DOE/LX/07-0004&D2/R2/A1
PRIMARY DOCUMENT

Remedial Action Work Plan for the Interim Remedial Action for the Volatile Organic Compound Contamination at the C-400 Cleaning Building at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky

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Remedial Action Work Plan for the Interim Remedial Action for the Volatile Organic Compound Contamination at the C-400 Cleaning Building at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky

Date Issued—July 2009

Date Revised—November 2010

U.S. DEPARTMENT OF ENERGY
Office of Environmental Management

Prepared by
PADUCAH REMEDIATION SERVICES, LLC

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

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ACRONYMS

ACGIH	American Conference of Governmental Industrial Hygienists
AHA	activity hazard analyses
ALARA	as low as reasonably achievable
ARAR	applicable or relevant and appropriate requirement
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
bgs	below ground surface
BMP	best management practice
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
CPR	cardiopulmonary resuscitation
CQCP	Construction Quality Control Plan
CRZ	contamination reduction zone
dBa	decibel (A-weighting filter)
DCE	dichloroethene
DMIP	Data Management Implementation Plan
DNAPL	dense nonaqueous-phase liquid
DOE	U.S. Department of Energy
DOECAP	Department of Energy Consolidated Audit Program
DPT	direct push technology
DQO	data quality objective
ECD	electron capture detector
EDD	Electronic Data Deliverable
EPA	U.S. Environment Protection Agency
ER	environmental restoration
ERH	electrical resistance heating
EZ	exclusion zone
FCR	Field Change Request
FFA	Federal Facility Agreement
FID	flame ionization detector
FS	Feasibility Study
GET	General Employee Training
GIS	geographic information system
gpm	gallons per minute
GWOU	groundwater operable unit
HAP	hazardous air pollutant
HASP	Health and Safety Plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
HP	health physics
HU	hydrogeologic unit
IM	intermodal
IRA	Interim Remedial Action
ISMS	Integrated Safety Management System
KAR	*Kentucky Administrative Regulations*
KDEP	Kentucky Department for Environmental Protection
KEPPC	Kentucky Environment and Public Protection Cabinet
KPDES	Kentucky Pollutant Discharge Elimination System
LCS	laboratory analytical control samples

LDR	land disposal restriction
LLW	low-level waste
LUC	land use control
M&TE	measuring and test equipment
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
MDL	method detection limit
MIP	membrane interface probe
MPE	multiphase extraction
mrem	millirem
MS	matrix spike
mS/m	milliSiemens/meter
MSD	matrix spike duplicate
MSDS	material safety data sheet
MW	monitoring well
NCP	National Contingency Plan
NCR	Nonconformance Report
NESHAP	National Emission Standards for Hazardous Air Pollutants
O&M	operation and maintenance
OREIS	Oak Ridge Environmental Information System
OSHA	Occupational Safety and Health Administration
PARCCS	Precision, Accuracy, Representativeness, Comparability, Completeness, and Sensitivity
PCB	polychlorinated biphenyl
PEMS	Paducah Environmental Measurements System
PGDP	Paducah Gaseous Diffusion Plant
pH	potential of hydrogen
PID	photoionization detector
POE	point of exposure
ppb	parts per billion
PPE	personal protective equipment
ppm	parts per million
PRG	preliminary remediation goal
PRS	Paducah Remediation Services, LLC
PRS-QAPP	Quality Assurance Program Plan for the Paducah Environmental Remediation Project
PSS	Plant Shift Superintendent
QA	quality assurance
QAP	Quality Assurance Plan
QC	quality control
RAD	radiological
RAWP	Remedial Action Work Plan
RCRA	Resource Conservation and Recovery Act
RCT	Radiation Control Technician
RDR	Remedial Design Report
RDSI	Remedial Design Support Investigation
RFD	Request for Disposal
RGA	Regional Gravel Aquifer
RI	Remedial Investigation
ROD	record of decision
RPD	relative percent difference
RPP	radiological protection program
RSD	relative standard deviation

RTL	Ready to Load
RWP	Radiological Work Permit
SAP	Sampling and Analysis Plan
SMO	Sample Management Office
SOP	Standard Operating Procedure
SOW	Statement of Work
SQA	software quality assurance
SVOC	semivolatile organic compound
SWMU	solid waste management unit
TBC	to be considered
^{99}Tc	technetium-99
TCA	trichloroethane
TCE	trichloroethene
TCL	target compound list
TCLP	toxicity characteristic leaching procedure
TPD	training position description
TRU	transuranic waste
TSCA	Toxic Substance Control Act
TSDF	treatment, storage, and disposal facilities
UCRS	Upper Continental Recharge System
UIC	Underground Injection Control
USC	*United States Code*
VOC	volatile organic compound
WAC	waste acceptance criteria
WAG	waste area grouping
WMC	Waste Management Coordinator
WMP	Waste Management Plan
μV	microvolt

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EXECUTIVE SUMMARY

The response action selected in the *Record of Decision for Interim Remedial Action for the Groundwater Operable Unit for the Volatile Organic Compound Contamination at the C-400 Cleaning Building at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (ROD), DOE/OR/07-2150&D2/R2, (DOE 2005a) for the source area comprised of trichloroethene (TCE) and other volatile organic compounds (VOCs) found at the C-400 Cleaning Building area is necessary to protect public health or welfare or the environment from actual or threatened releases of hazardous substances, pollutants, or contaminants from these areas that may present an imminent and substantial endangerment to public health and welfare. The releases resulted in a subsurface source zone of TCE and other VOCs at the south end of the C-400 Cleaning Building Area. This Remedial Action Work Plan (RAWP) defines the scope of activities and approach that are necessary to implement the Electrical Resistance Heating (ERH) alternative selected for this Interim Remedial Action (IRA) in the ROD.

The IRA includes the design, installation, operation, and subsequent decommissioning of an ERH system to heat discrete (vertical and horizontal) subsurface intervals of the subsurface source zone resulting in volatilization, removal, and recovery of VOCs from the C-400 treatment area.

The remediation goal for this interim action, as documented in the ROD, is to operate the ERH system until monitoring indicates that heating has stabilized in the subsurface and that recovery of TCE, as measured in the recovered vapor, diminishes to a point at which the recovery rate is constant (i.e., recovery is asymptotic). The ROD directs that remedial action design documents include the requirements and approach that will enable determination of asymptosis and heating stabilization, signaling when operation of the ERH system will cease. The *Remedial Design Report, Certified for Construction Design Drawings and Technical Specifications Package, for the Groundwater Operable Unit for the Volatile Organic Compound Contamination at the C-400 Cleaning Building at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (RDR), DOE/LX/07-0005&D2, (DOE 2008a) defines asymptotic recovery in more detail and provides additional detail regarding criteria for ceasing ERH operations that include temperature stabilization requirements.

A phased deployment of ERH will be implemented. The first phase (Phase I) will implement the design presented in the RDR, referred to as the base design, in the southwest and east treatment areas. In addition to removing VOCs from these areas, another important objective of Phase I will be to evaluate the heating performance of the base design through the Regional Gravel Aquifer down to the McNairy Formation interface in the southwest treatment area. Treatment in the east treatment area involves only the Upper Continental Recharge System. Lessons learned from Phase I will be evaluated and appropriate contingency actions will be implemented prior to start up of the second phase (Phase II) near the southeast corner of the C-400 Cleaning Building. In addition to evaluating heating performance in the Regional Gravel Aquifer, operation of Phase I also will provide the opportunity to evaluate the radius of influence of the vapor recovery system, assess hydraulic containment, and optimize the aboveground vapor/liquid treatment system.

This RAWP provides project background information, presents a summary of remedial design support investigation results, defines the project organization, and presents a project planning schedule. In addition, this RAWP addresses waste management and disposition, project health and safety, quality assurance and data management, and environmental compliance.

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1. INTRODUCTION

The Paducah Gaseous Diffusion Plant (PGDP), located approximately 16.1 km (10 miles) west of Paducah, Kentucky, and 5.6 km (3.5 miles) south of the Ohio River in the western part of McCracken County, is an active uranium enrichment facility owned by the U.S. Department of Energy (DOE). Bordering the PGDP to the northeast, between the plant and the Ohio River, is the Tennessee Valley Authority Shawnee Steam Plant.

This Remedial Action Work Plan (RAWP) has been prepared for the C-400 Cleaning Building Interim Remedial Action (IRA) at the PGDP. The IRA was chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 and is the response action selected in the *Record of Decision for Interim Remedial Action for the Groundwater Operable Unit for the Volatile Organic Compound Contamination at the C-400 Cleaning Building at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (ROD), DOE/OR/07-2150&D2/R2 (DOE 2005a).

The C-400 Cleaning Building is located inside the plant secured area, near the center of the industrial section of PGDP. The building is bound by 10th and 11th Streets to the west and east, respectively, and by Virginia and Tennessee Avenues to the north and south, respectively.

The C-400 Cleaning Building IRA will be conducted near the southeast and southwest corners of the C-400 Cleaning Building area of PGDP in areas identified as the southwest treatment area, southeast treatment area, and east treatment area on Figure 1. These areas have been identified as the major sources of groundwater contamination at PGDP. The primary contaminants are trichloroethene (TCE) and other volatile organic compounds (VOCs). A major component of the selected remedy is the reduction of the concentration of TCE and other VOCs in the soils in the C-400 Cleaning Building area through removal and treatment using electrical resistance heating (ERH) in both the Upper Continental Recharge System (UCRS) and the Regional Gravel Aquifer (RGA).

The IRA also includes a remedial design support investigation (RDSI), the necessary removal of infrastructure near the C-400 Building, and the implementation of land use controls (LUCs). The RDSI, which was completed in August 2006, further delineated areas of high TCE concentration and refined the placement of electrodes. The infrastructure removal activities may include, but are not limited to, dismantling and removing a bridge crane, removing a TCE tank and associated concrete, removing a TCE pumping station, excavating a concrete sump, removing aboveground secondary containment pits, and demolishing and removing a rail tanker unloading platform. Removal of this infrastructure will allow more flexibility in placement of remedial system components and reduce overhead hazards. Asphalt covering will be applied to the grassy areas surrounding the treatability study area once infrastructure removal activities are complete.

1.1 REGIONAL GEOLOGY AND HYDROGEOLOGY

The PGDP, including the C-400 area, is underlain by a sequence of clay, silt, sand, and gravel layers deposited on limestone bedrock. The sediments above the limestone bedrock are grouped into three major stratigraphic units (loess, Continental Deposits, and McNairy Formation) and three major hydrogeologic units (HUs) (UCRS, RGA, and McNairy Flow System) as shown in Figure 2.

Across the PGDP site, the upper-most stratigraphic unit consists primarily of wind-deposited, silty clay, known as loess, extending from the surface to a depth of approximately 6.1 m (20 ft) below ground surface (bgs). Fill material, when present, is included in this unit. Beneath the loess, the Upper

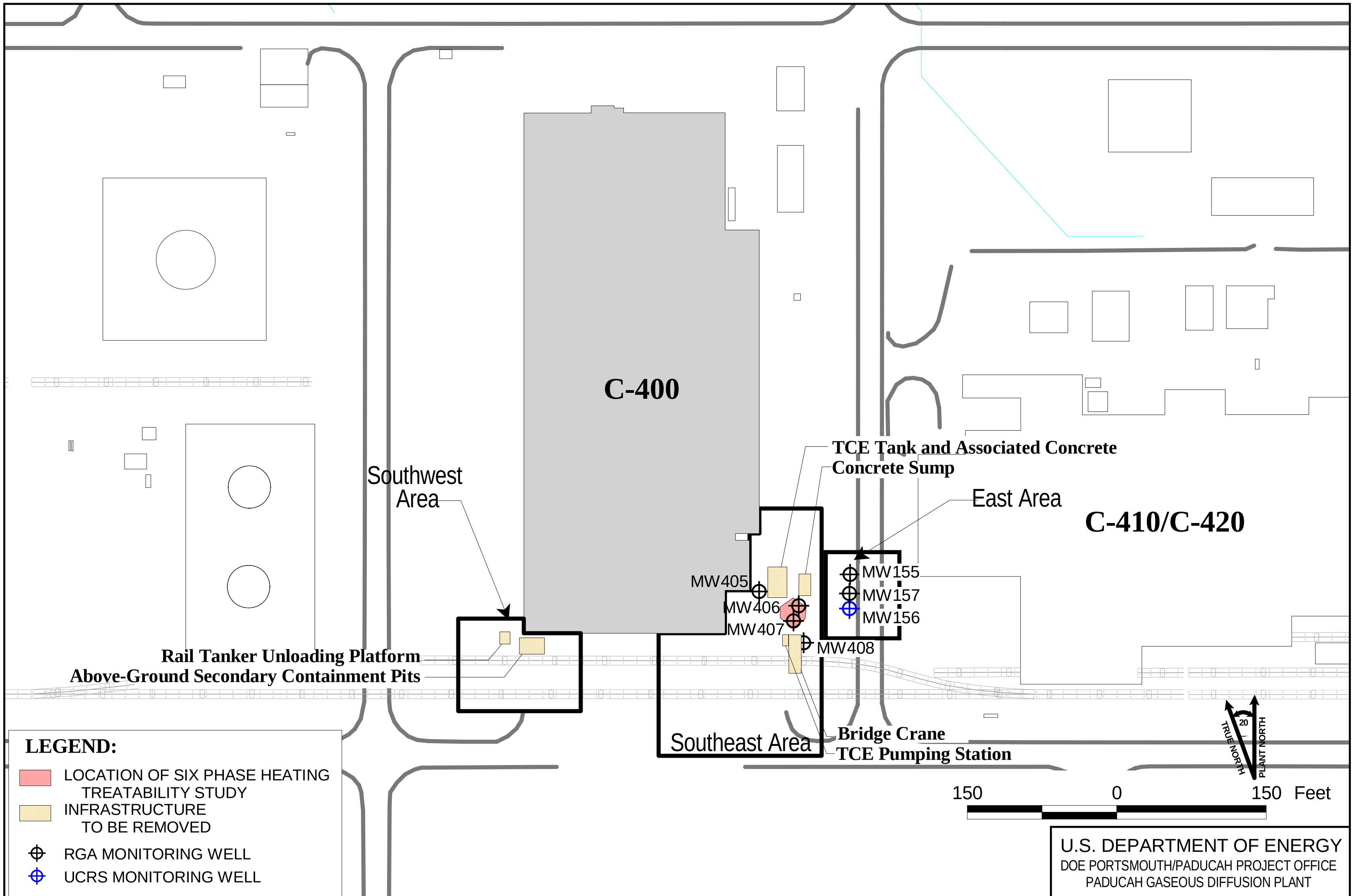

Figure 1. C-400 Area Layout

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SOURCE: DOE 1999. Remedial Investigation Report for Waste Area Grouping 6 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/OR/07-1727/V1&D2, United States Department of Energy, Paducah, KY, May.

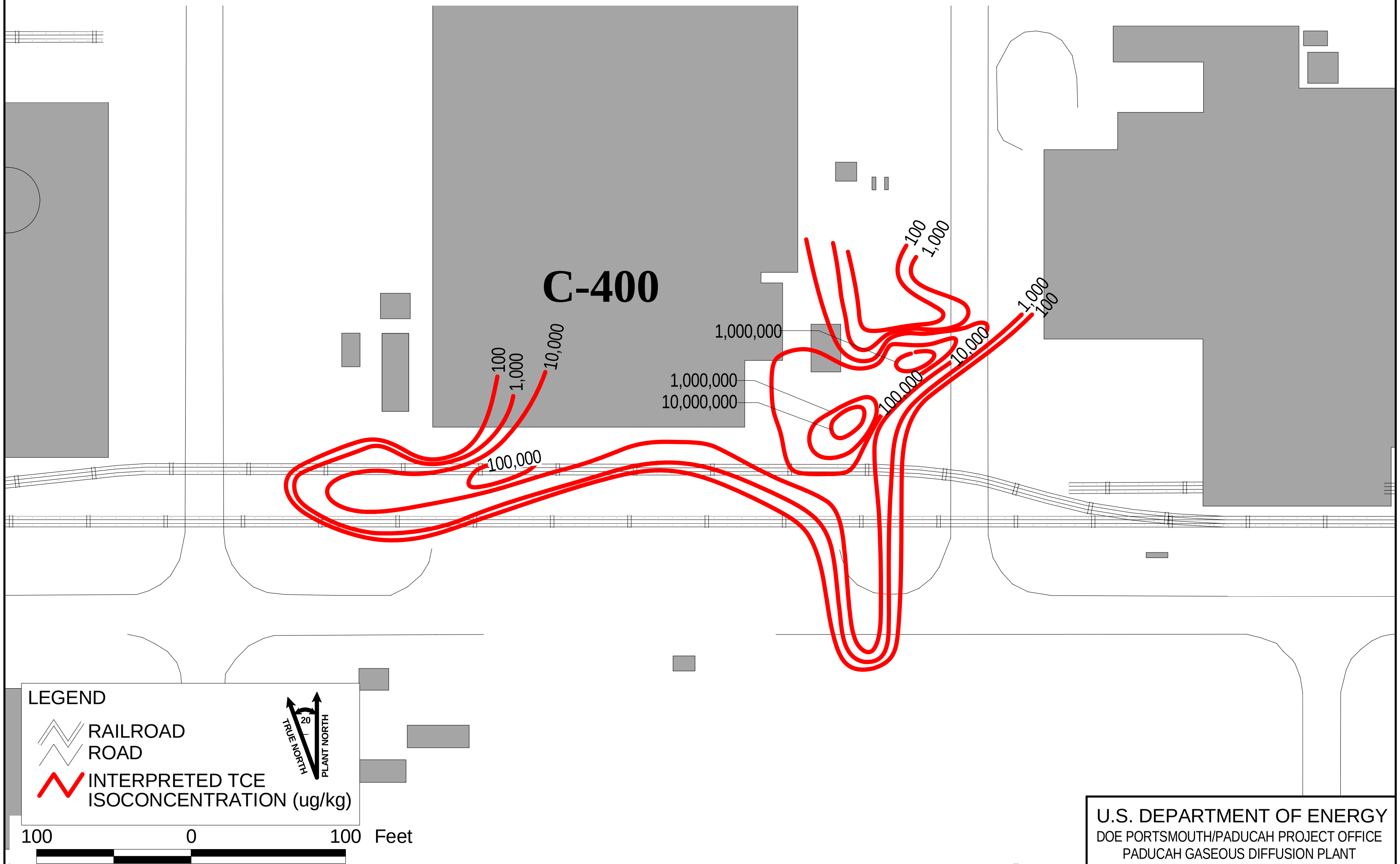

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Figure 3. Contour Map of Maximum TCE Concentration Detected in UCRS Soil

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Continental Deposits, a subunit of the Continental Deposits consisting of discontinuous sand and gravel layers within a sequence of silts and clays, extends to an average depth of 19.8 m (65 ft) bgs. The Lower Continental Deposits, also a subunit of the Continental Deposits, is a highly permeable layer of gravelly sand or chert gravel, typically extending from approximately 19.8 to 28.0 m (65 to 92 ft) bgs. Below the Continental Deposits is the McNairy Formation, a sequence of silts, clays, and fine sands that extends from approximately 28.0 to 106.7 m (92 to 350 ft) bgs. These depths represent general conditions; depths vary at specific locations.

Groundwater flow through the loess and the Upper Continental Deposits is predominately downward into the Lower Continental Deposits. The groundwater flow system in the loess and the Upper Continental Deposits is called the UCRS. Groundwater flow in the Lower Continental Deposits is generally northward toward the Ohio River, although there is variability in groundwater flow as evidenced by the existence of the Northwest, Northeast, and Southwest Plumes. The groundwater flow system in the Lower Continental Deposits is called the RGA and constitutes the uppermost aquifer beneath PGDP and the adjacent area to the north.

The UCRS is subdivided into layers consisting of the loess and the Underlying Upper Continental Deposits. Sand and gravel lenses are separated from the underlying RGA by a 3.7- to 5.5-m (12- to 18-ft)-thick silty or sandy clay in the UCRS. This aquitard reduces the vertical flow of groundwater from the sands and gravels unit to the gravels of the RGA. The RGA consists of a basal sand member of the Upper Continental Deposits and a thick, valley-fill deposit of sand and gravel of the Lower Continental Deposits. Below the RGA is the McNairy Flow System, which corresponds to the McNairy Formation. High contrast of hydraulic conductivity between the conductive Lower Continental Deposits and relatively nonconductive McNairy Formation limits flow between the Lower Continental Deposits and the McNairy. The middle portion of the McNairy Formation (the Levings Member, not shown in Figure 2) generally is considered an aquitard in the McNairy Flow System.

The depth of the shallow water table within the UCRS varies considerably across PGDP. In the C-400 area, ground covers (i.e., asphalt and concrete) and engineered drainage (i.e., storm sewers) limit rainfall infiltration. Many wells in the central and west areas of PGDP, including the C-400 area, define the site's water table trends. In monitoring well (MW)157, which monitors the water table near the southeast corner of C-400, the water table depth averages 9.4 m (31 ft).

The RGA potentiometric surface slopes to the north beneath PGDP. In the area of C-400, the depth of the RGA potentiometric surface is approximately 16.2 m (53 ft) bgs, as documented in the *Final Report Six-Phase Heating Treatability Study at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2004).

1.2 TREATMENT SITE LOCATION

Previous site investigations have identified three groundwater contaminant plumes resulting from past activities at PGDP. All three plumes are characterized by TCE contamination in the RGA. Two of these plumes, the Northwest and the Northeast Plumes, receive considerable contaminant loading from TCE source areas southeast and southwest of the C-400 Cleaning Building. The other groundwater plume, the

Southwest Plume, is located west of the C-400 Building and south of the Northwest Plume. TCE and other VOCs from the C-400 Cleaning Building also contribute to the Southwest Plume. [1]

The Waste Area Grouping (WAG) 6 Remedial Investigation (RI), as well as other investigations and studies, characterized the nature and extent of contamination around the C-400 Building (DOE 1999). Sample analyses from the WAG 6 RI indicate that the primary site-related VOCs in the subsurface soil and groundwater in the C-400 Building area are TCE and its breakdown products (*trans*-1,2-dichloroethene (DCE), *cis*-1,2-DCE, and vinyl chloride) and 1,1-DCE. The WAG 6 RI concluded that there are zones of dense nonaqueous-phase liquid (DNAPL) TCE in the UCRS and RGA adjacent to and potentially beneath the C-400 Building. The *Feasibility Study for the Groundwater Operable Unit at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (GWOU FS), DOE/OR/07-1857&D2, (DOE 2001) presents a summary of the characterization data for the C-400 area DNAPL zones and documents the DNAPL conceptual models for the area.

The data from the WAG 6 RI, as well as other investigations and studies, indicate that DNAPL zones in the southeast area of the C-400 area account for the majority of the mass of DNAPL. High concentrations of TCE in several RGA groundwater wells and the collection of DNAPL from an RGA MW, MW408, [2] shown on Figure 1, demonstrate that DNAPL is located in the UCRS and extends into the RGA. As part of the WAG 6 RI, UCRS soil was characterized and shown to be a residual source of DNAPL. Figure 3 presents a contour map of maximum TCE concentrations detected in UCRS soil near the C-400 Building (taken from the WAG 6 RI report).

Well cluster MW155 (lower RGA), MW156 (upper RGA), and MW157 (UCRS), located near the southeast corner of C-400 (Figure 1), have documented local TCE trends since 1991. Beginning in 1991 and continuing through 1995, dissolved TCE levels in the UCRS (MW157) and upper RGA (MW156) commonly exceeded 400,000 parts per billion (ppb). Meanwhile, TCE levels in the lower RGA (MW155) typically were 2,000 ppb or less. The TCE levels in the upper RGA have declined steadily to less than 10,000 ppb in 2006. Recent TCE trends in the UCRS are undocumented. MW157 (UCRS) last was sampled in 1997. Lower RGA TCE levels began rising in 2002 to greater than 10,000 ppb in 2006. The TCE analyses of MW155 and MW156, in conjunction with TCE analyses from monitoring in other on-site PGDP MWs, establish the directions of the TCE plumes that map the dominant groundwater flow pathways. The primary groundwater flow direction passing through the southeast corner of C-400 is to the northwest (with the Northwest Plume).

1.3 REMEDIAL DESIGN SUPPORT INVESTIGATION

The purpose of the RDSI was to improve the ERH design by determining the subsurface soil conditions and the presence and relative concentration of VOCs in the UCRS, the RGA, and the RGA/Upper

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[1] The evidence for a C-400 source to the Southwest Plume is the presence of dissolved TCE and technetium-99 (^{99}Tc) groundwater contamination in the RGA, upgradient of the C-747 Contaminated Burial Yard. No other potential source is known. The hydraulic gradient at C-400 toward the Southwest Plume is slight. The predominant groundwater flow direction in the area south of C-400 is to the northwest.

[2] MW408 is a multiport well, capable of supporting low-flow sampling, but inadequate to provide any appreciable groundwater or DNAPL recovery. TCE trends in MW408 indicate that pooled DNAPL accumulated within the basal sample interval of MW408 (completed within the McNairy Formation) for a period of four months during the Six-Phase Heating Treatability Study. Subsequent sampling of the basal sampling port in MW408 has recovered TCE levels indicative of residual DNAPL occurrence.

SOURCE: DOE 1999. Remedial Investigation Report for Waste Area Grouping 6 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/OR/07-1727/V1&D2, United States Department of Energy, Paducah, KY, May.

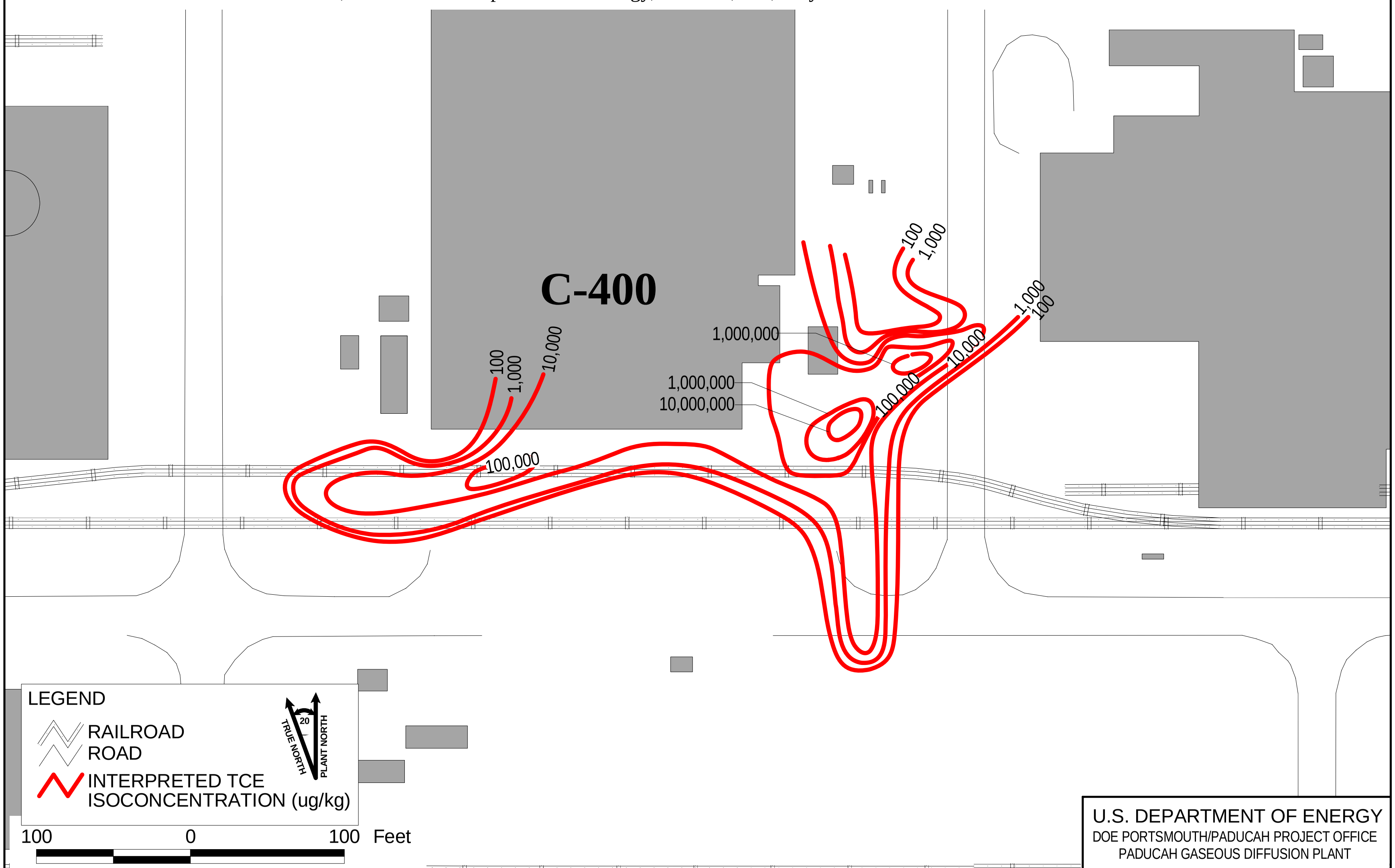

Figure 3. Contour Map of Maximum TCE Concentration Detected in UCRS Soil

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McNairy interface. The RDSI, conducted in accordance with *Remedial Design Support Investigation Characterization Plan for the Interim Remedial Action for the Volatile Organic Compound Contamination at the C-400 Cleaning Building at the Paducah Gaseous Diffusion Plant, Paducah Kentucky,* DOE/OR/07-2211&D2 (DOE 2005b) (RDSI Characterization Plan) was completed in August 2006, using membrane interface probe (MIP) technology. MIP technology readily collects soil conductivity profiles and VOC data from the UCRS, the RGA, and the McNairy with minimal generation of investigation derived waste. Figure 4 shows locations of the MIP borings around the C-400 facility. Soil conductivity logs of each boring were used to determine lithology. When the conductivity indicated that the probe entered the McNairy, the boring was considered complete. In one instance where conventional drilling techniques were utilized instead of direct push technology, gamma ray logging was performed to determine lithologic intervals. Additional detail concerning the MIP data interpretation is provided in the *Remedial Design Report, Certified for Construction Design Drawings and Technical Specifications Package, for the Groundwater Operable Unit for the Volatile Organic Compound Contamination at the C-400 Cleaning Building at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (RDR), DOE/LX/07-0005&D2 (DOE 2008a), which is provided in Appendix A.

Geoprobe direct push soil sample rigs were used to deploy the MIP probes. For the RDSI, the Geoprobe rods were equipped with a shock damper to lessen stress on the MIP probe. Initial attempts with the MIP probe/Geoprobe system met refusal at depths ranging from 20 ft to 40 ft. In attempting innovative methods to accomplish the RDSI, the investigation drillers found that standard Geoprobe rods with a slightly smaller diameter than that of the MIP probe and without the shock damper could be used to "pre" probe the sample locations to the planned depth. Thereafter, the investigation team was able to drive the MIP probe to the planned depths in "pre" probed soil borings at all locations. The MIP characterization data from the "pre" probed borings showed excellent response on all three organic chemical detectors (all three detectors demonstrated significant response to increasing VOC levels within the range of delineation of each detector) and definitive soil conductivity measurements. Intervals of high chemical detector response frequently presented significant detail with variations correlated to changes in lithology as defined by the soil conductivity log (as anticipated in undisturbed soils). The detailed responses, correlated to lithologic intervals, provided assurance that the "pre" probe process was not smearing DNAPL downward within the boreholes.

Damage to MIP tooling (i.e., MIP probe and carrier gas tubing) sometimes occurred during characterization of the RGA due to the extended stress on MIP tooling that was required to penetrate the geology encountered in the RGA. When equipment failures were encountered, advancement of the boring was terminated immediately. The failure then was evaluated to determine if tooling withdrawal was required to correct the problem. Often times, the problem could be corrected without withdrawing the MIP tooling from the boring. This sometimes was accomplished by reversing the airflow through the carrier gas tubing to remove obstructions that may have entered the system. When this approach was unsuccessful or other problems (i.e., heater failure, torn membrane, etc.) existed that couldn't be repaired from ground surface, the tooling had to be withdrawn and repaired. Once repaired, the tooling was advanced back to the depth interval where the problem began. Characterization of the subsurface then was reinitiated at that depth interval. No negative impact to the quality of the MIP data occurred as a result of the withdrawal/repair process. MIP tooling advanced into the subsurface was irretrievable in five separate locations and had to be abandoned in place. Only two of the locations are within proposed treatment areas. If it is determined during installation of the ERH system that these two tooling strings may interfere with operation of the ERH system, attempts will be made to over drill and recover them.

A MIP probe consists of a heating element and permeable membrane. VOCs diffusing through the MIP probe membrane are routed through tubing containing a carrier gas to a service truck at land surface containing organic chemical detectors. Detectors utilized in the RDSI included an electron capture detector (ECD), a flame ionization detector (FID), and a photoionization detector (PID). Each detector's

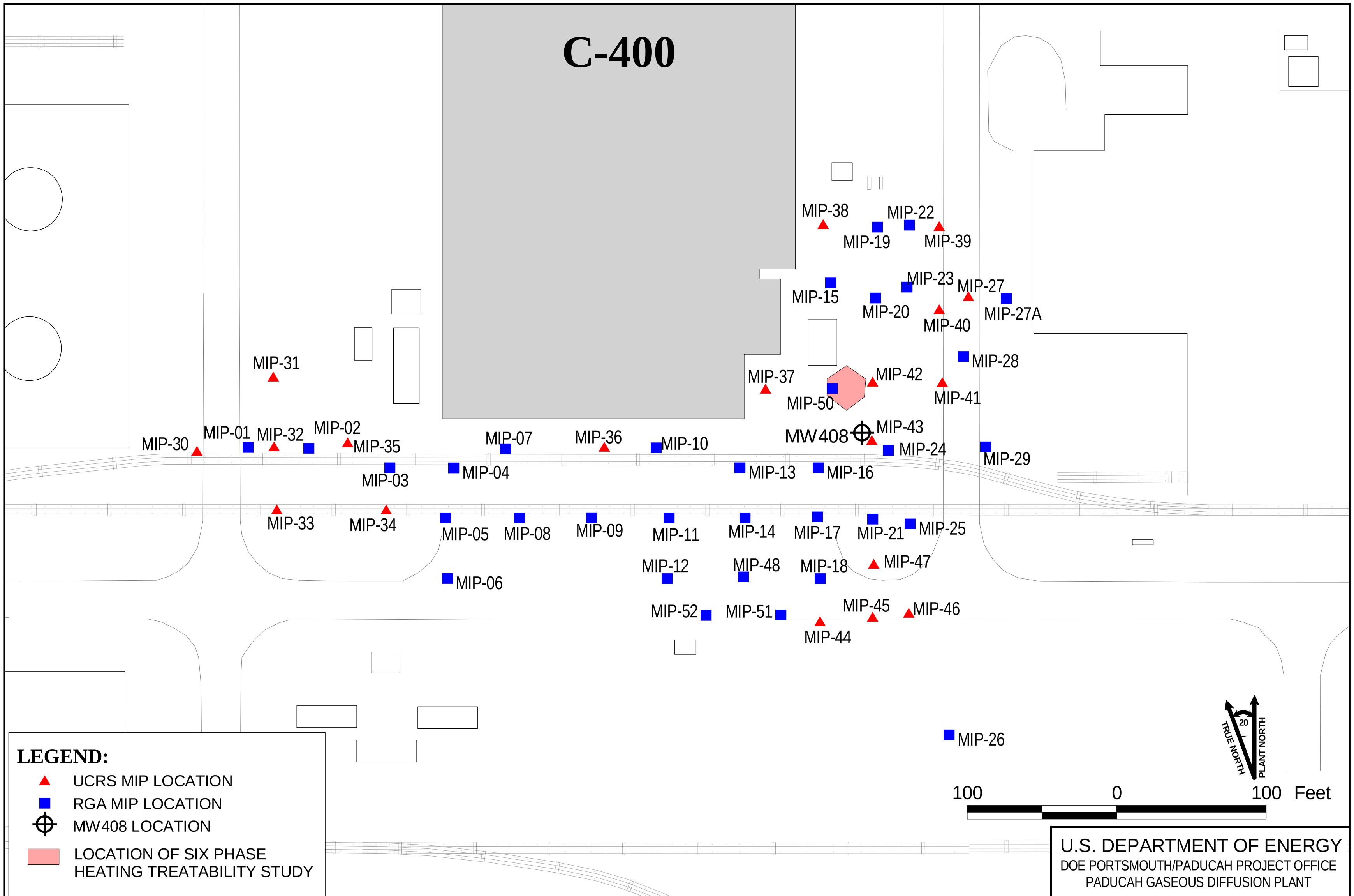

Figure 4. C-400 MIP Locations

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response is reported in microvolts (μV). All three detectors responded to soil contamination by chlorinated solvents (such as TCE) to varying degrees. The ECD is the most sensitive of the detectors to chlorinated solvents, but also was the first detector to become saturated, which made it unable to detect higher levels of contamination. As used in the RDSI, the ECD's effective response ranged up to 1.3×10^7 μV (equivalent to approximately 2.7×10^5 μV on the PID detector in the saturated zone). An FID typically is suited to nonchlorinated organics like methane and butane and generally proved to be the least responsive to soil contamination by chlorinated solvents. The FID response in the saturated zone commonly was approximately one half that of the PID. The PID is commonly used for investigation of soil contamination resulting from gasoline-related spills, but also is sensitive to chlorinated solvents and yielded good characterization of the primary TCE DNAPL zones. Example logs showing conductivity profiles [milliSiemens/meter (mS/m)] and PID response (μV) are shown in Figure 5 for MIP locations MIP-04 and MIP-07. Figure 6 shows how conductivity readings from the MIP logs were used to discriminate lithologic intervals. Note that the contact with the RGA/Upper McNairy interface is clearly distinguishable by the sudden increase in conductivity response at approximately 100 ft.

During the RDSI, 18 MIP borings were completed through the UCRS to a depth of approximately 55 ft (16.7 m) bgs and 33 MIP borings were completed to the base of the RGA at an approximate depth of 100 ft (30.5 m) bgs. This plan optimized the location and depth of the MIP borings to complement the characterization data from the WAG 6 RI. Four of the 33 MIP borings completed to the base of the RGA were contingency borings completed to assess uncertainties within the RGA in accordance with the RDSI Characterization Plan. These contingency borings are shown on Figure 4 as MIP-48, MIP-50, MIP-51, and MIP-52. Contingency boring MIP-50 assessed residual VOC levels in the RGA in the area of the Six-Phase Treatability Study. The other three contingency borings delineated the southern extent of a basal RGA DNAPL pool southeast area of the C-400 facility. In total, the MIP borings characterized 4,200 ft of soil column.

Figure 7 shows the locations for MIP borings in a three-dimensional aspect that displays the vertical extent of the MIP borings. Also shown on Figure 7 is the color coded PID response at each of the MIP borings.

To evaluate MIP data, the maximum PID response values over five ft depths were contoured in intervals of 1×10^6 μV. Review of the PID contour maps for the vadose zone (20 to 25 ft and 25 to 30 ft depth intervals) and comparison of results to the conceptual site model developed using WAG 6 RI data indicate that the contours of 2×10^6 μV (PID) delineate DNAPL occurrence. Similarly, a review of the PID contour maps for the saturated zone (five ft intervals between 30 ft and 100 ft bgs) and comparison of results to the conceptual site model developed using WAG 6 RI data indicate that the contours of 9×10^6 μV (PID) define areas of DNAPL in the saturated zone.

This criterion closely matched the experience of representatives of the MIP subcontractors who reported that areas with TCE contamination characterized as 1×10^7 μV by the PID commonly were DNAPL zones. Figure 8 shows examples of the interpreted DNAPL source zones on MIP logs from the vadose and saturated areas for location MIP-04 compared to readings for MIP-07 in which no DNAPL source zones were identified based on the before-mentioned criteria for DNAPL source zone delineations. Based on the MIP results and interpreted DNAPL source zones, a three-dimensional presentation of DNAPL source zones was defined as shown in Figure 9. Figure 10 shows the three-dimensional DNAPL source zone in relation to the C-400 Cleaning Building. This definitive DNAPL source zone delineation interpreted using data collected during the RDSI, coupled with data from previous investigations, has been assessed to delineate the areas of high TCE concentration more accurately, thereby allowing the design team to optimize placement of ERH electrodes, vapor recovery wells, and other subsurface components.

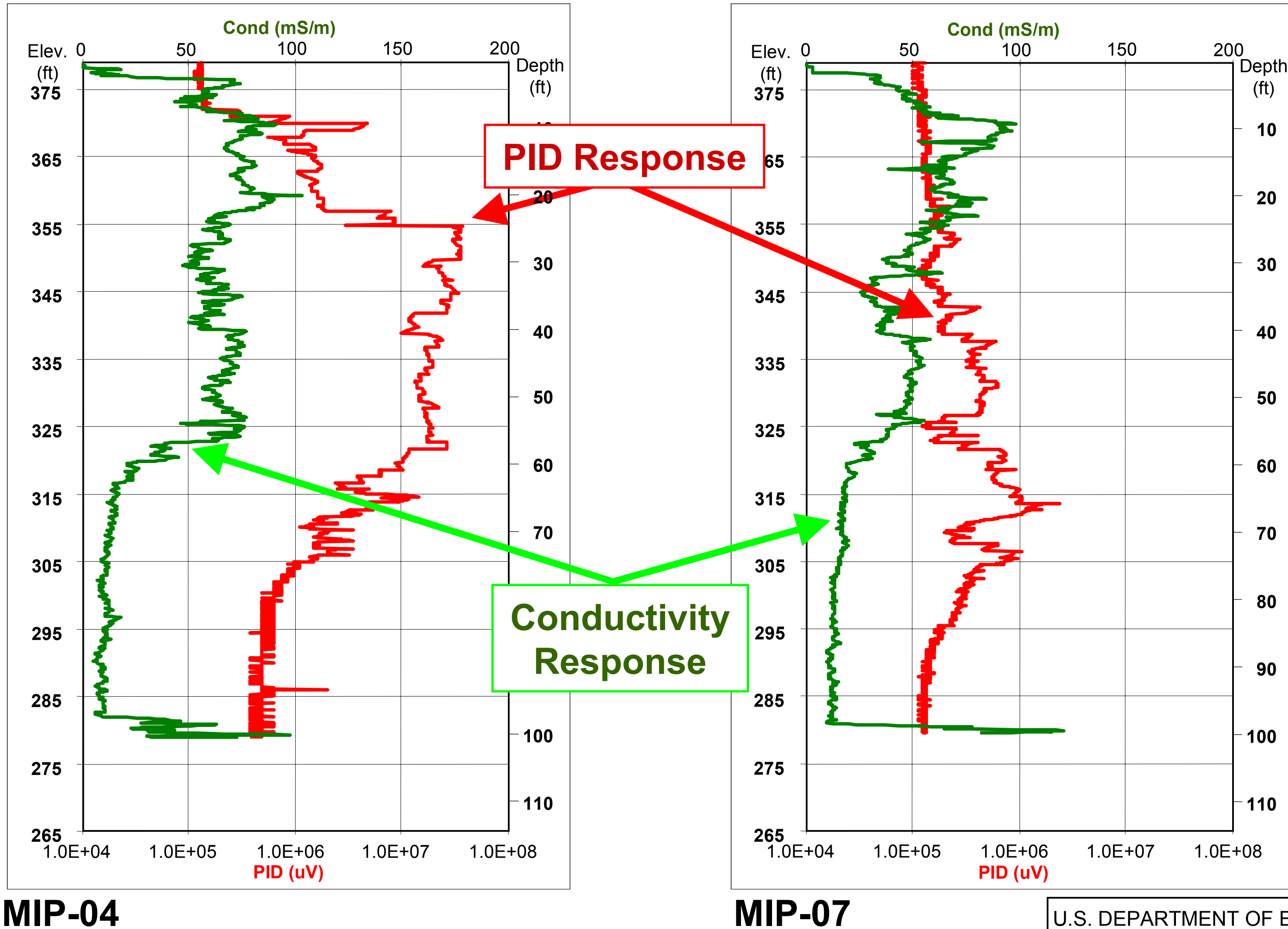

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Figure 5. Example MIP Log Showing PID and Conductivity Responses

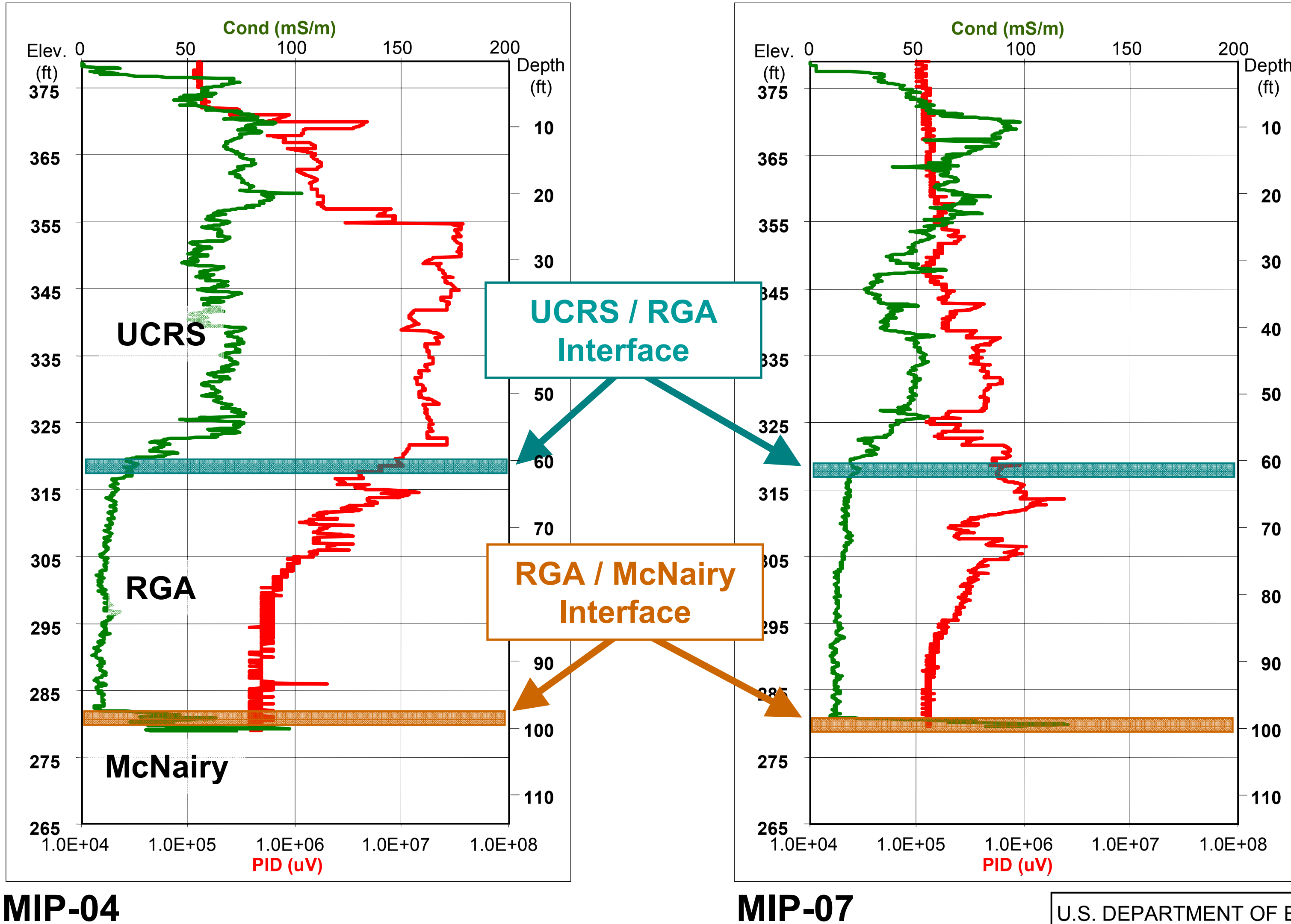

Figure 6. Example MIP Log Showing Formation Interfaces

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PADUCAH Remediation Services
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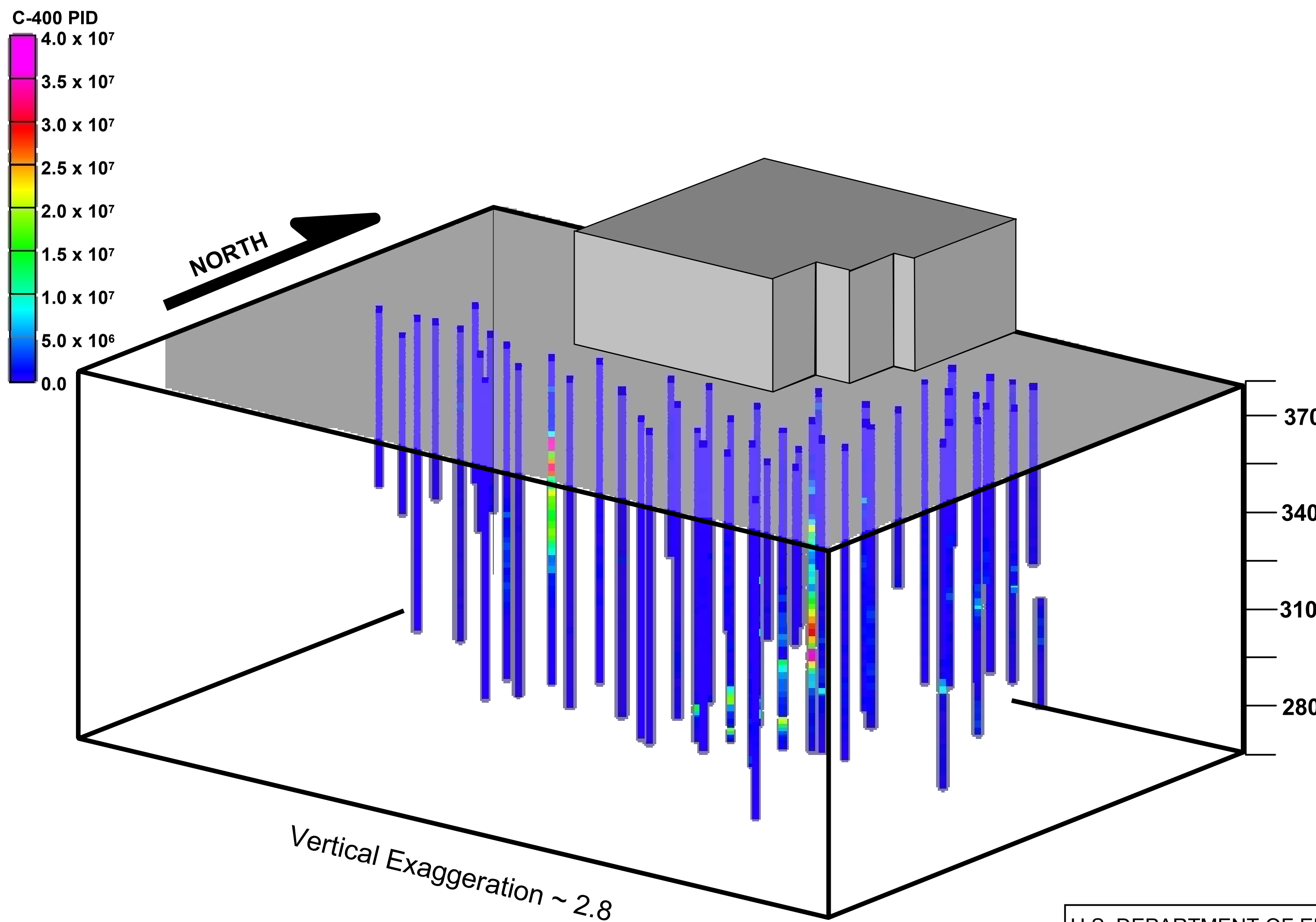

