Energy Systems procedures ESS-QA-16.1 (Revision 1). The ER Program Project Manager and the ER QA Specialist will be notified when a nonconformance is documented and furnished with a copy as soon as possible. Copies of nonconformances and their dispositions will be forwarded to the ER Program Project Manager for placement into the PGDP ER Document Management Center. Nonconformance Reports issued as a result of an audit or surveillance will identify the root cause of the problem.

A.13 QA REPORTS TO MANAGEMENT

All QA records concerning the investigation (e.g., internal and external correspondence, SAP, QAPjP, field logbooks and forms, chain-of-custody forms, data packages, Audit and Surveillance Reports, Nonconformance Reports, Corrective Action Reports, etc.) will be submitted to the subcontractor's Central Records Facility for dual storage and retrieval. Records concerning the project will be forwarded to the ER Program Project Manager for placement into the PGDP ER Document Management Center during the investigation. A complete copy of the investigation file will be submitted to the ER Program Project Manager at the end of the period of performance.

A.14 REFERENCES

Energy Systems (Martin Marietta Energy Systems, Inc.). 1992. *Requirements for Quality Control of Analytical Data for the Environmental Restoration Program,* ES /ER/TM- 16, Oak Ridge National Laboratory, Oak Ridge, Tennessee, December.

Energy Systems. 1994. *Environmental Restoration Division Quality Program Plan,* ES/ER/TM-4/R4, Oak Ridge National Laboratory, Oak Ridge, Tennessee, September.

EPA (U.S. Environmental Protection Agency). 1990. Test Methods for Evaluating Solid Waste, *Physical/Chemical Methods*, SW-846, 3rd Edition.

Stanley, T. W. and S. S. Verner. 1983. *Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans,* EPA-600/4-83-004 (QAMS-005/80), U.S. Environmental Protection Agency, Office of Exploratory Research, Washington, D.C., February.

Appendix B

ANALYTE COMPARISON TABLES

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Table B.1. Comparison of maximum detected concentrations (mg/kg) of inorganics in surface soil (0 to 1 ft below ground surface) to threshold values and industrial use preliminary remediation goals for exposure to contaminants in soil

Analyte	Maximum Detected Concentration	Sample Location	Sample Identifier	Threshold Value	IPRG[a]	Exceeds?[b]	COC?[c]
Aluminum	7,790	H-221	13353	13,000	----	NO	NO
Antimony	5.04N	H-262	14041	0.84[d]	1.1	YES	NO
Arsenic	24.6JNS	H-262	14041	12	0.85	YES	YES
Barium	162JE*	H-262	14041	200	660	NO	NO
Beryllium	0.8B	H-262	14041	1.3[d]	0.0092	NO	NO
Cadmium	ND	NA	NA	2.6[d]	1.4	NO	NO
Calcium	2,480JE	H-262	14041	200,000	----	NO	NO
Chromium	11.3	H-262	14041	16	Cr III 710	NO	NO
					Cr VI 14	NO	NO
Cobalt	13	H-221	13353	14	----	NO	NO
Copper	29.9	H-262	14041	19	----	NO	NO
Cyanide (CN^-)	ND	NA	NA	----	430	NO	NO
Iron	54,000JE	H-262	14041	28,000	----	YES	NO
Lead	24.4JN	H-262	14041	36	----	NO	NO
Magnesium	1,450	H-221	13353	7,700	----	NO	NO
Manganese	655	H-221	13353	1,500	760	NO	NO
Mercury	0.334	H-262	14041	0.20	2.9	NO	NO
Nickel	28.6	H-262	14041	21	650	NO	NO
Potassium	744B	H-262	14040	1,300	----	NO	NO
Selenium	0.48J	H-221	13353	0.80	240	NO	NO
Silver	6.3	H-221	13353	2.3	110	NO	NO
Sodium	344JB	H-262	14041	320	----	YES	NO
Thallium	ND	NA	NA	0.44[d]	----	NO	NO
Tin	NA	NA	NA	----	8,000	NA	NO

Table B.1. (continued)

Analyte	Maximum Detected Concentration	Sample Location	Sample Identifier	Threshold Value	IPRG[a]	Exceeds?[b]	COC?[c]
Vanadium	18.9	H-221	13353	38	9.9	NO	NO
Zinc	73.9JN	H-262	14041	65	7,500	NO	NO