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Figure 7. C-400 MIP PID Response

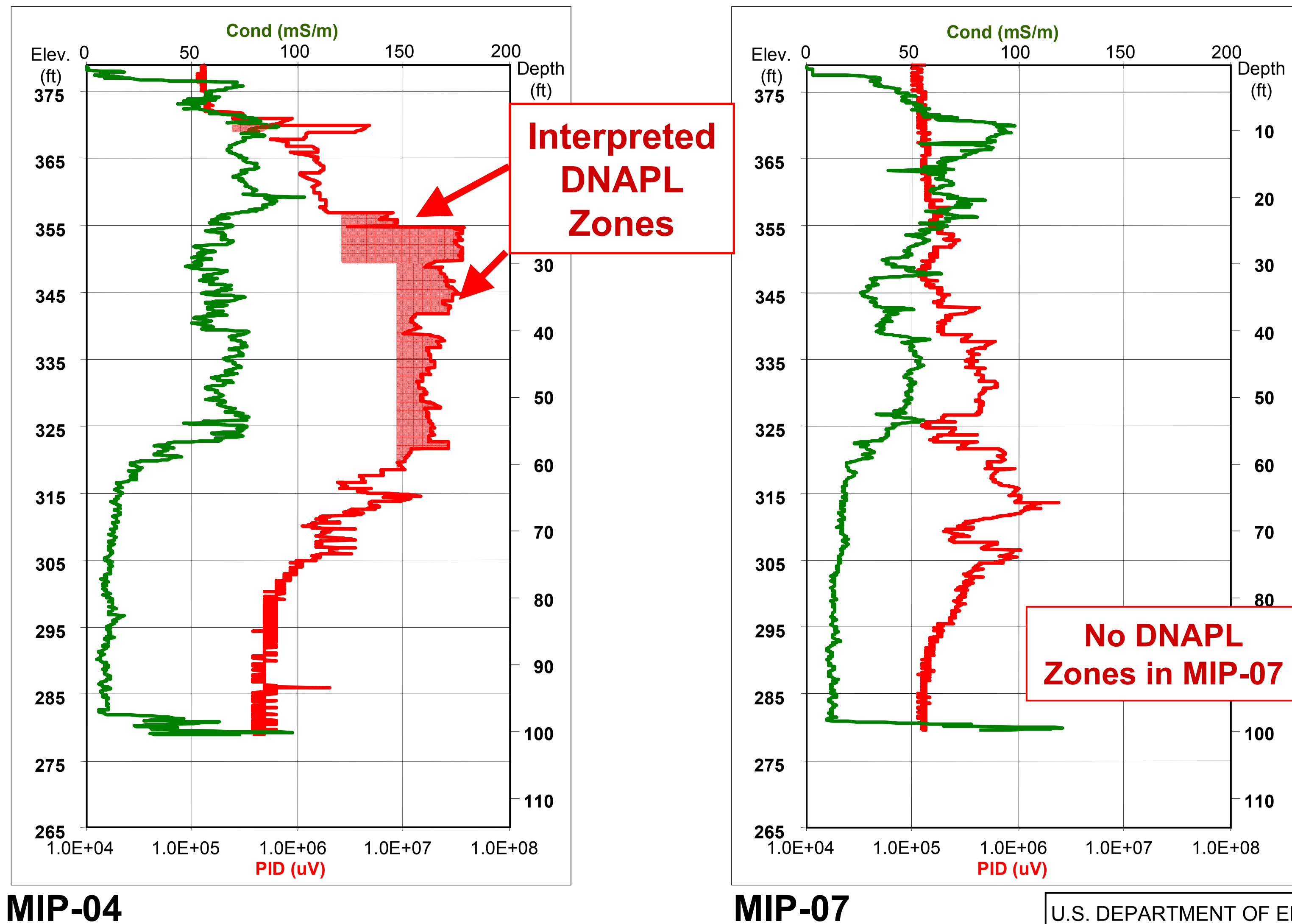

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Figure 8. Example MIP Log Showing Interpreted DNAPL Zones

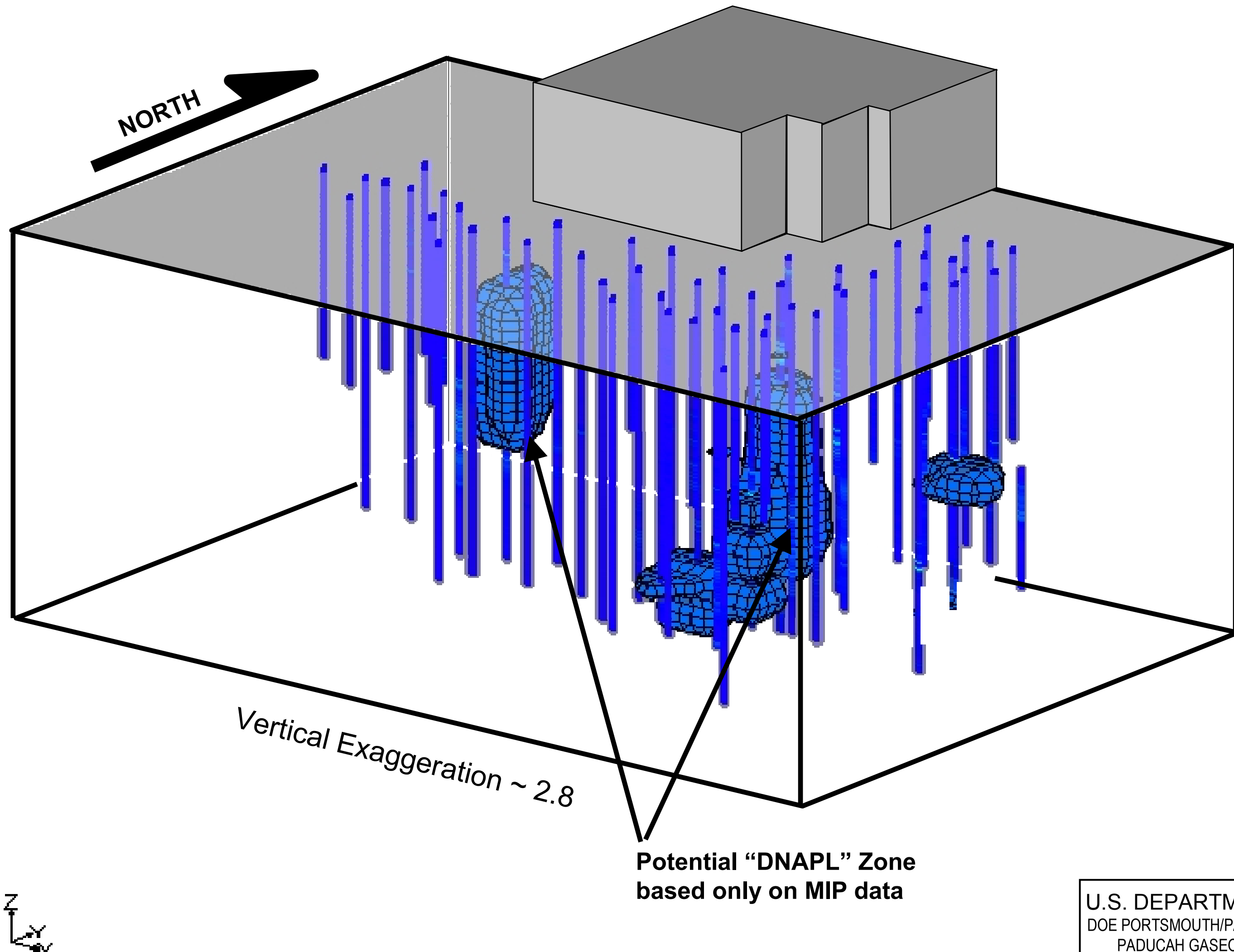

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Figure 9. Potential DNAPL Zone with MIP Borings

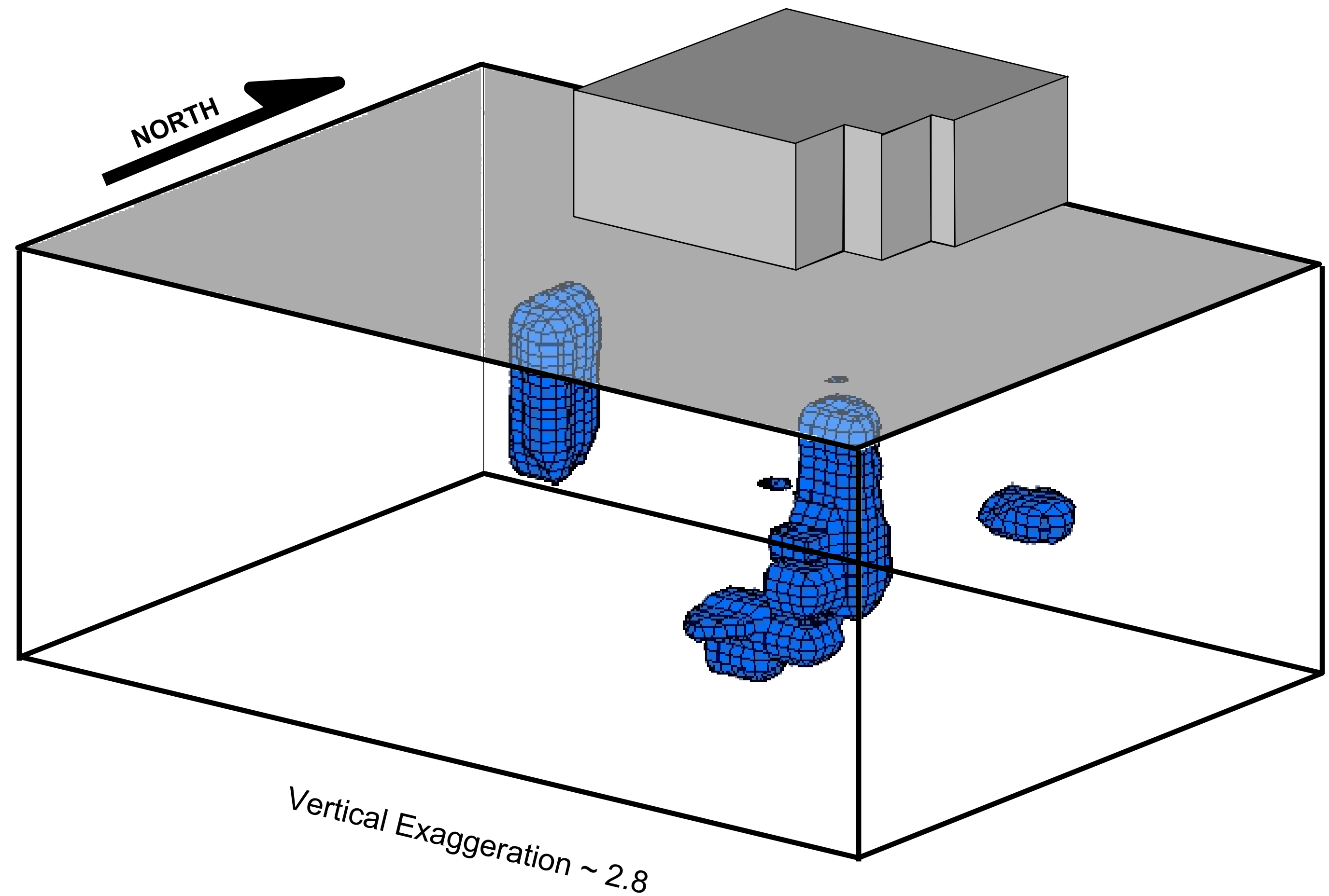

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Figure 10. Potential DNAPL Zone

MIP results from the RDSI were used to delineate the extent of TCE soil contamination. The results are critical to interpreting the distribution of TCE DNAPL and the topography of the base of the Continental Deposits south of the C-400 Building. These data characterize the three-dimensional aspects of the TCE DNAPL source zones and demonstrate that the residual TCE distribution is consistent with the conceptual model from the WAG 6 RI. Moreover, the data show that the vertical extent of the DNAPL does not extend downward appreciably (0 - 1 ft) into the McNairy Formation below the primary RGA DNAPL pool at the base of the RGA.

1.4 CONCEPTUAL SITE MODEL

The WAG 6 RI and GWOU FS established the basis of the conceptual site model for the TCE contamination of the south end of the C-400 Building. Refer to Figure 11 for an illustration of this conceptual model. Results from the WAG 6 RI and GWOU FS were used in the development of the map of the area to be addressed by the ROD (DOE 2005a). This area is defined by the hatched area on Figure 12.

Soil analyses for the WAG 6 RI document that the primary organic compounds in the DNAPL source zones and other areas of contaminated soil are TCE and degradation products of TCE. TCE is the most common soil contaminant in UCRS soil samples and the dominant dissolved contaminant in RGA water samples.

Combined data from the WAG 6 RI and the RDSI identify two main TCE DNAPL source zones and four other areas of TCE soil contamination in the area of the south end of the C-400 facility. In each of the main TCE DNAPL zones, the DNAPL mass migrated downward through the UCRS. An illustration of this process is shown in Figure 11. The larger of the two DNAPL source zones is suspected of being associated with leaking piping of a TCE transfer pump near the southeast corner of C-400 (Sector 4). This DNAPL spill has affected a large area, potentially including the UCRS soils below C-400. A large mass of DNAPL associated with the spill traveled to the southwest in the shallow UCRS soils until encountering a pathway for downward migration in the vicinity of RDSI boring MIP-16. [3] It is suspected that repeated spills from the TCE transfer pump provided enough spill mass that DNAPL penetrated to the base of the RGA and formed a DNAPL pool at the contact of the RGA and underlying McNairy Formation. A depression in the RGA/McNairy Formation contact created a structural trap for the DNAPL pool in the area of RDSI borings MIP-13, MIP-14, MIP-17, and MIP-48.[4] Because the RGA/McNairy Formation contact slopes southward on the south side of the C-400 Building, pooled DNAPL at the base of the RGA, from spills associated with the TCE transfer pump, should not have migrated under the C-400 Building.

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[3] Groundwater flow is known to be near vertical in response to the large downward hydraulic gradient that is common at PGDP. Conversely, the TCE DNAPL is not a “wetting” fluid in the soil-groundwater-DNAPL system and cannot readily penetrate downward in soils with small interstitial spaces. Although DNAPL moves in response to gravity, vertical flow is strongly influenced by the size and connection of soil porosity. The DNAPL moved laterally in a horizon of DNAPL-permeable soil until it encountered a deeper zone of increased permeability that allowed vertical migration.

[4] Figure 7 of Appendix A in the RDR presents a structure contour map of the base of the Continental Deposits (base of the RGA).

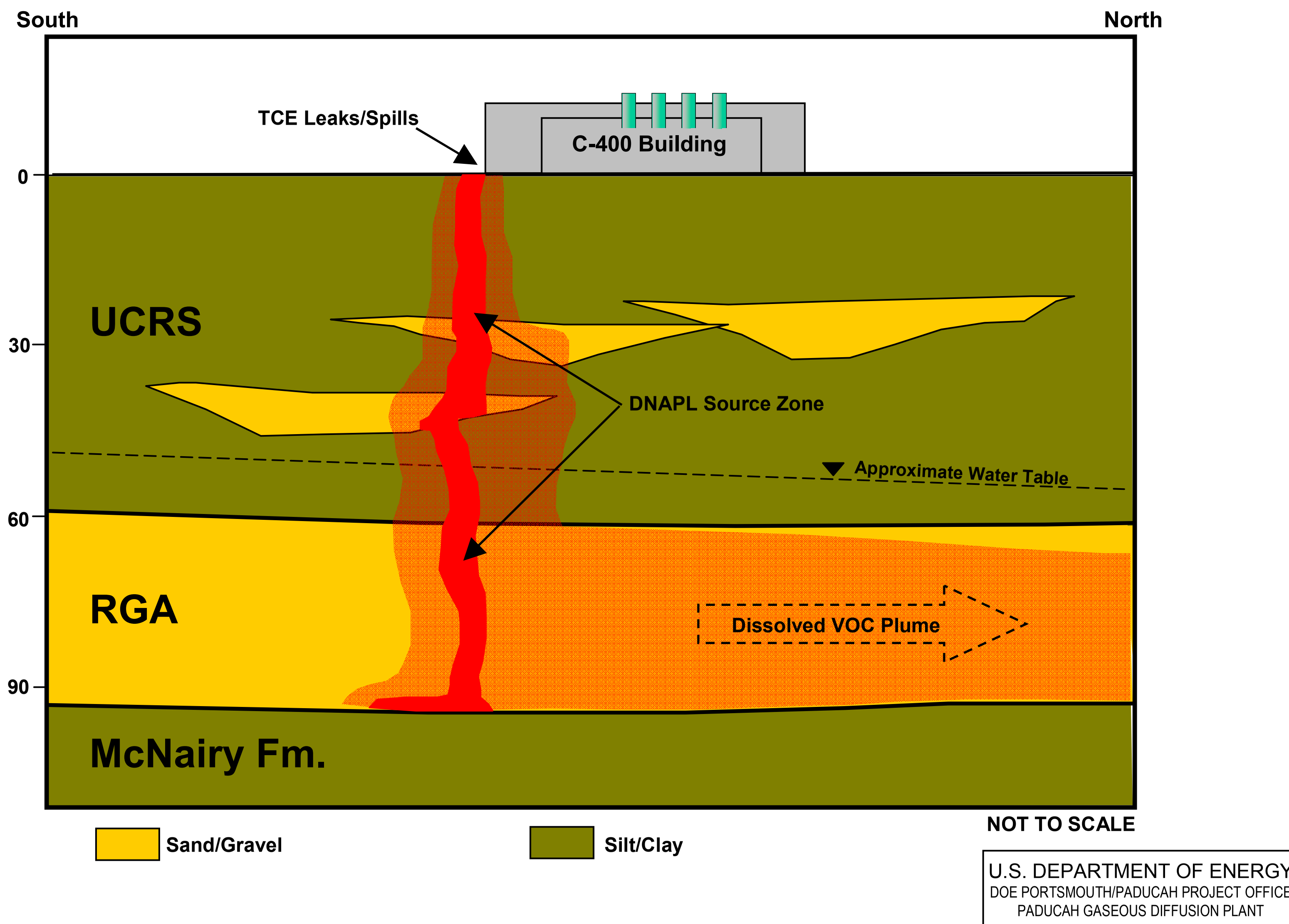


Figure 11. C-400 Conceptual Site Model

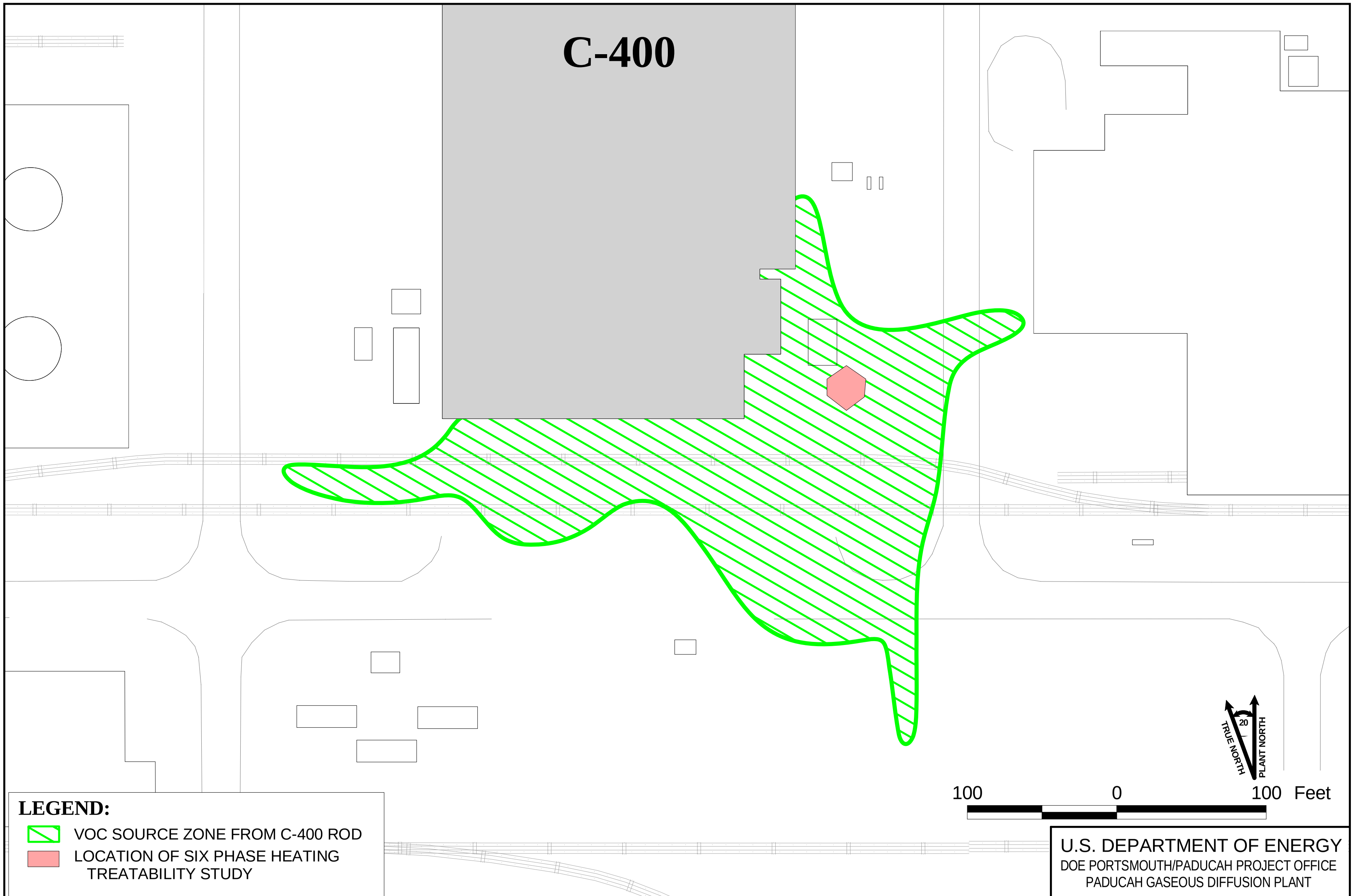


Figure 12. Contaminant Source Zones from the C-400 ROD

Figure No. c5ac90005sk012R7.apr
DATE 11-20-07

The other DNAPL source zone is suspected of being associated with a storm sewer system that serves the west side of C-400 in the southwest area. WAG 6 RI soil analyses and RDSI soil boring logs indicate that DNAPL migrated through the bedding material of the storm sewer that serves the west side of C-400 and penetrated underlying soils in the area of boring MIP-04. The DNAPL zone extends through the UCRS. It appears as though this TCE spill had insufficient mass for the DNAPL to penetrate the RGA. Analyses completed since issuance of the 60% RDR have established that the shallow soils adjacent to the storm sewer system leading away from the west side of the C-400 Building do not contain a significant DNAPL mass (Appendix B). The shallow soils adjacent to the west side storm sewer, therefore, no longer are included in the remedial design.

Additional areas of TCE-contaminated soil include an East Treatment Area containing the Solid Waste Management Unit (SWMU) 11 TCE Leak Site, 400-016 Area (WAG 6), 400-163 Area (WAG 6), and TCE Tank Area. SWMU 11 is the location of a former breach in a storm sewer on the east side of C-400. Effluent from a sump in the vicinity of a large TCE degreaser in the C-400 Building inadvertently was piped to the storm sewer, possibly beginning in the early 1950s. Repeated releases created a DNAPL pool in the storm sewer backfill beneath the breach in the storm sewer. This DNAPL was able to penetrate only the soils immediately adjacent to the storm sewer. Site construction uncovered the TCE leak in 1986. A subsequent removal action excavated approximately 9,200 ft^3 of TCE-contaminated soil and bedding material. The main excavation area measured approximately 20 ft wide (east to west) by 40 ft long (north to south). A 10-ft wide trench, centered on the storm sewer, was dug 16 ft deep to expose the pipe, which lay 13 ft below original grade. The remainder of the excavation was 7 ft deep. Concern for the stability of nearby structures (11^{th} Street and a TCE tank pad) limited the extent and depth of the excavation. PGDP backfilled the excavated area with clean fill material and capped the area with a layer of clay after excavation activities were completed. The fill material and clay cap approximate the textures of the area shallow soils.

The SWMU 11 removal action recovered a significant portion of the DNAPL. Forty 55-gallon drums were used to containerize excavated contaminated soil. TCE concentrations were as high as 700,000 µg/kg in soil samples collected adjacent to and below the storm sewer line. Note that this contamination level is reported as representative of both the excavated soil adjacent to the storm sewer and the soils remaining below the storm sewer after the excavation. Some contaminated soil is known to have been left in place. MIP results document the presence of a discrete DNAPL zone at the base of the UCRS that is associated with SWMU 11 (to be addressed by the East Treatment area). Figure 13 shows the location of the source zones discussed herein, which were delineated based on results from the RDSI and WAG 6 RI.

1.5 DNAPL MASS ESTIMATE

The MIP profiles are a qualitative measure of VOCs that are not directly correlated to TCE levels, but provide a basis for the site-specific conceptual model of DNAPL occurrence and the definition of extent of the DNAPL source zones. The RDR presents the measurements and assumptions that have been applied to the conceptual models to estimate the DNAPL volumes that are present in the ERH area. Table 1 summarizes the estimated DNAPL volumes. The actual DNAPL volume encountered during the remedy implementation may differ from these estimates. Further detail concerning the DNAPL mass estimate is provided in Appendix A of the RDR.

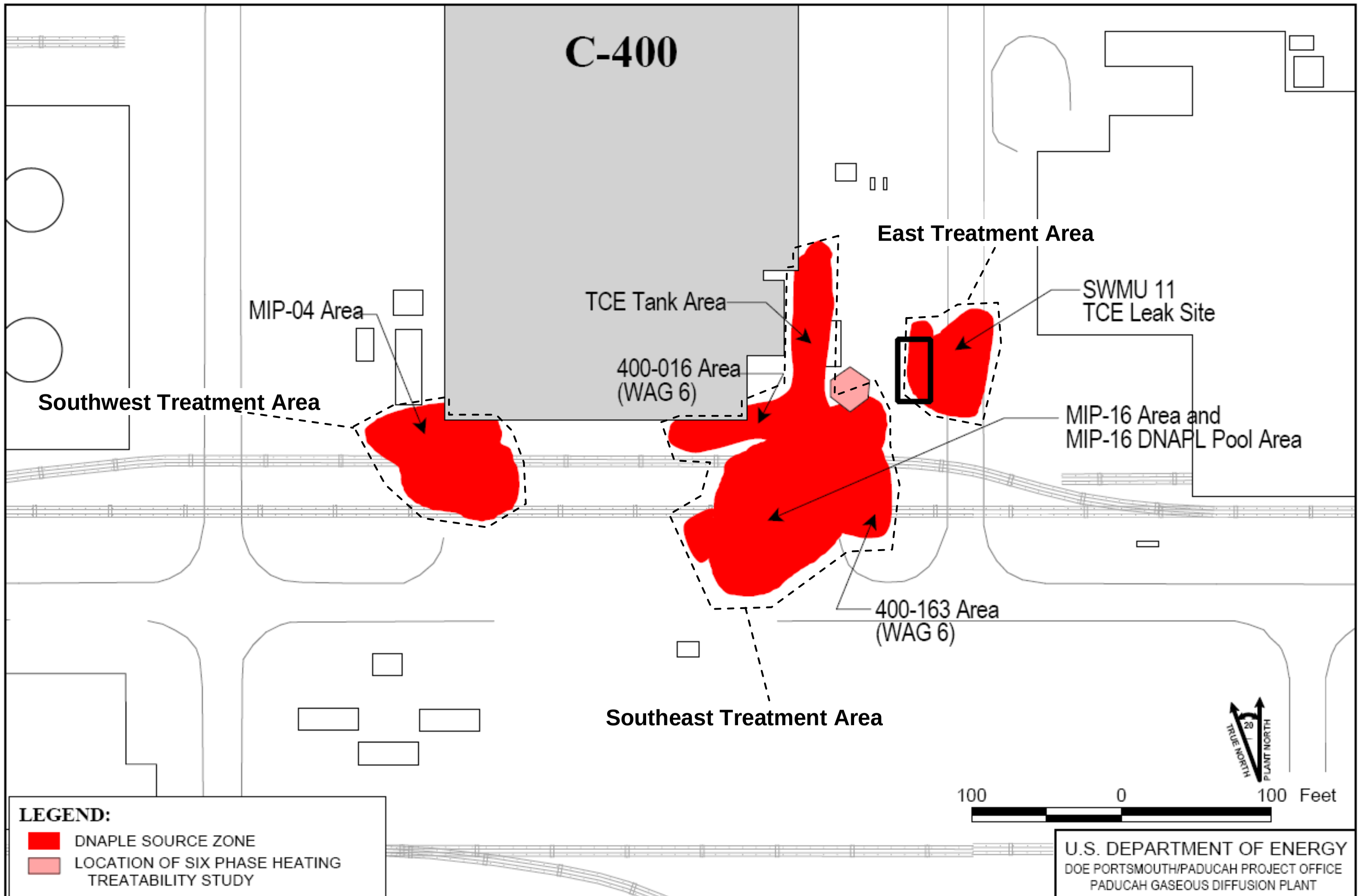


Figure 13. DNAPL Source Zone Delineations from RDSI and WAG 6 Results

Figure No. c5ac90005sk012R8.apr
DATE 11-28-07

Table 1. Summary of Estimated DNAPL Volumes

DNAPL Area	General Location	Maximum Area (ft^2)	Depth (ft bgs)	Estimated DNAPL Volume (gals)
MIP-04 Area	Northwest RDSI area	6,000	20 – 70	23,100
MIP-16 Area	East–central RDSI area	5,300	20 – 80	29,681
MIP-16 DNAPL Pool Area	East–central RDSI area	4,800	84 - 97	22,049
SWMU 11 TCE Leak Site	East RDSI area	775	28 – 32	250
TCE Tank Area	East side C-400	1,700	20 – 60	49
400-016 Area	South side C-400	2,000	16 – 34	1
400-163 Area	Southeast RDSI area	1,400	8 - 48	22

Additional detail concerning the DNAPL mass estimate is provided in the RDR.

2. TREATMENT TECHNOLOGY

2.1 ELECTRICAL RESISTANCE HEATING DESCRIPTION

The C-400 IRA includes the installation and operation of a three-phase ERH system to heat the subsurface, volatilize VOCs, and remove them by way of a vapor recovery system. The three-phase ERH system consists primarily of a network of inground electrodes, vapor extraction wells, and vacuum monitoring piezometers distributed throughout the zone of contamination shown in Figure 13. These vapors are collected by a vapor recovery system. In the process of VOC volatilization, steam also will be generated, which will facilitate the stripping of VOCs (primarily TCE and its breakdown products) from the treatment area. Three-phase heating is the preferred electrical phasing method for a large and noncircular remediation area such as that defined for the C-400 IRA. Electrical power for the electrodes will be supplied to the ERH system by an existing electrical feeder, 23B5B from the PGDP C-531-1 electrical switchyard.

The treatment system installation and operations will include the following activities:

- Installation of electrodes, vapor/liquid extraction wells, vacuum monitoring piezometers, thermocouple arrays, and pressure sensors in the TCE source zone at the C-400 Cleaning Building area;

- Heating of subsurface soil, contaminants, and groundwater via application of electrical current to the UCRS and RGA soils;

- Withdrawal of volatilized VOCs (primarily TCE and its breakdown products) by high vacuum extraction;

- Extraction of a nominal quantity of groundwater to assist in controlling local gradients and groundwater migration;

- Treatment of contaminated groundwater/vapor through the use of an aboveground treatment system;

- Reinjection of treated groundwater at subsurface electrodes to maintain electrical conductivity and facilitate heat transfer;

- Monitoring of contaminants in recovered groundwater and vapor;

- Discharge of treated groundwater/condensate through Kentucky Pollutant Discharge Elimination System (KPDES) Outfall 001;

- Discharge of treated vapors to the atmosphere and real-time monitoring of treated vapors;

- Waste characterization for on-site and off-site disposal; and

- Recovery of free-phase DNAPL as it is removed from the subsurface via pumps installed in sumps in extraction wells at the RGA/McNairy interface.

2.2 APPLICABILITY TO THE PGDP SITE

A treatability study of six-phase ERH was conducted in 2003 at the C-400 Cleaning Building to demonstrate the implementability of ERH technology in the unsaturated and saturated soils of the UCRS and in the underlying RGA. According to the results documented in the *Final Report Six-Phase Heating Treatability Study at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2004), the ERH implementation exceeded the criteria for success outlined in *Six-Phase Heating Technology Assessment* (GEO 2003). The criteria for success were defined as greater than 75% reduction of TCE soil concentrations in the UCRS and a reduction of TCE groundwater concentrations to less than 1% (11,000 ppb) solubility in the RGA. The ERH in the treatability study reported a 98% reduction in TCE soil concentration in the UCRS, on average, and reduced TCE groundwater concentration to less than 1% of solubility in the RGA. The C-400 ROD documented ERH as the selected remedy for the C-400 IRA.

ERH can be implemented in either a six-phase or three-phase heating approach. In both cases, the subsurface is heated as a result of the resistance of the soil to the flow of an applied electrical current. Three-phase heating is the preferred electrical phasing method for large and noncircular remediation areas, while six-phase heating is optimal for treatment of a single circular area. For almost any other application area or shape, six-phase heating suffers from inherent flaws due to uneven heating among arrays (TRS 2007). Three-phase heating was selected for the C-400 IRA because of the large size and irregular shape of the delineated DNAPL source zones targeted for heating using ERH.

2.3 PHASED DEPLOYMENT

A phased deployment of ERH will be implemented. The first phase (Phase I) will implement the design presented in the RDR, referred to as the base design, in the southwest and east treatment areas. In addition to removing VOCs from these areas, another important objective of Phase I will be to evaluate the heating performance of the base design through the RGA down to the McNairy Formation interface in the southwest treatment area. Treatment in the east treatment area involves only the UCRS. Lessons learned from Phase I will be evaluated and appropriate contingency actions will be self-implemented, without revision to the RDR, prior to start up of the second phase (Phase II) near the southeast corner of the C-400 Cleaning Building. In addition to evaluating heating performance in the RGA, operation of Phase I also will provide the opportunity to evaluate the radius of influence of the vapor recovery system, assess hydraulic containment, and optimize the aboveground vapor/liquid treatment system.

This report provides a contingency matrix (Section 3.3) that describes potential contingency actions to be implemented in response to lessons learned during Phase I. These contingency actions describe the changes to the base design, installation, and operation that will be implemented in response to lessons learned during Phase I.

3. TREATMENT SYSTEM OBJECTIVES AND UNCERTAINTY MANAGEMENT

3.1 INTERIM REMEDIAL ACTION OBJECTIVES

The IRA objectives for the C-400 Cleaning Building, as defined by Section 2.8 of the ROD, are as follows:

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

- Reduce VOC contamination (primarily TCE and it breakdown products) in UCRS soil at the C-400 Cleaning Building area to minimize the migration of these contaminants to RGA groundwater and to off-site points of exposure (POEs); and

- Reduce the extent and mass of the VOC source (primarily TCE and its breakdown products) in the RGA in the C-400 Cleaning Building area to reduce the migration of the VOC contamination to off-site POEs.

The RDR (DOE 2008a) presents the design of the treatment systems that address the IRA objectives.

3.2 CRITERIA FOR CEASING IRA SYSTEM OPERATIONS

The remediation goal for this interim action as stated in Section 2.9.3 of the ROD (DOE 2005a) is to operate the ERH system "until monitoring indicates that heating has stabilized in the subsurface and that recovery of TCE, as measured in the recovered vapor, diminishes to a point at which further recovery is at a constant rate (i.e., recovery is asymptotic). At asymptosis, continued heating would not be expected to result in any further significant reduction of toxicity, mobility, or volume of the zone of contamination." In addition to the vapor concentration, extracted groundwater TCE concentrations will be evaluated as an indicator of when the point of diminishing returns is being approached in TCE mass recovery. Section 3.3 of the RDR defines asymptotic recovery in more detail and provides additional detail regarding criteria for ceasing ERH operations, including temperature stabilization requirements.

3.3 UNCERTAINTY MANAGEMENT

Several uncertainties need to be managed during the implementation of the C-400 IRA. Phased deployment will be the primary means used to manage those uncertainties. In addition to evaluating heating performance in the RGA, operation of Phase I also will provide the opportunity to evaluate the radius of influence of the vapor recovery system, assess hydraulic containment, and optimize the aboveground vapor/liquid treatment system. Potential lessons learned during Phase I and contingency actions that may be implemented prior to Phase II are shown in Table 2. Table 3 shows an uncertainty matrix detailing responses to potential deviations in expected conditions for the C-400 IRA.

Table 2. Potential Phase I Lessons Learned and Possible Contingency Actions

Deviation	Cause of Deviation	Possible Contingency Actions to be Taken Prior to Phase II
Temperature levels not achieved	Higher than anticipated groundwater flow through treatment zone	• Control groundwater flux through heated area with hydraulic control measures such as upgradient pumping. • Install a bank of electrodes upgradient of the treatment zone to preheat groundwater. • Install electrodes on a closer spacing. • Install electrodes into the McNairy Formation. • Reevaluate design of groundwater extraction system.
	Higher than anticipated soil resistivity	• Inject electrolytic solution into the electrodes to increase soil conductivity. • Install electrodes on a closer spacing. • Increase diameter of electrode boring to allow more graphite/high conductivity material to be placed in the boring around an electrode. • Install graphite/high conductivity material around electrodes that are below the water table. • Size electrode wires for higher power levels at each electrode. • Operate electrodes at higher voltages, up to 347 volts, phase to neutral.
	Maintaining hydraulic and pneumatic control resulted in excessive extraction of energy	• Reevaluate whether pneumatic control can be maintained at a lower vapor extraction rate. • Reevaluate whether hydraulic control can be maintained at a lower groundwater extraction rate. • Determine if higher power input to the electrodes is required.
Ineffective capture of contaminants	Groundwater extraction wells/pumps not effective at capturing contaminants	• Install more extraction wells or more closely spaced extraction wells. • Redesign extraction wells (groundwater portion) for improved radius of capture. • Increase capacity of extraction pumps. • Redesign pumps to withstand higher temperatures or more aggressive chemical environment.
	Vapor extraction wells not effective at capturing contaminants	• Install more extraction wells or more closely spaced extraction wells. • Redesign extraction wells (vapor extraction portion) for improved vapor capture. • Heat a larger vertical area (e.g., heat the entire zone from bottom of RGA to 18 ft bgs) in areas where only a portion of the vertical profile is heated. • Increase capacity (e.g., vacuum, flow rate) of vacuum extraction pump(s). • Reevaluate operation/design of vapor extraction wells above electrodes.
	Treatment system not able to adequately handle contaminant levels	• Increase capacity of treatment system. • Redesign treatment system.

Table 2. Potential Phase I Lessons Learned and Possible Contingency Actions (Continued)

Deviation	Cause of Deviation	Contingency Action to be Taken for Phase II
Hydraulic control not maintained	Groundwater flow higher than estimated	• Increase groundwater extraction capability (more wells, larger pumps, increased treatment capacity, more efficient well design). • Reduce gradient across heated zone through downgradient or perimeter injection.
	Pumps not effective at extracting groundwater at high temperatures	• Redesign/reevaluate extraction pumps and other extraction equipment • Redesign groundwater extraction wells.
	Groundwater extraction well design prevents adequate or effective extraction	• Redesign groundwater extraction wells.
Pneumatic control not maintained	Vapor extraction wells not effective at capturing contaminants	• Increase vapor extraction capability (more wells, larger vacuum pumps, increased treatment capacity, more efficient well design).
	Preferential flow from some areas resulted in minimal extraction from other areas	• Redesign controls on vapor extraction wells to allow more viable extraction rates or adjustments.

Table 3. Uncertainty Matrix for the C-400 IRA

Expected Condition	Potential Deviation	Impact of Deviation	Contingency	Monitoring
Recoverable VOC source is appropriately estimated based on results of the RDSI and WAG 6 RI results.	VOC mass significantly over estimated.	Vapor treatment system over sized during design.	Design and install the vapor/liquid treatment system with the flexibility to allow for removal of components from service if not needed.	Routine monitoring of subsurface temperatures and TCE levels in recovered vapors and groundwater in accordance with the criteria for ceasing operations documented in the RDR.
		Operational period may be less than the 180 to 240 days estimated.	Respond in accordance with the criteria for ceasing operations documented in the RDR.	Monitor in accordance with the criteria for ceasing operations documented in the RDR.
	VOC mass significantly under estimated.	Above-ground treatment system under sized during design such that it is not able to treat the VOC loading on recovered vapor and groundwater.	Alter heating and vapor/liquid extraction operations to reduce the VOC loading on the treatment system.	Routine operational monitoring of the treatment system influent and effluent vapor and groundwater VOC concentrations.
		Operational period may be longer than the 180 to 240 days estimated.	Respond in accordance with the criteria for ceasing operations documented in the RDR.	Monitor in accordance with the criteria for ceasing documented in the RDR.
VOC target volume is well constrained	VOC source material exists beyond the design volume (outside perimeter and below design electrode depth).	VOC source material left in place after system shutdown.	Conduct real-time analyses during installation to evaluate treatment volume boundaries. Expand treatment volume if warranted.	Real-time analyses using PID and TCE DNAPL test dye.
Underground hazards and obstructions have been identified.	Additional underground obstacles encountered during installation of subsurface ERH components.	May require changes to proposed locations of subsurface components such as electrodes, extraction wells, temperature and pressure monitoring sensors. According to the RDR, electrodes can be relocated up to 3 ft in any direction without affecting expected heating conditions. Other subsurface components can be moved as necessary.	Field changes to subsurface component locations will be made in consultation with subject matter experts from the ERH vendor to ensure that heating, extraction, and monitoring functions are not negatively impacted.	N/A

Table 3. Uncertainty Matrix for the C-400 IRA (Continued)

Expected Condition	Potential Deviation	Impact of Deviation	Contingency	Monitoring
Required temperatures are achieved in the subsurface during the estimated operations period.	Subsurface temperatures do not reach design levels within the expected operations period due to unforeseen subsurface conditions.	VOCs may not be adequately volatilized in the affected zones.	Direct additional energy to electrodes in the affected zones and respond in accordance with the criteria for ceasing operations documented in the RDR.	Monitor in accordance with the criteria for ceasing operations.
	Subsurface temperatures do not reach design levels within the expected operations period due to electrode failure.	Uniform heating not achieved and VOCs not adequately volatilized.	Corrective maintenance to attempt to restore operations of failed electrodes, increase power to adjacent electrodes to compensate for failed electrodes.	Routine monitoring of subsurface temperatures and power consumption at electrodes.
Vapor recovery wells provide adequate area of influence for subsurface vapor recovery	Vapor recovery well area of influence is not adequate	Volatilized VOCs not adequately recovered from the subsurface	Connect piezometers and contingency wells to the vapor recovery process	Routine monitoring of subsurface pressure via a network of piezometers
Minimal to no migration of volatilized VOCs out of the treatment zone.	Hydraulic and pneumatic control is not maintained within the treatment area.	Increase in TCE concentrations in the dissolved phase plume beyond the boundaries of the treatment zone or VOCs recondensing outside of treatment zone.	Extraction wells with submersible groundwater pumps will be installed for use in initiating and maintaining hydraulic control. Groundwater extraction and injection rates will be monitored to ensure more water is extracted than is put back into the formation. Operators will make adjustments to vapor and groundwater extraction rates as needed.	Water withdrawal and addition rates will be monitored as will vapor pressure at vacuum monitoring piezometers as well as extraction wells across the treatment area.

Table 3. Uncertainty Matrix for the C-400 IRA (Continued)

Expected Condition	Potential Deviation	Impact of Deviation	Contingency	Monitoring
When the ROD criteria of heating in the subsurface and asymptosis in the offgas are met, the TCE removal rate will be low.	When the ROD criteria are met, the mass removal rate is still significant relative to the contaminant in the groundwater plume and the contaminant being treated by groundwater treatment systems.	If all parts of the system, heating and vapor extraction, are shutdown, the potential for additional cost-effective gains in the contaminant removal objective may be missed.	Evaluate the feasibility of continued heating and/or vapor extraction until mass removal in the vadose zone and groundwater no longer are cost-effective.	N/A
Uninterrupted electrical power supply.	Power outages due to supply system problems.	Vaporized VOCs and steam could recondense if not extracted due to extended vapor extraction or treatment system shut down.	Back up electrical power will be provided via an emergency power generator, which would supply electricity for critical service equipment (one vacuum blower and two cryogenic vapor treatment skids).	N/A
Reliable service expected from all critical treatment system equipment.	Extended system shut down due to equipment failure.	Vaporized VOCs and steam could recondense if not extracted due to extended vapor extraction or treatment system shut down.	Identify critical service equipment requiring long lead time for replacement. Adequate spare parts inventory will be established and maintained.	N/A

DNAPL = dense nonaqueous-phase liquid
RDR = Remedial Design Report
TCE = trichloroethene
ERH = Electrical Resistance Heating
RDSI = remedial design support investigation
VOC = volatile organic compound
N/A = not applicable
RI = Remedial Investigation
WAG = Waste Area Grouping

4. REMEDIAL ACTION APPROACH

The DOE Environmental Restoration (ER) contractor has overall contractor responsibility for the design, construction, sampling and analysis, operations and maintenance (O&M), waste management, and disposal associated with the remedy. The major activities for this remedial action are outlined in this section.

Table 4 is a general list of activities typically governed by procedures. Procedures referenced in the table are those followed by the current DOE Prime Contractor. If a change in DOE Prime Contractor occurs, the procedures followed by the new DOE Prime Contractor will be substantially equivalent to those referenced below. The most current versions of all contractor procedures are to be used. PRS-QAPP, RAWP, the RDR, CQCP, and all applicable procedures will be readily available in the field to all project personnel, including subcontractors, either in hard copy or electronic format. If electronic files are provided, a computer will be available to access the document.

Table 4. General Activities Governed by Procedures

Activity	Applicable Procedure
Accident/Incident Reporting	PRS-ESH-1007, *Incident/Event Reporting*
Analytical Laboratory Interface	PRS-ENM-5004, *Sample Tracking, Lab Coordination, & Sample Handling Guidance*
Calibration of Measuring and Test Equipment	PRS-QAP-1020, *Control and Calibration of Measuring and Test Equipment*
Chain-of-Custody	PRS-ENM-2708, *Chain-of-Custody forms, Field Sample Logs, Sample Labels, and Custody Seals*
Collection of Samples	PRS-ENM-0018, *Sampling Containerized Waste* PRS-ENM-0023, *Composite Sampling* PRS-ENM-2101, *Groundwater Sampling* PRS-ENM-2300, *Collection of Soil Samples* PRS-ENM-2704, *Trip, Equipment, and Field Blank Preparation* PRS-ESH-5560, *Workplace Industrial Hygiene Sampling*
Conducting Assessments	PRS-QAP-1420, *Conduct of Assessments* PRS-REG-0003, *Performing Environmental Compliance Assessments and Identification and Reporting of Environmental Issues*
Construction Equipment Inspection	PRS-PRF-0004, *Construction Equipment Inspection and Maintenance*
Control of Sample Temperature	PRS-ENM-0021, *Temperature Control for Sample Storage*
Data Verification and Validation	PRS-ENM-0026, *Wet Chemistry and Miscellaneous Analyses Data Verification and Validation* PRS-ENM-0811, *Pesticide and PCB Data Verification and Validation* PRS-ENM-5102, *Radiochemical Data Verification and Validation* PRS-ENM-5103, *Polychlorinated Dibensodioxins-Polychlorinated Dibensofurans Data Verification and Validation* PRS-ENM-5105, *Volatile and Semivolatile Data Verification and Validation* PRS-ENM-5107, *Inorganic Data Verification and Validation*
Decontamination of Large Equipment	PRS-FCD-2701, *Large Equipment Decontamination*
Decontamination of Sampling Equipment	PRS-ENM-2702, *Decontamination of Sampling Equipment and Devices*
Document Control	PRS-DOC-1107, *Development, Approval, and Change Control for PRS Performance Documents*

Table 4. General Activities Governed by Procedures (Continued)

Activity	Applicable Procedure
Documenting and Controlling Field Changes to Approved Plans	PRS-WCE-0021, *Work Execution* PRS-WCE-0027, *Field Change Request (FCR), Field Change Notice (FCN), and Design Change Notice (DCN) Process*
Evaluations for Suspect/Counterfeit Items	PRS-QAP-1009, *Identification, Control, and Disposition of Suspect/Counterfeit Items*
Fall Prevention	PRS-ESH-2004, *Fall Prevention and Protection*
Field Engineering Inspections and Surveys	PRS-WCE-0001, *Field Engineering Inspections and Surveys*
Field Logbooks	PRS-ENM-2700, *Logbooks and Data Forms*
Graded Approach	PRS-QAP-1650, *Graded Approach*
Handling, Transporting, and Relocating Waste Containers	PRS-WSD-0661, *Transportation Safety Document for On-site Transport within the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*
Hoisting and Rigging Operations	PRS-WCE-0012, *Hoisting and Rigging Operations*
Inspection and Test Plans and Review of Vendor/Supplier QA Program	PRS-QAP-1208, *Supplier Quality Program Evaluation and Receipt Inspection and Testing Requirements*
Issue Management (includes corrective action)	PRS-QAP-1210, *Issues Management Program*
Lithologic Logging	PRS-ENM-2303, *Borehole Logging*
Nonconforming Items and Services	PRS-QAP-1440, *Control of Nonconforming Items and Services* PRS-ESH-2001, *Identifying Defective Equipment*
Powered Industrial Trucks	PRS-ESH-2007, *Industrial Motorized Trucks (Forklifts)*
Quality Assured Data	PRS-ENM-5003, *Quality Assured Data*
Quality Assurance Program	PRS-CDL-0058, *Quality Assurance Program Plan for the Paducah Environmental Remediation Project, Paducah Kentucky*
Radiation Protection	PRS-CDL-0060, *Radiation Protection Program for the Paducah Environmental Remediation Project*
Records Management	PRS-DOC-1002, *PGDP DMC Document/Record Requests and Records Submittals* PRS-DOC-1009, *Records Management, Administrative Record, and Document Control*
Revisions to Procedures or Work Packages	PRS-DOC-1107, *Development, Approval, and Change Control for PRS Performance Documents* PRS-WCE-0018, *Work Management Program for the Paducah Environmental Remediation Project Paducah, Kentucky* PRS-WCE-0021, *Work Execution*
Shared Site Issue Resolution	PRS-PRM-4010, *Shared Site Issues*
Shipping Samples	PRS-WSD-9503, *Off-Site Sample Shipping*
Subcontract Management	PRS-BFM-0008, *Receipt and Evaluation of Proposals*
Suspend/Stop Work	PRS-ESH-2018, *Suspension of Work (Safety Related)*
Temperature Extremes	PRS-ESH-5134, *Temperature Extremes*
Training	PRS-TRN-0702, *Conduct of Training* PRS-TRN-0710, *Assignment of Training* PRS-TRN-0750, *Required Reading*
Transmission of Data	PRS-ENM-1001, *Transmitting Data to the Paducah Oak Ridge Environmental Information System (OREIS)*
Vendor/supplier evaluations	PRS-QAP-1208, *Supplier Quality Program Evaluation and Receipt Inspection and Testing Requirements*
Waste Management and Disposition	PRS-WSD-0016, *Waste Handling and Storage in DOE Waste Storage Facilities* PRS-WSD-0437, *Waste Characterization and Profiling* PRS-WSD-3010, *Waste Generator Responsibilities for Temporary On-Site Storage of Regulated Waste Materials at Paducah*

4.1 DESIGN

The design phase of the project selected the optimum sizing and placement of the ERH system components. Major components of the system include electrodes and power delivery systems; a vapor/liquid recovery and treatment system (extraction wells, liquid/vapor separator, and off-gas treatment unit, etc.); subsurface temperature monitoring equipment; water-level monitoring equipment and vacuum monitoring piezometers. Results from the RDSI and WAG 6 RI provided information relative to contaminant distribution for use during the design of the ERH system. The ER contractor has hired an ERH specialty contractor to assist with the design of the ERH system. The C-400 IRA design is documented in the RDR Certified for Construction, which was developed and documented in phases (30%, 60%, 90%, and Certified for Construction).

4.2 CONSTRUCTION

The construction phase of the project will include site preparation and installation of subsurface electrodes, extraction wells, subsurface temperature monitoring equipment, water-level monitoring equipment, vacuum monitoring piezometer, and an aboveground vapor and liquid treatment system.

Site preparation will include removal of interfering C-400 infrastructure and installation of asphalt. Interfering infrastructure to be removed from the southwest corner of C-400 consists of aboveground secondary containment pits and a steel tanker unloading platform. These infrastructure items must be removed before Phase I ERH components can be installed in the Southwest Treatment Area. In the Southeast Treatment Area infrastructure which must be removed before installation of ERH components includes an aboveground TCE storage tank, associated pump, piping, and an out-of-service semi-gantry crane. A concrete sump, located directly east of the TCE storage tank, will be removed if necessary to facilitate installation of aboveground treatment units. Asphalt covering will be placed over the grassy areas in the Southeast Treatment Area.

Many components of the ERH system will be installed in subsurface borings. These borings will be completed under the direction of a certified driller. Sonic drilling is the preferred method of installation for all ERH equipment; however, in some locations, sonic drilling equipment may not fit within the congested work area and an alternate drilling method will be used.

Electrode well borings will be approximately 12-inch diameter borings. After the boring is completed, the electrode will be lowered into the boring with an organic solvent and heat resistant synthetic support rope. When adding sand to an electrode well, sand will be added to the inside of the sonic drill stem maintaining 2 ft of fill material inside the drill stem at all times. Sonic casing will be vibrated as it is being removed allowing the sand to be packed around the electrode and into the annulus. Where required, well screen will be installed and sanded in place. The boring then will be completed with well materials (bentonite, grout, etc.) per the design.

Extraction well borings will be approximately 8 inch borings; Dual (DigiTAM/DigiPAM) sensor well borings, and vacuum monitoring or combination vacuum monitoring/DigiTAM sensor well borings will be approximately 7 inch borings; contingency well borings will be 6 inch borings; and DigiTAM sensor well borings, DigiPAM sensor well borings, and DigiPAM sensor/monitoring well borings will be approximately 6 inch borings. Where required, well screen will be installed and sanded in place. The boring will then be completed with well materials (bentonite, grout, etc.) per the design.

The extraction piping and wellheads will be installed with the completion of the subsurface equipment. After the power delivery system and water circulation systems are in place, the leads and hoses will be run from the wellheads to their pre-assigned location at each piece of equipment.

4.3 SAMPLING AND ANALYSIS

Three distinct phases of sampling and analysis will occur as a part of this IRA: baseline, operational, and post-operational. Baseline sampling and post operational sampling will be conducted as a means to determine the percent reduction in VOC contamination in the treatment area. The sampling plan for baseline and post-operational sampling activities is presented in Section 8.1 of this RAWP.

Operational sampling and analysis will be used to measure progress and determine when criteria for ceasing operations have been met. Additional discussion of operational sampling can be found in Section 8.2. A sampling and analysis plan for operational sampling will be included in the O&M Plan to be developed and submitted for review in accordance with the planning schedule in Section 6 of this RAWP. Section 8.3 addresses waste characterization sampling and analysis.

4.4 OPERATION AND MAINTENANCE

A period of system startup and pre-operational testing will be conducted prior to normal operations. During this startup period vapor and liquid extraction will be activated before the electrodes are activated.

The system is expected to operate 24 hours per day. Operators will be on-site during normal business hours. The ERH vendor will remain part of the operations team and is providing an operator. The subsurface equipment also will be monitored and adjusted remotely by the ERH vendor. System operational measurements and preventative maintenance will occur on a regular basis to ensure the system is functioning properly. Operational checks will include measuring critical system parameters such as soil temperature and VOC recovery. Maintenance activities will include lubrication and minor adjustment of system components. The maintenance activities will be conducted as required by the equipment manufacturers and sound engineering practice. Adjustments to system components will be directed by the appropriate subject matter experts. An O&M Plan will be developed to address system start-up, normal operations, routine maintenance, and system shutdown activities for the ERH components, as well as the aboveground vapor and liquids treatment components. The O&M Plan will be developed and submitted for review in accordance with the planning schedule in Section 6 of this RAWP.

4.5 WASTE MANAGEMENT AND DISPOSITION

Waste generated during installation, operations, and decommissioning of the C-400 IRA will be managed and dispositioned in accordance with the Waste Management Plan (WMP) and applicable or relevant and appropriate requirements (ARAR). Waste characterization will be performed using analytical results from waste sample analysis in Section 8.3 and from process knowledge where applicable. Refer to the WMP in Section 12 for additional detail concerning waste management and disposition.

5. PROJECT ORGANIZATION

The project organization chart showing relationships of key personnel and organizations is shown in Figure 14. The communication pathways that will be used during the project are shown on Figure 14. Plan-of-the-day/pre-job briefings will provide personnel an opportunity to discuss daily activities and any issues. Field changes will be made and documented in accordance with Section 9.17. All personnel have "stop work authority" and the responsibility to use this authority in accordance with PRS-ESH-2018, *Suspension of Work (Safety Related),* when they perceive the safety of workers or the public to be at risk.

- DOE—Lead agency. DOE performs oversight of PRS and the project. DOE reviews and approves project documents and participates, as needed, in Readiness Reviews. DOE also is responsible for communications with the EPA and state regulatory agencies.

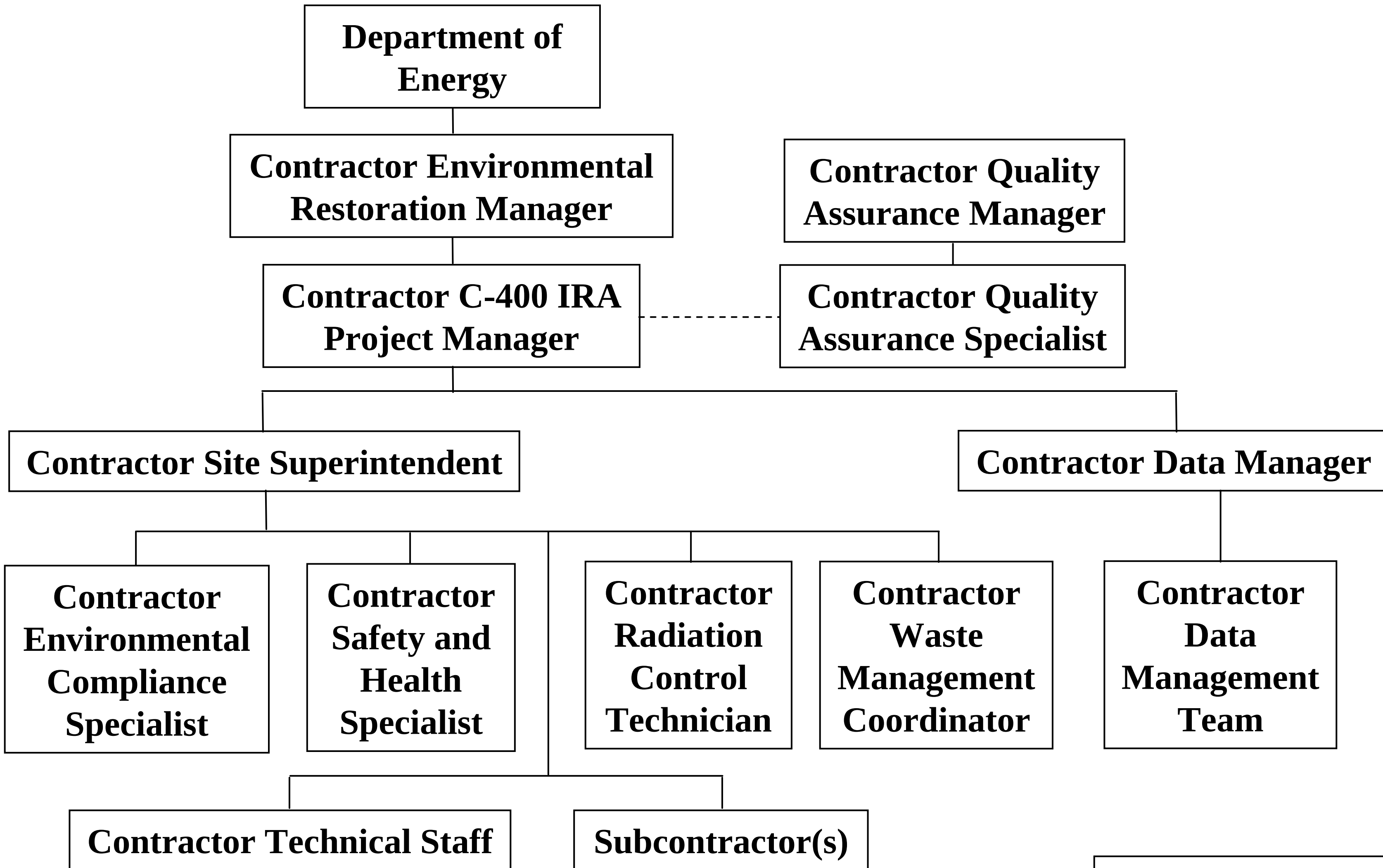
- Contractor—Responsible for communications with DOE and for planning, overseeing, and completing the project.

- Contractor Environmental Monitoring/Environmental Restoration Manager—Serves as the primary point of contact with DOE to implement site-wide environmental restoration programs. Performs work in accordance with the baseline scope and schedule and directs the day-to-day activities of DOE Contractor personnel performing environmental monitoring and restoration activities.

- Contractor C-400 IRA Project Manager—Serves as the IRA action primary point of contact and is responsible for the performance, quality, schedule, and budget. Provides overall project direction and execution, implements corrective actions as necessary, verifies compliance with safety and health requirements, and participates in the readiness review. Leads the effort to define the scope of an environmental problem or facility operation. Directs the project team in determining potential sources of existing data, identifying the study area and/or facility to be addressed by the project, and selecting the most effective data collection approach to pursue. May also be the technical contact for subcontracted project support and should ensure that the flow down of data management requirements are defined in a statement of work (SOW).

- Contractor Quality Assurance Manager—Responsible for coordination with the project quality assurance (QA) staff to ensure an appropriate level of QA oversight. Schedules audits and surveillances needed to verify compliance with quality commitments and requirements. Has overall responsibility of approving, tracking, and evaluating effectiveness of corrective actions. Receives copies of field changes and approves field changes related to quality. The QA Manager is independent of the project.

- Contractor Quality Assurance/Quality Control Specialist—Verifies all work is completed in accordance with the Quality Assurance Plan (QAP) and the Data Management and Implementation Plan (DMIP). Develops QA/quality control (QC) procedures and implements administrative procedures that govern both technical and non-technical work. Responsible for reviewing project documentation to determine if the project team followed applicable procedures. Responsible for maintaining the official, approved DMIP and QAP for the project.



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

PADUCAH Remediation Services
A Portage Shaw Joint Venture Company

Figure 14. Project Organization

- Contractor Site Superintendent—Oversees all field activities and verifies that field operations follow established and approved plans and procedures. Supervises the field team activities and field data collection. Ensures that all field activities are properly recorded and reviewed in the field logbooks and on any necessary data collection forms. Responsibilities include identifying, recording, and reporting project nonconformances or deviations. Interfaces with the IRA project manager during field activities.

- Contractor Safety and Health Specialist—Develops the Health and Safety Plan and oversees implementation of Integrated Safety Management System (ISMS) and the overall safety and health of employees, both in the field and the office. Provides direct support to the IRA project manager concerning the safety and health of project personnel and the general public and impacts to property and the environment. Ensures that each task has the proper safety and health controls in place before work begins, meeting all federal, state, and local regulations.

- Contractor Environmental Compliance Specialist—Ensure project activities are conducted in compliance with environmental laws and regulations including, but not limited to, National Environmental Policy Act and Clean Air Act, permits, regulatory agreements and documents, DOE Orders and Directives, and company policies and procedures. Review and prepare technical and regulatory documents/reports, National Emission Standards for Hazardous Air Pollutants (NESHAP) Reports, SWMU Notifications and Assessment Reports, and permit applications/modifications. Conduct regulatory research and reporting, perform field inspections, and support waste minimization and pollution prevention activities. Support implementation of the ISMS and Environmental Management System.

- Contractor Radiation Control Technician—Implement the day-to-day programmatic aspects of the Radiation Protection Program. Perform air sampling, radiation surveys, radioactive contamination control and monitoring, access control, posting and labeling, completion and management of records, responding to accidents and emergencies, vehicle and equipment control, instrumentation source check, personnel decontamination, and minor equipment decontamination during the course of surveying. Generate radiological data records and reports.

- Contractor Technical Staff—Provides direct support to the site superintendent and IRA project manager concerning technical aspects of the project during remedial design, construction, and operation.

- Contractor Waste Management Coordinator—Ensures adherence to the Waste Management Plan, documents and tracks field-related activities, including waste generation and handling, waste characterization sampling, waste transfer, and waste labeling. The Waste Management Coordinator (WMC) will perform the majority of waste handling field activities.

- Contractor Data Manager—Responsible for the coordination of all sampling activities. Ensures that all quality control sampling requirements are met, chain-of-custody forms are generated properly. Responsible for managing data generated during the remedial design, construction, and operation in accordance with the DMIP.

- Contractor Data Management Team—Responsible for entering project information into the project records file and/or database and ensuring that all information has been entered correctly. Ensures that hard copy data records are processed according to data records management requirements. Works with field teams to facilitate data collection and verification and with data users to ensure easy access to the data. Performs data reviews, verification and assessment, as appropriate. Determines project data usability by comparing the data against predefined acceptance criteria and assessing that the data are sufficient for intended use. Interacts with the Sample Management Office (SMO) to develop project-specific laboratory SOWs. Ensures that analytical methods, detection limits, minimum detectable activities, laboratory QC requirements, and deliverable requirements are specified in the SOW and that the SOW incorporates necessary deliverables so that data packages from the laboratory will be appropriate for verification and validation. Responsible for contracting any fixed-base laboratory utilized during sampling activities. Incorporates any existing data or new project data into the project's hard-copy data record file or data base, as appropriate. Performs data reviews, verification and assessment, as appropriate. Ensures that analytical and field data are validated, as required, against a defined set of criteria that includes evaluating associated QC samples to ensure that analyses were preformed within specified control parameters. Performs data reviews, as appropriate [e.g., quality checks; assessing sensitivity, precision, accuracy, representativeness, comparability, completeness, and sensitivity (PARCCS) parameter conformance; evaluating adherence to data quality requirements]. Ensures that the project data are properly incorporated into Paducah Oak Ridge Environmental Information System (OREIS). Responsible for interfacing with the SMO concerning laboratory data package deficiencies.

- Subcontractor(s)—An ERH specialty subcontractor will be hired to provide equipment and expertise during the design, construction, and operation of the ERH system. A drilling subcontractor will be hired to install all subsurface borings and assist the ERH subcontractor with installation of ERH system components

6. PROJECT PLANNING SCHEDULE

A generalized project planning schedule is shown in Table 5[5].

Table 5. Project Planning Schedule

Activity	Date
Completion of the RDSI	Completed August 2006
Submittal of D1 RDR to EPA/KY (FFA Milestone)	Completed April 2007
Submittal of D1 RAWP to EPA/KY (FFA Milestone)	Completed May 2007
Approval of the Certified for Construction Design	Completed July 2008
Approval of the Remedial Action Work Plan	October 2008
Approval of the Construction Quality Control Plan	October 2008
Complete Infrastructure Removal	January 2009
Begin Phase I Installation	~ 1 month following approval of the RAWP
Complete Phase I Installation	~ 6 months after start up of Phase I installation
Approval of the D2 O&M Plan	~ 1 month preceding Phase I start-up and testing
Begin Phase I Start Up and Testing	Following completion of Phase I installation
Begin Phase I Routine Operations	Following completion of Phase I start-up and testing
Complete Phase I Operations	~ 6 months after beginning Phase I Routine operations
Begin Installation of Phase II ERH Components	~ 3 months after start up of Phase I operations
Complete Phase II Installation	~ 6 months after start up of Phase II installation
Begin Phase II Start Up and Testing	Following completion of Phase II installation
Begin Phase II ERH Operations	Following completion of Phase II start up and testing
Complete Phase II ERH Operations	~ 6 months after beginning Phase II ERH operations
Issue the Remedial Action Completion Report[6] (FFA Milestone)	April 2011

[5] Projected schedules for completion of activities set forth herein are estimates provided for informational purposes only and are not considered to be enforceable elements of the remedial action or this document. The enforceable milestones for performance of activities included as part of the remedial action are set forth in the Federal Facility Agreement (FFA) (EPA 1998). Any additional milestones, timetables, or deadlines for activities included as part of the remedial action will be identified and established independent of this RAWP, in accordance with existing FFA protocols.

[6] A Post Construction Report will be issued as part of the Remedial Action Completion Report

7. HEALTH AND SAFETY PLAN

This Health and Safety Plan (HASP) establishes the specific applicable standards and practices to be used during execution of the C-400 IRA to protect the safety and health of workers and the public. This document contains information about potential contaminants and hazards that may be encountered on-site, and hazards inherent in routine procedures. The list of contaminants is site-specific and based on previous investigations.

This HASP will evolve as lessons learned are incorporated to continuously improve work processes, while maintaining focus on the functions and guiding principles of ISMS and the zero-accident performance philosophy.

This work will be performed in accordance with the DOE's ISMS and its Environmental Compliance and Health and Safety policy statement; these establish a goal of zero-accident performance. Hazard controls will include access restrictions, operator-training requirements, exclusion of nonessential personnel from the work zone, use of personal protective equipment (PPE), and other relevant controls.

7.1 INTEGRATED SAFETY MANAGEMENT SYSTEM

The project team is committed to implementing an ISMS that integrates safety into management and work practices at all levels so that missions are accomplished while protecting the public, the workers, and the environment. The concepts of the ISMS will be utilized to provide a formal, organized process to ensure the safe performance of work. The ISMS Plan identifies the methodologies that will be used to address previously recognized hazards and how the hazards are mitigated using PRS-accepted health and safety practices.

This project will pursue the DOE's goal of zero-accident performance through project-specific implementation of ISMS. The core functions and guiding principles of ISMS will be implemented by complying with 10 *CFR* § 851, *Worker Safety and Health Program* and incorporating applicable DOE orders, policies, technical specifications, and guidance. A brief description of the five ISMS core functions is provided below.

7.1.1 Define Scope of Work

Defining and understanding the scope of work is the first critical step in successfully performing any specific activity in a safe manner. Each member of the project team will participate in discussions conducted to understand the scope and contribute to the planning of the work. The project team may conduct a project team-planning meeting to discuss the team's general understanding of the scope and the technical and safety issues involved. This meeting is conducted to ensure all parities are in agreement on the scope and general approach to complete the scope.

7.1.2 Analyze Hazards

In the course of planning the work, the project team will identify hazards associated with the performance of the work. Hazards may be identified and assessed by performing a site visit, reviewing lessons learned, and reviewing project plans or historical data.

Once the hazards have been identified and assessed, measures will be identified to minimize risks to workers, the public, and the environment. These measures are described in the project-specific activity hazard analyses (AHAs), which serve to provide a control mechanism for all work activities. AHAs are detailed, activity-specific evaluations that address each step of the task and/or activity that will be performed. The AHA development process entails a detailed evaluation of each task to identify specific activities or operations that will be required to successfully complete the scope of work and defines the potential chemical, physical, radiological, and/or biological hazards that may be encountered; the media and manner in which they may occur; and how they are to be recognized, mitigated, and controlled. Appropriate hazard controls may include engineering controls, administrative controls, and the use of PPE. This approach has been developed to be consistent with the requirements in OSHA regulations for Health and Safety Plans for Hazardous Waste Operations and Emergency Response (29 *CFR* § 1910.120 and § 1926.65). The project team is responsible for the preparation, revision, and implementation of all AHAs.

The Safety and Health Specialist will review all AHAs with the personnel who will perform the work. Participants in this review will sign and date the AHA to signify they understand all hazards, preventative measures, and requirements in the AHA. A copy of the AHA with appropriate signatures shall be maintained at the work location.

7.1.3 Develop and Implement Hazards Controls

The primary mechanisms used to flow down ISMS controls to the project team are project-specific plans and technical standard operating procedures. Other mechanisms include program/project management systems, employee training, communication, work site inspections, independent assessments, and audits. These mechanisms are communicated in the following:

- Pre-job meetings
- Orientations
- Training
- Plan-of-the-day/pre-job briefings
- AHAs and STARRT Cards
- Radiological work permits

A project-specific pre-job meeting will be completed after the AHAs have been developed, reviewed, revised, and approved. The meeting will include a thorough review of the scope of work to be performed, the contents of the AHAs, and any project-specific information necessary to supplement the HASP. All personnel who will be conducting site activities, including subcontractors, will be required to participate in this meeting or be briefed on the required information. As part of that meeting, employee involvement will be emphasized and encouraged in all phases of the planned work.

The pre-job briefing also incorporates the principles of ISMS. The specific steps within ISMS are emphasized to each employee. It is emphasized that no employees will be directed or forced to perform any task that they believe is unsafe, puts their health at risk, or that could endanger the public or the environment. One of the key elements of this HASP is that all personnel have “stop work authority” and the responsibility to use this authority when they perceive the safety of workers or the public to be at risk.

Employee involvement is emphasized in all pre-job training sessions beginning with initial orientation training and then periodically being reinforced in refresher training, as applicable, and in safety and health briefings/meetings. Whenever possible, employees are involved in the selection, development, and presentation of training topics, and their full and constructive input is encouraged in all communication sessions.

7.1.4 Perform Work Within Controls

Once the project team has been given notice to proceed, the project-specific plans will be implemented. The project team will verify that all applicable plans, forms, and records are contained in the field project files to be kept on-site and accessible by all parties. Actions that will be taken during the performance of the work to incorporate these ISMS principles:

- Plan-of-the-day/pre-job briefings
- Safety and health oversight/inspections,
- Daily inspection of equipment
- Stop work authority

During field work, daily briefings (e.g., safety tailgate or toolbox meetings) will be conducted with all personnel participating, including subcontractor personnel. These sessions also will focus on fostering two-way communication, eliciting feedback, and reinforcing employee involvement.

Although line management holds the ultimate responsibility and accountability for safety and health matters, this does not, in any way, absolve individual employees from fulfilling their personal safety and health responsibilities. Each project employee is responsible for his/her own health and safety, including performing his/her work in accordance with established requirements, complying with specified policies and procedures, performing his/her work in a manner that is consistent with training and communications received, and actively participating in the safety and health program to continuously improve its effectiveness. The opportunity for employees to provide periodic feedback is provided during the daily briefing.

7.1.5 Feedback/Improvement

Feedback and improvement are accomplished through several channels, including safety audits, self-assessments, employee suggestions, lessons learned, and post-job briefings. These actions will be used to solicit worker feedback, as well as to identify, address, and communicate lessons learned using standard corrective action planning and continuous improvement processes.

A cornerstone of any effective safety and health program is the active involvement and participation of employees that it is designed to protect. An essential element of this is thorough communication and feedback throughout the organization, with an emphasis on identifying opportunities for continuous improvement of the program. The objective of active employee involvement in the safety and health program is to develop a culture in which employees feel empowered and take ownership of the program.

The Safety and Health Specialist and the C-400 IRA Project Manager will encourage employees to freely submit suggestions that offer opportunities for improvement.

At the conclusion of fieldwork, a post-job briefing will be conducted to allow project personnel to communicate:

- Lessons learned,
- How work steps/procedures could be modified to promote a safer working environment,
- How communications could be improved within the project team,
- Issues or concerns they may have regarding how the work was performed, and
- Any other topics relevant to the work performed.

7.2 KEY CONTRACTOR SAFETY AND HEALTH RESPONSIBILITIES

7.2.1 C-400 IRA Project Manager

The C-400 IRA Project Manager has overall responsibility and authority to direct technical, management, cost, and contractual matters related to the project. The C-400 IRA Project Manager ultimately is responsible for the safety and health of employees performing project-associated activities on the site.

Specific responsibilities of the C-400 IRA Project Manager will include, but are not be limited to, the following:

- Ensures that project work conducted by subcontractors is conducted safely.
- Serves as primary point of contact.
- Identifies required safety and health needs and ensures that project personnel are trained in requirements.
- Implements and enforces the HASP, the AHAs, and other addenda.
- Consults on safety-related matters with the Site Superintendent, the Safety and Health Manager, and the Safety and Health Specialist.
- Participates with the Site Superintendent, the Safety and Health Manager, and the Safety and Health Specialist in investigations or disciplinary actions for violations of the HASP.

7.2.2 Site Superintendent

The Site Superintendent will oversee the field activities associated with the project and will be responsible for overall execution of the field activities associated with the project. He or she is responsible for enforcing the field requirements of this plan. Specific responsibilities of the site superintendent are listed below.

- Enforces compliance with the project HASP.
- Coordinates on-site operations, including subcontractor activities.
- Ensures that subcontractors follow the requirements of this HASP.
- Coordinates and controls any emergency response actions.
- Reports accidents and injuries through the appropriate channels; and conducts accident/incident investigations as required, including the completion of appropriate forms.
- Conducts or ensures worksite inspections.
- Conducts or ensures daily “tailgate” safety briefings.
- Maintains current copies of the project HASP on-site.

7.2.3 Safety and Health Specialist

The Safety and Health Specialist has the following responsibilities and authorities:

- During fieldwork, conducts daily health and safety inspections of contractor/subcontractor work activities.
- Stops work and removes project personnel from the site if the safety or health of those personnel, other site personnel, or third parties is jeopardized by work activities.
- Ensure that all on-site personnel have the required training and certification and maintains copies of required documentation.
- Provides project-specific training for new employees and visitors.
- Establishes and implements applicable safety and health procedures.
- Establishes and maintains systems to inform personnel on how to respond to emergency warning systems for the project (including evacuation alarms, accountability rosters, assembly points, etc.).
- During fieldwork activities, participates in plan-of-the-day meetings.
- Ensures that the first aid kits are kept current.
- Ensures that proper chemical and safety postings are in place and legible.
- Ensures that all operations are conducted so as to mitigate adverse environmental impacts (e.g., spill containment, erosion control).
- Designs personnel Industrial Hygiene monitoring strategies to include, but not limit to, personal air monitoring (breathing zone), ambient breathing zone monitoring, noise surveys, and heat stress monitoring.
- Performs personnel monitoring to evaluate existing and potential exposure to chemical, physical, biological, and radiological hazards.
- Interprets, reports, and takes appropriate actions indicated by personnel monitoring results.
- Evaluates the site for any hazards not identified in the AHA, initiates safety measures required to protect personnel, and revises documents accordingly.
- Establishes and maintains programs required to mitigate hazards identified in the AHA.
- Maintains first aid and OSHA 300 logs; reports accidents and injuries through the appropriate channels; and assists with accident/incident investigations as required, including the completion of appropriate forms.
- Coordinates with off-site emergency responders and medical service organizations to establish required services and verify that phone numbers, addresses, and contacts are current and accurate.

7.2.4 Safety and Health Manager

The Safety and Health Manager has the following responsibilities:

- Reviews and approves all project HASPs.
- Oversees implementation of project HASPs and procedures.
- Conducts, or approves personnel to conduct, safety and health surveillances and audits, and directs and mentors the Safety and Health Specialist.
- Reviews Industrial Hygiene sampling strategy and resulting data.
- Assesses sampling strategy and required PPE based on sample results.

7.3 REPORT/RECORD KEEPING

Project requirements include the following:

- All accidents and near misses must be reported to the Safety and Health Specialist and the Site Superintendent immediately.
- Proof of personnel training and medical clearances required for this project will be maintained.

7.4 MEDICAL SURVEILLANCE

The medical surveillance program provides for baseline, annual, and termination medical examinations for the project team in accordance with 29 *CFR* § 1910.120, Hazardous Waste Operations and Emergency Response (HAZWOPER).

Employees and subcontractors conducting HAZWOPER fieldwork must complete an annual HAZWOPER physical. The examining physician will document the worker's fitness for work and ability to wear a respirator.

Radiation workers, working under a Radiological Work Permit (RWP), may be required to submit a site specific baseline bioassay and periodic bioassay as need through the project. Detailed explanation of the radiation worker requirements are described in PRS-CDL-0060, *Radiation Protection Program for the Paducah Environmental Remediation Project*.

7.5 FIRST AID AND MEDICAL SERVICES

Project requirements include all of the following:

- Only personnel with current first aid/cardiopulmonary resuscitation (CPR) training will administer minor job-site first aid.
- The PGDP Medical Facility will be the primary resource for emergency medical care during this project.

- All job-related injuries or illnesses must be reported immediately to the Safety and Health Specialist and the Site Superintendent.

7.6 TRAINING

7.6.1 Hazardous Waste Worker Training

Site personnel, such as equipment operators and field technicians, will be required to have successfully completed the initial 40-hour HAZWOPER Training Program, including all required annual updates consisting of eight hours of refresher training, as well as, three days of on-the-job training under the direct supervision of a trained, experienced supervisor. Personnel occasionally on-site for a specific limited task who are unlikely to be exposed above the permissible exposure limit will be required to have successfully completed a minimum of 24 hours of initial training. Site visitors (observers) will be restricted to the Support Zone unless documentation of training is presented.

7.6.2 Subcontractor Training

All subcontractor employees must provide documentation for training that is pertinent and relevant for the tasks to be performed and necessary for compliance with local, state, or federal regulations. Additional training may be required as needed.

7.6.3 Site Specific Training

All personnel may be required to attend the following site-specific training:

- General Employee Training (GET), and
- Radiological Worker II Training.

Additional training may be required as needed. This training may include (but not be limited to) the following:

- Fire Extinguisher,
- Lockout/Tagout, and
- Respiratory Protection.

7.7 ACTIVITY HAZARD ASSESSMENT

An AHA will be prepared for the major tasks planned for this project with the assistance of workers familiar with the type of tasks to be performed. If additional tasks are identified, the hazards and necessary controls will be determined and documented in a modified AHA. The AHA must be approved and reviewed with personnel prior to initiating these tasks.

All workers will be trained on the AHA as it applies to their work. This training will be documented by signing the AHA. Following completion of an activity, employees will provide feedback, and "lessons learned" will be documented.

The safe and effective implementation of the electrical heating technology necessitates that proper health and safety precautions be taken. These precautions will be included in project specific work control documents. The electrical heating technology uses voltage that is less than 600 volts. Also, the ERH vendor uses an electrical grounding system that is installed during the construction of the treatment system to ensure that electrical potentials at surface do not exceed National Electric Code guidelines of 15 volts. The electrical equipment used to transmit electrical energy to the subsurface has been designed to meet applicable electric codes and provide fail-safe operation. Work control documents will be implemented to address working with materials and fluids that will have the potential to be at high temperatures. High subsurface pressures are not expected during operation of the treatment system.

7.8 FACILITY/SITE ACCESS CONTROL

Work zones will be utilized to control access. These areas will be controlled by the appropriate subcontractor to minimize the number of individuals potentially exposed to site hazards and to ensure that individuals who enter follow the required procedures. The following is a description of the different types of zones that will be established at the site.

- Exclusion Zone (EZ) – The area where work is being performed and chemical, physical, and/or radiological hazards exist. Entry into this area is controlled and the area clearly marked with barrier tape, rope, or flagging. Signage required by OSHA will be posted. Unauthorized entry into these areas is strictly prohibited. Permission to enter the EZ is granted by the Safety and Health Specialist or designee.

- Contamination Reduction Zone (CRZ) – The transition area between the EZ and support area. This area will provide a buffer area to reduce the probability that contamination will leave the EZ and reduce the possibility of the support area becoming contaminated by site hazards. The degree of contamination in the CRZ decreases as the distance from the contaminants increases.

- Support Area – The outermost area of the worksite. This area is uncontaminated where workers provide operational and administrative support. The support area is clean and will not be entered by contaminated equipment or personnel, except under emergency or evacuation conditions. Normal work clothes are appropriate within this area.

7.9 HAZARD COMMUNICATION

OSHA's 29 *CFR* § 1910.1200, "Hazard Communication Standard," states that all employees handling or using hazardous or potentially hazardous materials be advised and informed of the health hazards associated with those materials.

7.9.1 Material Safety Data Sheet

A material safety data sheet (MSDS) provides specific material identification information; ingredients and hazards; physical data; fire and explosion information; reactivity data; health hazard information; spill, risk, and disposal procedures; special protection information; and special precautions required for materials manufactured for use. It is the manufacturer's responsibility to provide this information to the user for any materials that contain hazardous or potentially hazardous ingredients. Each employee is to be made aware that the MSDSs are available. The Safety and Health Specialist shall maintain copies of all MSDSs for chemicals brought on-site and shall have them readily available.

7.9.2 Chemical Inventory

A list of all chemicals brought on-site will be maintained by the Safety and Health Specialist. Prior to bringing hazardous materials on-site, personnel/subcontractors must submit an MSDS and receive approval from the Safety and Health Specialist.

It is the responsibility of the Safety and Health Specialist to ensure that all potentially hazardous materials taken to a project site are properly labeled as to the contents of the container and with the appropriate hazard warnings.

7.10 EMERGENCY MANAGEMENT

In the event of an emergency, all site personnel shall follow the requirements and provisions of the PGDP Emergency Management Plan. Emergency response shall be provided by the PGDP emergency response organization. The Site Superintendent and Safety and Health Specialist will be in charge of personnel accountability during emergency activities. All personnel working on-site will be trained to recognize and report emergencies to the Safety and Health Specialist or the Site Superintendent. The Safety and Health Specialist or Site Superintendent will be responsible for notifying the PGDP emergency response organization.

The PGDP emergency response organization will be contacted for emergency response to all medical emergencies, fires, spills, or other emergencies. The Plant Shift Superintendent (PSS) will coordinate 24-hour emergency response coverage. The requirements of this section will be communicated to site workers. Any new hazards or changes in the plan also will be communicated to site workers.

7.10.1 Potential Emergencies

Potential emergencies that could be encountered during this project include, but are not limited to, fires, spills, and personnel exposure or injury. A local emergency manual, which contains explicit instructions and information about required emergency actions and procedures, is located near the entrances of each PGDP facility.

7.10.2 Fires

In the event of a fire, the PSS shall be notified immediately. If it is safe to do so, and they are properly trained, on-site personnel may attempt to extinguish an incipient fire with the available fire extinguisher and isolate any nearby flammable materials. If there is any doubt about the safety of extinguishing the fire, all personnel must evacuate to an assembly location and perform a head count to ensure that personnel are accounted for and are safely evacuated. The Site Superintendent or designee will provide the fire department with relevant information.

7.10.3 Spills

In the event of a spill or leak, the employee making the discovery will immediately vacate the area and notify other personnel and his/her supervisor. The Site Superintendent or designee will determine whether the leak is an incidental spill or whether an emergency response is required. If there is a probability that the spill will extend beyond the immediate area, result in an environmental insult, or exceed the capabilities of the on-site personnel, the Site Superintendent is to inform the PSS, who will determine whether a response by the PGDP spill response team is warranted. If emergency response crews are mobilized, the Site Superintendent or knowledgeable employee will provide the responders with relevant information.

7.10.4 Medical Emergencies

The first aid/CPR provider will serve as the designated first aid provider. Any event that results in potential employee exposure to bloodborne pathogens will require a post-event evaluation and follow-up consistent with 29 *CFR* § 1910.1030. A person knowledgeable of the location and nature of the injury will meet the emergency response personnel to guide them to the injured person.

Site personnel may take workers with injuries that are more severe than can be addressed by first aid, but that do not constitute a medical emergency, to designated medical facility. The Site Superintendent, Safety and Health Specialist, and C-400 IRA Project Manager must be informed immediately that the worker has been taken to the medical facility and the nature of the injury.

7.10.5 Reporting an Emergency

Project personnel will be able to communicate by two-way, hand-held radio, or cellular telephone on-site.

7.10.6 Telephone

Inside the PGDP security perimeter, if a plant telephone is accessible, dial 6333. With a cellular phone, dial 441-6333. Describe the type and the location of the emergency. Identify who is calling. Identify the number on the phone being used. Tell whether an ambulance is needed. Listen and follow any instructions that are given. Do not hang up until after the Emergency Control Center has hung up.

7.10.7 Fire Alarm Pull Boxes

Pulling a fire alarm box at PGDP automatically transmits the location of the emergency to the Fire Department and the Emergency Control Center. The person pulling the alarm should remain at the alarm box, or nearest safe location, and supply any needed information to the emergency responders. Work personnel should note the location of pull boxes in each project area, where applicable.

7.10.8 Radio

Channel 16 is designated as the emergency channel on the plant radio system. By calling radio call number Alpha 1 and declaring "EMERGENCY TRAFFIC, EMERGENCY TRAFFIC," the PSS is alerted of the emergency. Describe the type and the location of the emergency as well as who is calling.

7.11 ALARM SIGNALS

7.11.1 Project-Specific Alarm

A prolonged blast of an air horn or vehicle horn will signal immediate work stoppage and evacuation to a pre-designated area.

7.11.2 Evacuation Alarms

PGDP facility evacuation alarms are denoted by a steady or continuous sound from the site public address system. Proceed to the predetermined assembly station. The assembly station director will provide further instruction.

7.11.3 Radiation Alarms

PGDP radiation alarms are denoted by a steady sound from a clarion horn and rotating red beacon lights. Evacuate the site or area and proceed to the predetermined assembly station. The assembly station director will give further instruction.

7.11.4 Take-Cover Alarms

PGDP take-cover alarms are denoted by an intermittent or wailing siren sound from the site public address system. Seek immediate protective cover in a strong sheltered part of a building. Evacuate mobile structures to a permanent building or underground shelter.

7.11.5 Standard Alerting Tone

The standard alerting tone at PGDP is a high/low tone from the public address system and is repeated on the plant radio frequencies. Listen carefully; an emergency announcement will follow.

7.11.6 Evacuation Procedures

The Safety and Health Specialist or Site Superintendent will designate the evacuation routes. Every on-site worker should familiarize himself/herself with the evacuation routes. In the event of an evacuation, proceed to the predetermined assembly station or designated area and wait for further instructions.

7.11.7 Sheltering In Place

Certain emergency conditions (e.g., chemical or radioactive material release, tornado warning, fire, security threat) may require that personnel be sheltered in place. Notification of a recommendation of “sheltering in place” is carried out by the PGDP Emergency Director on the emergency public address system and plant radio frequencies. Requirements for “sheltering in place” follow these steps:

- Go indoors immediately (permanent building or underground shelter, not “mobile-type” structures);
- Close all windows and doors;
- Turn off all sources of outdoor air (e.g., fans and air conditioners);
- Shut down equipment and processes, as necessary, for safety; and
- Remain indoors and listen for additional information on the public address system.

7.11.8 On-Site Relocation

Certain emergency conditions (e.g., chemical or radioactive material release, tornado warning, fire, security threat) may require that on-site personnel be relocated from their normal workstations and activities to locations more suitable to withstand the threat. Notification of on-site relocation is carried out by the PGDP Emergency Director on the public address system and plant radio frequencies. Specific instructions about where to relocate will be given with the message.

7.11.9 Facility Evacuation

For evacuations related to emergencies inside PGDP, the PGDP Emergency Director initiates notification of facility evacuation over the public address system. Assembly stations serve as gathering points for evacuating personnel. These stations are identified with an orange, disk-shaped sign with the assembly station number in black lettering. In the event of an evacuation alarm, employees will evacuate to the designated assembly point for the area and immediately report to the Site Superintendent or the assembly station director. An accounting will be conducted of all personnel who have evacuated. Further instructions and information about the emergency situation will be given to employees by the assembly station director or over the site public address system and plant radio.

7.11.10 Emergency Equipment

The following items of emergency equipment will be maintained at the work location:

- Hard-wired or cellular telephone and radios;
- First aid kit including bloodborne pathogen PPE;
- ABC-rated fire extinguishers; and
- Basic spill kit suitable to handle small spills.

7.12 HEAT AND COLD STRESS

The most common types of stress that affect field personnel are from heat and cold. Heat stress and cold stress may be the most serious hazards to workers at waste sites. In light of this, it is important that all employees understand the signs and symptoms of potential injuries associated with working in extreme temperatures.

7.12.1 Heat Stress

Heat stress occurs when the body's physiological processes fail to maintain a normal body temperature because of excessive heat. The body reacts to heat stress in a number of different ways. The reactions range from mild (such as fatigue, irritability, anxiety, and decreased concentration) to severe (such as death). Heat-related disorders are generally classified in four basic categories: heat rash, heat cramps, heat exhaustion, and heat stroke. The descriptions, symptoms, and treatments for these diseases are described in the following sections.

7.12.2 Heat Rash

Description. Heat rash is caused by continuous exposure to heat and humid air and is generally aggravated by coarse clothing. This condition decreases the body's ability to tolerate heat, but is the mildest of heat-related disorders.

Symptoms. Mild red rash is generally more prominent in areas of the body in contact with PPE.

Treatment. Decrease the amount of time in PPE and use powder to help absorb moisture.

7.12.3 Heat Cramps

Description. Heat cramps are caused by perspiration that is not offset by adequate fluid intake. This condition is the first sign of a situation that can lead to heat stroke.

Symptoms. Acute, painful spasms of the voluntary muscles (e.g., abdomen and extremities).

Treatment. Remove victim to a cool area and loosen clothing. Have victim drink one to two cups of water immediately and every 20 minutes thereafter until the symptoms subside. Consult a physician.

7.12.4 Heat Exhaustion

Description. Heat exhaustion is a state of very definite weakness or exhaustion caused by the loss of fluids from the body. This condition is more severe than heat cramps.

Symptoms. Pale, clammy, moist skin with profuse perspiration and extreme weakness. Body temperature is generally normal, but the pulse is weak and rapid. Breathing is shallow. The victim may show signs of dizziness and may vomit.

Treatment. Remove the victim to a cool, air-conditioned atmosphere. Loosen clothing and require the victim to lie in a flat position with the feet slightly elevated. Have the victim drink one to two cups of water immediately and every 20 minutes until the symptoms subside. Seek medical attention, particularly in severe situations.