Notes:
Values, data qualifiers, sample locations, and sample identifiers from *Results of the Site Investigation, Phase I at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (CH2M Hill 1991) and *Results of the Site Investigation, Phase II at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (CH2M Hill 1992). Qualifiers are defined as follows:

B	Element was detected at levels below the contract-required detection limit. Data are considered estimated but are usable.
E	Reported value is estimated because of interference.
J	Value is estimated due to either quality control problems or to detection below nominal detection limit.
N	Spike recovery for analyte was not within control limits.
S	Values was determined by the Method of Standard Additions (MSA).
*	Duplicate analyses was not within control limits.

ND indicates that the analyte was not detected in any sample.
NA indicates that the information to be provided is not applicable because the analyte was not detected or, in the case of tin, analyses were not performed.

Threshold values and IPRGs are taken from *Background Concentrations and Human Health Risk-based Screening Criteria for Metals in Soil at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1995).

[a] IPRG is the industrial use scenario preliminary remediation goal reported in DOE 1995.

[b] "YES" indicates that the maximum reported concentration exceeds both the threshold value and the IPRG. "NO" indicates that the maximum reported concentration did not exceed both the threshold value and the IPRG.

[c] "YES" indicates that the excess lifetime cancer risk or hazard quotient due to exposure to analyte in soil under industrial use was reported to be equal to or greater than 1×10^{-6} or 0.1, respectively, in *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). "NO" indicates that this condition was not met.

[d] These threshold values are to be verified with additional sampling. For beryllium, the subsurface threshold value is used.

Table B.2. Comparison of maximum detected concentrations (mg/kg) of inorganics in subsurface soil (greater than 1 ft below ground surface) to threshold values and industrial use preliminary remediation goals for exposure to contaminants in soil

Analyte	Maximum Detected Concentration	Sample Location	Sample Identifier	Threshold Value	IPRG[a]	Exceeds?[b]	COC?[c]
Aluminum	9,300	H-262	14042	12,000	----	NO	NO
Antimony	4.3N	H-221	13354	0.84[d]	1.1	YES	NO
Arsenic	6.3	H-262	14043	7.9	0.85	NO	YES
Barium	106	H-221	13356	170	660	NO	NO
Beryllium	0.99J	H-221	13361	1.3[d]	0.0092	NO	NO
Cadmium	ND	NA	NA	2.2[d]	1.4	NO	NO
Calcium	1,610	H-221	13354	6,100	----	NO	NO
Chromium	16.9	H-262	14042	43	Cr III 710	NO	NO
					Cr VI 14	NO	NO
Cobalt	25.9	H-221	13356	13	----	YES	NO
Copper	15.4	H-262	14042	25	----	NO	NO
Cyanide (CN^-)	ND	NA	NA	----	430	NO	NO
Iron	21,300	H-221	13361	28,000	----	NO	NO
Lead	16.8N	H-221	13355	23	----	NO	NO
Magnesium	1,170	H-262	14042	2,100	----	NO	NO
Manganese	1,560*	H-221	13356	820	760	YES	NO
Mercury	ND	NA	NA	0.13	2.9	NO	NO
Nickel	12.1	H-221	13356	22	650	NO	NO
Potassium	509J	H-221	13361	950	----	NO	NO
Selenium	0.28J	H-221	13359	0.7	240	NO	NO
Silver	7.6	H-221	13361	2.7	110	NO	NO
Sodium	151J	H-221	13356	340	----	NO	NO
Thallium	ND	NA	NA	0.38[d]	----	NO	NO
Tin	NA	NA	NA	----	8,000	NA	NO
Vanadium	22.6	H-262	14042	37	9.9	NO	NO

Table B.2. (continued)

Analyte	Maximum Detected Concentration	Sample Location	Sample Identifier	Threshold Value	IPRG[a]	Exceeds?[b]	COC?[c]
Zinc	42.4	H-262	14042	60	7,500	NO	NO

Notes:
Values, data qualifiers, sample locations, and sample identifiers from *Results of the Site Investigation, Phase I at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (CH2M Hill 1991) and *Results of the Site Investigation, Phase II at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (CH2M Hill 1992). Qualifiers are defined as follows:

J Value is estimated due to either quality control problems or to detection below nominal detection limit.

N Spike recovery for analyte was not within control limits.

* Duplicate analyses was not within control limits.

ND indicates that the analyte was not detected in any sample.
NA indicates that the information to be provided is not applicable because the analyte was not detected or, in the case of tin, analyses were not performed.

Threshold values and IPRGs are taken from *Background Concentrations and Human Health Risk-based Screening Criteria for Metals in Soil at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1995).

[a] IPRG is the industrial use scenario preliminary remediation goal reported in DOE 1995.
[b] "YES" indicates that the maximum reported concentration exceeds both the threshold value and the IPRG. "NO" indicates that the maximum reported concentration did not exceed both the threshold value and the IPRG.
[c] "YES" indicates that the excess lifetime cancer risk or hazard index due to exposure to analyte in soil under industrial use was reported to be equal to or greater than 1×10^{-6} or 0.1, respectively, in *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). "NO" indicates that this condition was not met.
[d] These threshold values are to be verified with additional sampling. For antimony, the surface threshold value is used.

Table B.3. Maximum detected concentrations (µg/l) of inorganics in unfiltered groundwater from shallow UCRS monitoring wells MW058 and MW154

Analyte	MW154[a] (10034)	MW058 (00020) (00471	Maximum Detected Concentration	Sample Location	Sample Number
Aluminum	4,210J	74,800 53,400J	74,800	MW058	00020
Antimony	18.2N	52U 40U	18.2N	MW154	10034
Arsenic	2.5R	260 3U	260	MW058	00020
Barium	77.4J	544 375	544	MW058	00020
Beryllium	ND	4.1J 3U	4.1J	MW058	00020
Cadmium	ND	3UR 3U	ND	NA	NA
Calcium	30,100J	147,000J 116,000	147,000J	MW058	00020
Chromium	14.2J	70.5 88	88	MW058	00471
Cobalt	ND	41.5 24.2	41.5	MW058	00020
Copper	7.6UJ	200 243	243	MW058	00471
Cyanide (CN^-)	ND	5U 5U	ND	NA	NA
Iron	4,310J	131,000J 109,000	131,000J	MW058	00020
Lead	7.2	89.5J 35.9	89.5J	MW058	00020
Magnesium	11,100J	26,200J 18,800	26,200J	MW058	00020
Manganese	177J	2,070J 1,440	2,070J	MW058	00020
Mercury	ND	0.2U 0.2U	ND	NA	NA
Nickel	5.9J	98 66.8	98	MW058	00020

Table B.3. (continued)

Analyte	MW154[a] (10034)	MW058 (00020) (00471	Maximum Detected Concentration	Sample Location	Sample Number
Potassium	1,320J	5,260 6,010	6010	MW058	00471
Selenium	1.1R	2U 3U	ND	NA	NA
Silver	38N	28.8J 29.8U	38N	MW154	10034
Sodium	54,500J	16,500J 10,400	54,500J	MW154	10034
Thallium	1.4N	3U 2U	1.4N	MW154	10034
Tin	NA	NA NA	NA	NA	NA
Vanadium	4.4J	67.4 56.5	67.4	MW058	00020
Zinc	46.7J	383J 228	383J	MW058	00020

Notes:

Values, data qualifiers, sample locations, and sample identifiers from *Results of the Site Investigation, Phase I at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (CH2M Hill 1991) and *Results of the Site Investigation, Phase II at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (CH2M Hill 1992). Qualifiers are defined as follows:

J	Value is estimated due to either quality control problems or to detection below nominal detection limit.
N	Spike recovery for analyte was not within control limits.
R	Data were rejected by the validator. Result is not usable.
U	Sample not detected above the detection limit.

ND indicates that analyte was not detected in any sample.

NA indicates that the information to be provided is not applicable because the analyte was not detected or, in the case of tin, analyses were not performed.

[a] Sample location (i.e., MW058) and sample number (i.e., 10034).