7.12.5 Heat Stroke

Description. Heat stroke is an acute, dangerous situation. It can happen in a very short time. The victim's temperature control system shuts down completely, resulting in a rise in body core temperature to levels that can cause brain damage and can be fatal if not treated promptly and effectively.

Symptoms. Red, hot, dry skin, with no perspiring. Rapid respiration, high pulse rate, and extremely high body temperature.

Treatment. Cool the victim quickly. If the body temperature is not brought down quickly, permanent brain damage or death can result. The victim should be soaked in cool water. Get medical attention as soon as possible.

7.12.6 Preventive Measures

A number of steps can be taken to minimize the potential for heat stress disorders.

- Acclimate employees to working conditions by slowly increasing work loads over extended periods of time. Do not begin site work activities with the most demanding physical expenditures.

- As practicable, conduct strenuous activities during cooler portions of the day, such as early morning or early evening.

- Provide employees with lots of tempered water and encourage them to drink it throughout the work shift; discourage the use of alcohol during nonworking hours. It is essential that fluids lost through perspiration be replenished. Total water consumption should equal one to two gal/day.

- During hot periods, rotate employees wearing impervious clothing.

- Provide cooling devices as appropriate. Mobile showers and/or hose-down facilities, powered air purifying respirators, and ice vests have all proven effective in helping prevent heat stress.

7.12.7 Heat Stress Monitoring

For strenuous field activities that are part of ongoing site activities in hot weather, site-specific procedures are used to monitor the body's physiological response to heat. These procedures will be implemented when employees are required to wear impervious clothing in atmospheres exceeding 70˚F.

The guidelines set forth in the current issue of the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values and Biological Indices shall be used to determine the work/rest regimen for working in environments conducive to heat stress.

7.12.8 Cold Stress

Persons working outdoors in low temperatures, especially at or below freezing, are subject to cold stress disorders. Exposure to extreme cold for even a short period of time can cause severe injury to the body surfaces and/or profound cooling, which can lead to death. Areas of the body that have high surface-area-to-volume ratios, such as fingers, toes, and ears, are the most susceptible.

Two basic types of cold disorders exist: localized (e.g., frostbite) and generalized (e.g., hypothermia). The descriptions, symptoms, and treatments for frostbite and hypothermia are provided below.

7.12.9 Frostbite

Description. Frostbite is a condition in which the fluids around the cells of body tissues freeze, damaging the tissues. The most vulnerable parts of the body are the nose, cheeks, ears, fingers, and toes.

Symptoms. Affected areas become white and firm.

Treatment. Get the individual to a warm environment and rewarm the areas quickly. Keep affected areas covered and warm. Warm water can be used to thaw the areas.

7.12.10 Hypothermia

Description. As the temperature of the body drops, the thermoregulatory system attempts to increase the body's generation of heat, blood vessels are constricted to conserve energy, and glucose is produced to increase the body's metabolic rate (i.e., glucose is used as fuel to generate heat).

Symptoms. Uncontrollable shivering with the sensation of cold. Slower heartbeat and weaker pulse.

Treatment. Get individual to a warm environment.

7.12.11 Preventive Measures

A number of steps can be taken to minimize the potential for cold stress.

- Individuals can achieve a certain degree of acclimation when working in cold environments as they can for warm environments. The body will undergo some changes that increase the body's comfort and reduce the risk of cold injury.

- Working in cold environments causes significant water losses through the skin and the lungs as a result of the dryness of the air. Increased fluid intake is essential to prevent dehydration, which affects the flow of blood to the extremities and increases the risk of cold injury. Warm drinks or soups should be readily available.

- The skin should not be continuously exposed to subzero temperatures.

7.12.12 Cold Stress Monitoring

Air temperature alone is not a sufficient criterion on which to judge the potential for cold-related disorders in a particular environment. Heat loss from convection (air movement at the surface of the skin) is probably the greatest and most deceptive factor in the loss of body heat. For this reason, wind speeds as well as air temperatures need to be considered in the evaluation of the potential for cold stress disorders. The ACGIH Threshold Limit Values and Biological Indices provide additional guidance on cold stress evaluation and the establishment of the work/rest regimen in environments conducive to cold stress.

7.13 HOUSEKEEPING

Work zones shall be picked up and wastes and debris will be properly stored. Tools, materials, welding leads, hoses, or debris shall not be strewn about in a manner that may cause tripping or other hazards. Stored material shall be placed and otherwise secured against sliding or collapse. All slip, trip, and fall hazards will be eliminated or adequately barricaded or marked.

7.14 HEARING CONSERVATION

- Exposures to noise levels greater than 85 decibels (A-weighting filter) (dBAs) will require hearing protection.
- Noise reduction ratings of hearing protection must be sufficient to reduce exposure to less than 85 dBAs.
- No unprotected exposure to noise levels greater than 115 dBAs will be allowed.
- Employees exposed to noise in excess of a time-weighted average of 85 dBAs must have annual audiograms.
- Engineering controls shall be used when possible to restrict noise to less than 85 dBAs.
- Areas with noise levels above 85 dBAs will be posted.

7.15 PERSONNEL DECONTAMINATION

Decontamination procedures will vary with different stages of work and with work conditions. The Safety and Health Specialist and Radiation Control Technician (RCT) will determine decontamination requirements to minimize potential for spread of contamination from work zones.

7.16 EXPOSURE MONITORING

Air monitoring shall be used to identify and quantify airborne levels of hazardous substances and health hazards in order to determine the appropriate level of employee protection needed on-site.

7.16.1 Routine Air Monitoring Requirements

Air monitoring will be performed during the following activities:

- Intrusive activities such as drilling and opening sampling tubes;
- Work begins on a different portion of the site;
- Contaminants other than those previously identified are being handled;
- A different type of operation is initiated; or
- Personnel are opening drums that contain material.

7.16.2 Site-Specific Air Monitoring Requirements

Measurements of airborne VOCs (primarily TCE) will be conducted in the work area during intrusive activities by using PID or equivalent. VOC monitoring primarily will be focused on the breathing zones of employees. Air monitoring results will be used to determine the effectiveness and/or need for control measures.

7.16.3 Time Integrated Sample Collection

Verification sampling will be completed for VOCs and potentially specific contaminants of concern. Integrated sampling methodology will be evaluated by the Safety and Health Manager and may be revised during the course of work based on real-time monitoring/sampling results and changing site conditions.

7.17 RADIOLOGICAL PROTECTION

The radiological contaminant of concern is technetium-99 (^{99}Tc). Due to varying levels of ^{99}Tc some work may be performed under an RWP.

7.17.1 Radiation Protection Plan

All workers will operate under the DOE-approved Radiological Protection Program (RPP) when performing activities where a potential hazard is posed by radiation exposure. The DOE Contractor will assess all radiological hazards that may be encountered. This has been accomplished primarily through the preparation of this HASP. Based on these evaluation activities, appropriate engineering, administrative, and PPE controls will be selected and implemented. Whenever possible, work will be arranged to avoid (or at least minimize) entry into radiological areas. The radiation safety work practices focus on establishing controls and procedures for conducting work with radioactive material, while maintaining radiation exposures as low as reasonably achievable (ALARA).

All work associated with radiological issues will be conducted in accordance with the RPP, and, as a result, the DOE Contractor will provide radiological support services activities with potential radiation exposure. RCTs also may perform surveys and monitoring, coordinate dose assessments, identify radiological areas, and prepare Radiation Work Authorizations or RWPs. All subcontractors will implement and maintain any controls identified as a result of these services.

7.17.2 Contractor/Subcontractor Responsibilities

The DOE Contractor and subcontractor responsibilities may include the following:

- Provide and erect any radiological barriers, barricades, warning devices, or locks needed to safely control the work site.

- Follow the requirements of the RWPs, including daily briefings, and requirements for signing in on all RWPs.
- Submit bioassay samples and use external dosimeters.
- Notify the C-400 IRA Project Manager after any employee declares a pregnancy.
- Establish radiation control measures that comply with the requirements specified by radiological personnel supporting the project.
- Determine required radiological PPE based on appropriate work processes and AHAs.

7.17.3 Site-Specific Radiation Safety Work Practices

The DOE Contractor and all subcontractors will implement the following radiation safety work practices when working in radiological areas:

- All personnel will adhere to the action levels and hold points identified in the RWP addressing the potential radiological hazards posed by work activities. Work practices and PPE will be altered according to changing radiological requirements as prescribed by the RWP and/or the RCT.
- All work activities to be performed will be designed and performed ensuring minimization of material brought into the Radiological Areas. Management, design engineers, and field personnel will jointly identify the materials and equipment needed to perform this work. Only equipment and supplies necessary to successfully accomplish the various tasks to be performed will be taken into the EZ. Work also will be planned and conducted in a manner that minimizes the generation of waste materials. All activities will be designed, before commencement of field activity to maintain radiation exposures and releases ALARA. Emphasis will be placed on engineering and administrative controls over the use of PPE, when feasible.
- All personnel working in, or subject to, work in the Radiological Areas will read the applicable RWP. The RCT or the Safety and Health Specialist also will verbally review the RWP during the initial pre-work safety briefing. The Site Superintendent, the RCT and the Safety and Health Specialist will continuously monitor worker compliance with the RWP. The Site Superintendent and/or the Safety and Health Specialist will communicate changes to the RWP immediately to all affected personnel, and work practices will be changed accordingly. Radiological controls specified by the RWP, such as PPE and work activity hold points, will be reviewed during "tailgate" safety briefings.
- Engineering and administrative controls will be utilized to minimize and control the spread of airborne and surface contamination. If airborne contamination is identified, water mist will be used to eliminate or reduce this hazard. The contaminated water will be contained by plastic sheeting covering the work area. Surface contamination, in the form of waste, will be properly containerized throughout the project.
- Personnel will be instructed in the proper use and care of external dosimeters before commencement of field activities and periodically during pre-work tailgate briefings. Personnel will be instructed to wear the dosimeters only during activities posing an occupational ionizing radiation exposure. This will include all field activities. Personnel will be instructed to wear their dosimeters outside of company clothing in the front torso area of the body. They are not to expose the dosimeters to excessive heat or moisture. Dosimeters must be exchanged on a quarterly basis.

- All personnel will participate in the DOE Contractor Bioassay Program. All personnel may be required to submit a baseline bioassay sample before receiving an external dosimeter and participating in any fieldwork. Periodic bioassays also will be submitted in a timely manner as directed by the radiological control organization. Personnel not complying with these requirements will be subject to removal from the project.

- The Site Superintendent and the Safety and Health Specialist will conduct a continuous observance of work in progress and of field personnel performance with respect to ALARA. Additional reviews of performance will be discussed during "tailgate" safety meetings with all field personnel.

- Applicable lessons learned will be reviewed with personnel during the project. Work practices will be modified to incorporate lessons learned. A post-job ALARA review will be conducted by the Safety and Health Specialist with input from the RCT, Site Superintendent, and field personnel.

7.17.4 Radiation Safety Training

The DOE Contractor and all personnel will observe the radiological training requirements, which require GET and Radworker II Training for all general employees who will perform hands-on work in radiological areas. The applicability of this training will be determined for each activity. Personnel, including visitors who are not necessary to the performance of the scope of work and who are not appropriately trained and qualified, will not enter any work areas where radiological exposures may occur. In areas where visitors are essential or otherwise approved to be present, they will be restricted from Contamination Areas, High Contamination Areas, High Radiation Areas, Very High Radiation Areas, or Airborne Radiation Areas. In all other radiological areas, visitors may be present only if escorted by a qualified radiological worker and will perform no hands-on activities.

7.18 HOISTING AND RIGGING PRACTICES

All hoisting and rigging will meet the DOE Contractor hoisting and rigging requirements, in PRS-WCE-0012, *Hoisting and Rigging Operations,* as well as those in OSHA 1926, Subpart N, OSHA 1910.180, OSHA 1910.184, and OSHA 1926.602. Hoisting and rigging equipment will not be modified such that manufacturer's specifications are invalidated.

In order to ensure that personnel are not injured or equipment is not damaged during hoisting and rigging operations, the following safe working guidelines will be utilized. These guidelines include those outlined in OSHA and DOE Hoisting and Rigging Standard DOE-STD-1090-2007. The Safety and Health Specialist or designee will be on-site during all lifting activities.

7.18.1 General

Hoisting and rigging activities will be reviewed to determine their classification according to the following definitions.

- Critical Lifts – A lift is classified as Critical if any of the following conditions are met:

    a. A dropped, damaged, or mishandled load would result in a significant release of radioactive or hazardous material to the environment.

    b. If lost, replacement of the load item would affect Facility Safety or put the Project at risk of exceeding financial and/or schedule obligations.

c. A mishandled load would result in damage to adjacent equipment or structures that would affect Facility Safety or put the Project at risk of exceeding financial and/or schedule obligations.

d. The lift presents a significant risk of injury to personnel that cannot be mitigated.

e. Load weighs in excess of 50 tons

f. If selected lifting equipment is to be used in excess of 90% of its rated capacity as configured for the lift. (This includes test lifts.)

g. The lift is adjacent to mechanical or electrical energy sources that cannot be locked out or de-energized.

h. The lift requires the use of multiple pieces of lifting equipment (cranes, forklifts, excavators, etc.).

i. The lift involves lifting personnel in a man basket.

- Pre-engineered Production Lifts – A Pre-engineered Production Lift is a repetitive, production-type lifting operation of less than 50 tons. Each Item to be lifted should be substantially similar so that a single assessment of weight, load center, and means of attaching the load are common to all. The probability of collision, up-set, or dropping has been reduced to a level acceptable to the responsible manager by preliminary operation evaluation, specialized lifting fixtures, detailed procedures, operation-specific training, and performance of an independent review of the entire process. Pre-engineered Production Lifts require the approval of the Project Manager as well as the Engineering Manager or designee.

- Ordinary Lifts – All lifts that are not classified as Critical or Pre-engineered Production Lifts are classified as Ordinary Lifts.

7.18.2 Hoisting

Only designated and qualified personnel will operate hoisting equipment. Hoisting operators will be in visual or radio contact with a flag person before and during every lift. If visual or radio contact is interrupted for any reason, the operator will stop the lift until full contact is restored.

- The equipment will be capable, within the manufacturer's specifications, of fulfilling all requirements of the work without endangering personnel or equipment.

- Equipment with outriggers will have the outriggers fully extended and set before all lifts.

- Before lifting, operators will know the total weight of the load.

- The operator will check the load line brake and crane for stability when the load is only inches from the ground. This lift of a few inches will be considered a "trial lift."

- A suspended load never will be left unattended. An operator will not leave the control station of a crane during a lift except under the conditions listed here.

- Personnel will not stand or pass under suspended loads.

- A tag line(s) will be used as necessary will be used to adequately control the load while landing.

- A crane load chart for the crane, as configured, will be posted in the cab of each crane, along with the rated load capacities, recommended operation speeds, and special hazard warnings or instructions.

- Cranes will be inspected in accordance with the guidelines provided below:

  — Applicable American Society of Mechanical Engineers (ASME) B30-series daily, monthly, quarterly, semiannual, annual, and special inspections will be completed before any crane is operated.

  — The annual certification sticker will be prominently displayed on the crane, but in such a manner that it does not obstruct the operator's view of any work operation.

  — Borrowed, rented, or leased cranes will be inspected before on-site use by the qualified crane inspector regardless of any other signed inspection forms.

- Hoisting and rigging equipment associated with drilling operations are subject to visual on-site hoisting and rigging hardware/device inspections by the DOE Contractor. Drill rig hoisting and rigging equipment will be inspected prior to its use by a competent person. Operations will be suspended if not in compliance with OSHA, DOE or PRS-WCE-0012, *Hoisting and Rigging Operations*.

7.18.3 Rigging

- Rigging equipment for material handling will be visually inspected before use and as necessary during its use to ensure that it is safe. Defective rigging equipment will be removed from service immediately. Inspections will be performed by a competent person who, by training or experience, can recognize defects and take appropriate action to correct them. Periodic inspection of rigging equipment will be performed and documented on a written checklist, signed, and dated. Periodic inspections are not to exceed one year. Defective rigging equipment shall be removed from service per PRS-ESH-2001, *Identifying Defective Equipment.*

- Rigging equipment will be identified and marked in accordance with ASME B30 series. Rigging equipment will not be loaded in excess of its recommended safe working load, as prescribed in Tables H-1 through H-20 of OSHA 29 *CFR* § 1926 Subpart H (29 *CFR* § 1926.251, "Rigging Equipment for Material Handling").

- Rigging equipment will be stored in designated areas where it will not be exposed to mechanical damage, corrosive material, moisture, kinking, or extreme temperatures.

- Any non-off-the-shelf, below-the-hook lifting device (lift beam, spreader, rod-clamp, etc.) rigging apparatus or component shall be designed, constructed, tested, and inspected in accordance with ASME B30.20.

8. SAMPLING AND ANALYSIS

8.1 BASELINE AND POST-OPERATION SAMPLING AND ANALYSIS PLAN

The Project Team will perform sampling work in accordance with PRS-approved procedures and work instructions. Procedures related to the sample collection are listed below. Additional procedures are referenced in Section 4, Table 4.

- PRS-ENM-0018, *Sampling Containerized Waste*
- PRS-ENM-0021, *Temperature Control for Sample Storage*
- PRS-ENM-0023, *Composite Sampling*
- PRS-ENM-2101, *Groundwater Sampling*
- PRS-ENM-2300, *Collection of Soil Samples*
- PRS-ENM-2303, *Borehole Logging*
- PRS-ENM-2700, *Logbooks and Data Forms*
- PRS-ENM-2702, *Decontamination of Sampling Equipment and Devices*
- PRS-ENM-2704, *Trip, Equipment, and Field Blank Preparation*
- PRS-ENM-2708, *Chain-of-Custody Forms, Field Sample Logs, Sample Labels, and Custody Seals*
- PRS-ENM-5003, *Quality Assured Data*
- PRS-ENM-5004, *Sample Tracking, Lab Coordination, & Sample Handling Guidance*
- PRS-WSD-9503, *Off-Site Sample Shipping*

8.1.1 Purpose

This plan describes soil and groundwater sampling to support analysis of the percent reduction of VOCs as a result of the C-400 IRA. Baseline and post-operational TCE and TCE degradation product concentrations will be used as an indicator of the reduction of these VOCs.

The primary means to assess the removal efficiency of TCE in the UCRS and RGA will be a comparison of baseline and post-operational soil sampling results. This sampling plan targets silt and sand units in the UCRS and sand lenses in the RGA. Clay and gravel members of the UCRS are less likely to be represented adequately by a single sample. The collection of representative soil samples from the RGA is problematic. As RGA soil samples are extracted, the escaping water column in the sample system tends to "wash" the soil samples. Sand intervals will be preferentially sampled as sand samples are more likely to retain representative TCE contaminant levels. Field scans of VOC levels (e.g., via PID) will be used to identify sands with highest levels of contamination for sampling.

Samples also will be collected from cores taken from the upper McNairy Formation to assess baseline and post-operations contaminant levels. These samples will undergo definitive analyses at a fixed-based laboratory.

The ERH electrode array consists of 110 electrode locations to address the three treatment areas on the southwest, southeast, and east sides of C-400. Electrode borings will be used to collect soil samples to determine the concentrations of TCE and TCE degradation products in the soil prior to the operation of the ERH electrodes. Collocated samples, collected from adjacent soil borings, will be used to determine the residual TCE concentrations subsequent to the operation of the ERH electrodes.

Groundwater wells that are part of the ERH system will be used to characterize TCE concentrations in groundwater before and after operation of the ERH system as a secondary indicator of TCE removal efficiency in the RGA. UCRS wells will most likely not yield groundwater after the ERH heating period because of temporarily reduced UCRS water saturation.

8.1.2 Introduction to the Data Quality Objective Process:

The data quality objective (DQO) process is a strategic planning approach based on the scientific method to prepare for a data collection activity. It consists of the seven key elements listed as follows:

- State the Problem
- Identify Decisions
- Identify Inputs
- Specify Boundaries
- Define Decision Rules
- Specify Error Tolerances
- Optimize Sample Design

The DQO Process, as it applies to this sampling and analysis plan, is summarized in the following text.

State the Problem:

The problem statement is as follows:

> *The efficacy of the ERH method on VOC mass removal must be determined. In order to assess the effectiveness of ERH in its application in the soils south of the C-400 Building, soil and groundwater samples will be collected and analyzed for a comparison of VOC levels in soil and groundwater of the treatment areas before and after application of ERH.*

Both soil and groundwater are useful media for the characterization of VOC presence and levels in the treatment areas. Soil samples potentially offer the best characterization of the mass of DNAPL present (DNAPL will be present in the soil samples as sorbed mass and as free-phase DNAPL contained in the soil pores); however, the collection of representative soil samples from the RGA is problematic. As the coarse sand and gravel samples of the RGA are recovered from depth, the overlying water column in the sampling system tends to "wash" the soil sample as it is withdrawn. This problem will tend to bias low the estimate of DNAPL mass that is present in the soil samples. Assuming that the application of ERH is successful, the bias is likely to be greatest in the soil samples collected prior to implementation of ERH, when the DNAPL mass is greatest and sorption is less affective. Thus, the comparison of VOC levels in collocated soil samples collected before and after ERH implementation will be a lower bounds on the effectiveness of the reduction of VOCs.

Within the treatment areas, the mass of VOCs dissolved in groundwater are limited by the solubility of the VOC constituents and other dissolved constituents in water and may not be representative of the mass of DNAPL present. Because VOC levels typically diffuse more readily in water than in soils, the water samples should provide a reasonable assessment of the presence of DNAPL in the vicinity of the water samples.

The analytes for soil and groundwater samples that will support the assessment of the percent reduction for the C-400 remedial action are TCE and its intermediate, reductive dechlorination[7] degradation

[7] Reductive dechlorination is not expected to be an active process in the aerobic groundwater of the treatment areas; however, lesser levels of these VOCs have been detected in samples of soil and groundwater from south of the C-400 Building. Intermediate products of other degradation pathways typically are short-lived.

products. These are as follows: 1,1-DCE; *cis*-1,2-DCE; *trans*-1,2-DCE; and vinyl chloride. These analyses will be performed using method SW-846, with a reporting limit of 10 µg/kg per analyte for soils and 5 µg/L per analyte for groundwater. These samples will be planned through the Paducah SMO and sent to a SMO-approved laboratory that has been audited under the DOE–Consolidated Audit Program (DOECAP), and if required, is certified by Kentucky Department for Environmental Protection (KDEP) to perform the requested analyses.

Identify Decisions:

The principal study question and associated alternative actions and decision rule typically are identified in this section. However, no decisions within the scope of this IRA will be made with the data. Rather the data will be analyzed to indicate the percent reduction in the VOC concentrations in the area. Therefore, only a principal study question will be defined in this section. It is inappropriate to define either Alternative Actions or a Decision Statement when no decisions are to be made with the data. The principal study question associated with this project is as follows:

What is the percent reduction in VOC levels in the C-400 Cleaning Building Area?

Identify Inputs:

The Study Inputs are identification and quantification of VOCs in groundwater and soils in the area south of the C-400 Cleaning Building area prior to and after the implementation of ERH.

Specify Boundaries:

The boundaries of the study are the soils and groundwater associated with the C-400 Cleaning Building. Three areas will be sampled within this boundary: the soils and groundwater associated with the East Treatment Area (including the SWMU 11 TCE Leak Site), the Southeast Treatment Area, and the Southwest Treatment Area. Soil cores up to 3 ft into the McNairy Formation will be sampled during installation of select subsurface components.[8] The field test process for the presence of DNAPL will be (1) a survey of the McNairy soil core with a field PID to target areas with greatest TCE level, followed by (2) an assessment of the presence of DNAPL using a TCE DNAPL test dye. If DNAPL is present in this additional 3 ft soil cores, adjustments to electrode depths will be made as shown in the D2 RDR, to ensure the additional 3 ft interval is appropriately heated. The boundaries for each area of interest are further defined below:

- East Treatment Area – soils 20-60 ft bgs (20-80 ft bgs at location E095) and groundwater 60-100 ft bgs.[9]
- Southeast Treatment Area – soils 20-100 bgs and groundwater 60-100 bgs.
- Southwest Treatment Area – soils 20-100 ft bgs and groundwater 60-100 bgs.

Each area is more clearly identified in Figure 13. Percent reduction in VOC levels will be calculated separately for each area.

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[8] The shallow McNairy soil will be field characterized using TCE DNAPL test dye in all borings where deep RGA soil and water samples are scheduled, excluding MW155 and MW156 (see Tables 6 and 7).

[9] In addition, wells MW155 (screened over the interval 87-92 ft bgs) and MW156 (screened over the interval 63-70 ft bgs) will be used to characterize TCE levels before and after ERH operation.

The temporal boundaries also must be defined. The collection of post-ERH soil and groundwater samples will begin as soon as temperatures within the subsurface treatment zone decline to a safe level for sampling as determined by the *in situ* temperature monitoring system. It is anticipated that the sample collection will commence approximately one month after the end of ERH operation.

Define Decision Rules:

The parameter of interest in this study is the mean difference in concentrations of VOCs prior to ERH operation and after ERH operation. These values will be used as an indicator of the percent reduction in VOC levels due to ERH. Because no decision will be made regarding this data it is inappropriate to define decision rules. Water samples collected pretreatment and posttreatment will be compared to a standard of 11,000 ppb TCE (general industry standard for the assessment of TCE DNAPL) to evaluate the presence of DNAPL.

Specify Error Tolerances:

This step of the DQO process includes the development of statistical hypotheses, decision rules, and the definition of appropriate error rates the decision errors. The overall effectiveness of the treatment system will be evaluated by comparing soil analyses of the pretreatment sampling results to the posttreatment sampling results for each of three treatment areas. An upper and lower bound for the pretreatment and posttreatment concentration values from the soil samples for each of the treatment areas, for each of the detected VOCs (e.g. TCE, *cis*-1,2-DCE, vinyl chloride), will be estimated by establishing a 90% confidence interval for the variance for each treatment area. After the intervals have been constructed, the upper tolerance level for the pretreatment sampling results will be compared by inspection with the upper tolerance level for the posttreatment sampling result within each treatment area (for each VOC) as one measure of the effectiveness of the IRA. The assessment of the reduction of VOCs will report the error tolerances of the data set for each treatment area.

Optimize Sampling Design:

This step is used to optimize sampling design. Sample locations were distributed across the three treatment areas based on professional judgment and biased to provide similar sample "coverage" in each of the treatment areas. The derived number of sample locations was independent of assumptions that would be required to support a statistical evaluation.

The distribution of DNAPL in subsurface soils is extremely heterogeneous and varies in response to depositional/erosional structures; textures resulting from subsequent chemical, physical, and biological processes; and the location, mass, and timing of the DNAPL release(s). TCE was the primary contaminant released into the soils south of the C-400 Cleaning Building. Subsequent degradation has resulted in lesser levels of other VOCs within the DNAPL. It is anticipated that VOC levels in soils collected from the pre-ERH operation period will vary significantly across the treatment areas and that the comparable, post-ERH operation period VOC levels will exhibit much less variability. The average and median of the measured VOC reductions[10] will be used as indicators of the removal effectiveness of the C-400 remedial action. While the mass of VOCs that are removed will be determined, the mass of VOCs that are present in the treatment areas prior to ERH operation can be approximated only poorly. The average of the VOC reductions in collocated samples will assess the overall efficiency of the ERH operations, while the

[10] The VOC reduction will be calculated for each pair of collocated samples by subtracting from one the fraction derived by dividing the post-ERH operation VOC level by the pre-ERH operation VOC level.

median of the VOC reductions in collocated samples will assess the typical efficiency of the ERH operations within the volume of the treatment zone.

VOC levels in groundwater samples will likely exhibit much less variability. Groundwater sample results will be used as a qualitative measure of the continuing presence of DNAPL following the application of ERH. Trends based on subsequent groundwater monitoring in the years following the ERH action can be used to assess the occurrence of rebound of TCE.

The C-400 Building has been the site of numerous chemical and operational processes in support of the plant. Sample analyses from a previous remedial investigation of the C-400 area identify polychlorinated biphenyls (PCBs) and semivolatile organic compounds (SVOCs) as possible co-contaminants associated with the DNAPL source zones at PGDP. Each of the soil samples collected for characterization of post-operational VOC levels and one of the groundwater samples from each sampling location collected for characterization of post operation VOC levels will also be analyzed for PCB and SVOC levels.

Sample locations are based on a hexagonal grid design; however, not all of the locations on the hexagonal grid will be sampled. The sample locations were determined by judgment, biased to the interior of the treatment areas where the VOC mass is anticipated to be greater. These analyses likely will provide a more significant measure of the removal effectiveness of the C-400 remedial action. Some sample locations have been retained on the perimeter of the treatment areas to assess removal effectiveness in these areas. Sample locations are documented in the following section.

8.1.3 Locations

8.1.3.1 Soil

Baseline soil sampling will be performed in accordance with procedure PRS-ENM-2300, *Collection of Soil Samples.* Soil core from a rotary sonic drill rig will be sampled to characterize baseline VOC levels. The rotary sonic drill rig will collect soil core in a flexible clear plastic liner that will be cut open for soil sampling once the liner has been extracted.

Collection of post-operation soil samples will be performed soon after subsurface temperatures decline below 100 ºC (approximately one month after ERH operation ends) using a direct push technology (DPT) sample system. The DPT soil samples will be collected in stainless steel liners. High residual heat of soil samples collected after ERH operation presents additional challenge to the samplers. Post-operation soil sampling will be performed in accordance with procedure PRS-ENM-2300, *Collection of Soil Samples,* with the additional steps that follow. The following steps for high temperature soil sampling will be used to supplement PRS sampling procedure. The field crew will cap the ends of the stainless steel liners and submerge them in an ice bath to lower the soil temperature and minimize the off-gassing of VOCs[11] before collecting the sample. The stainless steel liner will be removed from the bath, cut open, and then the sample will be collected following PRS sampling procedures. If the DPT system is not able to complete the post-operation sampling to the required depth, then appropriate drilling techniques and equipment will be deployed for collection of these soil samples.

In the UCRS and upper McNairy Formation cores, the selection of the sample interval will be biased to characterize zones of highest VOC level, as determined by field monitoring instruments (e.g., PID). In the RGA core, sand intervals with high VOC levels will be selectively sampled. A sand matrix is more readily sampled, especially with DPT, and analyzed than the gravels common to the RGA. In the UCRS,

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[11] It is anticipated that VOC vapors will condense inside the sample and will be captured in the laboratory sample.

RGA, and upper McNairy cores, a grab sample from the selected sample interval will be collected as soon as possible after the core liner is cut open, without compositing a sample. A stainless steel spatula or scoop will be used to sample the core, packing the sample in a 60 mL glass vial with septum seal. Samples will be preserved by cooling them to 4 °C ± 2 °C in a sample cooler or refrigerator.

The selected locations for the collection of soil samples address the full areal and vertical extent of the TCE contamination, with a bias to characterization of the centroids of contamination. For the purpose of the electrode design, the TCE soil contamination is defined as shallow, middle, and deep UCRS and shallow and deep RGA. This plan specifies the collection of soil samples from all heated intervals in 56 selected locations. Table 6 summarizes the distribution of the selected sampling intervals.

Table 6. Soil Sampling Summary

CONTAMINATION AREA	**TOTAL # of BORINGS**	**UCRS**			**RGA**		**McNAIRY**
		SHALLOW (20 – 35 ft bgs)	MIDDLE (35-45 ft bgs)	DEEP (52-60 ft bgs)	SHALLOW (60-80 ft bgs)	DEEP (80-100 ft bgs)	SHALLOW (100-103 ft bgs)
Southwest	15	15	15	9	8	8	8
Southeast	29	21	21	20	26	26	26
East	12	8	12	3	1	0	0

The characterization plan specifies 227 soil sample locations. Table 7 provides further details of the soil sample intervals. The field sampling crew will use VOC scans (e.g., PID) of the soil cores to target sand intervals with the highest VOC levels for sampling.

Table 7. Design of the Soil Sampling Plan

LOCATION ID	**AREA**	**ADJACENT MIP BORING**	**SAMPLE DEPTH INTERVAL**					
			UCRS			RGA		McNAIRY
			Shallow	Middle	Deep	Shallow	Deep	Shallow
E003	Southwest	MIP-08	X	X	--	--	--	--
E006	Southwest	--	X	X	X	X	X	X
E007	Southwest	--	X	X	X	X	X	X
E009	Southwest	MIP-03	X	X	--	--	--	--
E010	Southwest	--	X	X	X	X	X	X
E011	Southwest	MIP-04	X	X	X	X	X	X
E012	Southwest	--	X	X	X	X	X	X
E013	Southwest	--	X	X	--	--	--	--
E016	Southwest	--	X	X	--	--	--	--
E017	Southwest	--	X	X	X	X	X	X
E018	Southwest	--	X	X	X	X	X	X
E019	Southwest	MIP-07	X	X	X	--	--	--
E020	Southwest	--	X	X	--	--	--	--
E026	Southwest	--	X	X	--	--	--	--
X06	Southwest	--	X	X	X	X	X	X
DV06	Southeast	MIP-44	X	X	X	X	X	X
E030	Southeast	--	--	--	--	X	X	X
E031	Southeast	--	--	--	--	X	X	X
E032	Southeast	--	--	--	--	X	X	X
E036	Southeast	--	--	--	--	X	X	X

Table 7. Design of the Soil Sampling Plan (Continued)

LOCATION ID	AREA	ADJACENT MIP BORING	SAMPLE DEPTH INTERVAL					
			UCRS			RGA		McNAIRY
			Shallow	Middle	Deep	Shallow	Deep	Shallow
E037	Southeast	--	--	--	--	X	X	X
E044	Southeast	MIP-14	--	--	--	X	X	X
E045	Southeast	--	--	--	X	X	X	X
E046	Southeast	MIP-17	--	--	X	X	X	X
E047	Southeast	MIP-17*	X	X	X	X	X	X
E048	Southeast	MIP-25	X	X	X	X	X	X
E053	Southeast	--	X	X	X	X	X	X
E054	Southeast	--	X	X	X	X	X	X
E055	Southeast	--	X	X	X	X	X	X
E059	Southeast	MIP-13	X	X	X	X	X	X
E060	Southeast	--	X	X	X	X	X	X
E061	Southeast	MIP-16	X	X	X	X	X	X
E068	Southeast	--	X	X	X	X	X	X
E069	Southeast	--	X	X	X	X	X	X
E070	Southeast	--	X	X	X	X	X	X
E071	Southeast	--	X	X	X	X	X	X
E072	Southeast	MIP-24/43	X	X	X	X	X	X
E074	Southeast	--	X	X	X	X	X	X
E077	Southeast	--	X	X	X	X	X	X
E078	Southeast	--	X	X	X	X	X	X
E079	Southeast	MIP-50	X	X	X	X	X	X
E086	Southeast	--	X	X	--	--	--	--
E087	Southeast	--	X	X	--	--	--	--
E090	Southeast	MIP-15	X	X	--	--	--	--
E095	East	--	X	X	X	X	--	--
E097	East	--	--	X	--	--	--	--
E098	East	--	X	X	--	--	--	--
E099	East	--	--	X	--	--	--	--
E100	East	--	X	X	--	--	--	--
E102	East	--	X	X	--	--	--	--
E103	East	MIP-28	X	X	X	--	--	--
E104	East	--	X	X	--	--	--	--
E105	East	--	--	X	--	--	--	--
E106	East	--	X	X	--	--	--	--
E107	East	--	--	X	--	--	--	--
E110	East	MIP-27	X	X	X	--	--	--

* MIP-17 is located between E046 and E047. Groundwater

8.1.3.2 Groundwater

Baseline groundwater samples will be collected in accordance with procedure PRS-ENM-2101, *Groundwater Sampling*. Groundwater samples will be collected for analysis of VOCs in 40-mL glass vials with Teflon-lined closure, filled so no headspace remains in the vial. Samples will be preserved with hydrochloric acid to a potential of hydrogen (pH) of less than 2 and cooled to 4 °C ± 2 °C. High residual heat of groundwater samples collected after ERH operation presents additional challenge to the samplers. Post-operation groundwater sampling will be performed in accordance with procedure PRS-ENM-2101, *Groundwater Sampling,* with the additional steps that follow. The following steps for high temperature groundwater sampling will be used to supplement PRS sampling procedure. The field crew will route the sample discharge stream through a coil of copper or aluminum tubing, submerged in an ice bath, to lower the groundwater temperature before collecting the sample.

The IRA design includes 21 locations for extraction wells that are independent of the electrodes that will be used for the collection of groundwater samples. These wells provide for groundwater and vapor extraction during the ERH heating phase and allow collection of groundwater samples for characterization of dissolved TCE concentrations, both prior to and subsequent to heating the subsurface.

Each of these RGA wells will be sampled three times over a four week period before and after heating the subsurface to establish the representative dissolved TCE and TCE degradation products concentrations for each well for the period. Table 8 presents the details of the groundwater sampling plan. Figures 15 through 17 illustrate the spatial coverage of the soil and groundwater sampling plan.

Table 8. Design of the Groundwater Sampling Plan

WELL	**AREA**	**ADJACENT MIP BORING**	**RGA**		
			Shallow	Middle	Deep
X01	Southwest	--	X	X	X
X02	Southwest	--	X	X	X
X03	Southwest	--	X	--	--
X04	Southwest	--	X	X	X
X07	Southeast	MIP-48	X	--	X
X08	Southeast	--	X	X	X
X09	Southeast	--	--	--	X
X10	Southeast	--	X	X	X
X11	Southeast	--	X	X	X
X12	Southeast	--	--	--	X
X13	Southeast	MIP-17	X	--	X
X14	Southeast	--	--	--	X
X15	Southeast	--	X	X	X
X16	Southeast	--	--	--	X
X17	Southeast	MIP-16	X	X	X
X19	Southeast	--	--	--	X
X21	Southeast	--	--	--	X
X23	Southeast	--	X	X	X
X26	East	--	X	--	--
X27	East	MIP-41	X	--	--
X28	East	--	X	--	--
MW155	East	--	--	--	X
MW156	East	--	X	--	--
Total Number of Samples:(6X # of Wells)			96	54	108

Existing monitoring wells MW155 and MW156, located within the East Treatment Area, offer opportunity for additional groundwater characterization. Both of these wells are sampled twice yearly as a part of the Paducah site groundwater monitoring program. Historical sample results from these wells are available to support the evaluation of preheating VOC levels.

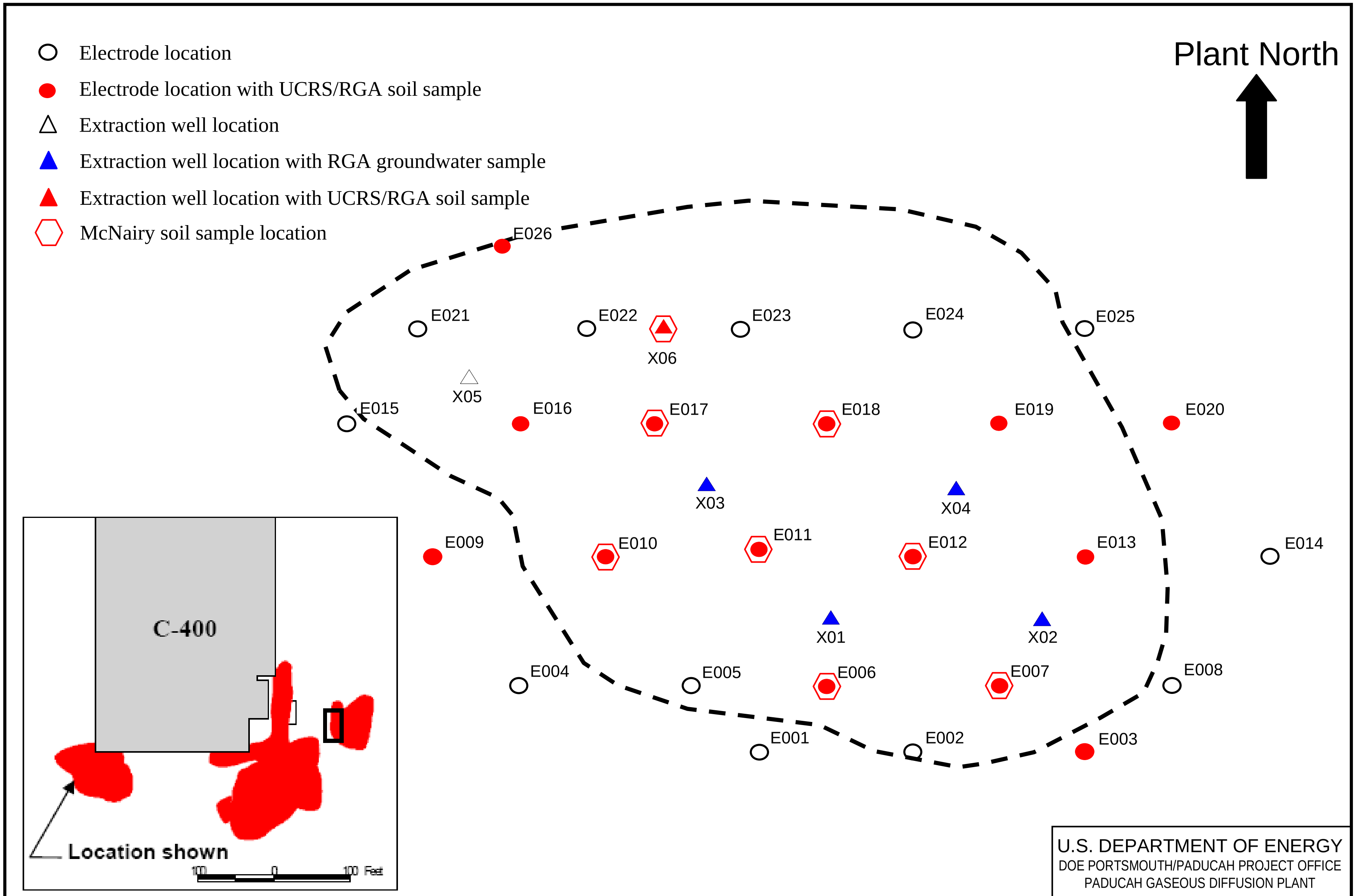

Figure 15. Sampling Plan for the Southwest Area of Contamination

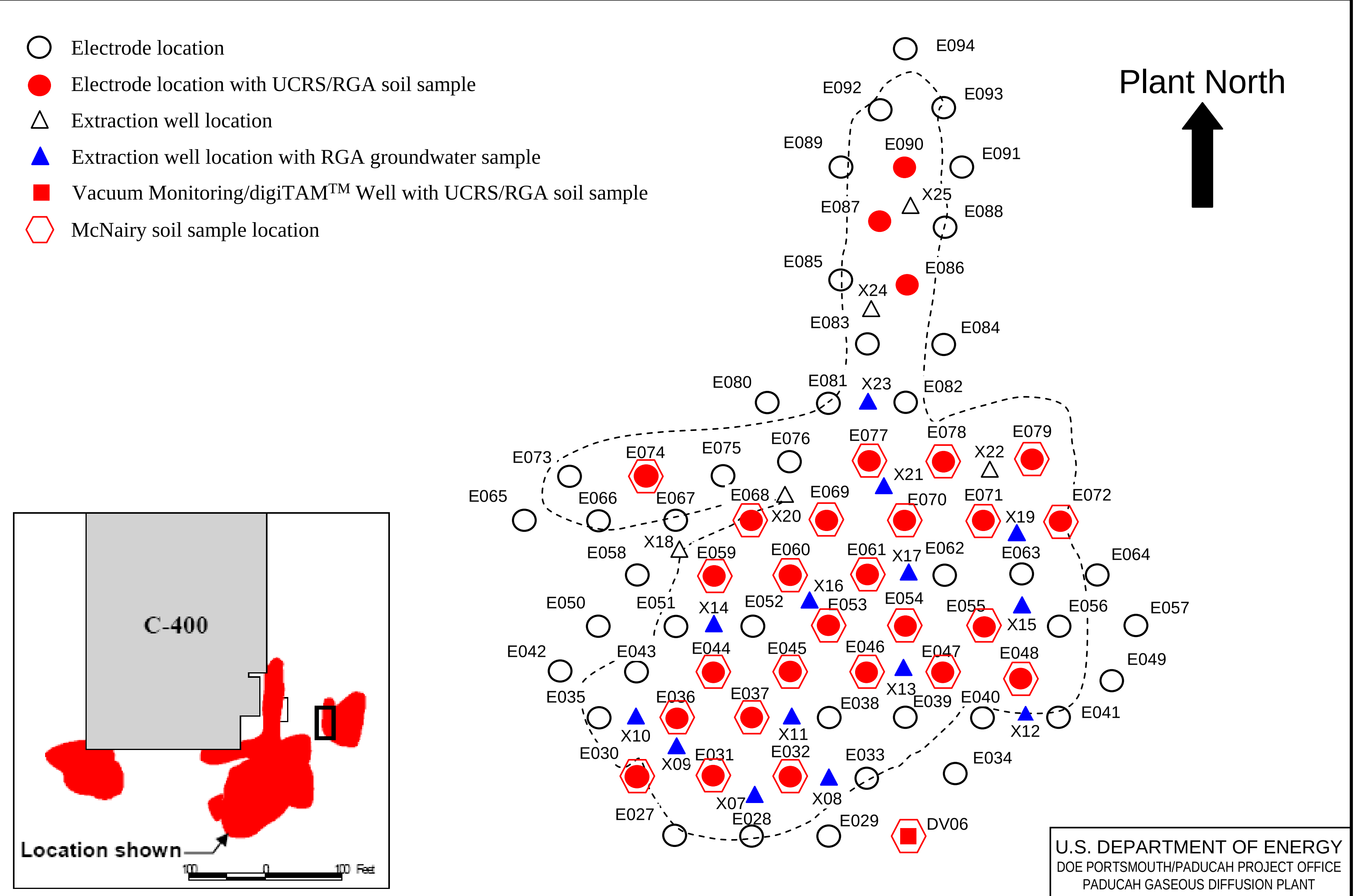

Figure 16. Sampling Plan for the Southeast Area of Contamination

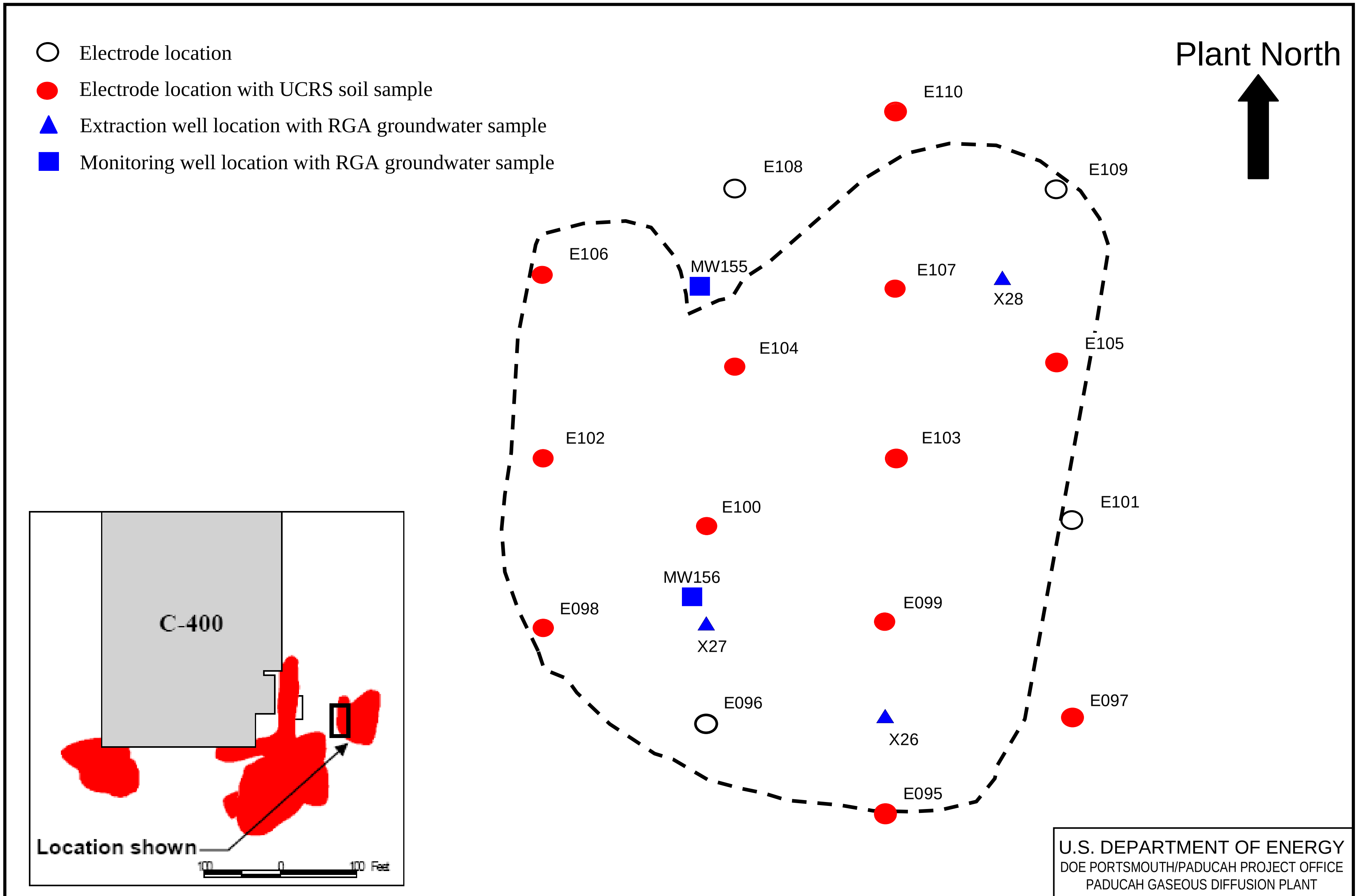

Figure 17. Sampling Plan for the SWMU 11 Area of Contamination

8.1.4 Monitoring

Additional monitoring wells will be installed near the northwest corner of the C-400 Building. These new wells will be operational before C-400 heating operations begin and will provide a meaningful tool for evaluating the downgradient dissolved-phase contamination in the Northwest Plume and the efficacy of the C-400 IRA.