Table B.4. Maximum detected concentrations (µg/l) of inorganics in unfiltered groundwater from deep UCRS monitoring wells MW005, MW049, MW057, and MW074

Analyte	MW005	MW049[a] (00015) (00467) (10078)	MW057	MW074 (00022) (00480) (10091)	Maximum Detected Concentration	Sample Location	Sample Number
Aluminum	NA	3,580J 5,160J 53,400J	NA	20,200 137,000J 86,500N*J	137,000J	MW074	00480
Antimony	NA	52U 40U 19U	NA	52U 40U 19U	ND	NA	NA
Arsenic	NA	8.9J 3.2 7.1BSJ	NA	3U 2U 2U	8.9J	MW049	00015
Barium	NA	75.2 91 486J	NA	175 1,200 527	1,200	MW074	00480
Beryllium	NA	2U 3U 10.6	NA	2UR 20.8 10.8	20.8	MW074	00480
Cadmium	NA	3U 3U 4U	NA	3UR 5.1J 4U	5.1J	MW074	00480
Calcium	NA	54,800 66,600 97,300J	NA	16,700J 43,800 25,500	97,300J	MW049	10078
Chromium	NA	7.8 45.1 3U	NA	34.3 279 106N*J	279	MW074	00480
Cobalt	NA	15.3 20U 90.2	NA	15U 191 85.4J	191	MW074	00480
Copper	NA	119 115 76.6J	NA	21.3 207 59.3J	207	MW074	00480
Cyanide (CN$^-$)	NA	5U 5U 10U	NA	5U 5U 5U	ND	NA	NA
Iron	NA	146,000J 113,000 396,000J	NA	30,600J 449,000 278,000N*J	396,000J	MW049	10078

Table B.4. (continued)

Analyte	MW005	MW049^a (00015) (00467) (10078)	MW057	MW074 (00022) (00480) (10091)	Maximum Detected Concentration	Sample Location	Sample Number
Lead	NA	40.2J 22.9 113J	NA	17.3J 68.2 56.8SNJ	113J	MW049	10078
Magnesium	NA	20,700 27,400 40,800J	NA	6,660J 20,700 12,300	40,800J	MW049	10078
Manganese	NA	1,150 552 2,520J	NA	316J 2,910 1,380*	2,520J	MW049	10078
Mercury	NA	0.2U 0.2U 0.22	NA	0.2U 0.2U 0.2U	0.22	MW049	10078
Nickel	NA	67.9 24 126	NA	34.1 239 103J	239	MW074	00480
Potassium	NA	1,620U 3,000 2,800B	NA	1,620U 9,340 4,160B	9,340	MW074	00480
Selenium	NA	2U 3U 1W	NA	2U 3U 1U	ND	MW049	10078
Silver	NA	9U 11.4 22.4	NA	9UR 46.9 37.3J	46.9	MW074	00480
Sodium	NA	125,000 150,000 135,000J	NA	18,800J 21,700 18,700	150,000	MW074	00467
Thallium	NA	3U 2U 5W	NA	3U 2U 5WJ	ND	NA	NA
Tin	NA	NA NA NA	NA	NA NA NA	NA	NA	NA
Vanadium	NA	32.4 45.2 18B	NA	71.4 805 354J	805	MW074	00480

Table B.4. (continued)

Analyte	MW005	MW049[a] (00015) (00467) (10078)	MW057	MW074 (00022) (00480) (10091)	Maximum Detected Concentration	Sample Location	Sample Number
Zinc	NA	108J 117 231	NA	132J 604 294	604	MW074	00480

Notes:

Values, data qualifiers, sample locations, and sample identifiers from *Results of the Site Investigation, Phase I at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (CH2M Hill 1991) and *Results of the Site Investigation, Phase II at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (CH2M Hill 1992). Qualifiers are defined as follows:

B Element was detected at levels below the contract-required detection limit. Data are considered estimated but are usable.

J Value is estimated due to either quality control problems or to detection below nominal detection limit.

N Spike recovery for analyte was not within control limits.

R Data were rejected by the validator. Result is not usable.

S Values was determined by the Method of Standard Additions (MSA).

U Sample not detected above the detection limit.

W Sample analysis is outside of control limits; result not usable.

* Duplicate analyses was not within control limits.

ND indicates that the analyte was not detected in any sample.
NA indicates that the information to be provided is not applicable because the analyte was not detected or, in the case of tin, analyses were not performed.

[a] Sample location (i.e., MW049) and sample number (e.g., 00015).

Table B.5. Maximum detected concentrations (µg/l) of inorganics in unfiltered groundwater from RGA monitoring wells 48, 50, 51, and 67

Analyte	MW048[a] (00014) (10077)	MW050 (00017) (00468) (00469) (00018)	MW051	MW067 (00021) (10088) (10089)	Maximum Detected Concentration	Sample Location	Sample Number
Aluminum	202 508J	3,650 1,700J 1,910J 524	NA	960 19.5U 19.5U	3,650	MW050	00017
Antimony	52U 19U	52U 41.4U 41.4U 52U	NA	52U 9.2U 9.2U	ND	NA	NA
Arsenic	3U 2W	6.8 1.3J 1.2J 10.9	NA	3U 6.5U 6.5U	10.9	MW050	00018
Barium	88.9 96.5JB	82.8 80.4 82.6 96.5	NA	82.8 80.7B 81.2B	96.5	MW050	00018
Beryllium	2U 1U	2UR 2.3J 0.17J 2UR	NA	2UR 0.21UJ 0.32UJ	2.3J	MW050	00468
Cadmium	3U 4U	3UR 4 6.1 3UR	NA	3UR 0.6U 0.6U	6.1	MW050	00469
Calcium	16,000 17,200J	11,300J 15,500 15,400 40U	NA	14,500J 15,200 15,100	17,200J	MW014	10077
Chromium	5.5 3U	31.6 60.3 55 44.7	NA	16 2.4UJ 2.1UJ	60.3	MW050	00468
Cobalt	15U 4B	20.3 11.2 8.6 23.1	NA	15U 2U 2U	23.1	MW050	00018

Table B.5. (continued.)

Analyte	MW048[a] (00014) (10077)	MW050 (00017) (00468) (00469) (00018)	MW051	MW067 (00021) (10088) (10089)	Maximum Detected Concentration	Sample Location	Sample Number
Copper	14.8 7U	47.4 35.9 42.7 70.3	NA	7U 0.9U 0.9U	70.3	MW050	00018
Cyanide (CN$^-$)	5U 10U	5U 3.6U 3.6U 5U	NA	5U 6.4J 4.4J	6.4J	MW067	10088
Iron	42,600 10,400J	56,300J 45,000 42,300 82,800J	NA	1,450J 87.8B 61B	82,800J	MW050	00018
Lead	18.9 7JS	78.9J 25.9 28.9 178J	NA	3U 0.6U 0.6U	178J	MW050	00018
Magnesium	5,940 6,990J	4,120J 4,820 4,760 5,010J	NA	5,190J 6,000 5,950	6,990J	MW048	10077
Manganese	821 308J	96.7J 911 863 1,390J	NA	30.2J 10.8B 8.6B	1,390J	MW050	00018
Mercury	0.2U 0.2U	0.2U 0.15U 0.15U 0.2U	NA	0.2U 0.1U 0.1U	ND	NA	NA
Nickel	34U 7U	59.3 56.8 62 84.3	NA	62 56.3 43.6	84.3	MW050	00018
Potassium	2070 1,010U	1,620U 891 965 1,620U	NA	1,620U 331B 538B	965	MW050	00469
Selenium	2U 1U	2U 1.1U 1.1U 2U	NA	2U 0.73B 0.6U	0.73B	MW067	10088

Table B.5. (continued.)

Analyte	MW048[a] (00014) (10077)	MW050 (00017) (00468) (00469) (00018)	MW051	MW067 (00021) (10088) (10089)	Maximum Detected Concentration	Sample Location	Sample Number
Silver	9U 4U	9UR 6.7U 6.7U 9UR	NA	9UR 1.6U 1.6U	ND	NA	NA
Sodium	13,000 13,700J	183,000J 14,000 14,700 333,000J	NA	15,900J 13,600J 13,500J	333,000J	MW050	00018
Thallium	2U 5U	3U 1.5U 1.5U 3U	NA	3U 0.7U 0.7U	ND	NA	NA
Tin	NA NA	NA NA NA NA	NA	NA NA NA	NA	NA	NA
Vanadium	8.5 8U	41.7 36.4 34.5 56.8	NA	3U 1U 1U	56.8	MW050	00018
Zinc	438J 35.2	343J 170 146 447J	NA	9U 3.4UJ 2UJ	447J	MW050	00018