MW155 (lower RGA)/MW156 (upper RGA)/MW157 (UCRS) near the southeast corner of C-400 and MW405, located on the east side of C-400, form a closely-spaced network of monitoring points just to the north of the DNAPL source zones and will provide information to assess IRA performance and near-term impact of the IRA on the dissolved-phase plume in close proximity to DNAPL zones. Long-term assessment of the C-400 IRA impact on the groundwater plumes will be provided by sampling of existing wells and installation and sampling of new wells. RGA wells MW175 (screened 75–80 ft bgs), MW342 (screened 75–85 ft bgs), and MW343 (screened 75–85 ft bgs) monitor the lower RGA along the west side of C-400 and extending north of C-400.

8.2 OPERATION AND MAINTENANCE SAMPLING

Throughout the treatment system start-up, testing, and routine operations, vapor and water samples will be collected and analyzed to assess the progress of the IRA, to monitor the above ground treatment system effectiveness, and to verify compliance with discharge criteria.

To assess the progress of the C-400 IRA, vapor samples will be collected from vapor extraction wells and vapor extraction headers coming from the treatment areas. Vapor samples will be collected periodically from various points in the vapor treatment stream to monitor the effectiveness of the treatment units. For example, samples will be collected from the lead vapor phase carbon vessel discharge to determine if and when a carbon changeout should be performed. Compliance with discharge criteria will be monitored at the vapor treatment system stack. Vapor analyses will be performed using photoacoustic analyzers and periodically by a fixed-based laboratory.

Results from groundwater samples collected at extraction wells, and as necessary from digiPAM sensor well locations throughout the treatment areas, will provide data for use in assessing the progress of the IRA. Groundwater samples collected at the digiPAM sensor locations will involve removing the digiPAM sensor and temporarily installing a sampling pump in the boring. The need for additional sample collection from digiPAM sensor locations will be a field decision made during operations. Water samples also will be collected from various sample ports throughout the groundwater treatment system in order to monitor the operational effectiveness of the treatment system. For example, results from water samples collected upstream of aqueous-phase carbon vessels will be compared to those from downstream of the carbon vessel to determine if and when a carbon changeout should take place. Samples will be collected routinely from the water treatment system effluent to monitor it for compliance with discharge criteria.

A Sampling and Analysis Plan (SAP) for operational sampling will be included in the O&M Plan to be developed and submitted for review in accordance with the planning schedule in Section 6 of this RAWP.

8.3 WASTE CHARACTERIZATION SAMPLING AND ANALYSIS PLAN

As discussed in the ROD (DOE 2005a), page A-5, a SAP is required as part of the WMP for waste characterization. This section serves as that SAP. Wastes generated from sites designated as potentially contaminated will be characterized to classify the waste for proper handling, record keeping, transfer, storage, and disposal. Waste analyses will be performed using the U.S. Environmental Protection Agency (EPA)-approved procedures, as applicable. Analyses required for hazardous waste classification will reference EPA SW-846 or other EPA-approved methods, as required. Wastewater analyses will reference the applicable analytical requirements in PGDP's KPDES permit, Clean Water Act, or Safe Drinking Water Act. QA/QC requirements and data management requirements, as specified in Sections 9 and 10 of this document, will be followed for waste characterization sampling activities.

Characterization requirements and guidance are provided in the site waste acceptance criteria (WAC) and PRS-WSD-0437, *Waste Characterization and Profiling*. Section 8.3.2 lists the analytical testing methods that will be used for analysis. The evaluation of the analytical results is discussed in Sections 9 and 10. The WMC will coordinate with the DOE prime contractor C-400 IRA project manager and DOE contractor sample and data management group for required analyses and guidance on collection and transfer of characterization samples to a SMO-approved fixed-base laboratory that has been audited under DOECAP.

8.3.1 Contained-In/Contaminated-With Determinations

Some of the waste debris, other than PPE, and environmental media such as soil and groundwater generated during this project will be characterized and the results compared to health-based standards to determine whether or not any concentrations of TCE and 1,1,1-trichloroethane (TCA) are above health-based levels listed in Table 9. If the concentrations are below the levels contained in Table 9, then the waste will be deemed not to contain or not to be contaminated with a Resource Conservation and Recovery Act (RCRA) listed waste (based on TCE/TCA content) for the purposes of management at the site.

Table 9. Health-Based Levels for TCE and 1,1,1-TCA

Constituent	Concentration in solids (ppm)	Concentration in aqueous liquids (ppb)
TCE	39.2	81
1,1,1-TCA	2080	If aqueous liquids are below health-based level for TCE, then 1,1,1-TCA is declared below contained-in levels.

ppm = parts per million   TCE = trichloroethene
ppb = parts per billion   1,1,1-TCA = trichloroethane

Because data from previous sampling events indicate that conditions for C-746-U Landfill disposal potentially will be met, characterization for C-746-U Landfill disposal will be undertaken at the same time as the sampling for the remedial action constituents. Land disposal restrictions (LDR) generally apply to media and debris generated from this project that no longer contain or are no longer contaminated with RCRA hazardous waste. If a contained in determination is made, the LDR is satisfied.

Health-based standards of 39.2 parts per million (ppm) TCE and 2,080 ppm 1,1,1-TCA in solids will be used as the criteria for making contained-in/contaminated-with determinations for environmental media and debris designated for disposal at the C-746-U Landfill. Solid wastes disposed of at landfills other than C-746-U will be subject to a contained-in/contaminated-with determination that will be approved by the commonwealth of Kentucky and the state in which the receiving landfill is located. The Kentucky Environmental and Public Protection Cabinet (KEPPC) has agreed to consult with DOE and the state where the off-site facility is located to reach agreement on the appropriate health-based standard for making such determinations for waste that is to be shipped to such a facility. Groundwater and any related aqueous wastes generated from well sampling, well development, and well purging shall be excluded from the definition of hazardous waste at the point of generation, if the TCE concentrations are below

1 ppm and the 1,1,1-TCA concentrations are below 25 ppm, provided that the subject aqueous waste will be further treated in an on-site wastewater treatment unit and discharged through a PGDP KPDES-permitted outfall consistent with 401 *KAR* 31:010, Section 3. Other aqueous environmental media waste contaminated with TCE or 1,1,1-TCA that do not qualify for the exemption cited herein will use a health-based concentration of 0.081 ppm as the criterion for making contained-in determinations for media destined for on-site treatment and discharge through a KPDES-permitted outfall. This self-implementing waste characterization and RCRA status determination will be used to decide on treatment requirements, if applicable, and the appropriate waste disposal facility for the waste. Aqueous waste (including, but not limited to, well sampling, well development, well purging, and decontamination waters) that has undergone wastewater treatment and meets the KPDES discharge limits shall be considered to "no longer contain" listed hazardous waste (i.e., TCE). This treated wastewater may be directly discharged to permitted KPDES Outfalls or on-site ditches that flow to permitted KPDES Outfalls.

In lieu of providing notification to the KEPPC as set forth in paragraph 63 of the October 3, 2003 *Agreed Order* (KNREPC 2003) (a procedural requirement), the contained-in/contaminated-with determination and supporting data will be documented in the post-ROD file and will be made available upon request for on-site inspection.

8.3.2 Waste Characterization

Waste characterization sampling will be performed in accordance with procedure PRS-WSD-0437, *Waste Characterization and Profiling.* Based on sample analyses, existing data, or process knowledge, the waste may be classified into one of the following categories:

- RCRA-listed hazardous waste
- RCRA characteristic hazardous waste
- PCB waste
- Transuranic waste (TRU)
- Low-level waste (LLW)
- Mixed waste or
- Nonhazardous solid waste

Tables 10, 11, 12, and 13 list the analytical testing methods that will be used for analysis.

Table 10. TCLP Parameters for Analysis of Solid Waste

Constituent	Method	TCLP Regulatory Limit (mg/L)	20 Times TCLP Regulatory Limit (mg/kg)
1,1-Dichloroethene	8240/8260	0.7	14
1,2-Dichloroethane	8240/8260	0.5	10
1,4-Dichlorobenzene	8270	7.5	150
2,4,5-TP (Silvex)	8150	1.0	20
2,4,5-Trichlorophenol	8270	400.0	8000
2,4,6-Trichlorophenol	8270	2.0	40
2,4-D	8150	10.0	200
2,4-Dinitrotoluene	8270	0.13	2.6
Arsenic	7060/6010/6020	5.0	100
Barium	6010/6020	100.0	2000
Benzene	8240/8260	0.5	10
Cadmium	6010/6020	1.0	20
Carbon tetrachloride	8240/8260	0.5	10

Table 10. TCLP Parameters for Analysis of Solid Waste (Continued)

Constituent	Method	TCLP Regulatory Limit (mg/L)	20 Times TCLP Regulatory Limit (mg/kg)
Chlordane	8081	0.03	0.6
Chlorobenzene	8240/8260	100.0	2000
Chloroform	8240/8260	6.0	120
Chromium	6010/6020	5.0	100
Endrin	8081	0.02	0.4
Heptachlor	8081	0.008	0.16
Hexachlorobenzene	8270	0.13	2.6
Hexachlorobutadiene	8270	0.5	10
Hexachloroethane	8270	3.0	60
Lead	7421/6010/6020	5.0	100
Lindane	8081	0.4	8
Mercury	7470/6020	0.2	4
Methoxychlor	8081	10.0	200
Methylethylketone	8240/8260	200.0	4000
Nitrobenzene	8270	2.0	40
Pentachlorophenol	8270	100.0	2000
Pyridine	8270	5.0	100
Selenium	7740/6010/6020	1.0	20
Silver	6010/6020	5.0	100
Tetrachloroethene	8240/8260	0.7	14
Total cresol	8270	200.0	4000
Toxaphene	8081	0.5	10
Trichloroethene	8240/8260	0.5	10
Vinyl chloride	8240/8260	0.2	4

TCLP = Toxic Characteristic Leaching Procedure

Table 11. Analytical Parameters for Classification of Solid Waste as TRU, LLW, or PCB Wastes

Constituent	Detection limit	Method
Total uranium	150 pCi/g	Method to be proposed by the lab and approved by the DOE Prime Contractor.
Neptunium-237	3 pCi/g	
Plutonium-239/240	3 pCi/g	
Plutonium-238	3 pCi/g	
Thorium-230/232	5 pCi/g	
Technetium-99	500 pCi/g	
Cesium-137	5 pCi/g	
PCB	0.1 mg/kg	8082

LLW = low-level waste PCB = polychlorinated biphenyl TRU = transuranic waste

Table 12. Waste Characterization Requirements for Solid Waste

Constituent	Method
Toxicity characteristic leaching procedure (TCLP) VOCs	SW-846 1311, 8260
TCLP SVOCs	SW-846 1311, 8270
TCLP metals	SW-846 1311, 6010/7470
TCLP pesticides	SW-846 1311, 8150
TCLP herbicides	SW-846 1311, 8150
Reactivity	SW-846 Section 7.3
Corrosivity	SW-846 1110
Moisture content	American Society for Testing and Materials (ASTM) D2216
Xylene	8260
Acetone	8260
Toluene	8260
Total cyanides	9010

Table 13. Waste Characterization Requirements for Decontamination, Development, and Purge Water

Parameter	Method	Detection Limit
Oil and grease	EPA 1664	10 mg/L
Total residue chlorine	Field Test	N/A
TCE	EPA 624	0.001 mg/L
1,1,1-TCA	EPA 624	0.001 mg/L
PCBs	EPA 608	varies by aroclor
Total uranium	EPA900/HASL-300[a]	30 pCi/L
Dissolved and suspended alpha	EPA900/HASL-300	15 pCi/L
Dissolved and suspended beta	EPA 900/HASL-300	50 pCi/L
Technetium-99	EPA 900/HASL-300	25 pCi/L
Total recoverable metals*	EPA 200.8/245.2	varies by metal
Total suspended solids	EPA 160.2	30 mg/L

[a] The procedure is derived from a variety of sources including, but not limited to, *Environmental Measurements Laboratory Procedures Manual* (DOE 1982) and *Prescribed Procedures for Measurement of Radioactivity in Drinking Water* (EPA 1980).

* Total recoverable metals: antimony, arsenic, beryllium, cadmium, chromium, copper, iron, lead, nickel, calcium, silver, tantalum, uranium, zinc, and mercury.

8.3.2.1 RCRA-listed hazardous waste

Based on process knowledge and existing historical sample data, the generation of RCRA-listed hazardous waste is expected on this project. The waste is listed-hazardous due to the presence of TCE in the RGA underlying the majority of the area in which the soil borings and wells are to be installed. Waste generated during soil borings (i.e., drilling cuttings, purge water, sample residuals), will be classified as RCRA-listed hazardous wastes with waste codes F001, F002, and U228 if analytical results for the associated soil samples and water samples are above the health-based levels discussed in Table 9. If the concentrations are below the levels contained in Table 9, then the waste will be deemed not to contain or not to be contaminated-with a RCRA listed waste (based on TCE/TCA content) for the purposes of on-site management. If the WAC is met, the waste will be properly disposed of in the C-746-U Landfill.

Groundwater and any related aqueous wastes generated from well sampling, well development, and well purging shall be excluded from the definition of hazardous waste at the point of generation, if the TCE concentrations are below 1 ppm and the 1,1,1-TCA concentrations are below 25 ppm, provided that the subject aqueous waste will be further treated in an on-site wastewater treatment unit and discharged through a PGDP KPDES-permitted outfall as required by 401 *KAR* 31:010, Section 3. Other aqueous environmental media waste contaminated with TCE or 1,1,1-TCA that does not qualify for the exemption cited herein will use a health-based concentration of 0.081 ppm as the criterion for making contained-in determinations for media destined for on-site treatment and discharge through a KPDES-permitted outfall. Aqueous waste (including, but not limited to, well sampling, well development, well purging, and decontamination waters) that has undergone wastewater treatment and meets the KPDES discharge limits shall be considered to "no longer contain" listed hazardous waste (i.e., TCE). This treated wastewater may be directly discharged to permitted KPDES Outfalls or on-site ditches that flow to permitted KPDES Outfalls.

8.3.2.2 RCRA-characteristic hazardous waste

Based on process knowledge and existing historical sample data, the generation of RCRA characteristic-hazardous waste is possible during this IRA. Any waste determined to be RCRA characteristic-hazardous waste will be treated in the same manner as RCRA listed-hazardous waste for storage and disposal requirements.

8.3.2.3 PCB wastes

If waste characterization analyses or additional process knowledge indicate the presence of PCBs in concentrations regulated under 40 *CFR* Part 761, then the wastes will be managed, transported, and disposed of in accordance with the requirement under that Part.

8.3.2.4 TRU wastes

TRU wastes are those that are contaminated with elements that have an atomic number greater than 92, including neptunium, plutonium, americium, and curium that are in concentrations greater than 100 nCi/g. Although it is possible that TRU elements may be detected in characterization samples collected on this project, it is unlikely that any of the waste generated will be at or above the TRU threshold limit.

8.3.2.5 LLW

LLWs are described as any nonhazardous, non-PCB, or non-TRU waste containing radioactivity or other radionuclides in a concentration greater than authorized limits or the latest off-site release criteria and are not classified as high-level waste, TRU waste, spent nuclear fuel, or by-product material. LLW may be generated from materials removed from the Radiological Areas. All wastes from this project have the potential to be classified as LLW. The radiological contaminant of concern is ^{99}Tc. Due to varying levels of ^{99}Tc some work may be performed under an RWP.

8.3.2.6 Mixed wastes

Mixed waste contains both hazardous waste and source, special nuclear, or byproduct material subject to the Atomic Energy Act of 1954. The generation of mixed waste is possible on this project.

8.3.2.7 Nonhazardous wastes

Waste that does not meet the classification requirements of RCRA hazardous wastes, PCB wastes, LLW, TRU waste, or mixed wastes will be classified as nonhazardous solid waste.

8.3.3 Sampling and Analysis of Waste

The WMC will be responsible for sampling the solid and liquid waste as needed. During sampling, all appropriate health and safety concerns will be addressed. All samples will be screened for radioactivity based on the RWP and appropriate actions taken to prevent the spread of contamination. Sample materials from different containers will not be mixed unless they are from the same waste stream, and only containers requiring further characterization will be sampled. Samples will be assigned a unique identifier. The following text summarizes the waste characterization requirements. The sampling procedures for waste characterization are described in the following text.

8.3.3.1 Solid Waste

For solid wastes, the "20 times" rule will be used to determine if the waste is characteristically hazardous. That is, if the total concentrations of RCRA constituents are less than 20 times the toxicity characteristic leaching procedure (TCLP) limits in 40 *CFR* § 261.24, then the waste will be considered not to be characteristically hazardous. Where the total concentrations of RCRA constituents are greater than 20 times the TCLP limits, TCLP analyses will be performed to confirm the result.

For listed waste determinations for media or debris, the total concentrations of TCE and 1,1,1-TCA will be compared to the approved health-based levels of 39.2 ppm for TCE and 2,080 ppm for 1,1,1-TCA. If the total concentrations of TCE and/or 1,1,1-TCA are less than laboratory detection levels then the solid waste will be considered nonhazardous non-listed waste for these constituents. If total concentrations are detected, but less than 39.2 ppm TCE and 2,080 ppm 1,1,1-TCA, the waste will be determined to "no longer contain" listed constituents. If the results exceed the health-based levels, the waste will be considered a RCRA-listed hazardous waste and must be managed and disposed of as such.

Solid waste may be containerized in drums, ST-90 boxes, or 25-yd^3 intermodal (IM) containers during generation. The IM is the preferred container for solid wastes such as soil cuttings from drilling because it is the most reusable container and its greater size reduces both physical risk and cost by minimizing container movements as well as sampling activities. Additional information relative to management of waste in IM containers is provided in Section 12.2.2, and additional IM sampling information is provided below.

The waste sampling strategy for an IM is based on the following assumptions that allow the waste volume to be broken into five equal volume sections laterally:

- Waste is typically loaded from the center resulting in mounding towards the center.
- Approximate waste weight is 35,000 lbs. Using a density of 90 lbs/ft^3, this yields an assumed volume of 389 ft^3.

When keeping with these assumptions, the IM is broken into five sections that are approximately 4.3 ft wide on the edges (2), 4.1 ft wide inside the edges (2), and a center section that is 3.3 ft wide. This results in five sections that are all approximately equal. Figure 18 shows a diagram of the approximate divisions.

One VOC sample will be taken from each of the five sections of the IM using an EnCore sampler (or an alternate method described in PRS-ENM-2300, *Collection of Soil Samples*) that is designed for VOC sampling. Per procedure, three EnCore samples will be used to represent a single sample point. Each sample point will be chosen randomly. This will result in five random and representative VOC samples per IM that have not been composited to minimize the loss of contaminants due to volatilization. Where waste in an IM is in excess of 35,000 pounds, an additional randomly located VOC sample will be collected for each additional 7,000 pounds (partial or full) of waste in the IM. Other methods, such as always performing VOC sampling first (prior to disturbing the waste with other sampling activities) will be employed to minimize VOC losses during sampling. Hold times and sample preservation will be performed in accordance with EPA method SW-846 8260. VOC laboratory results will be statistically evaluated and the 95% UCL at 2 sigma will be used to represent VOC concentrations in the IM.

For all parameters, except VOC samples, one core sample will be taken from the center of each of the 10 grids depicted in Figure 18 for composite sampling. These ten cores will be mixed individually and then equal volumes from each core will be composited into a single sample. This physically representative sample of the IM will be aliquoted for all parameters except VOCs.

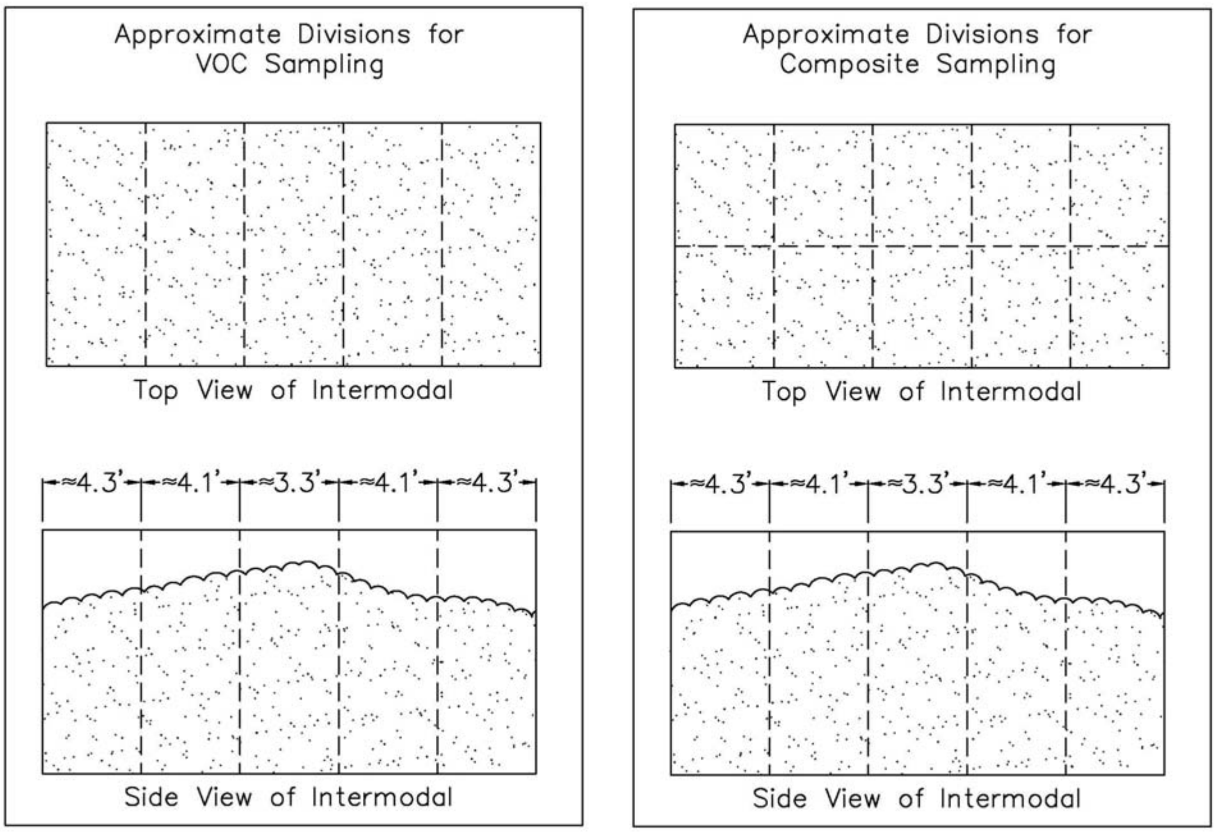

Figure 18. Approximate Division Locations for Intermodal Waste Sampling

Additional analyses to meet off-site disposal WAC also may be required and will be specified upon selection of the disposal site.

8.3.3.2 Aqueous Waste

All liquid waste water samples will be collected directly from the 55-gal drums, 1000-gal portable containers, or larger tanks, as applicable, which will be located in a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) storage area.

Collecting samples from the drain valve is the preferred method, but this method will be conducted only if the drain valve is high enough from the ground to allow containment of any spilled material.

Decontamination/drilling water containing solids will be transferred to the C-752-C filter press, which will serve as an on-site treatment unit for suspended solids removal, if necessary. Once the solids are removed (when required), the water will be characterized for treatment and disposal at the C-612 Northwest Plume Groundwater System. If the water otherwise meets discharge requirements for KPDES Outfall 001, including health-based levels for TCE and TCA and water quality criteria for TCE of 30.8 ppb, then the C-613 Sedimentation Basin may be used as the most appropriate on-site treatment for high total suspended solids removal before discharge. The water will be discharged through a KPDES-permitted outfall. One sample per portable water tank or drum will be collected for analysis when capacity is reached or fieldwork is complete. One duplicate sample will be obtained for every 20 samples collected.

8.3.4 Waste Water Treatment

Water from the decontamination of drilling equipment will be collected, and stored as CERCLA waste. Following sampling and characterization to determine if the acceptance criteria are met, the water will be processed to remove suspended solids, if necessary, and then transported to either the C-400 IRA water treatment facility, C-612 Northwest Plume Groundwater System, or other acceptable facility for treatment to remove the hazardous constituent TCE. Following treatment, as necessary, to meet the effective effluent parameters in the KPDES permit, the wastewater will be discharged through a KPDES-permitted Outfall 001.

9. QUALITY ASSURANCE PLAN

An approval page for this Quality Assurance Plan is included in Appendix C.

Table 14 is a crosswalk between the QA elements contained in *EPA Requirements for QA Project Plans* (QA/R-5) and the related sections of this QAP. Table 15 is a crosswalk between the ten QA elements in 10 *CFR* § 830.122 and the related sections of the governing QA documents for the RAWP field activities. The governing QA documents include, but are not limited to, this QAP, the PRS *Quality Assurance Program Plan for the Paducah Environmental Remediation Project*, PRS-CDL-0058 (PRS-QAPP) (DOE 2007), and the *Construction Quality Control Plan for the Interim Remedial Action for the Volatile Organic Compound Contamination at the C-400 Cleaning Building at the C-400 Cleaning Building at the Paducah Gaseous Diffusion Plant, Paducah Kentucky,* DOE/LX/07-0031&D1 (CQCP) (DOE 2008b).

9.1 PROJECT DESCRIPTION

The work to be performed under this RAWP includes the remedial design, construction, and operation of a treatment system for the area around the C-400 Building. The CQCP (DOE 2008b) has been developed for and is applicable to the construction activities. This QAP has been developed specifically for this RAWP and is to be used along with the PRS-QAPP for the RAWP field activities. Other sections of this work plan present the background information, reason for initiating this project, regulatory information, applicable criteria, and procedures that will apply to RAWP during remedial design, construction, and operation of the treatment system. Decisions to be made while the treatment system is operational include when the criteria have been met to cease the operation of the treatment system. After the established criteria have been met, treatment system operations will cease. Upon completion of the operations of the remedial action treatment system, an analysis of the efficiency of removal of TCE will be made using the data gathered during sampling. Baseline and post-operational results are intended to be a direct measure of the percent reduction of contaminants.

9.2 PROJECT ORGANIZATION

Adherence to the QA/QC requirements in this QAP will require coordination and integration of work processes among QA, project management, and project and/or subcontractor staff to ensure that requirements that control data quality are properly communicated and implemented. The roles and responsibilities for the key individuals participating in the project, including QA representatives, are described in Section 5 of this RAWP. The QA Specialist will assume responsibility for day-to-day QA activities associated with the project during remedial design, construction, and operation treatment system along with all QA issues related to the QA program and maintaining the QAP. The QA Manager will provide QA oversight and coordination with DOE and the regulatory agencies on all QA issues.

Table 14. QA/R-5 Locator Page

QA/R-5	Section number and title in Quality Assurance Plan
A1 Title and Approval Sheet	Appendix C, Section 9 QAP Approval Page
A2 Table of Contents	Contents
A3 Distribution List	Distribution List on Transmittal Letter
A4 Project/Task Organization	9.2 Project Organization
A5 Project Definition/Background	9.1 Project Description
A6 Project/Task Description	9.1 Project Description 9.14 Audits, Surveillances, and Assessments
A7 Quality Objectives and Criteria	9.5 Quality Objectives and Criteria for Measurement Data
A8 Special Training/Certification	9.3 Personnel Qualifications and Training
A9 Documents and Records	9.4 Document Control and Records Management
B1 Sampling Process Design (Experimental Design) B2 Sampling Methods	9.6 Sampling Procedures
B3 Sample Handling and Custody	9.7 Sample Handling and Sample Custody
B4 Analytical Methods	9.11 Analytical Procedures 9.13.2 Laboratory QC Samples and Internal QC Checks
B5 Quality Control	9.13.2 Laboratory QC Samples and Internal QC Checks
B6 Instrument/Equipment Testing, Inspection, and Maintenance	9.16 Preventive Maintenance
B7 Instrument/Equipment Calibration and Frequency	9.10 Instrument Calibration and Frequency
B8 Inspection/Acceptance of Supplies and Consumables	9.18 Inspection of Materials
B9 Non-direct Measurements	9.12 Data Review and Reporting
B10 Data Management	9.12 Data Review and Reporting
C1 Assessment and Response Actions	9.14 Audits and Surveillances
C2 Reports to Management	9.15 QA Reports to Management 9.17 Field Changes
D1 Data Review, Verification, and Validation	9.12 Data Review and Reporting
D2 Verification and Validation Methods	9.12 Data Review and Reporting
D3 Reconciliation with User Requirements	9.5 Quality Objectives and Criteria for Measurement Data

Table 15. 10 *CFR* § 830.122 Locator Page

10 *CFR* § 830.122 Element	Project Reference
Criterion 1—Management/Program (1) Establish an organizational structure, functional responsibilities, levels of authority, and interfaces for those managing, performing, and assessing the work. (2) Establish management processes, including planning, scheduling, and providing resources for the work.	PRS-QAPP Sections: 1.4 Organization and Responsibilities 1.5 Management Processes RAWP Sections: 5 Project Organization 9.2 Project Organization 10.9 Data Management Tasks and Roles and Responsibilities CQCP Section: 4 Quality Assurance Responsibilities and Authorities
Criterion 2—Management/Personnel Training and Qualification (1) Train and qualify personnel to be capable of performing their assigned work. (2) Provide continuing training to personnel to maintain their job proficiency.	PRS-QAPP Sections: 2.2 Training Requirements and Qualification of Personnel 2.3 Training Implementation RAWP Sections: 12.3.4 Waste Management Training 7.6 Training 7.17.4 Radiation Safety Training 9.3 Personnel Qualifications and Training CQCP Section: 5 Personnel Qualifications and Training
Criterion 3—Management/Quality Improvement (1) Establish and implement processes to detect and prevent quality problems. (2) Identify, control, and correct items, services, and processes that do not meet established requirements. (3) Identify the causes of problems and work to prevent recurrence as a part of correcting the problem. (4) Review item characteristics, process implementation, and other quality-related information to identify items, services, and processes needing improvement.	PRS-QAPP Sections: 3.1 Quality Improvement Program 3.2 Issues Management Program RAWP Sections: 7.1.5 Feedback/Improvement 9.14 Audits, Surveillances, and Assessments CQCP Sections: 6 Quality Control Activities 10.2 Supplier Selection and Evaluation
Criterion 4—Management/Documents and Records (1) Prepare, review, approve, issue, use, and revise documents to prescribe processes, specify requirements, or establish design. (2) Specify, prepare, review, approve, and maintain records	PRS-QAPP Sections: 4.1 Documents 4.2 Records RAWP Section: 9.4 Document Control and Records Management CQCP Sections: 6 Quality Control Activities 8 Documentation

Table 15. 10 *CFR* § 830.122 Locator Page (Continued)

Criterion 5—Performance/Work Processes (1) Perform work consistent with technical standards, administrative controls, and other hazard controls adopted to meet regulatory or contract requirements, using approved instructions, procedures, or other appropriate means. (2) Identify and control items to ensure their proper use. (3) Maintain items to prevent their damage, loss, or deterioration. (4) Calibrate and maintain equipment used for process monitoring or data collection.	PRS-QAPP Sections: 1.8 Special Program requirements 5.2 Work Management System 5.3 Identification and Control of Items, Including Suspect or Counterfeit 5.4 Handling, Storing, and Shipping 5.5 Control of Process Monitoring and Data Collection Equipment 11.1 Control of Safety-Related Software RAWP Sections: 4.3 Sampling and Analysis 8.1 Baseline and Post-Operation Sampling and Analysis Plan 9.10 Instrument Calibration and Frequency CQCP Sections: 13 Data Gathering Devices 14 Measuring and Test Equipment 15.1 Inspection and Test Plans 15.2 Inspection and Acceptance Testing
Criterion 6—Performance/Design (1) Design items and processes using sound engineering/scientific principles and appropriate standards. (2) Incorporate applicable requirements and design bases in design work and design changes. (3) Identify and control design interfaces. (4) Verify or validate the adequacy of design products using individuals or groups other than those who performed the work. (5) Verify or validate work before approval and implementation of the design.	PRS-QAPP Sections: 6.1 General 6.2 Design Process 6.3 Design Interface and Communication 6.4 Design Verification and Validation 6.5 Design Change Control 6.6 Temporary Modifications 6.7 Design Records 6.8 Suspect/Counterfeit Items RAWP Sections: 4.1 Design 8.1 Baseline and Post-Operation Sampling and Analysis Plan
Criterion 7—Performance/Procurement (1) Procure items and services that meet established requirements and perform as specified. (2) Evaluate and select prospective suppliers on the basis of specified criteria. (3) Establish and implement processes to ensure that approved suppliers continue to provide acceptable items and services.	PRS-QAPP Sections: 7.1 Procurement Program 7.2 Supplier Selection and Evaluation 7.3 Product Acceptance CQCP Sections: 10 Procurement Requirements and Supplier Selection 11 Critical Items 12 Commercial Grade Items 16.1 Procurement Phase

Table 15. 10 *CFR* § 830.122 Locator Page (Continued)

Criterion 8—Performance/Inspection and Acceptance Testing 1) Inspect and test specified items, services, and processes using established acceptance and performance criteria. (2) Calibrate and maintain equipment used for inspections and tests.	PRS-QAPP Sections: 8.1 Inspection and Acceptance Testing 8.2 Measuring and Test Equipment 8.3 Radiation Safety Measuring and Test Equipment RAWP Section: 9.18 Inspection of Materials CQCP Sections: 11 Critical Items 12 Commercial Grade Items 14 Measuring and Test Equipment 15 Product Acceptance 15.1 Inspection and Test Plans 15.2 Inspection and Acceptance Testing 16 Installation Phases
Criterion 9—Assessment/Management Assessment Ensure managers assess their management processes and identify and correct problems that hinder the organization from achieving its objectives.	PRS-QAPP Section: 9.0 Management Assessments RAWP Section: 9.14 Audits, Surveillances, and Assessments CQCP Section: 6 Quality Control Activities
Criterion 10—Assessment/Independent Assessment. (1) Plan and conduct independent assessments to measure item and service quality, to measure the adequacy of work performance, and to promote improvement. (2) Establish sufficient authority, and freedom from line management, for the group performing independent assessments. (3) Ensure persons who perform independent assessments are technically qualified and knowledgeable in the areas to be assessed.	PRS-QAPP Section: 10.0 Independent Assessments RAWP Section: 9.14 Audits, Surveillances, and Assessments CQCP Sections: 6 Quality Control Activities 10.2 Supplier Selection and Evaluation

9.3 PERSONNEL QUALIFICATIONS AND TRAINING

Personnel assigned to the project, including field personnel and subcontractors, will be qualified to perform the tasks to which they are assigned. A Training position description (TPD) (required training for each work assignment) will be established for each individual. The TPD will document each employee's experience. In addition to experience, specific training may be required to qualify individuals to perform certain activities. All personnel qualifications and training records will be recorded and maintained in accordance with PRS-TRN-0702, *Conduct of Training*.

A copy of this RAWP will be available to all field personnel while in the field. Project personnel will receive an orientation to the following sections of this RAWP, as well as to their responsibilities, before participating in project activities.

- Sampling Plan
- HASP
- QAP
- DMIP
- WMP

A field-planning meeting will be the forum for the orientation. All field personnel will be required to read and familiarize themselves with these documents before performing any work at the site. At a minimum, records of required reading reports and attendance lists will be maintained.

Changes in controlled documents will be monitored and training assignments will be issued to individuals as changes occur. The Safety and Health Specialist and/or Training Coordinator will be the point of contact for training requirements and verification that training requirements are met.

9.4 DOCUMENT CONTROL AND RECORDS MANAGEMENT

Document control and records management plans will be implemented according to PRS-approved procedures. The format for any needed reports and data packages will be consistent with the approved format and style guide, as applicable. Electronic databases will be backed up according to approved information technology procedures. The document management center will ensure that the most current copy of plans and procedures are provided to users.

9.5 QUALITY OBJECTIVES AND CRITERIA FOR MEASUREMENT DATA

This section describes project DQOs and defines the goals of PARCCS parameters for the data. Appropriate procedures and QC checks, as specified in the analytical method, are employed by the laboratory to assess the level of performance for these parameters. All sample results are reported for the data when the analytical sample set is completed. When needed to verify that targets for data quality are achieved, the SMO also requests that the laboratory include the QC data and raw sample data, as needed to support data validation. Acceptance criteria and evaluation of laboratory analytical results for the PARCCS parameters are determined according to the following outline. Once determined, appropriate analytical methods are selected that provide data to meet the objectives for data quality. These are identified in Section 9.11 and Section 8.3.2.

Once generated data has been reviewed, verified, and/or validated, data assessment personnel will evaluate the finalized sample data assessment packages against the project DQOs that define the PARCCS parameters. Data packages are submitted for review. The evaluation serves as a check on whether the total measurement set meets the work assignment scope and objectives. The following text presents the methods used to evaluate the PARCCS parameters.

9.5.1 Data Quality Objectives

DQOs are qualitative statements developed by data users to specify the quality of data from field and laboratory data collection activities to support specific decisions or regulatory actions. During operation of the ERH system data will be collected and analyzed to determine when the system has achieved the criteria for ceasing operations as defined in Section 3.2. Data will also be generated as a result of baseline and post-operational sampling activities. These data are intended to be used to calculate the percent reduction of TCE in the ERH treatment zones.

The Data Objectives are as follows:

- Scientific data generated will be of sufficient quality to withstand scientific and legal scrutiny

- Data will be gathered or developed in accordance with procedures appropriate for its intended use. All field and laboratory methods/procedures specified for this project will comply with EPA requirements for CERCLA investigations

- Data will be of known PARCCSs within the limits of the project. Specific criteria for PARCCSs parameters have been established, as appropriate.

9.5.2 Accuracy, Precision, and Sensitivity of Analysis

The objective of the analytical QC requirements is to ensure adequate accuracy, precision and sensitivity of analysis. Samples collected for groundwater analysis during the project will be analyzed using EPA SW-846 analytical methods, *Test Methods for Evaluating Solid Waste,* for which QA/QC procedures have been established. Samples collected for KPDES compliance will be analyzed using the EPA analytical methods, *Methods for Chemical Analysis of Water and Wastes* (EPA/600/4-79-020). Toxicity samples are analyzed in accordance with protocol published in *Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms,* EPA/600/4-89/001 (Second Edition). The precision and accuracy for each parameter/method also is provided in SW-846.

- **Accuracy**

  Accuracy is defined as the nearness of a measurement to its true value. Accuracy measures the average or systematic error of a method. Accuracy is determined by measuring percent recoveries associated with blank spikes, laboratory analytical control samples (LCS), surrogate spikes, or matrix spikes (MS). Blank samples such as trip blanks, field blanks, and method blanks are also reviewed to assess any positive bias affecting accuracy. Acceptance criteria for accuracy are usually method specific and often involve performance-based limits.

  Percent recovery is defined as

$$\% \text{ Recovery} = \frac{R - U}{S} \times 100$$

where S = concentration of spike added
U = measured concentration in unspiked aliquot
R = measured concentration in spiked aliquot

- **Precision**

Precision is the agreement between a set of duplicate measurements without assumption of knowledge of the true value. Laboratory precision is usually measured by analyzing LCS samples in duplicate. Sample duplicates, and duplicate matrix spikes (MS/MSD) are also measured to assess method and/or sampling precision. Precision can usually be expressed as relative percent difference (RPD) or relative standard deviation (RSD). Acceptance criteria for precision are usually method specific. Criteria commonly employed for assessing field precision are <RPD 35 for aqueous samples and <RPD 50 for solids, but can be varied based on the expected variability in the sampled media. The quantities are defined as follows:

$RPD = 100 \times 2 |X_1 - X_2| / (X_1 + X_2)$

where X1 and X2 are the reported concentrations for each duplicate or replicate

$$RSD = \frac{S}{X} \times 100$$

where S is the standard deviation of the series of individual measurements and X is the mean of the series of individual measurements.

- **Sensitivity**

The sensitivity of analysis (or the detection limit) is determined primarily by the analytical method, calibration range employed, any dilutions required, and the sample matrix and instrumentation that is available. During the development of DQOs, the required reporting limits are determined based on project requirements and regulatory restrictions. Reporting limits are frequently defined at the level of the lowest calibration standard employed, or represent the 95% confidence level when the compound or analyte is present.

9.5.3 Field Representativeness, Completeness, and Comparability

The following discussion covers the DQOs of representativeness, completeness, and comparability and how these DQOs may be achievable through the field sampling operations and the analytical process.

- **Representativeness**

Representativeness expresses the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, or an environmental condition. The documentation required in this QAP will enable checking that sampling protocols have been followed and sample identification and integrity have been assured. Field planning meetings, field assessments, and oversight by the Site Superintendent will provide opportunities to check that field procedures are being correctly implemented.

To ensure the representativeness of sampled media, demonstrated analyte-free water will be used in various field operations and during the preparation of trip blanks and field blanks. PRS-approved sampling procedures or work instructions will be used to collect the samples. Samples will be preserved in accordance with analytical method requirements and will be cooled to 4°C ± 2°C in a refrigerator or cooler, upon sample collection if required. See Section 9.11 for specific sample preservation requirements. Disposable gloves will be worn by field personnel and changed between sampling locations. The use of dedicated, decontaminated sampling equipment constructed with required material such as Teflon or stainless steel also contributes to the sample's representativeness.

For the low-flow groundwater purging and sampling method, representativeness will be achieved by performing the sampling operation within the required criteria for water quality measurements, minimal drawdown, and low flow rate. The pump intake will be placed within the targeted horizon of the screened interval of the well. The water will be evacuated until water quality parameters have stabilized. Care will be taken to maintain sufficient pressure so as not to introduce air into the pump tubing. Samples will be collected with minimal turbulence directly from tubing constructed of appropriate material. The use of this sampling method should produce samples with less suspended solids than other groundwater sampling methods. Sampling methods and locations provide good representation of site characteristics.

- **Completeness**

  Completeness is defined as the percentage of all measurements made whose results are judged to be valid. Invalid data will be the data that have been rejected during data validation. It is expected that the laboratory will provide valid data meeting acceptance criteria for 90 percent of the samples analyzed. If the data provided is less than 90 percent complete, an evaluation will be made to determine whether additional samples should be collected.

  The completeness objective for this project is 90 percent.

  Percent of completeness is defined as

  $$\%\ \text{Completeness} = \frac{V}{n} \times 100$$

  where V= number of measurements judged valid
  n = total number of measurements made

- **Comparability**

  Comparability is a qualitative parameter expressing the confidence with which one data set can be compared with another. Sample data will be comparable with other measurement data for similar samples and sample conditions. Use of consistent and standardized methods and units of measurement will maintain comparability of the data. Actual detection limits will depend on the sample matrix (necessary dilutions, etc.) and will be reported as defined for the specific samples.

9.5.4 Data Categories

Two descriptive data categories have been specified by EPA in *Data Quality Objectives Process for Superfund*, Interim Final Guidance, EPA540-R-93-071 (EPA 1993). These two data categories supersede the five QC levels (Levels I, II, III, IV, and V) defined in EPA's *Data Quality Objectives for Remedial Response Activities, Development Process* (EPA 1987). The two new data categories are associated with specific QA/QC elements and may be generated using a wide range of analytical methods. The two data categories are described below.

- **Screening data with definitive confirmation.** Screening data provide analyte identification and quantification using rapid, less precise analytical methods than definitive data. At least 10% of the screening data must be confirmed with definitive data in order to be recognized as being of known a and definitive data is the level of QA/QC required. The QA/QC requirements for screening data are as follows:

— Sample documentation (location, date and time collected, batch, etc.);
— Sample chain-of-custody (when appropriate);
— Sampling design approach;
— Initial and continuing calibration;
— Determination and documentation of detection limits;
— Identification of compounds and analytes detected;
— Quantification of compounds and analytes detected;
— Analytical error determination; and
— Definitive confirmation.

- **Definitive data.** Definitive data are generated using EPA-approved or other nationally recognized analytical methods. Data are compound- or analyte-specific; the identity and concentration of the analyte are confirmed. Data can be generated on-site or at an off-site, fixed-base laboratory as long as the following QA/QC elements are satisfied:

— Sample documentation (location, date and time collected, batch, etc.);

— Sample chain-of-custody (when appropriate);

— Sampling design approach;

— Initial and continuing calibration;

— Determination and documentation of detection limits;

— Identification of compounds and analytes detected;

— Quantification of compounds and analytes detected;

— QC blanks (trip, method, equipment rinsates);

— MS recoveries;

— Analytical error determination (measures precision of analytical method); and

— Total measurement error determination (measures overall precision of measurement system from sample acquisition through analysis).

When this RAWP is implemented, definitive data will be collected and analyzed according to the sampling plan by a SMO-approved fixed-base laboratory. These samples will be planned through the Paducah SMO and sent to a laboratory that has been audited under DOECAP and, if required, is certified by KDEP to perform the requested analyses. The SMO continually reviews the performance of approved laboratories and evaluates the impact on project samples if problems arise. In the event that an approved laboratory is decertified, the SMO will direct samples to a different SMO-approved laboratory for analysis.

Field measurements collected during the RAWP activities will be measured in the field using appropriate field instruments. Table 16 summarizes the data uses, data users, data categories, and data deliverable QC levels for each of the media and sample types that will be collected during the remedial design, construction, and operation.

Table 16. Data Uses and QC Levels

Field Activity / Media	Intended Uses	Intended Users[a]	Data Category
Health and Safety Monitoring	Determination of appropriate protection levels for field personnel.	Field Personnel Project Technical Support	None specified
Field Measurements	Field analysis of groundwater parameters, such as pH, temperature, dissolved oxygen, etc.	C-400 IRA Project Manager Field Personnel Project Technical Support	None specified
Field Screening	Screening samples for radionuclides before off-site shipment. Field analysis to determine presence and concentration of radiological-indicator chemicals.	C-400 IRA Project Manager Field Personnel Project Technical Support	Screening with definitive confirmation
Water Samples	Determine presence and concentration of contamination.	C-400 IRA Project Manager Project Technical Support	Definitive
Soil Samples	Determine presence and concentration of contamination.	C-400 IRA Project Manager Project Technical Support	Definitive
Vapors	Determine presence and concentration of contamination.	C-400 IRA Project Manager Project Technical Support	None specified

[a] Secondary data users are listed. Primary data users include DOE, PRS, EPA, and KEPPC personnel.

9.5.5 Intended Uses of Acquired Data

Three distinct phases of sampling and analysis will occur as a part of this remedial action: baseline, operational, and post-operational. Baseline sampling and analysis will establish the baseline concentration of VOCs in the subsurface by collecting soil and water samples, while installing the subsurface components of the system. Operational sampling and analysis will be used to measure progress and determine when criteria for ceasing ERH operations have been met. Post-operational sampling and analysis will determine the concentration of VOCs in the subsurface soil and water samples after the system ceases operation. Characterization of the waste will utilize the results from the baseline, operational, and post-operational sampling events. Compliance monitoring of water and vapors prior to discharge will utilize results from the baseline, operational, and post-operational sampling events.

9.6 SAMPLING PROCEDURES

The Project Team will perform sampling work in accordance with PRS-approved procedures and work instructions. Procedures related to the sample collection are listed below. Additional procedures are referenced in Section 4, Table 4.