Notes:

Values, data qualifiers, sample locations, and sample identifiers from *Results of the Site Investigation, Phase I at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (CH2M Hill 1991) and *Results of the Site Investigation, Phase II at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (CH2M Hill 1992). Qualifiers are defined as follows:

B Element was detected at levels below the contract-required detection limit. Data are considered estimated but are usable.

J Value is estimated due to either quality control problems or to detection below nominal detection limit.

R Data were rejected by the validator. Result is not usable.

Table B.5. (continued.)

U Sample not detected above the detection limit.

W Sample analysis is outside of control limits; result not usable.

ND indicates that the analyte was not detected in any sample.
NA indicates that the information to be provided is not applicable because the analyte was not detected or, in the case of tin, analyses were not performed.

[a] Sample location (i.e., MW048) and sample number (e.g., 00014). ND indicates that analyte was not detected in any sample.

Table B.6. Comparison of maximum detected concentrations (µg/l) of inorganics in groundwater samples taken from wells completed in the RGA to RGA background values and residential use preliminary remediation goals for exposure to contaminants in water

Analyte	Maximum Detected Concentration	Sample Location	Sample Number	Background Value	RPRG[a]	Exceeds?[b]	COC?[c]
Aluminum	3,650	MW050	00017	2,190	NA	YES	NO
Antimony	ND	NA	NA	111	13	NO	NO
Arsenic	10.9	MW050	00018	11.2	11	NO	YES
Barium	96.5	MW050	00018	286	2,500	NO	NO
Beryllium	2.3J	MW050	00468	9.32	0.016	NO	YES
Cadmium	6.1	MW050	00469	20.6	15	NO	YES
Calcium	17,200J	MW014	10077	44,200	NA	NO	NO
Chromium	60.3	MW050	00468	131	Cr III 25,000 Cr VI 160	NO	YES
Cobalt	23.1	MW050	00018	95.5	NA	NO	NO
Copper	70.3	MW050	00018	22.3	NA	YES	NO
Cyanide (CN^-)	6.4J	MW067	10088	6.0	660	NO	NO
Iron	82,800J	MW050	00018	5,060	NA	YES	NO
Lead	178J	MW050	00018	104	NA	YES	NO
Magnesium	6,990J	MW048	10077	16,700	NA	NO	NO
Manganese	1,390J	MW050	00018	159	170	YES	YES
Mercury	ND	NA	NA	0.379	11	NO	NO
Nickel	84.3	MW050	00018	61.9	720	NO	NO
Potassium	965	MW050	00469	6,180	NA	NO	NO
Selenium	0.73B	MW067	10088	9.29	180	NO	NO
Silver	ND	NA	NA	4.10	180	NO	NO
Sodium	333,000J	MW050	00018	60,200	NA	YES	NO
Thallium	ND	NA	NA	108	NA	NO	NO
Tin	NA	NA	NA	NA	21,000	NO	NO
Vanadium	56.8	MW050	00018	137	210	NO	YES

Table B.6. (continued)

Analyte	Maximum Detected Concentration	Sample Location	Sample Number	Background Value	RPRG[a]	Exceeds?[b]	COC?[c]
Zinc	447J	MW050	00018	26.6	11,000	NO	NO

Notes:
Values, data qualifiers, sample locations, and sample identifiers from *Results of the Site Investigation, Phase I at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (CH2M Hill 1991) and *Results of the Site Investigation, Phase II at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (CH2M Hill 1992). Qualifiers are defined as follows:

B Element was detected at levels below the contract-required detection limit. Data are considered estimated but are usable.

J Value is estimated due to either quality control problems or to detection below nominal detection limit.

ND indicates that the analyte was not detected in any sample.
NA indicates that the information to be provided is not applicable because the analyte was not detected or, in the case of tin, analyses were not performed.

Background values from *Baseline Risk Assessment and Technical Investigation Report for the Northwest Dissolved Phase Plume, Paducah Gaseous Diffusion Plant* (DOE 1994). RPRGs are taken from *Preliminary Remediation Goals for Use at the U.S. Department of Energy Oak Ridge Operations Office* (Lockheed Martin 1995).

[a] RPRG is the residential use scenario preliminary remediation goal reported in Lockheed Martin 1995.

[b] "YES" indicates that the maximum reported concentration exceeds both the background value and the RPRG. "NO" indicates that the maximum reported concentration did not exceed both the background value and the RPRG.

[c] "YES" indicates that the excess lifetime cancer risk or hazard index due to exposure to analyte in groundwater under residential use was reported to be equal to or greater than 1×10^{-6} or 0.1, respectively, in *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); Attachments 2-13 and 2-14; MW048, MW050, and MW067. "NO" indicates that this condition was not met.

Table B.7. Comparison of maximum detected concentrations (µg/l) of inorganics in groundwater samples taken from wells completed in the deep UCRS to RGA background values and residential use preliminary remediation goals for exposure to contaminants in water

Analyte	Maximum Detected Concentration	Sample Location	Sample Number	Background Value	RPRG[a]	Exceeds?[b]	COC?[c]
Aluminum	137,000J	MW074	00480	2,190	NA	YES	NO
Antimony	ND	NA	NA	111	13	NO	NO
Arsenic	8.9J	MW049	00015	11.2	11	NO	YES
Barium	1,200	MW074	00480	286	2,500	NO	YES
Beryllium	20.8	MW074	00480	9.32	0.016	YES	YES
Cadmium	5.1J	MW074	00480	20.6	15	NO	YES
Calcium	97,300J	MW049	10078	44,200	NA	YES	NO
Chromium	279	MW074	00480	131	Cr III 25,000	NO	NO
					Cr VI 160	YES	YES
Cobalt	191	MW074	00480	95.5	NA	YES	NO
Copper	207	MW074	00480	22.3	NA	YES	NO
Cyanide (CN^-)	ND	NA	NA	6.0	660	NO	NO
Iron	396,000J	MW049	10078	5,060	NA	YES	NO
Lead	113J	MW049	10078	104	NA	NO	NO
Magnesium	40,800J	MW049	10078	16,700	NA	YES	NO
Manganese	2,520J	MW049	10078	159	170	YES	YES
Mercury	0.22	MW049	10078	0.379	11	NO	NO
Nickel	239	MW074	00480	61.9	720	NO	YES
Potassium	9,340	MW074	00480	6,180	NA	YES	NO
Selenium	ND	MW049	10078	9.29	180	NO	NO
Silver	46.9	MW074	00480	4.10	180	NO	YES
Sodium	150,000	MW074	00467	60,200	NA	YES	NO
Thallium	ND	NA	NA	108	NA	NO	NO
Tin	NA	NA	NA	NA	21,000	NO	NO
Vanadium	805	MW074	00480	137	210	YES	YES

Table B.7. (continued)

Analyte	Maximum Detected Concentration	Sample Location	Sample Number	Background Value	RPRG[a]	Exceeds?[b]	COC?[c]
Zinc	604	MW074	00480	26.6	11,000	NO	NO

Notes:

Values, data qualifiers, sample locations, and sample identifiers from *Results of the Site Investigation, Phase I at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (CH2M Hill 1991) and *Results of the Site Investigation, Phase II at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (CH2M Hill 1992). Qualifiers are defined as follows:

J Value is estimated due to either quality control problems or to detection below nominal detection limit.

ND indicates that the analyte was not detected in any sample.
NA indicates that the information to be provided is not applicable because the analyte was not detected or, in the case of tin, analyses were not performed.

Background values from *Baseline Risk Assessment and Technical Investigation Report for the Northwest Dissolved Phase Plume, Paducah Gaseous Diffusion Plant* (DOE 1994). RPRGs are taken from *Preliminary Remediation Goals for Use at the U.S. Department of Energy Oak Ridge Operations Office* (Lockheed Martin 1995).

[a] RPRG is the residential use scenario preliminary remediation goal reported in Lockheed Martin 1995.