- PRS-ENM-0018, *Sampling Containerized Waste*
- PRS-ENM-0021, *Temperature Control for Sample Storage*
- PRS-ENM-0023, *Composite Sampling*
- PRS-ENM-2101, *Groundwater Sampling*
- PRS-ENM-2300, *Collection of Soil Samples*
- PRS-ENM-2303, *Borehole Logging*
- PRS-ENM-2700, *Logbooks and Data Forms*

- PRS-ENM-2702, *Decontamination of Sampling Equipment and Devices*
- PRS-ENM-2704, *Trip, Equipment, and Field Blank Preparation*
- PRS-ENM-2708, *Chain-of-Custody Forms, Field Sample Logs, Sample Labels, and Custody Seals*
- PRS-ENM-5003, *Quality Assured Data*
- PRS-ENM-5004, *Sample Tracking, Lab Coordination, & Sample Handling Guidance*
- PRS-WSD-9503, *Off-Site Sample Shipping*

The following subsections provide a brief summary of the key sampling procedure elements for this project.

9.6.1 Sampling Logbook Requirements

Logbooks are used to record field sampling activities and sample records, equipment calibrations, equipment decontamination activities, shipping documentation, health and safety-related notes, and general day-to-day field notes. Field documentation shall conform to guidance, as detailed in PRS-approved procedures. Additional information regarding logbooks is provided in the DMIP, Section 10.

9.6.2 Field Measurement Requirements

Field measurements may be recorded on appropriate data log sheets or in logbooks. Data log sheets will specify the appropriate type of information to be placed in each field on the sheet. The Sampler will review data log sheets for completeness and will check the sheets against field logbooks. Field measurement data will be entered manually into Paducah Environmental Measurements System (PEMS) using appropriate sample tracking and handling guidance procedures.

9.6.3 Sample Collection

During the sampling events, three types of analytical samples, (1) field screening samples, (2) characterization samples, and (3) field QC samples, shall be collected and submitted for analysis. Field screening samples, characterization samples, and field quality control samples shall be collected as specified in this RAWP and PRS-approved procedures. QC frequencies for field samples are defined in Section 9.13.1. Samples submitted for VOC analysis shall not be homogenized.

All sample collection activities will be documented in the appropriate sampling logbook. The C-400 IRA Project Manager, the Data Manager, and the samplers shall determine which sampling methods are to be used. Specific equipment for taking samples shall be determined by the sampling team and approved by the C-400 IRA Project Manager, but must be consistent with EPA Region 4 sampling methodologies. Any deviations shall require the initiation of a Field Change Form, approved by the C-400 IRA Project Manager and the QA Manager, and must be documented in the appropriate sampling logbook.

Sample container, preservation, and holding time requirements shall be in accordance with the EPA Region 4 standard operating procedures (SOPs), this QAP, and the project-specific analytical SOW. Trip blanks shall be shipped to the field pre-preserved.

9.6.4 Sample Identification, Numbering, and Labeling

Sample identification, numbering, and labeling shall be consistent with the requirements identified in the DMIP, and shall be applied to sample labels and will follow PRS-approved procedures.

9.7 SAMPLE HANDLING AND CUSTODY REQUIREMENTS

Handling, shipping, and storing samples will adhere to custody requirements of appropriate procedures for sample chain-of-custody forms for sample tracking and handling and for temperature control for sample storage. Handling, shipping, and storage procedures will ensure that sample integrity is maintained for analytical purposes.

During transport of samples from the field to the laboratory, the chain-of-custody requirements, specified in the appropriate PRS-approved procedures, shall be met. For shipment of samples to an off-site laboratory, U.S. Department of Transportation shipping and handling regulations will be met and performed according to PRS-approved procedures. Gross alpha and gross beta screenings of all samples will be performed if sufficient process knowledge does not exist to allow for sample shipment.

9.8 MEASURING AND TEST EQUIPMENT

Measuring and test equipment (M&TE) typically include instruments, tools, gauges, reference and transfer standards, and nondestructive examination equipment. Equipment used for inspection and testing is calibrated, handled, stored, and maintained in accordance with written procedures and/or manufacturers' instructions. Calibration and maintenance controls applicable to M&TE are established and implemented by PRS-QAP-1020, *Control and Calibration of Measuring and Test Equipment*. Appropriate training (and/or qualification) requirements and records of training activities for M&TE users shall be documented, implemented, and maintained per PRS-QAP-1020, *Control and Calibration of Measuring and Test Equipment*.

Calibration and traceability requirements for M&TE are defined and based on usage. Engineering is responsible for defining M&TE calibration frequencies. Calibration frequencies are based on required accuracy, intended use, frequency of use, stability characteristics, and other conditions affecting M&TE performance. M&TE calibration is performed using proper environmental controls based on manufacturer instructions and/or applicable consensus industry standards. Accuracy of each M&TE calibration standard is established so that equipment being calibrated will be within required tolerances. When required, reference standards have a minimum accuracy four times greater than the M&TE being calibrated so that the reference standard contributes no more than one-fourth (25 percent) of the allowable calibration tolerances. Calibration standards shall be traceable to national standards. If no national standards exist, engineering will identify acceptable alternative standards.

M&TE traceability and accountability also is required. M&TE shall be labeled, tagged, or otherwise controlled to indicate calibration status. M&TE identification provides traceability to calibration and test data. Calibration certificates include date of calibration, any calibration information necessary for interpretation of calibration result, and verification of conformances with calibration criteria. M&TE is checked prior to its use to verify the proper type, range, and accuracy and that it is uniquely identified, traceable to its calibration data, and not beyond its calibration due date.

M&TE found to be out of calibration or out of tolerance is tagged or segregated to prevent inadvertent use until it is recalibrated or replaced. The M&TE control program requires formal, documented review, in accordance with PRS-QAP-1020, *Control and Calibration of Measuring and Test Equipment*, of the usage of such equipment dating back to its last known in-calibration date (reverse traceability). This review is to determine if the use of the M&TE resulted in the acceptability of items or processes becoming either invalid or indeterminate. The basis for acceptance of these nonconforming or indeterminate items and processes is formally evaluated and documented.

9.9 SOFTWARE QUALITY ASSURANCE

A software quality assurance (SQA) review will be performed by the project team to verify that software related to the operation of safety systems has been independently verified and validated to ensure the accuracy of output data. SQA requirements will remain in place throughout the duration of the IRA. Software maintained and used by the fixed-base analytical laboratory is reviewed as part of the DOECAP audit. See PRS-QAPP Section 11 for more information on SQA.

9.10 INSTRUMENT CALIBRATION AND FREQUENCY

9.10.1 Field Equipment Calibration Procedures and Frequencies

The calibration of field instruments will be checked in the field in accordance with PRS-approved procedures or manufacturer instructions. Initial instrument calibrations typically are performed by the manufacturer and a daily functional check is performed to verify that the results are within the manufacturer's requirements. Field calibration records will be documented in logbooks and, if applicable, on field data sheets. Calibration frequency is summarized in Table 17. The identified field instruments may or may not be used during the project.

Table 17. Field Equipment and Calibration/Functional Check Frequencies

Equipment	Field Usage	Frequency	Calibration/ Functional Material	Calibration Check Procedure
Hand-held PID	Health and safety	Daily before use[a]	Traceable calibration gas	Manufacturer Specifications
Radiation Detectors	Field screen, health and safety	Daily before use[a]	Alpha, gamma, and beta radioactive sources	Manufacturer Specifications
Combustible gas indicator	Health and safety	Daily before use[a]	Traceable methane	Manufacturer Specifications
Water quality meter for groundwater parameters	Field analysis	Daily before use[a]	Manufacturer Specifications	Manufacturer Specifications
Photoacoustic Analyzer	Field analysis	Manufacturer Specifications	Manufacturer Specifications	Manufacturer Specifications
DigiPAM/DigiTAM	Field monitoring	Manufacturer Specifications	Manufacturer Specifications	Manufacturer Specifications
Gauges/Flow meters	Field monitoring	Manufacturer Specifications	Manufacturer Specifications	Manufacturer Specifications

[a] These instruments are initially calibrated according to manufacturer specifications. A functional check (i.e., calibration verification) will be conducted daily before use to ensure that the equipment is working properly.
PID = photoionization detector

9.10.2 Laboratory Equipment Calibration Procedures and Frequencies

The laboratories will use written, standard procedures for equipment calibration and frequency. These procedures are based on EPA approved analytical methods and manufacturers' recommendations. Supplemental calibration details, such as documentation and reporting requirements, are given in the laboratory QA plan. The laboratory QA plan will be reviewed and statused by PRS, as part of the laboratory review process. The appropriate references for all analytical parameters are included in the reference section of this document. Standards used for calibration will be traceable to the National Institute of Standards and Technology or another nationally recognized standardization entity. Corrective action procedures for improperly functioning equipment will be addressed in the laboratory QA plan. Any calibration failures will be documented with a specific qualifier for the affected results. Calibration records, in accordance with the laboratory QA plan, will be maintained for each piece of M&TE and each piece of reference equipment. The records will indicate that established calibration procedures have been followed. Records of equipment use will be kept in the laboratory files.

9.11 ANALYTICAL PROCEDURES

When available and appropriate for the sample matrix, SW-846 methods will be used. When not available, other nationally recognized methods such as those of EPA, DOE, and the American Society for Testing and Materials (ASTM) will be used. Multi-Agency Radiological Laboratory Analytical Protocols guidance will be used where appropriate. Target compound list (TCL) parameters and typical reporting limits are listed in Table 18.

Method detection limits (MDLs) are the extent to which the equipment or analytical processes can provide accurate, minimum data measurements of a reliable quality for specific constituents. MDL is defined as the minimum concentration of a substance that can be measured and reported with 99% confidence that the value is above zero. The actual quantitation limit for a given analysis will vary depending on instrument sensitivity, matrix effects, and cleanup level requirements. Some MDLs vary based upon individual laboratories, methods, and matrices. Contracts with laboratories will specify analytes, methods, and limits required to meet project specific requirements. Typical analytical methods and sample requirements for environmental samples are provided in Table 19.

9.12 DATA REVIEW AND REPORTING

The data reduction, validation, assessment, and reporting for the remedial design, construction, and operation will be performed in accordance with PRS-approved procedures. To ensure that data management activities provide an accurate and controlled flow of data generated by the laboratory, it is important that the following data handling and reporting steps be defined and implemented.

9.12.1 Data Reduction

Field data will be produced by means of visual observation, direct-reading instrumentation, and measuring devices. All field activities, direct-reading instruments, and measuring devices will occur or be used in accordance with the SOPs and the specifications in the manufacturers' O&M manuals, as appropriate.

To present field data in a report, the data recorded in field logbooks and forms will need to be summarized and transferred to tables, figures, maps, or logs. To analyze data, some data will need to be entered into computer databases or onto spreadsheets. The Data Manager and other team members are responsible for data transfer and verification activities pertinent to their roles on the project. The Data Manager will ensure that data transfers to the Paducah PEMS are performed accurately. Initially, 100% of the transfer activities will be checked. All copies (paper and electronic) of data transferred will be checked at least once for completeness and accuracy. After the first two satisfactory transfers, 10% of the transfer activities will be checked.

Data generated by the laboratory will be reduced using the format specified by EPA or other standard methods. The analytical data will be checked for completeness and reasonableness. Laboratory data will be reconciled with field identifiers and will be transferred from the laboratory electronic data deliverable to Paducah PEMS.

Table 18. Reporting Limit for DOECAP Laboratory Analyses of Environmental Samples

Reporting Limit	TCL volatiles[a] SW-846, 8260			
Soil (µg/kg) 10 **Water (µg/L)** 5	Benzene Bromodichloromethane Bromoform Carbon disulfide Carbon tetrachloride Chlorobenzene Chloroform *cis*-1,3-Dichloroprene *trans*-1,3-Dichloropropene *cis*-1,3-Dichloropropene Dibromochloromethane Dibromomethane 1,2-Dibromomethane	Bromomethane Chloroethane 4-Methyl-2-pentanone Acetone 1,1-Dichloroethane 1,2-Dichloroethane 1,1-Dichlorethene *cis*-1,2-Dichloroethene 1,2-Dichloropropane Ethyl methacrylate Ethyl benzene Iodomethane Methylene chloride	Styrene Dichlorodifluoromethane 1,1,2,2-Tetrachoroethane 1,1,1,2-Tetrachloroethane 2-Chloroethyl vinyl ether 2-Butanone Acrolein Acrylonitrile Tetrachloroethene Toluene *trans*-1,2-Dichloropropene *trans*-1,4-Dichloro-2-butene	1,1,1-Trichloroethane 1,1,2-Trichloroethane Trichloroethene Trichlorofluoromethane 1,2,3-Trichloropropane *trans*-1,2 Dichloroethene *m,p-* xylene *o-* xylene Chloromethane Vinyl chloride Vinyl acetate 2-Hexanone
Reporting Limit	**TCL semivolatiles SW-846, 8270**			
Soil (µg/kg) 660 **Water (µg/L)** 5	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-Chloronaphthalene 2-Chlorophenol 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 (o-cresol) 4-Methylphenol (p-cresol)	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 4-Chlorophenyl-phenylether Chrysene
Soil (µg/kg) 1300 **Water (µg/L)** 5	Benzyl alcohol	4-Chloro-3-methylphenol	4-Chloroanaline	3,3-Dichlorobenzidine
Soil (µg/kg) 3300 **Water (µg/L)** 5	Benzoic acid 4,6-Dinitro-2-methylphenol	2,4-Dinitrophenol 2-Nitroanaline	3-Nitroanaline 4-Nitroanaline	4-Nitrophenol Pentachlorophenol
Reporting Limit	**TCL PCBs SW-846, 8082**			
Soil (mg/kg) 0.1 **Water (µg/L)** 0.1	Aroclor-1016 Aroclor-1221	Aroclor-1232 Aroclor-1242	Aroclor-1248 Aroclor-1254	Aroclor-1260 Aroclor-1268 PCB, Total

[a] Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, Second Edition, Final Update II, SW-846.
TCL = Target Compound List

Table 19. Analytical Methods and Sample Requirements for Environmental Samples

Parameter	Method Number	Holding time [b]	Matrix	Sample container	Preservative
TCL Volatile Organics	SW-846[a], 8260, Prep 5030	14 days	Soil	60 mL glass vial with septum seal	Cool to 4 ^{o}C
			Water	40 mL glass vials with Teflon-lined closure	HCl , pH <2, Cool to 4 ^{o}C
TCL Semivolatile Organics	SW-846[a], 8270 Prep 3550	7 days extraction/ 40 days analysis	Soil	8-oz. wide-mouth glass jar	Cool to 4 ^{o}C
			Water	1 L amber glass	Cool to 4 ^{o}C
PCBs	SW-846, 8082	14 days extraction/ 40 days analysis	Soil	8-oz. wide-mouth glass jar	Cool to 4 ^{o}C
		7 days extraction/ 40 days analysis	Water	1 L amber glass	Cool to 4 ^{o}C

[a] Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, Second Edition, Final Update II, SW-846.
[b] Holding time is from time of collection
HCl = hydrochloric acid TCL = Target Compound List PCB = polychlorinated biphenyl

9.12.2 Data Verification, Validation, and Assessment

The data review process consists of the verification, validation, and assessment of environmental measurements, waste management data, field screening data, and analytical data from the fixed-base laboratory. The data verification process determines if results have been returned for all samples, if the proper analytical and field methods have been used, if analyses were performed for the desired parameters, and if the requirements of any laboratory subcontracts have been met. The data validation process determines whether proper QC methods were used and whether the results met established QC criteria. The data assessment process determines whether data are adequate for the intended use. Any problems found during the review process are documented and resolved. Procedures used for data verification, validation, and assessments are these:

- PRS-ENM-0026, *Wet Chemistry and Miscellaneous Analyses Data Verification and Validation*
- PRS-ENM-0811, *Pesticide and PCB Data Verification and Validation*
- PRS-ENM-5003, *Quality Assured Data*
- PRS-ENM-5102, *Radiochemical Data Verification and Validation*
- PRS-ENM-5103, *Polychlorinated Dibensodioxins-Polychlorinated Dibensofurans Data Verification and Validation*
- PRS-ENM-5105, *Volatile and Semivolatile Data Verification and Validation*
- PRS-ENM-5107, *Inorganic Data Verification and Validation*

Data management information/ requirements for data review are discussed in the DMIP.

9.12.2.1 Data Verification

Verification of analytical data can be broken down into two steps, (1) laboratory contractual screening and (2) electronic Paducah PEMS verification. Laboratory contractual screening is the process of evaluating a set of data against the requirements specified in the analytical SOW to ensure that all requested information is received. The contractual screening includes, but is not limited to, analytes requested, total number of analyses, method used, electronic data deliverables (EDDs), units, holding times, and reporting limits achieved. The Data Management Team primarily is responsible for the screening upon receipt of data from the analytical laboratory. Electronic Paducah PEMS verification is the process for comparing a data set against a set standard or contractual requirement, specific to the project. The Data Management Team performs this electronic verification. Data is flagged, as necessary, and qualifiers are stored in Paducah PEMS for transfer to Paducah OREIS.

Verification of field measurements and field screening data consists of establishing that data are recorded correctly and that field instruments have been calibrated properly, ensuring the accuracy and completeness of all field forms and logbooks (e.g., sample information forms, chain-of-custody forms, requests for samples analysis, etc.). Any problems with the data will be documented, and preventive and possible corrective actions will be taken, if necessary.

9.12.2.2 Data Validation

Data validation is the process of screening data and accepting, rejecting, or qualifying the data on the basis of sound criteria. Data validation will be performed in accordance with EPA procedures and shall be validated at a target frequency of a minimum of 10% of the project's total number of samples. PRS-approved procedures regarding "Data Validation" will be used to validate the data. Data will be validated, as appropriate, based on holding times, initial calibration, continuing calibration, blank results, and other QC sample results. The process includes these steps:

- Reviewing data for compliance with contract provisions;

- Reviewing data collection and analysis methods for conformance with established criteria, such as the Sampling Plan, the QAP, and the latest revision of the analytical methods; and

- Eliminating obvious errors by checking data for proper sample identification, transmittal errors, internal consistency, and temporal and spatial consistency.

9.12.2.3 Data Assessment

The data assessment process will be performed to determine whether the total set of environmental measurements data available to the project satisfies the requirements of the project DQOs. The RAWP Project Team will perform data assessment. The evaluation is concerned with the set of all data collected during a project or phase of a project that is intended for use in characterization, risk assessment, or remedial action decisions.

Environmental measurements data must have completed the verification and validation phases before being assessed. The verification and validation of any existing data before assessment is required whenever possible, but the validation activity may not be possible for some existing data, given previous deliverable requirements. All QC data from a project or phase of a project are reviewed to evaluate the quality of the data. The total set of data for the project is reviewed for sensitivity and PARCCS parameters.

An integral component of the data assessment process is the comparison of measurement results against the DQOs to determine if the data meet or exceed the "level of certainty" required for decision-making purposes. The field and analytical results are evaluated to see if the requirements determined by the DQO process were met by the sampling and analysis activities. The C-400 IRA Project Manager or designee makes a final determination of the usability of the data. Data qualifiers are assigned to indicate the usability of the data for meeting project requirements.

9.12.3 Data Reporting

The fixed-base laboratories are required to report data in accordance with applicable laboratory procedures and consistent with PRS project requirements for data deliverables. Data deliverables will be reported in a format that fulfills the requirements of these procedures. For this project, all laboratory analyses will include definitive deliverables. For data targeted to support data validation, the laboratory will provide complete data packages that include sample report forms, QC result summaries, and all raw data associated with instrument calibration, sample prep, internal QC, and measurement of QC and field samples.

9.13 FIELD AND LABORATORY QC CHECKS

SOPs are used for all routine sampling operations. Field QC sampling will be conducted to check sampling accuracy and precision and to assess the overall representativeness of field samples. Trip blanks and rinsate blanks are used to evaluate the potential for contamination of samples from field sources of contamination. If contaminants are found in the field blanks, attempts will be made to identify the source of contamination, and corrective action will be initiated in accordance with this QAP. The laboratory analyzing the samples also will include internal QC checks and samples in accordance with the specified analytical method, or as required by appropriate PRS-approved procedures. Performance of these samples is discussed in the laboratory's QA plan, which identifies the corrective actions that will be taken when performance criteria are not achieved. The field and analytical QC field samples and frequencies summarized in this section will be used for this task. The types of field and laboratory QC samples used in this study are described in the following text.

9.13.1 Field QC Samples

Field QC samples will be analyzed for the parameters of interest; the results will be included in the analytical report. The number of required QC samples is based on requirements that are specified herein. To ensure reliability of the analytical data to meet the DQOs for the project, the following QC samples shall be obtained during sample collection.

Trip blanks are used to detect VOC cross-contamination from field sources during sample collection, shipping, and handling. A trip blank consists of a sealed container of ASTM Type II water, or other similar characteristic water, that shall be kept with the investigative samples they represent from the field to the laboratory and shall be left unopened. The trip blank is kept near the sample containers; therefore, it identifies contamination that may potentially contaminate field samples during transport. One trip blank will be placed in each cooler containing samples to be analyzed for VOCs. Trip blanks are analyzed for VOCs only.

Temperature blanks also may be submitted with VOC samples and are used to verify sample preservation at 4°C ± 2. The temperature blank can be potable, deionized, or ASTM Type II water in a sealed volatile organic analyte vial or similar bottle and marked "Temperature Blank." This sample is only used for temperature measurement and is not otherwise preserved.

A **field blank** serves as a check on environmental contamination at the sample site. ASTM Type II water is transported to the site, opened in the field, transferred into each type of sample bottle, and returned to the laboratory for analysis of all parameters associated with that sampling event. It also is acceptable for field blanks to be filled in the laboratory, transported to the field, and then opened. Field blanks may be used as a reagent blank, as needed. Field blanks will be collected at a frequency of 1 in 20 samples (5%) for each sample matrix.

An **equipment blank or rinsate sample** is a sample of ASTM Type II water passed through, or over, decontaminated sampling equipment. Equipment blanks are used as a measure of decontamination process effectiveness and are analyzed for the same parameters as the samples collected with the equipment. Equipment blanks also may be used as reagent blanks, as needed. Equipment blanks are required only when nondisposable equipment is being used. Equipment blanks will be collected at a frequency of 1 in 20 samples (5%).

A **source water blank** is a sample of the ASTM Type II water, or other water sources used for the project. These samples are collected at the beginning of the project and monthly, if the project will be of long duration. Source water blanks are used to demonstrate that the source water is not contaminated.

One **field duplicate** is collected for every 20 samples (5%) per matrix and shall be analyzed for the same set of analytical parameters it is duplicating to determine whether the field sampling technique is reproducible. The field duplicate is a split sample collected from one sampling location, placed in a separate set of containers, and labeled with a different sample number such that the identification of the duplicate sample is “blind” to the laboratory.

9.13.2 Laboratory QC Samples and Internal QC Checks

Analytical laboratory QC checks and samples will be analyzed as required by the analytical method for the parameters of interest; the results will be included in the analytical report. These include, but are not limited to, the following:

Lab **preparation and method blanks** are samples of the laboratory’s ASTM Type II water that are carried through the same sample preparation and analysis procedures as field samples. Laboratory blanks are used assess potential laboratory sources of contamination that could affect the analysis of field samples. Preparation and method blanks are included for each sample matrix and batch.

Instrument and calibration blanks are analyzed according to method requirements to verify instrument zero following calibration, or after samples are analyzed that exceed instrument calibration ranges. These blanks consist of analyte-free water or solvent used to dilute samples to their final volume for analysis. Whenever contamination is observed, the instrument is allowed to equilibrate, or the source of contamination is identified and corrected. Analysis proceeds, or continues, once an acceptable blank is observed. Background measurements are performed for radiological samples and are used in a similar manner to assess the influence of background radiation on sample measurements. When specified by the method, corrective action is used to identify sources of contamination that are above natural backgrounds.

Surrogate spikes and chemical tracers are non-target compounds and analytes that are chemically similar to parameters being measured, and are specified by the individual method. Known quantities of these compounds are added to each field sample and their percent recoveries are determined. When recoveries fall outside acceptable limits for performance, the source of error is investigated and the analysis is reperformed.

LCS are spike samples of target compounds that are analyzed with each sample batch and matrix. For aqueous samples, these are blank-spikes and are often prepared from second-source calibration standards. Solid LCS are prepared by spiking the LCS standards into a sand, or other well-characterized matrix. The LCS is designed to assess method performance and analytical accuracy without the influences of matrix interferences. LCS are often analyzed in pairs (e.g., LCS/LCS Duplicate) to assess analytical precision. When required by the method, LCS and LCS/LCSD samples are analyzed at a frequency of 1 LCS or LCS/LCSD per matrix for every 20 samples (5%).

MS/MSD samples require the collection of additional sample volume for aqueous samples. The laboratory splits the samples into duplicates and adds predetermined quantities of stock solutions to them before extraction and analysis. Percent recoveries are calculated to assess accuracy. Relative Percent Differences are calculated to assess analytical precision. MS/MSD samples will be analyzed at a frequency of 1 for every 20 samples (5%) for organic parameters. For inorganic parameters, a laboratory duplicate will be analyzed instead of an MSD.

Other internal QC checks are specified by individual methods and include performance evaluation mixtures, interference check samples, serial dilution analyses, use of internal standards, and application of MDL verification standards. Corrective actions are applied by the laboratory whenever method performance criteria are not met and are reported in the data deliverables as required.

9.14 AUDITS, SURVEILLANCES, AND ASSESSMENTS

Audits, surveillances, and assessments are conducted by the QA staff in accordance with procedures PRS-QAP-1420, *Conduct of Assessments,* and PRS-QAP-1210, *Issues Management Program*. The detail and frequency of review will be determined using a graded approach based on the work and complexity involved to do the following:

- Check for adherence to the QA/QC requirements specified in the project documents;
- Evaluate the procedures used for data collection, data handling, and project management;
- Verify that the QA program developed for this project is being implemented according to the specified requirements;
- Verify that the laboratory is participating in a Performance Evaluation Program;
- Assess the effectiveness of the QA program; and
- Verify that identified deficiencies are corrected.

The QA Manager is responsible for defining audits, surveillances, and assessments and will perform or assign them according to a schedule that coincides with appropriate activities on the project schedule and sampling plans. Scheduled audits, surveillances, and assessments may be supplemented by additional ones for any of the following reasons:

- Significant changes are made in the QAP,
- It is necessary to verify that corrective action has been taken on a deficiency previously reported, or
- Additional audits or surveillances are requested by DOE, project management, or the QA Manager.

9.14.1 Audits

Audits are the most comprehensive type of independent assessment and must be performed by an assigned audit team led by a qualified Lead Auditor. No audits are planned for this task, though audits may be conducted at the discretion of the QA Manager.

9.14.2 Surveillances

Surveillances follow the same general format as an audit, but are less detailed and require a less formal report. Personnel who perform surveillances are not required to be qualified as a Lead Auditor. A surveillance is designed to give project staff rapid feedback concerning QA compliance and facilitate corrective action.

For this project, one field surveillance is planned shortly after field mobilization. Additional field surveillances may be conducted at critical milestones. The following are example activities and documentation that may be subject to surveillance:

- Sampling
- Decontamination
- Chain-of-custody
- Field documentation
- Field training records
- Equipment calibration
- Field QC procedures
- Work performance
- Program implementation within the project
- Compliance with environment, health, safety, quality, and regulatory requirements
- Adequacy of work controls, reliability, and performance and to promote continuous improvement

QA surveillances will be performed in accordance with PRS-approved procedures. Problems identified during surveillances will be documented, resolved, and closed in accordance with PRS-approved procedures. The QA Manager or QA Specialist may schedule other periodic surveillances. The QA Specialist will provide results of the surveillances to the C-400 IRA Project Manager.

9.14.3 Assessments

The project team, including QA Specialists, is responsible for monitoring progress through QA assessments, management assessments, or independent assessments as applicable. A minimum of one assessment shall be performed within the first month of construction field work, which shall include an evaluation of how the project is managing QA requirements.

Independent assessments are routinely planned, scheduled, and conducted to evaluate compliance with environmental, health, safety, quality, and regulatory requirements. The focus of independent assessments is to assess the adequacy of work controls, reliability, and performance and to promote continuous improvement. Management assessments focus on those issues that affect performance and related processes such as these:

- Planning and work control elements
- Personnel qualification and training
- Resource requirements, staffing and skills mix

- Communications
- Cost and budget performance
- Quality, safety and effectiveness of performed work
- Customer satisfaction

9.14.4 Nonconformances

Nonconforming items, services, or processes will be identified, controlled, and reported in accordance with PRS-approved procedures. QA personnel will complete a Nonconformance Report (NCR) as required. Nonconforming equipment immediately will be labeled or tagged and segregated.

9.14.5 Corrective Action

Each project team member is responsible for notifying the Site Superintendent, the C-400 IRA Project Manager, the QA staff, or other responsible persons if he/she discovers a condition that may affect the quality of the work being performed. Immediate corrective actions will be noted in task notebooks. Problems not immediately corrected will require formal corrective action.

The following staff members have specific corrective action responsibilities:

- ER Manager - Overall responsibility for implementing corrective actions.

- QA Manager - Overall responsibility for tracking and accepting corrective actions, including tracking implementation of laboratory corrective action in conjunction with the Data Manager.

- C-400 IRA Project Manager - Implementing task-specific corrective actions.

- Site Superintendent - Identify and implement corrective actions during field activities, and notify the C-400 IRA Project Manager and QA staff of conditions not immediately corrected.

- Data Manager - Identify and implement corrective action during analysis and track implementation of laboratory corrective action in conjunction with the QA Manager, and notify the C-400 IRA Project Manager and QA Specialist when applicable analytical acceptance criteria are not satisfied.

9.15 QA REPORTS TO MANAGEMENT

All levels of the QA team are responsible for preparing QA reports. The QA Specialist will submit reports to the QA Manager on an as-needed basis. The reports will summarize the following, as applicable:

- NCRs issued during the reporting period,
- Status of open NCRs during the reporting period,
- Corrective actions initiated,
- Status of overdue issues, and
- The status of open corrective actions during the reporting period.

9.16 PREVENTATIVE MAINTENANCE

Periodic preventive maintenance is required for all sensitive equipment. Specific field equipment preventive maintenance practices and frequencies are described in the factory manual for each instrument.

All maintenance activities will be recorded in maintenance logs or appropriate logbook. Preventative maintenance procedures for laboratory equipment and instruments are managed by the laboratory.

9.17 FIELD CHANGES

Field changes must be governed and documented by control measures in accordance with PRS-WCE-0027, *Field Change Request (FCR), Field Change Notice (FCN), and Design Change Notice (DCN) Process* commensurate with those applied to the documentation of the original design.

- Major changes from approved field operating procedures or project scope, cost, or schedule will be documented on a Field Change Request Form (FCR). The Site Superintendent will initiate and maintain the FCR forms.
- The C-400 IRA Project Manager or designee must approve each FCR form before work proceeds. Approval by the C-400 IRA Project Manager or designee can be obtained verbally or via telephone, with follow-up sign-off. In no case will a field change be initiated that has not been appropriately approved.
- The lead engineer must evaluate all FCRs, to determine whether review is needed from other organizations (e.g., Nuclear Safety, QA, Health and Safety, etc.) in accordance with PRS-WCE-0027, *Field Change Request (FCR), Field Change Notice (FCN), and Design Change Notice (DCN) Process*.
- If a field change is proposed by DOE or other oversight agency, the group proposing the change will be documented on the FCR.
- Copies of the FCR will be kept on-site until the fieldwork is complete and then will be transmitted to the project files.
- Variances or minor changes to field operating procedures and other work control documents will be allowed and performed in accordance with PRS-WCE-0021, *Work Execution* or PRS-DOC-1107, *Development, Approval, and Change Control for PRS Performance Documents*.
- If deemed necessary, relevant project documents will be revised, reviewed, accepted, and reissued with control measures commensurate with the original documents.
- Specific additional requirements for field changes, such as required PGDP approvals, will be addressed in contractual documentation as necessary.

9.18 INSPECTION OF MATERIALS

All project materials (i.e., sampling instruments, etc.) will be inspected prior to acceptance and use. All records generated as a result will be managed according to PRS-approved procedures. The Site Superintendent or designee will inspect all incoming shipments for apparent damage, shipping documentation discrepancies, and overages or shortages. For all discrepancies noted, the QA Specialist will initiate an NCR, if necessary, in accordance with PRS-approved procedures.

10. DATA MANAGEMENT AND IMPLEMENTATION PLAN

10.1 INTRODUCTION

The purpose of this DMIP is to identify and document data management requirements, applicable procedures, expected data types and information flow, and roles and responsibilities for data management activities associated with the C-400 IRA during remedial design, construction, and operation treatment system. Data management provides a system for efficiently generating and maintaining technically and legally defensible data that provide the basis for making sound decisions regarding environmental and waste characterization.

To meet current regulatory requirements for environmental management projects, complete documentation of the information flow must be established. Each phase of the environmental data management process (planning, collection, analysis, management, verification/validation, assessment, reporting, consolidation, and archival) must be appropriately planned and documented.

The scope of the DMIP is limited to environmental information collected during the design, construction, and operation of the IRA treatment system. This information includes electronic and/or hard copy records that describe environmental processes or conditions. Information generated by the project (e.g., analytical results from samples collected) and obtained from sources outside the project (e.g., historical data) falls within the scope of this DMIP. Certain types of information, such as personnel or financial records, are outside the scope of this DMIP.

10.1.1 Project Mission

The mission of the C-400 IRA is the reduction of the VOC source (TCE and breakdown products) in the subsurface at the C-400 Cleaning Building area through removal and treatment using ERH in both the UCRS and RGA. As part of the C-400 IRA, three distinct phases of sampling and analysis will occur: baseline, operational, and post-operational. Baseline sampling and analysis will establish the baseline concentration of VOCs in the subsurface by collecting soil and water samples, while installing the subsurface components of the system. Operational sampling and analysis will be used to measure progress and determine when remedial action goals have been met. Results from post-operational sampling and analysis will be compared to baseline results to calculate the percent reduction in VOC levels in the treatment area.

Specific activities involving data include, but are not limited to, collecting environmental and waste samples; storing, analyzing, and, if necessary, shipping samples; collection of operational and maintenance data; and evaluation, verification, validation, assessment, and reporting of analytical results.

10.2 DATA MANAGEMENT ACTIVITIES

Data management for the IRA will be implemented throughout the life cycle of environmental measurements and waste characterization data. This life cycle occurs from the planning of data, through the collection, review, usage of the data for decision-making purposes, and the long-term storage of data. The following sections contain a detailed description of these data management activities:

- Acquire existing data;
- Plan data collection;
- Prepare for field activities;

- Collect field data;
- Process field data;
- Collect field samples;
- Submit samples for analysis;
- Process laboratory analytical data;
- Review data;
- Verify data;
- Coordinate and perform data validation;
- Assess data;
- Consolidate, analyze, and use data and records; and
- Submit data to the Paducah OREIS.

10.2.1 Acquire Existing Data

The primary background data to be used for this project consist primarily of analytical data. All available historical data pertaining to the area included in the C-400 IRA will be downloaded from Paducah OREIS.

10.2.2 Plan Data Collection

Other documents in this RAWP provide additional information for the tasks of project environmental data collection, including the baseline/post operational sampling plan, HASP, the QAP, and the WMP. In addition, a laboratory SOW will be developed following approval of this work plan.

10.2.3 Prepare for Field Activities

The data management tasks involved in field preparation activities include identifying all sampling locations and preparing descriptions of these stations, developing summaries of all the samples and analyses to be conducted at each sampling location, developing field forms for capturing field data, coordinating sample shipment/delivery with off-site laboratories, and coordinating screening analyses with designated laboratories. The Data Management Team will conduct these activities. The Site Superintendent and the Data Management Team will coordinate data management activities with field sampling activities.

Before the start of field sampling, the Data Management Team will specify and provide the contents of sample kits, which will include sample containers, labels, preservatives, chain-of-custody records, and any necessary sampling data forms. Samples will be collected according to PRS-approved procedures. Logbooks, sample labels, and chain-of-custody will be completed according to PRS-approved procedures. A comprehensive sampling list will be developed and used as the basis for finalizing the sample containers to

- Be used for sample collection;
- Ordering sufficient amount of containers and other supplies; and
- Verifying the numbers of samples presented in the laboratory scope of work.

10.2.4 Collect field data

Field data will be collected, documented, and maintained according to the SAPs and PRS-approved procedures.

10.2.5 Process Field Data

Field measurements will be recorded on appropriate field forms or in field data compilers. These forms will be checked against the field logbooks, and the data will be manually entered into Paducah PEMS using PRS-approved procedures.

10.2.6 Collect Field Samples

Personnel collecting samples for the project will record pertinent sampling information on the chain-of-custody, along with maintaining a field logbook. The Data Management Team will manually enter information from the chain-of-custody forms and field forms into Paducah PEMS. Sampling locations will be surveyed using appropriate methods. Sample coordinates will be transferred to the PGDP coordinate system.

10.2.7 Submit Samples for Analysis

Before the start of field sampling, the Data Management Team will coordinate the delivery of samples, and the receipt of results with the contract laboratories. The Data Management Team will present a general sampling schedule to the off-site laboratories. The receipt of sample shipments and containers will be coordinated with the laboratories, and any requirements for laboratory permission to ship will be met. The Data Management Team will ensure that hard-copy deliverables and EDDs, from the laboratories, contain the appropriate information and are in the correct formats.

10.2.8 Process Laboratory Analytical Data

Data packages and EDDs received from the laboratory will be tracked, reviewed, and maintained in a secure environment. Paducah PEMS will be used for tracking project-generated data from point of collection through final data reporting. The Data Management Team is responsible for these tasks. The following information will be tracked, as applicable:

- Sample delivery group number;
- Date received;
- Number of samples;
- Sample analyses;
- Receipt of EDD, and;
- Comments.

The Data Management Team will compare the contents of the data package with the chain-of-custody form and identify discrepancies. Discrepancies will be reported immediately to the laboratory and the Data Manager. Copies of the Form I's from the data package will be distributed as necessary.

To evaluate the quality of laboratory EDDs, the first two EDDs from each laboratory will be 100% checked against the hard-copy data packages. After the first two EDDS from each laboratory are checked, every fifth EDD will be 100% checked. The results from the EDD will be checked, as will the format of all fields provided. The Data Management Team will report immediately any discrepancies to the Data Manager, so that the laboratory can be notified and EDDs can be corrected.

10.2.9 Review data

The Data Management Team will review the contents of the data package to ensure all necessary information is present and consistent with expectations.

10.2.10 Verify Data

The Data Management Team is responsible for ensuring that data verification occurs as outlined in the procedure for Quality Assured Data. Data verification processes for laboratory data will be implemented for both hard-copy data and EDDs. The data packages will be reviewed to ensure that all samples receive the analyses requested. Discrepancies will be reported to the laboratory. Electronic data verification of the EDDs will be performed as data are loaded into Paducah PEMS. The hard-copy will be checked to ensure that requested parameters, indeed, were analyzed for; those missing from the EDD will be requested from the laboratory. Integrity checks in Paducah PEMS also will review the results generated by the laboratory to ensure that data for all requested parameters have been provided. Discrepancies will be reported to the Data Manager. Additional information relating to Data Verification is included in the QAP.

10.2.11 Coordinate and Perform Data Validation

The Data Management Team is responsible for coordinating data validation and for implementation of validation through the appropriate data validation procedures. Data validation will be performed on 100% of the selected data packages. Validation will be performed on a minimum of 10% of the environmental data collected. Validators not associated with the project will perform validation following PRS-approved procedures. Additional information relating to data validation is included in the QAP. A validation SOW is generated specifying the requirements for the validation of the data. Validation problems must be identified and appropriately resolved. Qualifiers and reason codes may be assigned to the data to indicate usability concerns. Validation qualifiers are input and stored in Paducah PEMS and transferred with the data to Paducah OREIS.

10.2.12 Assess Data

Data assessment will be conducted and documented by a technical reviewer in conjunction with other project team members, according to the PRS-approved procedure for Quality Assured Data. Data assessment follows data verification and data validation (if applicable) and must be performed at a rate of 100% to ensure data are useable. The data review process determines whether a set of data satisfies the data requirements defined in the project-scoping phase and assures that the type, quality, and quantity of data are appropriate for their intended use. It allows for the determination that a decision (or estimate) can be made with the desired level of confidence, given the quality of the data set. This process involves the integration and evaluation of all information associated with a result.

Data review consists of an evaluation of the following: data authenticity, data integrity, data usability, outliers, and PARCCS parameters. Additional requirements for data assessment and review are included in the QAP. Assessment qualifiers are stored in Paducah PEMS and transferred with the data to Paducah OREIS. Data are made available for reporting upon completion of the data assessment, and associated documentation is stored with the project files.

10.2.13 Consolidate, Analyze, and Use Data and Records

The data consolidation process consists of the activities necessary to prepare the evaluated data for the users. The project team will evaluate the field and analytical data from the environmental and waste samples in support of operational decision making and to characterize the project waste before disposal. The data will be stored in the Paducah OREIS database for future use.

Project reports are generated for the purpose of evaluating the data for the project. These reports include the status of the sampling event, reports of data compared to various criteria, and reports of the complete set of data. Data analysis will be documented in sufficient detail to allow re-creation of the analysis.

Project reports may be generated from PEMS. Official data reporting for reports to outside agencies will be generated from data stored in Paducah OREIS, as applicable.

10.2.14 Submit Data to the Paducah OREIS

Upon completion of the data assessment, verification, and validation, the data will be transferred from Paducah PEMS to Paducah OREIS. The Data Management Team is responsible for transferring the data to Paducah OREIS.

10.3 DATA MANAGEMENT INTERACTIONS

The Data Manager will interface with the Data Management Team to oversee the use of Paducah PEMS and to ensure that data deliverables meet project requirements. The Data Management Team will enter information related to the fixed-base laboratory data packages and the tracking associated with the samples once the samples have been shipped and the receipt of the samples has been verified. The Data Management Team will load the fixed-base laboratory hard-copy data, the EDDs, and the field measurement data into Paducah PEMS. The Data Management Team is responsible for transferring the data from the Ready to Load (RTL) files to the Paducah OREIS database.

The Data Management Team will develop the SOW to be performed by a SMO-approved analytical laboratory that has been audited under DOECAP in the form of a project-specific, laboratory SOW utilizing an SOW template populated according to the sampling requirements in this RAWP. Analytical methods, laboratory QC requirements, and deliverable requirements will be specified in this SOW. The Data Management Team will receive EDDs, perform contractual screenings, and distribute data packages. The Data Management Team will interface with the contract laboratory to ensure that hard copy and electronic deliverable formats are properly specified and the requirements are understood and met.

10.4 DATA NEEDS AND SOURCES

10.4.1 Data Types

Multiple data types will be generated and/or assessed during this project. These data types include field measurements, inspection checklists, historical data, analytical data (including environmental data and waste data), and geographic information system (GIS) data.

10.4.2 Historical Data

Historical data consist primarily of analytical data. Existing and historical data will be evaluated prior to field activities (e.g., sampling, field measurements). Paducah OREIS and the Paducah OREIS Data Catalog will be queried as necessary for existing information relating to the project. Historical data downloaded from Paducah OREIS will be available in Paducah PEMS for project team use for the duration of the project.

10.4.3 Field Measurements

Field measurements that may be collected include field measurements of environmental and waste samples and global positioning system readings for each sample location. Field measurements may be recorded on appropriate data log sheets. The Data Management Team will enter the data from these sheets, manually, into Paducah PEMS. A QC check of this data entry, that involves comparing printouts of the data in the project Paducah PEMS to the original field logbook or data log sheet, will be made.

10.4.4 Analytical Data

Analytical data that will be collected includes volatile, semivolatile, and radionuclides from soil and groundwater samples. Paducah PEMS will be used to plan, track, and manage the collection of all analytical data. The tracking system for the project will include field logbooks, field forms, chain-of-custody records, and hard-copy data packages, as well as EDDs. Following completion of the appropriate data verification, validation, and assessment activities, the final data set will be uploaded from Paducah PEMS to Paducah OREIS.

10.5 GEOGRAPHIC INFORMATION SYSTEM DATA

The Paducah GIS network will be used to prepare maps to be used in data analysis of both historical and newly generated data and reporting. Coverage anticipated for use during the project is as follows:

- Stations (station coordinates will be downloaded from Paducah OREIS)
- Facilities
- Plant roads
- Plant fences
- Streams
- Topographic contours (as available from the 1990 flyover)

10.6 DATA FORMS/LOGBOOKS

Field logbooks, site logbooks, diskette logs, chain-of-custody forms, data packages with associated QA/QC information, and field forms will be assigned document control numbers and maintained according to PRS-approved procedures for Records Management.

Duplicates of field records will be maintained until the completion of the project according to PRS-approved procedures. Logbooks and field documentation will be copied periodically. The originals will be forwarded to the project files; the copies will be maintained in a separate location. The project file will be considered the Record Copy and, as such, will be stored in accordance with PRS-approved procedures.

Electronic versions also will be stored in the project file; the originator or the original recipient of the diskette will maintain backup copies.

10.6.1 Field Forms

Sample information is environmental data describing the sampling event and consists of the following: station (or location), date collected, time collected, and other sampling conditions. This information is recorded in field forms, such as logbooks, chain-of-custody forms, or sample labels.

Field chain-of-custody forms contain sample-specific information recorded during collection of the sample. This information is entered directly into Paducah PEMS by the Data Management Team. The SAP provides detailed information on sampling locations, types of samples, sample parameters required at each location, and the frequency of collection for samples. Any deviations from the sampling plan will be noted on the field chain-of-custody form. The Sampler will review each field chain-of-custody form for accuracy and completeness, as soon as practical, following sample collection.

Chain-of-custody forms will be generated from Paducah PEMS with the following information:

- **Information that is preprinted**

  - Chain-of-custody number
  - Project name or number
  - Sample ID number
  - Sampling location (e.g., 001-001)
  - Sample type (e.g., REG = regular sample)
  - Sample matrix (e.g., SO = soil)
  - Analysis (e.g., ^{99}Tc)
  - Sample container (volume, type)
  - Preservative

- **Information that is entered manually**

  - Sample date and time
  - Top and bottom depths and units
  - Sample comments (optional)

Sample identification numbers are identified in Paducah PEMS, assigned by the Data Management Team, and uniquely identify each sample. Sample labels shall contain sufficient information to identify the sample in the absence of other documentation. The label shall be affixed to the sample container; shall be completed with black, indelible ink; and shall include the following, at a minimum:

- Project number,
- Unique sample number,
- Sample location,
- Sample media,
- Analysis to be performed,
- Sampling date and time,
- Organization collecting the sample, and
- Preservation method.

An example of the sample identification scheme is as follows:

C400nnnM000

where:

C400	Identifies facility
nnn	Identifies the sequential boring number
M	Identifies the media type (W identifies the sample as groundwater, S identifies the sample as soil)
000	Identifies the planned depth of the sample in feet bgs

10.7 DATA AND DATA RECORDS TRANSMITTALS

10.7.1 Paducah OREIS Data Transmittals

All data (measurements and geographic) contained in reports submitted to state and federal regulators are required by the FFA to be transferred to OREIS before or on the date of the report submission. Official data reporting, contained in other reports to outside agencies, will be generated from data stored in Paducah OREIS for any applicable data stored there. The Data Management Team will submit data to be stored in Paducah OREIS prior to reporting.

10.7.2 Data Records Transmittals

Upon completion of the project, the original logbooks, field documentation, and project deliverables will be forwarded to the PGDP Document Management Center according to PRS-approved procedures.

10.8 DATA MANAGEMENT SYSTEMS

10.8.1 Paducah PEMS

Paducah PEMS is the data management system that supports the project's sampling and measurements collection activities, the automatic transfer of laboratory SOW and chain-of-custody information to the SMO Tracker database, and the generation of Paducah OREIS RTL files. Appropriate project staff can access Paducah PEMS throughout the life cycle of the project. Paducah PEMS will be used for the following functions:

- Initiate the project;
- Plan for sampling;
- Record sample collection and field measurements;
- Record sample shipment information;
- Receive and process analytical results;
- Evaluate and verify data;
- Analyze and access data;
- Transfer project data (in RTL format) to Paducah OREIS; and
- Store non-Paducah OREIS data.

Paducah PEMS will be used for the project to generate sample chain-of-custody forms; manage field-generated data; import laboratory-generated data; update field and laboratory data based on data verification, validation (if applicable) and assessment; and transfer data to Paducah OREIS.

The Network Administrator will perform system backups daily. Security of Paducah PEMS and of data generated during the project data management effort is essential for the success of the project. The security precautions and procedures implemented by the Data Management Team are designed to minimize the vulnerability of the data to unauthorized access or corruption. Only members of the Data Management Team will have access to the project's Paducah PEMS, the hard-copy data files, and the diskettes and tape backups. Members of the Data Management Team have installed password-protected screen savers.

10.8.2 Paducah OREIS

Paducah OREIS is the centralized, standardized, quality assured, and configuration-controlled data management system that is the long-term repository for environmental data (measurements and geographic) for environmental management projects. Paducah OREIS is comprised of hardware, commercial software, customized integration software, an environmental measurements database, a geographic database, and associated documentation. Paducah OREIS will be used for the following functions:

- Access to existing data,
- Access to project data,
- Report generation, and
- Long-term storage of project data (as applicable), and
- Submit data to regulators.

10.8.3 Paducah Analytical Project Tracking System

The Paducah Analytical Project Tracking System is the business management information system that manages analytical sample analyses for all environmental projects within the Paducah Site. The Paducah Analytical Project Tracking System supplements the SMO Tracker in cradle-to-grave tracking of sampling and analysis activities. The Paducah Analytical Project Tracking System generates the SOW, tracks collection and receipt of samples by the laboratory, flags availability of the analytical results, and allows invoice reconciliation. The Paducah Analytical Project Tracking System interfaces with Paducah PEMS (output from the Paducah Analytical Project Tracking System automatically goes to Paducah PEMS).

10.9 DATA MANAGEMENT TASKS AND ROLES AND RESPONSIBILITIES

10.9.1 Data Management Tasks

The data management activities are described in Section 10.2. PRS-approved procedures will be used to complete all of the necessary data management tasks.

10.9.2 Data Management Roles and Responsibilities

Roles and responsibilities are described in Section 5 of this RAWP.

11. ENVIRONMENTAL COMPLIANCE

11.1 INTRODUCTION

Environmental regulatory compliance will be facilitated during the implementation of the C-400 IRA by adhering to ARARs that have been identified throughout the project planning, scoping and decision making process. The CERCLA Act of 1980, as amended, requires, in part, that remedial actions for cleanup of hazardous substances comply with promulgated requirements and/or standards under federal or more stringent state environmental laws and regulations. These requirements are identified as those being specific to the hazardous substances or particular circumstances at a site and must be complied with, or be waived, as part of a total remedial action, under the CERCLA decision making process [40 *CFR* § 300.430(f)(1)(ii)(B)]. ARARs include only federal and state environmental or facility siting laws/regulations and do not include occupational safety or worker radiation protection requirements. Per 40 *CFR* § 300.405(g)(3), nonpromulgated advisories, criteria, or guidance, known as to be considered (TBC), may be considered in determining remedies. Because this IRA will be conducted in accordance with Section XXI of the FFA for the PGDP and Section 121(e)(1) of CERCLA, on-site activities are exempted from procedural requirements to obtain federal, state, and local permits.

ERH will result in reducing the source of TCE and other VOC contaminants reaching groundwater. On completion of the ERH source reduction, a continued decrease in concentrations of TCE and other VOCs is expected. Because the GWOU contamination is extensive, multiple actions are planned to provide overall remediation of the groundwater. ERH is one of the IRAs to be taken to provide overall remediation of groundwater and its sources of contamination

Other environmental contamination at PGDP not related to this remedial action is to be addressed in separate decision documents (i.e., ROD); however, those decisions will be supported by this interim remedial action.

A brief summary of the ARARs/TBCs associated with the interim remedial action follows.

11.2 CHEMICAL-SPECIFIC ARARS/TBCS

These requirements provide health or risk-based concentration limits or values in environmental media for hazardous substances, pollutants, or contaminants. The specific requirements associated with ERH are discussed further below.

11.2.1 National Primary Drinking Water Standards

The National Primary Drinking Water Standards include maximum contaminant levels (MCLs) for several of the contaminants found within groundwater at the PGDP and are considered relevant and appropriate requirements for potable groundwater. While ERH is not expected to result in attainment of the MCL for TCE and its degradation products (*trans*-1,2-DCE, *cis*-1,2-DCE, vinyl chloride, and 1,1-DCE) at the time treatment ceases, it satisfies the requirements in 40 *CFR* § 300.430(f)(1)(ii) for interim actions to meet ARARs. Under the National Contingency Plan (NCP) at 40 *CFR* § 300.340(f)(1)(ii)(C)(1), an alternative that does not meet an ARAR may be selected when the alternative is an interim measure and the ARAR will be attained or waived as part of a total remedial action.

11.2.2 Kentucky Surface Water Standards

Kentucky Surface Water Standards are included as ARARs for this interim remedial action because treated groundwater will be discharged to surface water bodies after treatment. The substantive requirements include discharge limits of KPDES permit KY0004049.

11.3 LOCATION-SPECIFIC ARARS/TBC

Location-specific requirements establish restrictions on activities conducted within protected or environmentally sensitive areas. In addition, these requirements establish restrictions on permissible concentrations of hazardous substances within these areas. Section 11.5 lists the federal and state location-specific ARARs for protection of sensitive resources.

11.3.1 Protection of Wetlands

Installation of treatment systems may impact nondelineated wetlands during the construction phase of remedy implementation. As required at 10 *CFR* § 1022, 40 *CFR* § 230.10, and 33 *CFR* § 330.5, all activities will be designed to avoid or minimize impacts to wetlands identified within the area of deployment of the remedy. The use of best management practices (BMPs) and proper siting of equipment and construction areas will be considered and conducted, as necessary, to comply with these substantive requirements.

11.3.2 Endangered Species Act

Installation activities must not impact or jeopardize the existence of a listed species or result in the destruction or impact to critical habitat. These requirements are specified at 16 *USC* 1531 Section 7(a)(2). Possible existence of endangered species or species habitat must be considered within the area of deployment of the remedy. This ARAR shall be achieved by avoiding such areas.

11.3.3 Migratory Bird Treaty Act

The requirements of the Migratory Bird Treaty Act require that similar measures are taken with regard to protected migratory species. As with endangered species, these substantive requirements shall be complied with through assessment of the area of deployment to ensure no adverse impact occurs.

11.4 ACTION-SPECIFIC ARARS/TBCS

Action-specific ARARs include requirements that pertain to the operation, performance, and design of a remedial response and are based on waste types, media being treated, and treatment technology being implemented. Component actions include groundwater extraction, treatment, and monitoring; waste management; and transportation. ARARs/TBCs for each component action are listed in Section 11.5. The substantive requirements of applicable requirements are described below.

11.4.1 Fugitive Dust Emissions

Substantive requirements for the control of fugitive dust and storm water runoff potentially provide ARARs for all construction and site preparation activities. Reasonable precautions must be taken, including the use of BMPs for erosion control to prevent runoff and application of water on exposed soil/debris surfaces to prevent particulate matter from becoming airborne. In addition, diffuse or fugitive emissions of radionuclides to the ambient air from remediation activities, which are only one of potentially many sources of radionuclide emissions at a DOE facility, must comply with the Clean Air Act of 1970, as amended, requirements in 40 *CFR* § 61.92 (substantive requirements). Chemical-specific ARARs for these actions include radiation emission requirements for the public and control of potential fugitive emissions of TCE and other VOCs, as applicable.

General surface activities have the potential to create dust. These surface dust emissions will be minimized by covering all ground surfaces with concrete, asphalt, or gravel. If dust is observed, a water spray will be used to control the observed dust. No particulate emissions are anticipated for the below grade activities.

11.4.2 Toxic Emissions

C-400 potential hazardous air pollutants (HAPs) have been identified based on characterization of the groundwater as documented in *Remedial Design Support Investigation Characterization Plan for the Interim Remedial Action for the Volatile Organic Compound Contamination Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-2211&D2, (DOE 2005b). The potential HAPs identified are TCE, vinyl chloride, *trans*-1,2-DCE, *cis*-1,2-DCE, and 1,1-DCE. These HAPs will be removed from the subsurface using ERH. ERH involves *in situ* heating of soils resulting in the collection and recovery of contaminants from the aquifer and vadose zone. The treated vapor/gases must comply with the contaminant concentration requirements of 401 *KAR*: 63:020. An off-gas treatment system shall be employed to ensure contaminant emissions do not exceed allowable levels. This system may include such equipment as condensers and/or filters to accomplish the required contaminant removal.

In accordance with 401 *KAR* 63:020, the concentration of each of the HAPs that is released must be not be more than a value calculated that would be protective of human health and the environment. This is accomplished by ensuring that HAPs concentrations at the property boundary of the facility are less than the values required under 401 *KAR* 63:020. The required air concentrations were calculated using values in the EPA Toxics Table, Prioritized Chronic Dose-Response Values for Screening Risk Assessments (6/12/2007), at http://www.epa.gov/ttn/atw/toxsource/table1.pdf and may have their basis in either Region 9 Preliminary Remediation Goals (PRG) values at http://www.epa.gov/region09/waste/sfund/prg or Integrated Risk Information System values. Allowable concentrations then were calculated using the methods outlined in EPA's *Air Toxics Risk Assessment Reference Library, Volume 2, Facility Specific Assessment*. These values are based on the cancer and non-cancer risks posed by long-term exposure to HAPs. The chemicals that are a cancer risk have an associated concentration that will result in a receptor at the property boundary having an increase of less than one in one million (1×10^{-6}) of getting cancer from exposure to a carcinogen over a 70-year time period. The health effects of exposure to chemicals that are a non-cancer risk are measured by a hazardous index; with a hazard index of 1 being an indication of a boundary-located receptor having detrimental health effects from exposure to that chemical. The C-400 IRA HAPs are both carcinogenic and noncarcinogenic, with the greater of the two risks for each chemical as follows:

- Noncancer - 1,1-DCE, *trans*-1,2-DCE, *cis*-1,2-DCE
- Cancer – vinyl chloride, TCE.

11.4.3 Emissions Estimate

This section summarizes the air dispersion analysis of potential hazardous air pollutant emissions from the implementation of the C-400 IRA. The property boundary concentrations for these potential hazardous air pollutant emissions were estimated utilizing using BREEZE AERMOD GIS Pro v5.1.7. Appendix D contains a more detailed discussion of this analysis as well as an electronic copy of output reports and model-ready input files.

11.4.3.1 Construction Fugitive Emissions

During construction of the ERH, fugitive emissions will be released. The fugitive emissions occur when the subsurface equipment, such as electrodes and well completion components, is placed in the boreholes and displace the contaminate-laden air. The amount released is estimated to be 2.5 pounds of all HAPs over five months. The off-site limit, estimated fugitive emission rate, and resulting maximum off-site concentration for each HAP, is shown in Table 20.

Table 20. Estimated Off-site Concentrations for Fugitive Emissions

Chemical	Off-site limit	Fugitive Emission Rate	Annual Average Maximum Off-site Concentration
	ug/m^3	g/s	ug/m^3
TCE	0.5	7.23E-6	1.1E-5
vinyl chloride	0.11	8.6E-7	1.3E-6
trans-1,2-dichloroethene	73	7.9E-6	1.2E-5
cis-1,2-dichloroethene	37	1.5E-6	2.3E-6
1,1-dichloroethene	210	1.0E-6	1.5E-6

The estimated air concentration for each hazardous air pollutant is less than the off-site limit. This demonstrates compliance of the design with 401 *KAR* 63:020.

11.4.3.2 Operations Emissions

During operation of the project, the hazardous constituents in the subsurface will be volatilized underground and recovered by a vapor phase extraction system. The system will capture the soil vapors, which will be treated and released through a stack. The current design utilizes a cryogenic adsorption system to remove hazardous constituents from the off-gas; then an activated carbon filtration will polish the treatment prior to discharge to the atmosphere. The current design criteria for the treatment system is such that the concentrations of an individual HAP in the exhaust stack will not exceed 20 ppmv. Analyzer results will be recorded in two minute or less intervals during operation. The sampling frequency may be evaluated after initial operation to determine if a longer duration for sampling would adequately record data and may be adjusted with the concurrence of EPA and KDEP. Calibration/functional checks will be performed in accordance with manufacturer specifications, as indicated in Table 17.

The property boundary ambient concentration for each HAP was estimated utilizing the air dispersion model BREEZE AERMOD GIS Pro v5.1.7. The exhaust was assumed to contain the maximum concentration of each HAP. The preliminary design parameters[12] for the stack were used in the model, which are as follows:

- 8-inch diameter
- 20-ft. high
- 1,500 scfm flow rate
- 70 °F exhaust gas temperature

The meteorological data from 2003 was used in the model because it will result in higher off-site concentrations than any other of the past 5 years of valid meteorological data. Because the project is adjacent to C-400 building, building wake effects are included in the analysis.

The annual average maximum off-site concentration estimated by the air dispersion model is listed for each pollutant in Table 21.

[12] The last paragraph of Section 4.5.3 in the RDR states, “Off-gas from the vapor-phase polishing system will be discharged to the atmosphere through a 20-ft tall by 8 inch diameter stack.” The flow rate and temperature are shown on drawing P7DC40000A001 in Appendix F of the RDR.

Table 21. Estimated Off-site Concentrations for Emission Stack Design Concentrations

Chemical	Off-site limit	Stack Design Concentration		Annual Average Maximum Off-site Concentration
	ug/m^3	ppmv	g/s	ug/m^3
TCE	0.5	20	0.0601	3.75E-2
vinyl chloride	0.11	20	0.0286	1.8E-2
trans-1,2-dichloroethene	73	20	0.0444	2.8E-2
cis-1,2 dichloroethene	37	20	0.0444	2.8E-2
1,1-dichloroethene	210	20	0.0444	2.8E-2

The maximum off-site concentration for each hazardous air pollutant is less than the off-site limit listed in Table 21, demonstrating compliance of the design with 401 *KAR*: 63:020.

Off-gas emissions from the treatment system will be monitored by a photoacoustic analyzer. The analyzer will communicate with a control system to shut down the vapor extraction and treatment system and notify operations personnel in the event of an exceedance of discharge criteria.

11.4.4 Subsurface ERH Components

Subsurface ERH components will consist of electrodes, vapor/groundwater extraction wells, and temperature/pressure monitoring equipment. These components will be installed in boreholes created using traditional drilling techniques. The subsurface equipment will be installed to minimize the potential for the introduction of pollutants into the subsurface during construction and operations.

A portion of the groundwater extracted during operations will be reintroduced to the heated volume at the electrodes after treatment to maintain moisture levels. Section 11.4.10 provides more detail with regard to groundwater injection at the electrodes. The remainder of the treated water will be discharged and will meet KPDES-permitted Outfall 001 discharge criteria.

The multiphase extraction (MPE)-Dual Well Borings, Extraction Well Borings, and Contingency Well Borings (shown on drawing C7DC40000A002 in Appendix C of the RDR) will be abandoned by extracting the casing and grouting to the surface as required for MWs by 401 *KAR* 6:310 (6).

Although removal of other subsurface system elements such as the vapor extraction wells, temperature monitoring borings, and pressure monitoring borings is not required by regulation, an attempt to abandon these components will be made by the following methods. All of these borings, except for the groundwater sampling/extraction wells listed above, will have high temperature cement grout installed to a minimum depth of 5.0 ft bgs. This is intended to minimize the potential of infiltration of surface waters along the borehole. The Vacuum Monitoring Well Borings, DigiTAM Sensor Well Borings, DigiPAM Sensor Well Borings, Dual Sensor Well Borings, and DigiPAM Sensor/Monitoring Well borings (shown on drawing C7DC40000A001 in Appendix C of the RDR) will have the sensors removed and the 2 inch fiberglass pipe perforated and then filled with grout to the surface.

Piezometers and vapor extraction wells from the Six-Phase Treatability Study will be abandoned in place using permeation grouting (cement) in the pipe and screens. Riser pipes and tubing will be sealed with an appropriate chemical grout and the boring sealed at the ground surface with cement.

Electrode borings will be abandoned as outlined in Section 11.4.10.

11.4.5 Discharge of Storm Water and Treated Groundwater

Management of aqueous wastes will include procedures to minimize the possibility of spills and releases to the environment. Berms and dikes will be constructed to minimize contact of waste with surface water run-on and run-off. Where precipitation accumulates in the diked areas that hold contaminated wastes, it will be managed as contaminated until analyses show otherwise. It will be treated, as needed, to meet the KPDES-permitted Outfall 001 discharge limits prior to discharge.

Contaminated water, including decontamination fluid, collected storm water, groundwater, and condensate from the off-gas treatment system, will be treated as need to meet discharge limits. Where these waters meet the acceptance criteria for on-site treatment facilities at the PGDP, treatment is expected to occur on-site with discharge through KPDES-permitted Outfall 001. Where these waters do not meet on-site acceptance criteria or result in exceedances of on-site treatment capacity, they will be shipped to an appropriate off-site wastewater treatment facility for treatment and subsequent discharge. Shipment to any off-site facility shall be conducted in accordance with the applicable requirements of 40 *CFR* § 300.440 *et seq.* (CERCLA Off-site Rule).

11.4.6 Hazardous Waste Management

All primary wastes (i.e., groundwater and contaminated soils) and secondary wastes (i.e., treatment residuals, and decontamination wastewaters) generated during remedial activities will be appropriately characterized as RCRA wastes (solid or hazardous); PCB waste; radioactive waste(s); and/or mixed waste(s), as appropriate, and, respectively, be managed in accordance with appropriate RCRA, Toxic Substances Control Act (TSCA), or DOE Order/Manual requirements. Wastes managed on-site must comply with the substantive requirements of the aforementioned ARARs. When wastes are transferred off-site, waste management must be conducted in compliance with all applicable laws and regulations. Shipment of CERCLA wastes to any off-site facility shall be conducted in accordance with the approval requirements of 40 *CFR* § 300.440 *et seq.* (CERCLA Off-site Rule).

For contained-in/no-longer-contaminated-with determinations for environmental media and debris, DOE will apply the contained-in/no-longer-contaminated levels of 39.2 ppm TCE in solids and 0.081 ppm TCE in aqueous wastes generated by this interim remedial action. The WMP, as part of this RAWP, is subject to regulator review and approval under the procedures outlined in the FFA. The analytical results will be compared against the contained-in, health-based levels listed above, and a determination made. Land Disposal Restrictions apply to media and debris that no longer contain or are no longer contaminated with RCRA regulated waste.

11.4.7 PCB Waste Management

One of the substantive requirements of TSCA is that wastes that have concentrations of PCBs greater than ≥50 ppm must be managed in accordance with 40 *CFR* § 761. These requirements include labeling, characterization, manifesting, and disposal in a facility that is designed for and permitted to receive PCB-contaminated wastes.

11.4.8 National Emission Standards for Hazardous Air Pollutants

EPA regulations also include limitations on the radiological dose allowed to members of the public in the NESHAP regulations in 40 *CFR* § 61 (and 401 *KAR* 57:002, which incorporates the federal regulations by reference). 40 *CFR* § 61.92 establishes a limit of 10 millirem (mrem)/year from all radioactive air emissions at a DOE facility to the most exposed member of the public from radionuclide emissions to the atmosphere.

The system design capacity for groundwater extraction is approximately 80 gallons per minute (303 L per minute). This would result in extraction of approximately 159,278,000 L of water during the estimated 12 months of system operation, if operated continuously. The highest ^{99}Tc concentration detected in the groundwater in the area during the Six-Phase Treatability Study was 160 pCi/L. The annual amount of ^{99}Tc released using these conservative assumptions are calculated as follows:

[(159,278,000 L/year) x (160 pCi/L)] x (1 Ci/10^{12}pCi) = 0.0255 Ci/year

The ERH process could heat the ^{99}Tc above 100 ºC; therefore, in accordance with 40 *CFR* § 61Appendix D, it is assumed the ^{99}Tc becomes a gas and that it will all be emitted from the stack.

The following stack parameters are used to estimate resultant dose:

- 20-ft tall stack
- 8-inch diameter stack
- 1,500 scfm flow rate
- 70 ºF stack temperature

These parameters, in addition to the ^{99}Tc value calculated above, were used in the CAP88-PC Version 2.00 program to estimate the potential dose to the maximum exposed individual. The resulting dose would be approximately 7.6 x 10^{-3} mrem/yr, well below the threshold requiring regulatory permission to construct.

Using the stack parameters above, an influent ^{99}Tc concentration of 2,075 pCi/L would be required to result in a dose approaching the regulatory threshold. The treatment system influent will be sampled weekly for ^{99}Tc and, if the level is observed to be 1,500 pCi/L or above, the potential dose will be reevaluated.

This limit should not be exceeded, because as the system operates, water will be extracted from the treatment zone. The groundwater will be treated using an ion exchange resin to remove ^{99}Tc. A portion of this treated water will be returned to the treatment zone. Dose calculations herein are based on an assumption of constant ^{99}Tc concentrations in extracted groundwater. Actual conditions are expected to be a reduction in ^{99}Tc concentrations over time due to the reinjection of treated groundwater.

11.4.9 Transportation

Any remediation wastes transferred off-site or transported in commerce along public rights-of-way must meet all applicable requirements found in the federal and Commonwealth of Kentucky transportation laws and regulations. These transportation requirements include provisions for proper packaging, labeling, marking, manifesting, record keeping, licensing, and placarding that must be fully complied with for shipment. Before shipment of CERCLA wastes to any off-site facility, DOE must ensure the acceptance of the receiving site under the CERCLA Off-site Rule (40 *CFR* § 300.440 *et seq.*).

11.4.10 Underground Injection Control

The project design for the remedial action requires that treated groundwater be injected into the subsurface to enhance heating of the area surrounding the electrodes. The injection of fluids is necessary because the water in the formation immediately surrounding the boreholes evaporates as the formation is heated, reducing the ability of the formation to conduct heat, thereby reducing the effectiveness of ERH. To prevent these conditions, groundwater extracted as part of the remediation process will undergo initial treatment and then be reinjected into the subsurface treatment zone to maintain moisture around the electrodes, thereby providing favorable conditions for conductivity and heat transfer, as well as serving to cool the electrodes and prevent burnout. Prior to reinjection, the contaminated groundwater will undergo treatment to significantly reduce contaminant concentrations, but the reinjected groundwater still will contain TCE at elevated levels. These specific design parameters, which pertain to reinjection of groundwater, were developed as part of the post-ROD design phase, but do not constitute a change in the scope, performance, or cost of the selected remedy.

Injection of fluids into groundwater may trigger certain ARARs under the Underground Injection Control (UIC) program of the Safe Drinking Water Act. Accordingly, the following substantive requirements of the UIC regulations are considered relevant and appropriate: 1) 40 *CFR* § 144.12(a), states that no owner or operator shall construct, operate, maintain, covert, plug, abandon, or conduct any other injection activity in a manner that allows the movement of fluid containing any contaminant into underground sources of drinking water, if the presence of that contaminant may cause a violation of any primary drinking water regulation under 40 *CFR* part 142 or may otherwise adversely affect the health of persons; and 2) 40 *CFR* § 144.23(b)(1), which pertains to closure of Class IV injection wells.

While treated TCE contaminated groundwater will be intermittently reinjected during operation of the ERH system, such reinjection is expected to beneficially contribute to the efficiency of the operation and result in an overall reduction in TCE concentrations in treated zones upon completion of the action. The area affected by the reinjection is expected to be limited to the immediate area within the treatment zone as a result of hydraulic control measures that will be implemented during operation to reduce contaminant migration. The design of this remedy is intended to meet the substantive requirements of 40 *CFR* § 144.12(a). The plugging and abandonment method that will be used to meet the substantive requirements for closure under 40 *CFR* § 144.23(b)(1) is as follows. During installation, all of the electrode borings will have high temperature cement grout installed to a minimum depth of 5.0 ft bgs. This is intended to minimize the potential of infiltration of surface waters along the borehole. Electrode borings (shown on drawing E7DC40000A008 in Appendix C of the RDR) that contain screened intervals will have the 2 inch fiberglass pipe perforated down to the screened interval and then filled with grout to the surface. All electrode borings will have grout pumped through the water injection lines into the electrodes that are 53.15 ft bgs and above (53.15 ft bgs is the depth of the electrode nearest the UCRS/RGA interface, which is at approximately 55 ft bgs).

40 *CFR* § 144.13 contains a prohibition for construction, operation, or maintenance of Class IV wells except in cases where the reinjection of contaminated groundwater has undergone prior treatment, is being reinjected into the same formation from which it was drawn, and such injection is approved by EPA or a state, pursuant to provisions for cleanup of releases under CERCLA or RCRA. The reinjection of the TCE-contaminated groundwater associated with the C-400 action meets the exception criteria outlined in 40 *CFR* § 144.13(c) and RCRA § 3020(b) and, therefore, is not prohibited by regulation or statute.

11.5 SUMMARY OF ARARS FOR PRIMARY SOURCE AREA

Tables 22 through 24 list the chemical-specific, location-specific, and action-specific ARARs/TBCs for the IRAs in the selected remedy.

Table 22. Summary of Chemical-Specific ARARs for Primary Source Area—Electrical Resistance Heating

Standard, Requirement, Criteria, or Limitation	Citation	Description of Requirement	Comments
National Primary Drinking Water Standards	40 *CFR* § 141	Provides chemical-specific numeric standards for toxic pollutants expressed as MCLs and MCLGs.	The substantive requirements are relevant and appropriate due to the nature of the contaminants found within the groundwater. The substantive requirements will be met to the extent practicable for an interim action. While ERH is not expected to result in attainment of the MCL for TCE and its degradation products (*trans*-1,2-DCE, *cis*-1,2-DCE, vinyl chloride, and 1,1-DCE) at the time treatment ceases, it satisfies the requirements in 40 *CFR* § 300.430(f)(1)(ii) for interim actions to meet ARARs. Under the National Contingency Plan (NCP) at 40 *CFR* § 300.340(f)(1)(ii)(C)(1), an alternative that does not meet an ARAR may be selected when the alternative is an interim measure and the ARAR will be attained or waived as part of a total remedial action.

Table 22. Summary of Chemical-Specific ARARs for Primary Source Area—Electrical Resistance Heating (Continued)

Standard, Requirement, Criteria, or Limitation	Citation	Description of Requirement	Comments
Kentucky Surface Water Standards	401 *KAR* 5:031 and 5:026	Provides chemical-specific numeric standards for discharge of pollutants in domestic water supplies. Provides chemical-specific numeric standards for pollutants discharged or found in surface waters.	The substantive standards are ARAR to the segment of the Ohio River (domestic water supply) into which the Little Bayou Creek discharges. The substantive requirements found in these standards are ARAR due to the discharges at seeps in to Little Bayou Creek (outside of the current KPDES outfalls), which subsequently discharges to the Ohio River. The ERH action will reduce VOCs in the groundwater at the C-400 area, which is contributing to downgradient TCE contamination at the seeps. While the ERH action is not expected to attain Kentucky Surface Water Standards at the seeps, these standards will be met or waived by subsequent remedial actions under other operable units, including, but not limited to, the surface water operable unit and the groundwater dissolved-phase plume operable unit. See 40 *CFR* § 300.430(f)(1)(ii) (C)(1). Note: Clean Water Act Water Quality Criteria are not ARAR because Kentucky has promulgated state standards determined to be appropriate for Kentucky waters.
Radiation Exposure of the General Public at DOE Facilities Decommissioning Standards at Nuclear Facilities	DOE Order 5400.5 10 *CFR* § 20, Subpart E	Specifies that the public must not receive an effective dose equivalent of >100 mrem/year from all exposure pathways. In addition, all releases of radioactive materials resulting in doses to the public must meet the ALARA criteria. Specifies a residual activity at nuclear facilities for unrestricted release of 25 mrem/year.	The substantive requirement is TBC information. The substantive requirements are considered to be relevant and appropriate because radionuclides are found in groundwater in the C-400 Cleaning Building area.

ALARA = as low as reasonably achievable
ERH = Electrical Resistance Heating
MCLG = maximum contaminant level goal
ARAR = applicable or relevant and appropriate requirements
KPDES = Kentucky Pollutant Discharge Elimination System
DCE = dichloroethene
MCL = maximum contaminant level

Table 23. Summary of Location-Specific ARARs for Primary Source Area—Electrical Resistance Heating

Standards, Requirement, Criteria, or Limitation	Citation	Description of Requirement	Comments
Protection of Wetlands	10 *CFR* § 1022; Executive Order 11990; 40 *CFR* § 230.10; 33 *CFR* § 330.5	Activities must avoid or minimize impacts to wetlands to preserve and enhance their natural and beneficial value. If wetland resources are not avoided, measures must be taken to address ecologically sensitive areas and mitigate adverse effects. Such measures may include minimum grading requirements, runoff controls, design, and construction considerations. Allows minor discharges of dredge and fill material or other minor activities for which there is no practicable alternative, provided that the substantive requirements of the Nationwide Permit system are met.	The substantive requirements of the regulations are ARAR due to the presence of wetlands and will be met through avoidance of wetlands during construction and implementation of alternatives. Discharges of dredge and fill material will not be necessary in this interim action.
Endangered Species Act	16 *USC* 1531 *et seq.* § 7(a)(2)	Actions that jeopardize the existence of listed species or result in the destruction or adverse modification of critical habitat must be avoided or reasonable and prudent mitigation measures taken.	The substantive requirements are ARAR because habitat for threatened and endangered species is present near the PGDP outside the industrialized area. They will be met through avoidance of critical habitat because the construction of this interim action is within the industrial section of the plant.
Migratory Bird Treaty Act	16 *USC* 703-711; Executive Order 13186	Federal agencies are encouraged (until requirements are established under a formal Memorandum of Understanding) to do the following: • Avoid or minimize, to the extent practicable, adverse impacts on migratory bird resources when conducting agency actions; • Restore and enhance the habitats of migratory birds, as practicable; • Prevent or abate the pollution or detrimental alteration of the environment for the benefit of migratory birds, as practicable; • Ensure that environmental analysis of federal actions required by the National Environmental Policy Act or other established environmental review processes evaluate the effects of actions and agency plans on migratory birds, with emphasis on species of concern; and • Identify where unintentional uptake likely will result from agency actions and develop standards and/or practices to minimize such unintentional take.	The substantive requirements are ARAR because migratory birds frequent the PGDP. The requirements will be met by avoiding habitat and controlling airborne releases of contaminated media. Due to the highly industrialized nature of the C-400 Cleaning Building area, no migratory bird habitat will be disturbed.

ARAR = applicable or relevant and appropriate requirements
KPDES = Kentucky Pollutant Discharge Elimination System
CFR = *Code of Federal Regulations*
USC = *U.S. Code*
PGDP = Paducah Gaseous Diffusion Plant

Table 24. Summary of Action-Specific ARARs for Primary Source Area—Electrical Resistance Heating

Standard, Requirement, Criteria, or Limitation	Citation	Description of Requirement	Comments
Fugitive Dust Emissions during site preparation and construction activities.	401 *KAR* 63:010	Precautions must be taken to control particulate matter from becoming airborne. Such precautions must be incorporated into the planning and design of activities and include actions such as these: Wetting or adding chemicals to control dust from construction activities; Using materials such as asphalt or concrete (or other suitable chemicals/fixing agents) on roads or material stockpiles to prevent fugitive emissions; and Using covers on trucks when transporting materials to and from the construction site(s). This requirement specifies that, for on-site construction activities, no visible emissions may occur at the PGDP fence line.	The substantive requirements are applicable and will be met through the use of appropriate dust control practices such as water spraying.
Toxic Emissions	401 *KAR* 63:020 and 401 *KAR* 63:002	401 *KAR* 63:020 requires that no emissions are allowed that are harmful to the health and welfare of humans, animals, and plants.	The substantive requirements of these regulations are considered to be applicable. Consistent with CERCLA Section 121(e)(1), no Title V Air Permit will be required for the production of toxic emissions. Dispersion modeling has confirmed that the concentrations of hazardous air pollutants result in a risk to the closest residential receptor of less than 1×10^{-6}; therefore, control technologies are not required pursuant to this ARAR.
Monitoring Well Installation	401 *KAR* 6:310	Monitoring wells (including extractions wells) must be constructed in a manner to maintain existing protection against the introduction of pollutants into aquifers and to prevent the entry of pollutants through the borehole. In addition, abandoned wells must be plugged and abandoned in accordance with the requirements specified.	The substantive requirements are considered to be ARAR. Compliance with well design and protection standards shall be achieved using approved well design and materials of construction. While in service, wells shall be secured as required. Abandoned wells shall be plugged and abandoned as described in Section 12.2.10.

Table 24. Summary of Action-Specific ARARs for Primary Source Area—Electrical Resistance Heating (Continued)

Standard, Requirement, Criteria, or Limitation	Citation	Description of Requirement	Comments
Discharge of Stormwater and Treated Groundwater	40 *CFR* § 122; 401 *KAR* 5:055; 401 *KAR* 5:031 and 5:026	Stormwater discharges from construction activities on-site are subject to the substantive requirements of the KPDES permit. This requires that BMPs to control storm water runoff and sedimentation be employed. Discharge of treated groundwater will be conducted in compliance with the substantive requirements of the KPDES program and the Clean Water Act. Provides chemical-specific numeric standards for pollutants discharged or found in surface waters. Provides chemical-specific numeric standards for pollutants in domestic water supplies.	The substantive requirements are considered applicable for all on-site construction or treatment activities where a discharge of storm water or treated groundwater occurs. Compliance with these ARARs shall be achieved by application of required controls during the construction and operation phases of the alternative. Consistent with CERCLA § 121(e)(1), no KPDES permit or permit modification will be required for on-site discharges of storm water, decontamination water, and treated groundwater. The applicable and substantive requirements will be met through the use of on-site treatment systems, which may include the Northwest Plume treatment system or C-613 Sedimentation Basin.

Table 24. Summary of Action-Specific ARARs for Primary Source Area—Electrical Resistance Heating (Continued)

Standard, Requirement, Criteria, or Limitation	Citation	Description of Requirement	Comments
Injection of groundwater into an underground source of drinking water.	40 *CFR* § 144.12	No owner or operator shall construct, operate, maintain, covert, plug, abandon, or conduct any other injection activity in a manner that allows he movement of fluid containing any contaminant into underground sources of drinking water, if the presence of that contaminant may cause a violation of any primary drinking water regulation under 40 *CFR* part 142 or may otherwise adversely affect the health of persons.	This action will involve reinjection of treated TCE contaminated groundwater into the electrodes of the treatment zone to improve efficiency of the remedial action. The treated groundwater to be injected at the electrodes is expected to have a significantly lower concentration (5 ppm or less) of TCE than when it initially was extracted from the same area (as high as 1,100 ppm). Hydraulic control will be maintained during operation by maintaining groundwater extraction at a greater rate than injection. The substantive requirements of the UIC program contained in 40 *CFR* § 144.12 and 40 *CFR* § 144.23(b)(1) are relevant and appropriate.
	40 *CFR* § 144.23(b)(1)	Prior to abandonment any Class IV well, the owner or operator shall plug or otherwise close the well in a manner acceptable to the Regional Administrator.	Abandonment of these borings will be accomplished as indicated in Section 11.4.10, Underground Injection Control.
	40 *CFR* § 144.13	Construction, operation, or maintenance of Class IV wells are prohibited except in cases where the reinjection of contaminated groundwater has undergone prior treatment, is being reinjected into the same formation from which it was drawn, and such injection is approved by EPA or a state, pursuant to provisions for cleanup of releases under CERCLA or RCRA.	The reinjection of the TCE-contaminated groundwater associated with the C-400 action meets the exception criteria outlined in 40 *CFR* § 144.13(c) and RCRA § 3020(b) and, therefore, is not prohibited by regulation or statute.

Table 24. Summary of Action-Specific ARARs for Primary Source Area—Electrical Resistance Heating (Continued)

Standard, Requirement, Criteria, or Limitation	Citation	Description of Requirement	Comments
Hazardous Waste Management	40 *CFR* § 260–264 and § 268; 401 *KAR* 31–34, 36 and 37	All wastes or environmental media containing wastes must be characterized to determine whether the waste also is a hazardous waste in accordance with 40 *CFR* § 262.11 and 401 *KAR* 32:010. If it is determined that a waste is a hazardous waste or that environmental media contains a hazardous waste subject to the RCRA regulation, the substantive requirements of 40 *CFR* § 262–268 are applicable.	The substantive requirements are ARAR and will be complied with through characterization of wastes and environmental media generated as a result of implementation of the alternative. Waste management will be predicated upon the characterization and will comply with all substantive requirements associated with hazardous waste management, if identified as such. Consistent with CERCLA § 121(e)(1), no RCRA permits (e.g., treatment permits) will be required for this action. The levels of 39.2 ppm TCE in solids and 0.081 ppm TCE in water will be used for contained-in/no-longer-contaminated-with determinations. Land Disposal Restrictions apply to media and debris that no longer contain or no longer are contaminated with RCRA regulated waste.
PCB Waste Management	40 *CFR* § 761	TSCA requirements for the management of PCB wastes or items containing ≥50 ppm PCBs or from a source of 50 ppm or greater. Requirements include the following: Management of waste and material; Characterization of PCB-containing materials; Labeling and storage for disposal; Manifest completion for shipment off-site; Decontamination of affected equipment or items; and Disposal of PCB wastes. These requirements will be complied with in the event that PCBs are found at concentrations requiring compliance with this part.	The substantive requirements are ARAR if PCBs are found or result from items or equipment regulated under 40 *CFR* § 761. Activities necessary to comply with these ARARs shall be incorporated into the planning phase of the alternative implementation.

Table 24. Summary of Action-Specific ARARs for Primary Source Area—Electrical Resistance Heating (Continued)

Standard, Requirement, Criteria, or Limitation	Citation	Description of Requirement	Comments
National Emission Standards for Hazardous Air Pollutants	401 *KAR* 57:002	The radiological dose to the most exposed member of the public resulting from site wide radionuclide emissions to the atmosphere must not exceed 10 mrem/year.	The substantive requirements shall be complied with through calculation of emission levels for radionuclides during design and operation of the remedial action. Consistent with CERCLA Section 121(e)(1), no air permit will be required for the emissions of radionuclides.
Environmental Radiation Protection Standards for Nuclear Power Operations	40 *CFR* § 190, Subpart B	Requires that the annual dose equivalent to the public not exceed 25 mrem to the whole body, 75 mrem to the thyroid, and 25 mrem to any other organ as the result of exposures to planned discharges of radioactive materials, radon and its daughters excepted, to the general environment from uranium fuel cycle operations and radiation from these operations.	The substantive standards are considered ARAR and are equivalent to the NRC standards.

ARAR = applicable or relevant and appropriate requirements
CFR = *Code of Federal Regulations*
KPDES = Kentucky Pollutant Discharge Elimination System
PCB = polychlorinated biphenyl
RCRA = Resource Conservation and Recovery Act
CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
KAR = *Kentucky Administrative Regulations*
mrem = millirem
PGDP = Paducah Gaseous Diffusion Plant
TCE = trichloroethene
NRC = Nuclear Regulatory Commission
ppm = parts per million
UIC = Underground Injection Control

12. WASTE MANAGEMENT PLAN

12.1 OVERVIEW

This WMP is the primary document for management of waste that will be generated during implementation of a C-400 IRA to be conducted in the vicinity of the C-400 Building. Previous investigations indicate that elevated concentrations of TCE and its breakdown products exist in soils and groundwater and that free-phase DNAPL exists in the UCRS soil at the south end of the C-400 Building. In addition, TCE concentrations detected in the RGA suggest that free-phase DNAPL is in the RGA in the same area and is acting as a secondary source of groundwater contamination. A major component of this IRA is the removal of free-phase TCE and the reduction of dissolved-phase concentrations of TCE and its breakdown products in the soils in the C-400 Cleaning Building area through removal and treatment using ERH. These actions will produce the waste materials covered by this WMP.

This WMP addresses the management of wastes generated on this project from the point of generation through final disposition. The C-400 IRA is being conducted as a part of the environmental restoration activities at PGDP. The DOE Contractor will be responsible for waste management activities associated with this project. Standard practices and procedures outlined in this WMP regarding the generation, handling, transportation, and storage of waste will comply with all DOE requirements, RCRA requirements, and the TSCA requirements [should polychlorinated biphenyls (PCBs) become an issue].

A copy of this WMP will be available on-site during fieldwork. Copies of the plan will be issued to the DOE Contractor WMC, who will be responsible for daily oversight of all waste management activities and for ensuring overall compliance with the WMP.

The approach outlined in this WMP emphasizes the following objectives:

- Management of the waste in a manner that is protective of human health and the environment;
- Minimization of waste generation, thereby reducing unnecessary costs (e.g., analytical costs), and use of the permitted storage and disposal facilities that are limited in number;
- Compliance with ARARs; and
- Selection of storage and/or disposal alternative(s) for the waste.

Waste management activities must comply with this WMP, ARARs, applicable procedures, the site WAC, and WAC for other specific treatment, storage, and disposal facilities (TSDF) that are designated to receive the waste. The decision has not been made as to the final TSDF that will be used. Potential off-site TSDFs that may be used include, but are not limited to, Energy*Solutions*, Nevada Test Site, Perma-Fix, and Waste Control Specialists.

During the course of this project, additional PGDP and DOE waste management requirements may be identified. Necessary revisions to the WMP will ensure the inclusion of these additional requirements into the daily activities of waste management personnel. DOE will inform the FFA parties of any substantive changes to the WMP or to any other of the C-400 project CERCLA documents. The criteria for different levels of document changes will be those found in *Guide to Preparing Superfund Proposed Plans, Records of Decision, and Other Remedy Selection Decision Documents,* EPA 540-R-98-031.

12.2 WASTE GENERATION AND PLANNING

12.2.1 Waste Generation

A variety of waste will be generated during this project, including soil cuttings and water from drilling activities in the UCRS and RGA; treatment media (carbon, ion exchange resin, zeolite, etc.) from operation of an on-site treatment facility; ERH process piping and equipment; debris generated from infrastructure removal activities around the C-400 Cleaning Building; and sample residuals collected from borings within areas with known TCE/TCA contamination. As such, the waste generated from field-related activities has the potential to contain contaminants related to known or suspected past operations; therefore, this waste must be stored and disposed of in accordance with ARARs. Waste that is likely to have either hazardous or radiological contamination typically will be stored on-site in containers in CERCLA waste storage areas in accordance with PRS-WSD-3010, *Waste Generator Responsibilities for Temporary On-Site Storage of Regulated Waste Materials at Paducah*, during the characterization period and prior to treatment/disposal. Consistent with EPA Policy, the generation, storage, and movement of waste during a CERCLA project and storing it on-site does not trigger the administrative RCRA storage or disposal requirements. On-site waste storage areas will be managed in accordance with the substantive RCRA hazardous waste storage standards. Among the substantive requirements are compatible containers in good condition, regular inspections, containment to control spills or leaks, and characterization of run-on and run-off, either by process knowledge or by sampling. In the event that any wastes are stored in temporary staging piles, plastic sheeting will be placed on the ground under the waste, and additional plastic sheets will be used to cover it to prevent the spread of contamination from rainfall in accordance with substantive RCRA standards for such piles. Final disposition of the materials will depend on final characterization.

Sections 12.2.2 through 12.2.11 provide a brief description of each potential waste stream. As discussed in the ROD (DOE 2005a), page A-5, a SAP is required as part of the WMP for waste characterization. Section 8.3 of this RAWP serves as the SAP required by page A-5 of the ROD (DOE 2005a).

12.2.2 Drill Cuttings from Soil Borings

Drilling cuttings will be generated from installation of the new soil borings and wells. It is assumed that all drill cuttings will have a 25 percent swell factor. An estimated total of 11,600 ft^3 of this waste is expected to be generated.

All drill cuttings will be containerized as they are generated, labeled, and managed on-site according to the substantive requirements of RCRA, until they are either determined not to be RCRA waste or dispositioned to an appropriate disposal facility. Wastes will be stored at the C-760 CERCLA storage area during characterization. The C-760 CERCLA storage area is managed according to the substantive requirements of RCRA. The soil will be sampled and analyzed as described in Section 8.3 for proper waste determination.

Drill cutting waste may be containerized in drums, ST-90 boxes, or 25-yd^3 IM containers during generation. The IM is preferred because it is the most reusable container and its greater size reduces both physical risk and cost by minimizing container movements as well as sampling activities. Dry drill cuttings generally will be loaded first into a self-tipping hopper attached to a forklift. The hopper will be dumped into the top of an IM that, at least, has been partially lined with a ploy liner to facilitate unloading and decontamination. This operation will continue until the IM container is approximately half-full, ensuring that the weight limit for the transport vehicle is not exceeded. The IM then will be sampled for waste characterization as discussed in Section 8.3.3.1.

A portion of the drill cuttings from inside the areas mapped to have free-phase DNAPL may be determined to be characteristically hazardous and will be managed on-site in accordance with substantive requirements of RCRA. Wastes determined to be hazardous will be transferred to an on-site, permitted RCRA storage facility until such time as it is transferred off-site to an approved RCRA treatment and disposal facility.

The remainder of the drill cuttings that are not from the mapped areas of free-phase DNAPL is assumed not to be characteristically hazardous. This waste will be characterized and the concentrations of listed constituents, TCE and 1,1,1-TCA, will be compared to health-based levels for a "no longer contains" determination. If the concentrations are less than health based levels, the waste will not be managed as a RCRA-listed waste. If analytical results show that this waste meets the WAC of the C-746-U Landfill, the waste will be disposed of there as nonhazardous waste.

12.2.3 Personal Protective Equipment

PPE will be worn as specified in the HASP, Chapter 9 of this work plan, by personnel performing the field tasks during the C-400 IRA. While site personnel use procedures and BMP to minimize opportunities for contacting TCE contaminated media and equipment, it is likely that some PPE or related debris (e.g., plastic sheeting) will come into contact with TCE contaminated materials during the remediation process. Process knowledge, visual inspections, or direct sampling will be used to characterize PPE and any related debris. Based on the results of the characterization, any PPE or the related debris determined by site personnel to be contaminated by a listed waste or exhibiting a RCRA characteristic will be managed as hazardous waste, decontaminated, or a no longer contaminated-with determination will be made pursuant to Section 8.3.1. In cases where site personnel conclude, based on the above characterization process, that the PPE or related debris has not been contaminated by a listed waste or does not exhibit a characteristic, then the materials will not be considered a RCRA hazardous waste. An estimated total of 38 ft^3 of this waste is expected to be generated as hazardous waste and an estimated total 337 ft^3 of this waste is expected to be generated as nonhazardous waste.

12.2.4 Purge/Decontamination/Drilling Water

Wastewater will be generated during the installation and development of newly constructed soil borings. An estimated total of 187,000 gallons of this waste is expected to be generated during approximately eight months of drilling activities.

Groundwater and any related aqueous wastes generated from well sampling, well development, and well purging shall not be considered a hazardous waste at the point of generation, if the TCE concentrations are below 1 ppm and the 1,1,1-TCA concentrations are below 25 ppm, provided that the subject aqueous waste will be further treated in an on-site wastewater treatment unit and discharged through a PGDP KPDES-permitted outfall as required by 401 *KAR* 31:010, Section 3. Other aqueous environmental media waste contaminated with TCE or 1,1,1-TCA that does not qualify for the exemption cited herein will use a health-based concentration of 0.081 ppm as the criterion for making contained-in determinations for media destined for on-site treatment and discharge through a KPDES-permitted outfall.

Waste water will be accumulated and stored on-site until it can be processed through the on-site C-752-C treatment plant for removal of suspended solids, as necessary. The C-752-C treatment unit meets the definition of a wastewater treatment unit in 40 *CFR* § 260.10 and can process water at a rate of approximately 1,200 gallons per day. After solids removal, the water will be collected in a manner that will minimize the possibility of spills; then it will be sampled to ensure it meets the appropriate acceptance criteria and treated at the on-site C-400 IRA water treatment facility or transported to the on-site C-612 Northwest Plume Groundwater System, the on-site C-613 Sediment Basin, or other acceptable facility for treatment and/or disposal through KPDES-permitted Outfall 001. The C-400 IRA water treatment facility and the C-612 facility both have adequate additional capacity to treat the 1,200 gallons per day produced generated through C-752-C. The 187,000 gallons of treated drilling, purge, and decontamination water to be discharged through Outfall 001 is a small fraction of the approximately 800,000,000 gallons released annually to this outfall from current sources.

Aqueous waste (including, but not limited to, well sampling, well development, well purging, and decontamination waters) that has undergone wastewater treatment and meets the KPDES discharge limits shall be considered to "no longer contain" listed hazardous waste (i.e., TCE). This treated wastewater may be directly discharged to permitted KPDES Outfalls or on-site ditches that flow to permitted KPDES Outfalls.

The proposed target analytes for this waste are those required to meet KPDES discharge limits and include TCE, PCBs, oil and grease, total residual chlorine, total phosphorous, total metals, ^{99}Tc, hardness, dissolved and suspended alpha, beta, total uranium, and pH.