[b] "YES" indicates that the maximum reported concentration exceeds both the background value and the RPRG. "NO" indicates that the maximum reported concentration did not exceed both the background value and the RPRG.

[c] "YES" indicates that the excess lifetime cancer risk or hazard index due to exposure to analyte in groundwater under residential use was reported to be equal to or greater than 1×10^{-6} or 0.1, respectively, in *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); Attachments 2-13 and 2-14; MW049 and MW074. "NO" indicates that this condition was not met.

Table B.8. Comparison of maximum detected concentrations (µg/l) of inorganics in groundwater samples taken from wells completed in the shallow UCRS to RGA background values and residential use preliminary remediation goals for exposure to contaminants in water

Analyte	Maximum Detected Concentration	Sample Location	Sample Number	Background Value	RPRG[a]	Exceeds?[b]	COC?[c]
Aluminum	74,800	MW058	00020	2,190	NA	YES	NO
Antimony	18.2N	MW154	10034	111	13	NO	NO
Arsenic	260	MW058	00020	11.2	11	YES	NO
Barium	544	MW058	00020	286	2,500	NO	NO
Beryllium	4.1J	MW058	00020	9.32	0.016	NO	NO
Cadmium	ND	NA	NA	20.6	15	NO	NO
Calcium	147,000J	MW058	00020	44,200	NA	YES	NO
Chromium	88	MW058	00471	131	Cr III 25,000	NO	NO
					Cr VI 160	NO	NO
Cobalt	41.5	MW058	00020	95.5	NA	NO	NO
Copper	243	MW058	00471	22.3	NA	YES	NO
Cyanide (CN^-)	ND	NA	NA	6.0	660	NO	NO
Iron	131,000J	MW058	00020	5,060	NA	YES	NO
Lead	89.5J	MW058	00020	104	NA	NO	NO
Magnesium	26,200J	MW058	00020	16,700	NA	YES	NO
Manganese	2,070J	MW058	00020	159	170	YES	YES
Mercury	ND	NA	NA	0.379	11	NO	NO
Nickel	98	MW058	00020	61.9	720	NO	NO
Potassium	6,010	MW058	00471	6,180	NA	NO	NO
Selenium	ND	NA	NA	9.29	180	NO	NO
Silver	38N	MW154	10034	4.10	180	NO	NO
Sodium	54,500J	MW154	10034	60,200	NA	NO	NO
Thallium	1.4N	MW154	10034	108	NA	NO	NO
Tin	NA	NA	NA	NA	21,000	NO	NO
Vanadium	67.4	MW058	00020	137	210	NO	NO

Table B.8. (continued)

Analyte	Maximum Detected Concentration	Sample Location	Sample Number	Background Value	RPRG[a]	Exceeds?[b]	COC?[c]
Zinc	383J	MW058	00020	26.6	11,000	NO	NO

Notes:
Values, data qualifiers, sample locations, and sample identifiers from *Results of the Site Investigation, Phase I at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (CH2M Hill 1991) and *Results of the Site Investigation, Phase II at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (CH2M Hill 1992). Qualifiers are defined as follows:

J Value is estimated due to either quality control problems or to detection below nominal detection limit.

N Spike recovery for analyte was not within control limits.

ND indicates that the analyte was not detected in any sample.
NA indicates that the information to be provided is not applicable because the analyte was not detected or, in the case of tin, analyses were not performed.

Background values from *Baseline Risk Assessment and Technical Investigation Report for the Northwest Dissolved Phase Plume, Paducah Gaseous Diffusion Plant* (DOE 1994). RPRGs are taken from *Preliminary Remediation Goals for Use at the U.S. Department of Energy Oak Ridge Operations Office* (Lockheed Martin 1995).

[a] RPRG is the residential use scenario preliminary remediation goal reported in Lockheed Martin 1995.

[b] "YES" indicates that the maximum reported concentration exceeds both the background value and the RPRG. "NO" indicates that the maximum reported concentration did not exceed both the background value and the RPRG.

[c] "YES" indicates that the excess lifetime cancer risk or hazard index due to exposure to analyte in groundwater under residential use was reported to be equal to or greater than 1×10^{-6} or 0.1, respectively, in *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); Attachments 2-13 and 2-14; MW154. "NO" indicates that this condition was not met.

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