12.2.5 Sediment and Mud from Separation of Decontamination and Purge Water

Decontamination water and mud (soil sediment/mud) will be generated during cleaning of the drilling and sampling equipment. An estimated total of 375 ft^3 is expected to be generated. The water will be collected in a sump in the decontamination facility, decanted on-site and collected in a manner that will minimize the possibility of spills, to the extent possible, and added to the Purge/Decontamination/Drilling water waste stream described in Section 12.2.4. The mud will be containerized as it is removed from the sump, then sampled and managed similarly to drill cuttings (Section 12.2.2).

12.2.6 Treated Groundwater

An aboveground treatment system will be installed to treat groundwater extracted during operation of the ERH process. The treatment system will remove VOCs and ^{99}Tc from the groundwater prior to discharge to an on-site ditch, which drains to KPDES-permitted Outfall 001. The system will have a treatment capacity of approximately 80 gallons per minute (gpm). During Phase I operations the system is expected to operate at approximately 30 to 50 gpm and during Phase II the system is expected to operate at 45 to 65 gpm. At full capacity of 80 gpm the C-400 treatment system discharge will only increase the overall flow to Outfall 001 by approximately 5%.

The treatment system influent and discharge design parameters are shown in the Table 25.

Table 25. Liquid Treatment System Design Parameters and Discharge Criteria

Analyte/Design Parameter	Influent	Discharge Limit
TCE concentration	5 - 1,100 ppm	30 ppb[1]
1,1-DCE concentration	154 ppb	3.2 ppb[1]
Technetium-99 activity	40-160 pCi/L (observed in groundwater sampled during the Six-Phase Treatability Study)	900 pCi/L[2]
Temperature	203 ˚F (95˚C) maximum 185 ˚F (85˚C) average	89 ˚F (31 ˚C) daily max[3]
pH	5.5 - 6.5	6 - 9[3]
Total suspended solids	10 - 50 ppm	30 mg/L monthly average[3] 60 mg/L daily max[3]
Total residual chlorine	Plant potable water levels	0.011 mg/L monthly

average[3]
0.019 daily max[3]

1 Discharge limits are based on Kentucky Administrative Regulations (*KAR)* 401 *KAR* 5:031
2 DOE target limit
3 KPDES permit limit for Outfall 001 effluent discharge

During system startup and testing treated water will be sampled prior to discharge to verify that the system is adequately treating the groundwater. During routine operations weekly samples of the system effluent will be analyzed to monitor on going performance of the treatment system.

Aqueous waste (including, but not limited to, well sampling, well development, well purging, and decontamination waters) that has undergone wastewater treatment and meets the KPDES discharge limits shall be considered to “no longer contain” listed hazardous waste (i.e., TCE). This treated wastewater may be directly discharged to permitted KPDES Outfalls or on-site ditches that flow to permitted KPDES Outfalls.

12.2.7 Spent Carbon Media, Ion Exchange Resin, and Spent Zeolite Media

During the implementation of the C-400 IRA, the aboveground treatment system will contain several types of media used in the treatment of VOC-contaminated extracted groundwater and vapors including activated carbon, ion exchange resin, zeolite, and cloth filters. In addition to VOCs, other laboratory analyses conducted on these wastes include TCLP SVOCs and metals and total radiological (RAD). If any of these analyses indicate that the waste is characteristically hazardous or a listed-hazardous waste, the waste will be managed and disposed of as such.

The carbon, ion exchange resin and zeolite are recyclable, which is the preferred disposition for these materials if health physics (HP) survey indicates that radiological contamination is less than free-release limits. If the analytical results show that the wastes are not characteristically hazardous but the HP survey indicates that radiological contamination is too high for recycling (free-release), but less than the authorized limits of the C-746-U Landfill, they will be disposed of there if other disposal criteria are met. An estimated total of 1,850 ft^3 of carbon media, 240 ft^3 of ion exchange media, and 925 ft^3 of zeolite media is expected to be generated.

12.2.8 Infrastructure Removal Debris

Infrastructure removal activities included in this project are the demolition of the overhead crane, TCE tank, the sump, and the TCE pumping station and associated piping at the southeast corner of the C-400 building, and the tanker off-loading platform and the containment tank in the southwest corner. This will result in the largest volume waste stream, estimated at 12,150 ft^3, generated from this project. In the event that any TCE or other listed solvent is found on this waste debris stream, it will be decontaminated according to the provisions of 40 *CFR* § 268.45. The presence of residual solvents will be determined by visual inspection. Any debris that has no visible residual solvents will be considered nonhazardous and either recycled or disposed of in the C-746-U Landfill, as appropriate. If scrap metal is able to be recycled under 40 *CFR* § 261.6(a)(3)(ii), the waste is exempt from regulation as a hazardous waste. Any hazardous waste that has residual solvents on it will be decontaminated and also will be considered nonhazardous per the provisions of 40 *CFR* § 268.45(c) and 40 *CFR* § 261.3(f)(1). Any debris found to be contaminated with greater than 50 ppm PCB or painted with PCB bulk product greater than 50 ppm will be managed in accordance with Section 8.3.2.3.

12.2.9 DNAPL VOC

To accomplish the mass reduction of VOCs (primarily TCE and its breakdown products) in the C-400 area, free-phase DNAPL VOCs will be recovered by the aboveground treatment system. All liquid phase VOCs will be containerized, labeled, and managed according to the substantive requirements of RCRA while on-site. The analytical results are expected to exceed the levels listed in Section 8.3.1; therefore, the liquid VOCs are expected to be treated at an off-site RCRA-permitted hazardous waste facility. Other target analytes for this waste are SVOCs, metals, and total RAD. An estimated total of approximately 75,000 gallons of this waste is expected to be generated from this project.

12.2.10 Process Piping, Equipment, and Well Abandonment Waste

During the implementation of the C-400 IRA, a subsurface ERH treatment system and an aboveground treatment system will be constructed and operated. Following completion of the C-400 IRA, the process piping and equipment from these systems will be dismantled. Equipment from the aboveground portions of the treatment system will be dismantled and removed from the site. A portion of the equipment will be leased or rented equipment that will be returned to the appropriate vendor following decontamination activities. The remaining equipment and process piping is expected to be recycled or disposed of in the C-746-U Landfill, as appropriate. If scrap metal is able to be recycled under 40 *CFR* § 261.6(a)(3)(ii), the waste is exempt from regulation as a hazardous waste. Any hazardous waste that has residual solvents on it will be decontaminated per 40 *CFR* § 268.45 and disposed of as nonhazardous according to the provisions of 40 *CFR* § 268.45(c) and 40 *CFR* § 261.3(f)(1). Any process piping and equipment that cannot be successfully decontaminated will be disposed of off-site at a RCRA-permitted hazardous waste facility. An estimated total of 10,800 ft^3 of this waste is expected to be generated.

Approximately 1,500 ft^3 of waste will be generated during abandonment of ERH subsurface components, including piezometers from the Six-Phase Treatability Study. The waste generated from these activities will be stored at the C-760 CERCLA storage area during characterization. Wastes determined to be hazardous will be transferred to an on-site permitted RCRA storage facility until such time as it is transferred off-site to an approved RCRA treatment and disposal facility. See sections 11.4.4 and 11.4.10 for details regarding abandonment of ERH subsurface components.

12.2.11 Miscellaneous Noncontaminated Clean Trash

DOE has implemented waste management activities for the segregation of all clean trash (i.e., trash that is not chemically or radiologically contaminated). Examples of clean trash are office paper, aluminum cans, packaging materials, and glass bottles not used to store potentially hazardous chemicals, aluminum foil, and food items. During implementation of this WMP, all clean trash will be segregated according to those guidelines and then collected and recycled/disposed of by the WMC once it has been approved for removal. An estimated total of 740 ft^3 of this waste is expected to be generated.

12.3 WASTE MANAGEMENT ROLES AND RESPONSIBILITIES

12.3.1 Waste Management Tracking Responsibilities

Waste generated during sampling activities at PGDP will require a comprehensive waste-tracking system capable of maintaining an up-to-date inventory of waste. The inventory database will be used to store data that will enable determination of management, storage, treatment, and disposal requirements for the waste.

12.3.2 Waste Management Coordinator

The WMC will ensure that all waste activities are conducted in accordance with PGDP facility requirements and this WMP. Responsibilities of the WMC also include coordinating activities with field personnel, overseeing daily waste management operations, and maintaining a waste management logbook that contains a complete history of generated waste and the current status of individual waste containers. Designated waste operators also may complete the waste management logbook.

The WMC will ensure that procurement and inspection of equipment, material or services critical for shipments of waste to off-site TSDFs are conducted in accordance with appropriate procedures. In addition, the WMC will ensure that wastes are packaged and managed in accordance with applicable requirements (e.g. the WAC for the landfill).

Additional responsibilities of the WMC include the following:

- Maintaining an adequate supply of labels;
- Maintaining drum inventories at sites;
- Interfacing with all necessary personnel;
- Preparing Requests for Disposal (RFDs);
- Tracking generated waste;
- Ensuring that drums are properly labeled;
- Coordinating waste recycling, disposal, or transfers;
- Sampling waste containers to characterize wastes;
- Coordinating pollution prevention and waste minimization activities;
- Transferring characterization data to DOE Prime Contractor's Data Manager; and
- Ensuring that temporary project waste storage areas are properly established, maintained, and closed.

The WMC or designee will update a computer-generated status sheet that can be retrieved quickly and will list all waste generated during field activities. The waste status sheet will supply information such as the following:

- Generation date;
- RFD number;
- Waste origination point;
- Waste type (solid or liquid);
- Description (e.g., soil, PPE, plastic);
- Quantity of waste;
- Current location of waste;
- Sampling status;
- Sampling results status; and
- Resampling needed.

This status sheet will be prepared monthly or as necessary to report the status of project waste generation. Waste item container logs will be used to document each addition of waste to containers.

The WMC and waste operators will perform the majority of waste handling activities. These activities will involve coordination with the DOE Prime Contractor IRA Project Manager or designee who will perform periodic inspections to verify that drums are labeled in accordance with the WMP guidelines.

The WMC will be responsible for ensuring characterization sampling of the waste in accordance with the procedures outlined in this plan. When sampling is complete, the WMC will transfer the waste into the waste holding area established for this project, if necessary.

The WMC or designee will complete all chain-of-custody forms relating to the shipment of waste characterization samples. The chain-of-custody forms, along with the associated samples, will be transferred to the personnel responsible for packaging and delivery of the samples.

The WMC or designee will inspect the decontamination facility to ensure that waste generation is minimized to the extent possible and that the transfer of liquids to the waste holding area is arranged such that the work schedule is not delayed. If improper waste-handling activities are observed, the WMC will notify the DOE Prime Contractor IRA Project Manager and temporarily stop decontamination activities. All activities not in compliance with the WMP will be identified and corrected before decontamination activities continue.

12.3.2.1 Coordination with Field Crews

The WMC will be responsible for daily coordination with all field crews involved in activities that generate waste. The WMC will perform daily rounds of each of the work sites to oversee the waste collection and will verify that procedures used by the field crews comply with the WMP guidelines. Deficiencies will be documented in the waste management logbook, and appropriate direction will be given to the field crews. Site visits will be documented in the field logbook.

12.3.3 Coordination with Treatment, Storage, and Disposal Facilities

The waste streams generated on the C-400 IRA may be managed and disposed of in a variety of ways depending on characterization and classification. Waste will be temporarily stored on-site as previously discussed. Waste that is to be shipped to an off-site TSDF must be done so in accordance with applicable DOE Contractor procedures and U.S. Department of Transportation requirements.

12.3.4 Waste Management Training

The WMC and other project personnel with assigned waste management responsibilities will be trained and qualified in accordance with DOE Contractor-approved Training Position Descriptions.

12.4 TRANSPORTATION OF WASTE

The areas where the C-400 IRA activities will be conducted are on DOE property. Transportation of waste on DOE property will be conducted in accordance with applicable DOE, PGDP, and DOE Prime Contractor policies and procedures. In the event that it becomes necessary to transport known or suspected hazardous waste over public roads, coordination will be initiated with PGDP Security, as necessary, which may result in the temporary closing of roads. Once hazardous wastes are transported from a CERCLA site, they are subject to full RCRA regulation; therefore, all transportation and TSDF requirements under RCRA must be followed. Off-site shipments must be accompanied by a manifest. Off-site disposal of hazardous wastes will occur only at a RCRA facility in a unit in full compliance with the Subtitle C requirements. Transportation of known or suspected hazardous waste on public roads will be conducted in accordance with applicable U.S. Department of Transportation regulations (*CFR* Title 49).

12.4.1 Screening of Analytical Samples

During the course of the C-400 IRA field activities, screening of samples in the field and in an on-site laboratory routinely will be performed to protect the health and safety of on-site personnel to ensure compliance with regulatory requirements.

12.4.2 Field Screening

Field screening for health and safety will be conducted during project field activities and sample collection. The field screening to be performed will incorporate the use of instrumentation to monitor for organic vapors, as well as radiation meters capable of detecting alpha and beta/gamma radioactivity. An elevated reading from field monitoring may be cause for reevaluation of current waste classification, labeling, and handling activities.

12.4.3 On-Site Laboratory Radiation Screening

A fixed-base laboratory will analyze all waste characterization samples. All samples to be shipped off-site for laboratory analysis will be screened for radiation at an on-site laboratory before shipment and will receive approval for off-site shipment.

12.5 SAMPLE RESIDUALS AND MISCELLANEOUS WASTE MANAGEMENT

The SMO-approved analytical laboratory that has been audited under DOECAP will generate sample residuals and laboratory wastes. The laboratory will manage and return waste sample residuals to the project. Nonhazardous wastes generated during analyses will be disposed of by the laboratory.

12.6 WASTE MINIMIZATION

Waste minimization requirements that will be implemented, as appropriate, include those established by the 1984 Hazardous and Solid Waste Amendments of RCRA; DOE Orders 5400.1, 5400.3, 435.1; and DOE Contractor's requirements. Requirements specified in the DOE Contractor's WMP regarding waste generation, waste tracking, waste reduction techniques, and the waste reduction program, in general, also will be implemented.

To support DOE's commitment to waste reduction, an effort will be made during field activities to minimize waste generation as much as possible, largely through ensuring that potentially contaminated wastes are localized and do not come into contact with any clean media (which could create more contaminated waste). Waste minimization also will be accomplished through waste segregation, immediate containerization of waste, selection of PPE, and waste handling (spill control). Efforts will be made to avoid stockpiling soil waste, use coveralls only when necessary, attempt to reuse coveralls, and segregate visibly soiled coveralls from clean coveralls.

12.7 HEALTH AND SAFETY ISSUES RELATED TO WASTE ACTIVITIES

Waste management activities will be conducted in accordance with health and safety procedures documented in the HASP included as Section 7 of this work plan.

13. REFERENCES

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TRS (Thermal Remediation Services) 2007. Technical Paper: *Three-Phase Heating? Six-Phase Heating? Which is Better?* Accessed on the World Wide Web at http://www.thermalrs.com/technology/whitePapers/ThreePhase vs_SixPhase.pdf, February 2007.

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APPENDIX A

CD—*REMEDIAL DESIGN REPORT, CERTIFIED FOR CONSTRUCTION DESIGN DRAWINGS AND TECHNICAL SPECIFICATIONS PACKAGE, FOR THE GROUNDWATER OPERABLE UNIT FOR THE VOLATILE ORGANIC COMPOUND CONTAMINATION AT THE C-400 CLEANING BUILDING AT THE PADUCAH GASEOUS DIFFUSION PLANT, PADUCAH, KENTUCKY* (RDR), DOE/LX/07-0005&D2/R1

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CD—*REMEDIAL DESIGN REPORT, CERTIFIED FOR CONSTRUCTION DESIGN DRAWINGS AND TECHNICAL SPECIFICATIONS PACKAGE, FOR THE GROUNDWATER OPERABLE UNIT FOR THE VOLATILE ORGANIC COMPOUND CONTAMINATION AT THE C-400 CLEANING BUILDING AT THE PADUCAH GASEOUS DIFFUSION PLANT, PADUCAH, KENTUCKY* (RDR), DOE/LX/07-0005&D2/R1

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APPENDIX B

WEST STORM SEWER AREA ASSESSMENT OF TCE

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The Waste Area Grouping 6 Remedial Investigation (WAG 6 RI) Report (DOE 1999) is the primary source of trichloroethene (TCE) analyses of soil in the area to the south of the C-400 Cleaning Building. This appendix summarizes the WAG 6 RI data for the west storm sewer area and documents the calculation of the TCE volume.

The vadose zone at the Paducah Gaseous Diffusion Plant exists primarily in a loess unit (silt). A high percentage of the porosity between 20 and 30 ft below ground surface is expected to be filled with water. The following dense nonaqueous-phase liquid volume calculation does not include a correction for reduced water saturation in the vadose zone.

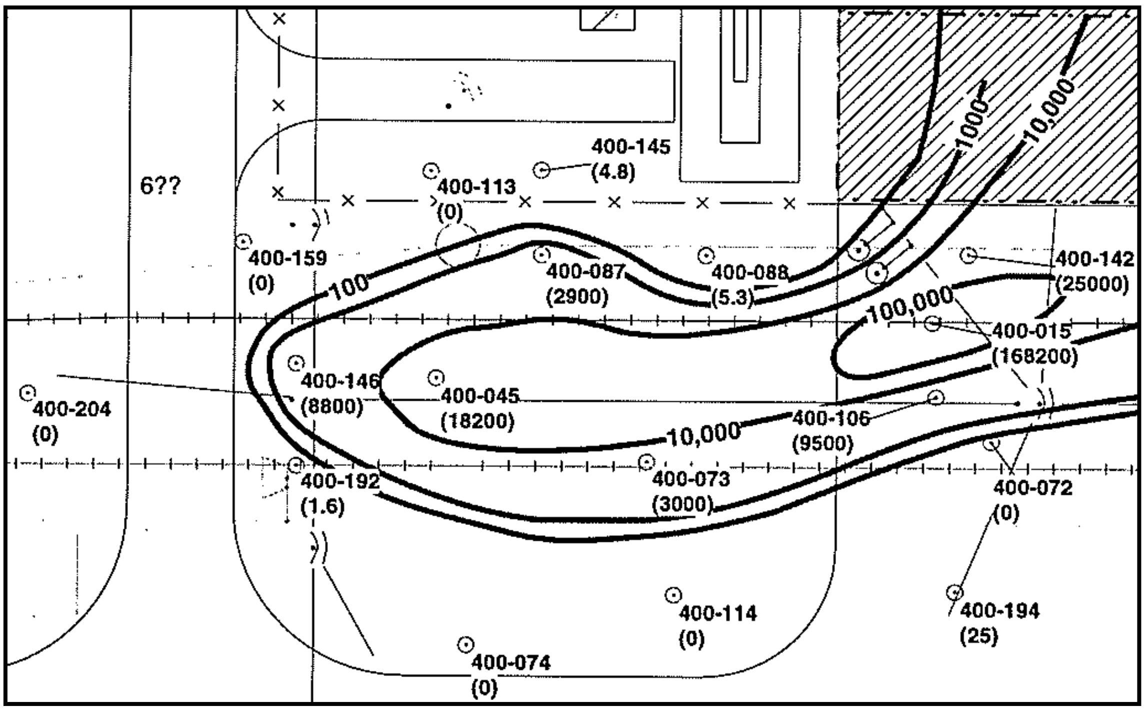

Figure B.1. Inset from "Figure 4.10. Sector 4 and 5 Maximum TCE Concentration in Soil" of the WAG 6 Remedial Investigation Report (DOE 1999)

West Storm Sewer Area

TCE analyses for soil for 0 - 40 ft depth in West Storm Sewer Area					
	DEPTH (ft)		TCE (ug/kg)		
BORING	TOP	BOTTOM	SW846-8010M		
400-087	4	8	2,900		
400-045	6	10	18,200		
400-142	7	11	25,000		
400-073	13	17	3,000		
400-106	13	17	9,500		
400-146	15	19	8,800		
Max detected TCE near 20 ft depth ~ 10,000 ug/kg = DNAPL saturation of ~ 0.004 %.					
The closest boring to the West Storm Sewer area with TCE analyses below 20 ft is 400-015.					
	DEPTH (ft)		TCE (ug/kg)		
BORING	TOP	BOTTOM	SW846-8010M		
400-015	19	23	200,000		
	30	33	94,400		
	40	43	28,000		
Soil TCE concentrations in 400-015 decline 86% over the 20 - 40 ft depth interval.					
Average TCE concentration for the West Storm Sewer Area with a similar trend would be 4,440 ug/kg = DNAPL saturation of ~ 0.002 %.					
Area (sq ft)	Volume (cu ft)	Porosity Volume			
1,315.2	26,304.6		26,305 cu ft x 36% porosity =	9,470	cu ft
			=	70,842	gal
			0.002% DNAPL saturation =	**1**	**gal TCE**

APPENDIX C

SECTION 9 QAP APPROVAL PAGE

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QUALITY ASSURANCE PLAN APPROVALS

Remedial Action Work Plan
for the
Interim Remedial Action
for the Volatile Organic Compound Contamination
at the C-400 Cleaning Building
at the
Paducah Gaseous Diffusion Plant,
Paducah, Kentucky

DOE/LX/07-0004&D2/R2

July 2009

Rick Keeling Quality Assurance Manager	Date
John Lea Environmental Restoration Manager	Date
Mike Clark Interim Remedial Action Project Manager	Date

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APPENDIX D

AIR DISPERSION ANALYSIS

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D.1 AIR DISPERSION ANALYSIS

D.1.1 INTRODUCTION

This appendix describes the air dispersion analysis of potential hazardous air pollutant emissions from the implementation of the C-400 Interim Remedial Action (IRA). The property boundary concentrations for these potential hazardous air pollutant emissions were estimated utilizing using BREEZE AERMOD GIS Pro v5.1.7. Report printouts and electronic model-ready input files are included in the attachment to this appendix. The results of the dispersion analysis are summarized in Section 11.

D.1.2 IDENTIFICATION OF TOXIC POLLUTANTS

The potential hazardous air pollutants (HAPs) that could be emitted by the C-400 IRA have been identified based on groundwater characterization. The groundwater characterization is documented in *Remedial Design Support Investigation Characterization Plan for the Interim Remedial Action for the Volatile Organic Compound Contamination Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-2211&D2, (DOE 2005b). The potential HAPs that could be emitted are trichloroethene (TCE), vinyl chloride, *trans*-1,2-dichloroethene (DCE), *cis*-1,2-DCE, and 1,1-DCE. These hazardous air pollutants will be removed from the subsurface using Electrical Resistance Heating (ERH). ERH involves *in situ* heating of soils resulting in the collection and recovery of contaminants from the aquifer and vadose zone.

D.1.3. ALLOWABLE OFF-SITE CONCENTRATIONS CALCULATIONS

The treated vapor/gases must comply with the contaminant concentration requirements of 401 *KAR* 63:020. This states that no owner or operator shall allow any affected facility to emit potentially hazardous matter or toxic substances in such quantities or duration as to be harmful to the health and welfare of humans, animals and plants.

D.1.3.1 TCE and Vinyl Chloride Allowable Off-site Concentrations

The concentrations of TCE and vinyl chloride are based on the EAP Air Toxics Risk Assessment Reference Library, Volume 2, Facility Specific Assessment. These values are located at the following Web site http://www.epa.gov/ttn/atw/toxsource/table1.pdf. Both TCE and vinyl chloride are possible carcinogens. The cancer chronic inhalation value for each is used in calculating the maximum allowable concentration. The value for TCE is 0.000002 per $\mu g/m^3$ and the value for vinyl chloride is 0.0000088 per $\mu g/m^3$. The allowable risk is assumed to be 1×10^{-6}. The maximum allowable concentration is calculated by the following formula:

Allowable Risk = Estimate of continuous inhalation exposure X Inhalation Unit Risk Estimate

Or

Estimate of continuous inhalation exposure = Allowable Risk/Inhalation Unit Risk Estimate

For TCE the calculation would be as follows:

TCE Allowable concentration = 1 x 10^{-6} /0.000002 per µg/m^3

TCE Allowable concentration = 0.5 µg/m^3

Similarly for vinyl chloride the allowable concentration would be 0.11 µg/m^3

D.1.3.2 DCE Allowable Off-site Concentrations

The maximum allowable air concentrations for dichloroethene (dichloroethylene) were calculated using the EPA Regions 9 Preliminary Remediation Goals (PRG) values, which are available at http://www.epa.gov/region09/waste/sfund/prg. These values are based on the non-cancer risks posed by long-term exposure to DCE. The health effects of exposure to DCE are measured by a hazardous index, with a hazard index of 1 being an indication of the nearest off-site receptor having detrimental health effects from exposure to that chemical.

DCE is present in three chemical forms, 1,1-DCE; *cis*-1,2-DCE, and *trans*-1.2-DCE. The ambient air PRG for each chemical form is 1,1-DCE – 210 µg/m^3; *cis*-1,2-DCE – 37 µg/m^3; and *trans*-1,2-DCE – 73 µg/m^3.

All of the allowable off-site concentrations are shown in Table D.1.

Table D.1. Allowable Off-site Concentration Limits

Pollutant	Allowable Off-site Concentration (µg/m^3)	Reference Source
TCE	0.5	EAP Air Toxics Risk Assessment Reference Library, Volume 2, Facility Specific Assessment
vinyl chloride	0.11	EAP Air Toxics Risk Assessment Reference Library, Volume 2, Facility Specific Assessment
1,1-DCE	210	Preliminary Remediation Goals
cis-1,2-DCE	37	Preliminary Remediation Goals
trans-1,2-DCE	73	Preliminary Remediation Goals

µg/m^3 = micrograms per cubic meter

D.1.4 ESTIMATED EMISSION RATES

D.1.4.1 Construction Fugitive Emissions

During construction of the ERH, fugitive emissions will be released. The fugitive emissions occur when the subsurface equipment, such as electrodes and well completion components, is placed in the boreholes and displace the contaminate-laden air.

Assuming the average depth to of each borehole is 85 feet and the average borehole diameter is 9 inches, the volume of a borehole is 37.6 ft^3. Assuming all 220 boreholes will be filled over 8 months.

The estimated contaminant fractions of the displaced air is based on the characterization of the groundwater contamination. The assumed contaminants occupy the entire volume and are present at the following fractions: TCE – 0.395; vinyl chloride – 0.047; 1,1-DCE – 0.055; *cis*-1,2-DCE – 0.079; *trans*-1,2-DCE – 0.432

The estimated fugitive emission rates are shown in Table D.2.

Table D.2. Estimated Fugitive Emission Rates

Chemical	Fugitive Emission Rate
	g/s
TCE	2.5E-5
vinyl chloride	3.0E-6
1,1-DCE	3.5E-6
cis-1,2-DCE	5.1E-6
trans-1,2-DCE	2.8E-5

g/s = grams per second

D.1.4.2 Operations Emissions

During operation of the project, the hazardous constituents in the subsurface will be volatilized underground and recovered by a vapor phase extraction system. The system will capture the soil vapors, which will be treated and released through a stack. The current design utilizes a cryogenic adsorption system to remove hazardous constituents from the off-gas; then an activated carbon filtration will polish the treatment prior to discharge to the atmosphere. The current design criteria for the treatment system is such that the concentrations of an individual HAP in the exhaust stack will not exceed 20 ppmv.

In order to estimate the maximum off-site concentration the exhaust was assumed to contain the maximum concentration of each HAP. The following preliminary design parameters[1] for the stack were used in the model to estimate the dispersion of the hazardous constituents:

- 8-inch diameter
- 20-ft high
- 1,500 scfm flow rate
- 70 °F exhaust gas temperature

The air dispersion model input is grams per second. The stack concentration is converted from ppmv to grams per second using the following formula:

$$\text{ppmv} = (\text{mg/m}^3)(273.15 + {}^{\circ}\text{C})/(12.187)(\text{Molecular Weight})$$

The maximum emission rates during operation are listed in Table D.3 in both ppmv and grams per second.

---

[1]The last paragraph of Section 4.5.3 in the *Remedial Design Report, Certified for Construction Design Drawings and Technical Specifications Package, for the Groundwater Operable Unit for the Volatile Organic Compound Contamination at the C-400 Cleaning Building at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE/LX/07-0005&D2) (RDR) states, "Off-gas from the vapor-phase polishing system will be discharged to the atmosphere through a 20-ft tall by 8-inch diameter stack." The flow rate and temperature are shown on drawing P7DC40000A001 in Appendix F of the RDR.

Table D.3. Estimated Operational Emission Rates

Chemical	Stack Design Concentration	
	ppmv	g/s
TCE	20	0.0601
vinyl chloride	20	0.0286
1,1-DCE	20	0.0444
cis-1,2-DCE	20	0.0444
trans-1,2-DCE	20	0.0444

g/s = grams per second
ppmv = parts per million by volume

D.1.4.3 Maximum Off-site Concentrations

The property boundary ambient concentration for each HAP was estimated utilizing the air dispersion model BREEZE AERMOD GIS Pro v5.1.7.

Surface meteorology data from station number 72435 and upper air meteorology data from station 00013897 were used. Dispersion analysis of meteorological data from these stations for 2000 and 2002 through 2005 showed the highest boundary concentration occurred for 2003 data (January 1, 2003 through December 31, 2003). The dataset for 2001 was incomplete and 2000 was used as a replacement; therefore, this data was used to calculate the maximum off-site concentration. The AERMOD ready meteorological files were purchased from Trinity Consultants, Inc.

The dispersion analysis averages the concentration annually. The results of the TCE operational emissions are shown in the attached model reports. The same model parameters were run for the emission rates for all of the pollutants for both fugitive and operational emissions. The estimated maximum concentrations to a receptor at the property boundary resulting from the dispersion analysis for fugitive emissions are shown in Table D.4.

Table D.4. Estimated Off-site Concentrations for Fugitive Emissions

Chemical	Off-site limit	Annual Average Maximum Off-site Concentration
	ug/m^3	ug/m^3
TCE	0.5	3.8E-5
vinyl chloride	0.11	4.5E-6
1,1-DCE	210	5.3E-6
cis-1,2-DCE	37	7.6E-6
trans-1,2-DCE	73	4.2E-5

µg/m^3 = micrograms per cubic meter

The estimated maximum off-site concentrations to a receptor at the property boundary resulting from operational emissions are shown in Table D.5.

Table D.5. Estimated Off-site Concentrations for Operational Emissions

Chemical	Off-site limit	Stack Design Concentration		Annual Average Maximum Off-site Concentration
	ug/m^3	ppmv	g/s	ug/m^3
TCE	0.5	20	0.0601	3.75E-2
vinyl chloride	0.11	20	0.0286	1.8E-2
1,1-DCE	210	20	0.0444	2.8E-2
cis-1,2-DCE	37	20	0.0444	2.8E-2
trans-1,2-DCE	73	20	0.0444	2.8E-2

g/s = grams per second
ppmv = parts per million by volume
µg/m^3 = micrograms per cubic meter

The estimated concentrations are well below maximum allowable off-site concentrations. The sum hazard index for the three DCE chemical forms when combined are less than one, indicating the combination of HAPs is less than the allowable concentration.

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ATTACHMENT

AIR DISPERSION ANALYSIS REPORTS AND MODEL READY INPUT FILES

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CD—AERMOD INPUT AND OUTPUT FILES

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APPENDIX E

ADDENDUM TO REMEDIAL ACTION WORK PLAN FOR THE INTERIM REMEDIAL ACTION FOR THE VOLATILE ORGANIC COMPOUND CONTAMINATION AT THE C-400 CLEANING BUILDING AT THE PADUCAH GASEOUS DIFFUSION PLANT, PADUCAH, KENTUCKY—FIELD SAMPLING PLAN FOR DEVELOPING PREDICTIVE RELATIONSHIPS AND AUGMENTATION OF RESULTS OF THE MEMBRANE INTERFACE PROBE LOGS OF THE SOUTHEAST C-400 DENSE NONAQUEOUS-PHASE LIQUID AREA AT THE PADUCAH GASEOUS DIFFUSION PLANT, PADUCAH, KENTUCKY

Field Sampling Plan
for Developing Predictive Relationships and Augmentation of Results of the Membrane Interface Probe Logs of the Southeast C-400 Dense Nonaqueous-Phase Liquid Area at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky

Field Sampling Plan for Developing Predictive Relationships and Augmentation of Results of the Membrane Interface Probe Logs of the Southeast C-400 Dense Nonaqueous-Phase Liquid Area at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky

Date Issued—November 2010

U.S. DEPARTMENT OF ENERGY
Office of Environmental Management

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

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CONTENTS

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FIGURES

TABLES

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ACRONYMS

bgs	below ground surface
DCE	dichloroethene
DNAPL	dense nonaqueous-phase liquid
DOE	U.S. Department of Energy
DPT	direct push technology
DQO	data quality objective
ECD	electron capture detector
ERH	electrical resistance heating
FFA	Federal Facility Agreement
FID	flame ionization detector
FS	feasibility study
FSP	field sampling plan
GC	gas chromatograph
GWOU	groundwater operable unit
HSA	hollow stem auger
HU	hydrogeological unit
IRA	interim remedial action
LATA Kentucky	LATA Environmental Services of Kentucky, LLC
MIP	membrane interface probe
MW	monitoring well
NA	not available
NOD	natural oxidant demand
PGDP	Paducah Gaseous Diffusion Plant
PID	photoionization detector
RAWP	Remedial Action Work Plan
RDR	remedial design report
RDSI	remedial design support investigation
RGA	Regional Gravel Aquifer
RI	remedial investigation
ROD	record of decision
SMO	sample management office
SWMU	solid waste management unit
TCE	trichloroethene
UCRS	Upper Continental Recharge System
VOC	volatile organic compound
WAG	waste area grouping

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EXECUTIVE SUMMARY

LATA Environmental Services of Kentucky, LLC, (LATA Kentucky) completed the Phase I Electrical Resistance Heating Interim Remedial Action at the Paducah Gaseous Diffusion Plant and is in the process of preparing for implementation of Phase II. A key Lesson Learned from Phase I was that the estimate of trichloroethene (TCE) mass in the Phase I area may have been substantially overestimated due to reliance on an interpretation of Membrane Interface Probe (MIP) results. Upon comparison of predesign estimates of potentially recoverable TCE mass and observed TCE mass recovered as part of Phase I, the basis of estimate for potentially recoverable TCE mass for Phase II requires reassessment. Additional data for mass estimation should be collected before proceeding with Phase II. This Field Sampling Plan (FSP) was developed to guide the collection of additional data in the vicinity of the planned Phase II area to refine the estimate of mass.

This FSP addresses the development of predictive relationships of historical and proposed MIP records with TCE concentrations in soil and groundwater and the collection of independent data to assess the mass of TCE contamination present. In addition, this FSP describes the collection of some limited screening-level data to assess potential remedial actions for the C-400 TCE. This field sampling plan includes the following:

- At four locations in the suspected primary dense nonaqueous-phase liquid (DNAPL) zone of Phase II, using MIP technology, characterize soils of the Upper Continental Recharge System (UCRS) and Regional Gravel Aquifer (RGA). At least two of the locations for the proposed MIP logs will be collocated with MIP boreholes from a 2006 investigation to assess the similarity of the new and previous MIP logs. Dependent on the similarity of these two proposed MIP logs with the previous collocated MIP logs, the remaining two MIP locations for this investigation may be collocated with previous MIP borings or placed in areas of greater uncertainty.

- At eight locations within and peripheral to the suspected primary DNAPL zone of Phase II, collect soil samples in the UCRS and groundwater samples in the RGA for analysis of TCE and degradation product concentrations. These analyses will be used to develop predictive relationships between the existing MIP logs and additional MIP logs proposed in this FSP and TCE concentrations in the subsurface.

- At one location upgradient to the suspected DNAPL zones of the area southeast of Building C-400, install and develop a monitoring well cluster with well screens in the upper, middle, and lower RGA.

- Install passive flux meters in the monitoring well cluster to assess groundwater flow rates in the RGA in the area of C-400.

- In the borehole for the upgradient monitoring well cluster, collect soil samples from the UCRS, RGA, and upper McNairy Formation for analysis of Natural Oxidant Demand. These analyses will provide screening level data for assessment of chemical oxidation of the TCE contamination.

- Sample the existing groundwater microbial community in the vicinity of C-400 with passive sampling traps in monitoring wells of the UCRS and upper and lower RGA. The analyses of these microbial communities will provide screening level data for assessment of enhanced microbial degradation of the TCE contamination.

The data from this investigation will be used to evaluate implementation of Phase II of the C-400 Interim Remedial Action. LATA Kentucky prepared this FSP on behalf of the U.S. Department of Energy.

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E.1. INTRODUCTION

LATA Environmental Services of Kentucky, LLC, (LATA Kentucky) completed the Phase I Electrical Resistance Heating (ERH) Interim Remedial Action (IRA) at the Paducah Gaseous Diffusion Plant (PGDP) and is in the process of preparing for implementation of Phase II. A key Lesson Learned from Phase I was that the estimate of trichloroethene (TCE) mass in the Phase I area may have been substantially overestimated due to reliance on an interpretation of Membrane Interface Probe (MIP) results. Upon comparison of predesign estimates of potentially recoverable TCE mass and observed TCE mass recovered as part of Phase I, the basis of estimate for potentially recoverable TCE mass for Phase II requires reassessment. Additional data for mass estimation should be collected before proceeding with Phase II. This Field Sampling Plan (FSP) was developed to collect additional data in the vicinity of the planned Phase II area to refine the estimate of mass. The technique includes use of MIP technology and conventional soil and groundwater sampling to refine the mass estimate to allow for focused implementation of Phase II. LATA Kentucky prepared this FSP on behalf of the U.S. Department of Energy (DOE).

Historical sampling using conventional soil and groundwater sample and MIP technology logs of the area southeast of the C-400 Building identify a suspected dense nonaqueous-phase liquid (DNAPL) zone that underlies an area of approximately 10,000 ft^2 (Figure E.1). The surface area consists primarily of a paved apron and graveled curb on the south side of the C-400 Building and is located immediately south of the site of a former TCE unloading pump for rail cars. Spills and leaks associated with the unloading pump are the suspected source of much of the TCE DNAPL. Other TCE-related utilities were located previously in the vicinity and also may have been important contributors.

The response action selected in the *Record of Decision for Interim Remedial Action for the Groundwater Operable Unit for the Volatile Organic Compound Contamination at the C-400 Cleaning Building at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* (ROD) DOE/OR/07-2150&D2/R2, (DOE 2005a) is the design, installation, operation, and subsequent decommissioning of an ERH system to heat discrete (vertical and horizontal) subsurface intervals of the subsurface source zone, resulting in volatilization, removal, and recovery of volatile organic compounds (VOCs) from the C-400 treatment area. The ROD is being implemented as a phased deployment of ERH. Active heating of the first stage (Phase I) has finished. The treatment system recovered far less TCE volume from a southwest treatment area (approximately 160 gal[1]) than was anticipated to be in the area (approximately 23,100 gal), based on a volume estimated using an interpretation of MIP log data.

The focus of this FSP is to characterize the presence of TCE and other VOCs[2] in soils and groundwater in the area southeast of building C-400 (the focus of Phase II heating), with many sample locations placed in the immediate vicinity of former MIP boreholes. The analyses of these samples are intended to provide a means of developing predictive relationships for the MIP logs and to support an empirical calculation of the DNAPL volume and mass in the Upper Continental Recharge System (UCRS) of the southeast C-400 area.[3] This analysis could be used to improve the estimate of DNAPL volume and mass based on MIP logs in the UCRS and Regional Gravel Aquifer (RGA) of the southeast C-400 area.

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[1] As measured in the recovered vapor of Phase I ERH.
[2] The RAWP addresses both TCE and other VOCs.
[3] MIP technology contains significant uncertainty. Mass and volume estimates based on MIP logs are order-of-magnitude calculations.

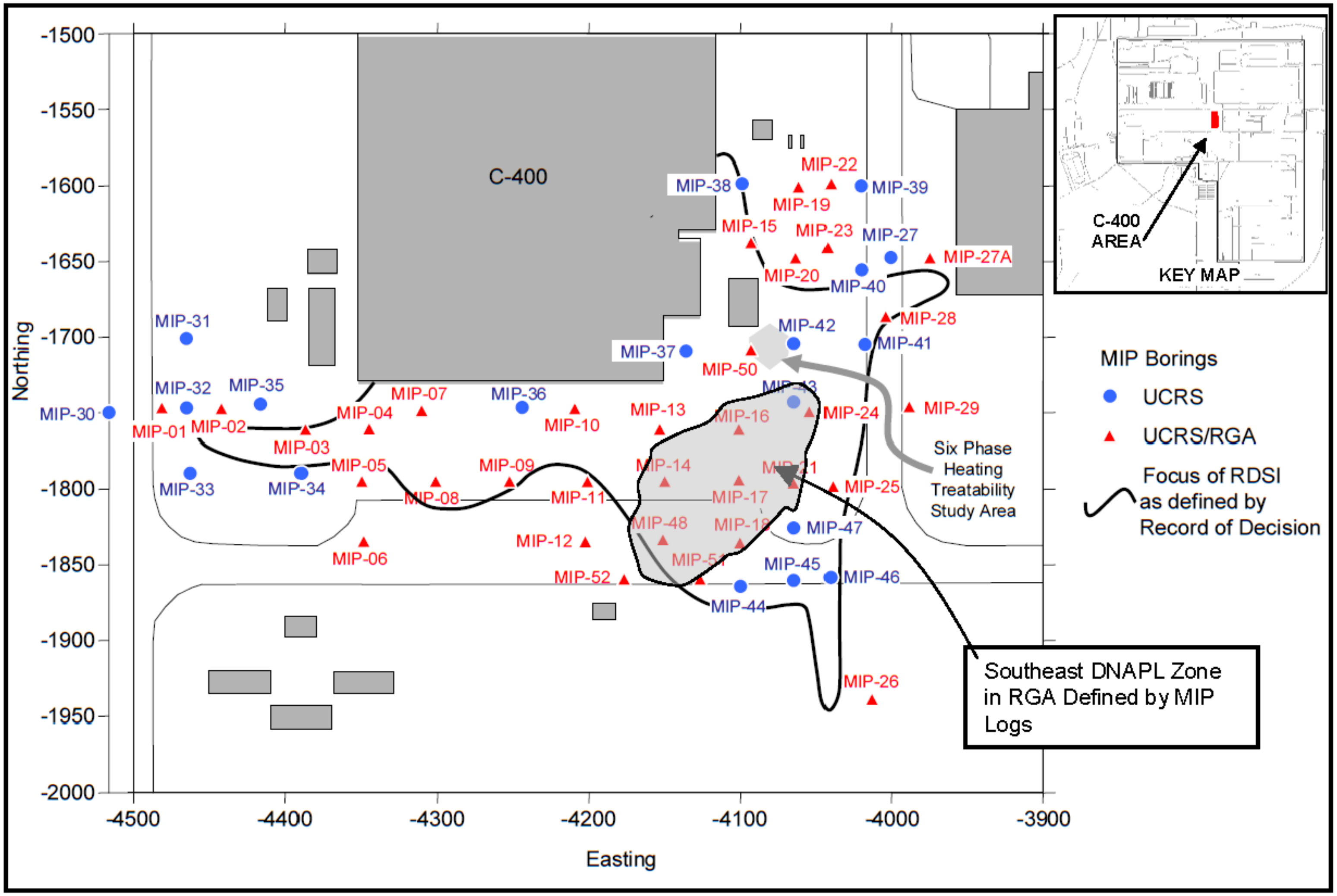

Figure E.1. Area of Southeast C-400 DNAPL Zone

In concert with the *Remedial Action Work Plan for the Interim Remedial action for the Volatile Organic Compound Contamination at the C-400 Cleaning Building at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0004&D2/R2, (DOE 2009) this document summarizes existing information and fulfills the intent of a FSP within a Remedial Investigation/Feasibility Study Work Plan (RI/FS), as required by the Federal Facility Agreement (FFA) (EPA 1998). Section E.2 presents the existing data for the area southeast of the C-400 Building. The conceptual site model (Section E.3) serves as the basis for the proposed investigative activities. Data gaps are summarized in Section E.4. Sections E.5 and E.6 present the sampling media and methods and documentation for sample analysis. (FFA requirements for a site-specific sampling plan are addressed in Section E.5.) Sampling procedures, documentation, and the sample location survey are the subjects of Sections E.7, E.8, and E.9.

E.2. REVIEW OF EXISTING DATA

The C-400 Cleaning Building is located inside the plant secured area, near the center of the industrial section of the PGDP. The building is bound by 10th and 11th Streets to the west and east, respectively, and by Virginia and Tennessee Avenues to the north and south, respectively.

The C-400 Cleaning Building IRA is being conducted near the southeast and southwest corners of the C-400 Cleaning Building area of PGDP (Figure E.1) in areas identified as the southwest treatment area, southeast treatment area, and east treatment area. These areas have been identified as the major sources of groundwater contamination at PGDP. The primary contaminants are TCE and other VOCs. A major component of the selected remedy is the reduction of the concentration of TCE and other VOCs in the soils in the C-400 Cleaning Building area through removal and treatment using ERH in both the UCRS and the RGA. Results of Phase I of the IRA indicate that ERH will treat the UCRS, but will be ineffective in the RGA, based on the present electrode spacing because of the presence of high groundwater flow rates.

The IRA also includes a remedial design support investigation (RDSI), the necessary removal of infrastructure near the C-400 Building, and the implementation of land use controls. The RDSI, which was completed in August 2006, further delineated areas of high TCE concentration, which were used to refine the placement of electrodes based on MIP logs. Infrastructure removal activities have included, but are not limited to, dismantling and removing a bridge crane, removing a TCE tank and associated concrete, removing a TCE pumping station, excavating a concrete sump, removing aboveground secondary containment pits, and demolishing and removing a rail tanker unloading platform. Removal of this infrastructure has allowed flexibility in placement of remedial system components and reduced overhead hazards.

E.2.1 TREATMENT SITE LOCATION

Previous site investigations have identified three commingled groundwater contaminant plumes resulting from past activities at PGDP. The area near the C-400 Cleaning Building is one of the contributing sources of TCE (and its breakdown products) to the groundwater plume at PGDP.

The Waste Area Grouping (WAG) 6 RI, as well as other investigations and studies, characterized the nature and extent of contamination around the C-400 Building (DOE 1999). Sample analyses from the WAG 6 RI indicate that the primary site-related VOCs in the subsurface soil and groundwater in the C-400 Building area include TCE and its breakdown products [*cis*-1,2-dichloroethene (DCE); *trans*-1,2-DCE; and vinyl chloride)]. The WAG 6 RI (DOE 1999) concluded that there are zones of DNAPL TCE in the UCRS and RGA adjacent to and potentially beneath the C-400 Building. The *Feasibility Study for the Groundwater Operable Unit at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (GWOU) FS, DOE/OR/07-1857&D2, (DOE 2001) presents a summary of the characterization data for the C-400 area DNAPL zones and documents the DNAPL conceptual models for the area.

The data from the WAG 6 RI, as well as other investigations and studies, indicate that DNAPL zones in the southeast corner of the C-400 area account for the majority of the mass of DNAPL (DOE 1999). High concentrations of TCE in several RGA monitoring wells (MWs) and the collection of DNAPL from MW408[4] (southeast C-400 area), demonstrate that DNAPL is located in the UCRS and extends into the RGA. As part of the WAG 6 RI (DOE 1999), UCRS soil was characterized and shown to be a residual source of DNAPL. Figure E.2 presents a contour map of maximum TCE concentrations detected in UCRS soil near the C-400 Building (taken from the WAG 6 RI report).

Well cluster MW155 (lower RGA), MW156 (upper RGA), and MW157 (UCRS), located near the southeast corner of C-400 (Figure E.3), have documented local TCE trends since 1991. Beginning in 1991 and continuing through 1995, dissolved TCE concentrations in the UCRS (MW157) and upper RGA (MW156) commonly exceeded 400,000 parts per billion (ppb). Meanwhile, TCE concentrations in the lower RGA (MW155) typically were 2,000 ppb or less. The TCE concentrations in the upper RGA declined steadily to less than 10,000 ppb in 2006, but rebounded to 32,000 to 39,000 ppb in 2009. Recent TCE trends in the UCRS are undocumented. MW157 (UCRS) last was sampled in 1997. Lower RGA TCE concentrations began rising in 2002 to between 13,000 and 20,000 ppb in 2009. The TCE analyses of MW155 and MW156, in conjunction with TCE analyses from monitoring in other on-site PGDP MWs, establish the directions of the TCE plumes that map the dominant groundwater flow pathways. The primary groundwater flow direction passing through the southeast corner of C-400 is to the north.

E.2.2 REMEDIAL DESIGN SUPPORT INVESTIGATION

The purpose of the RDSI was to improve the ERH design by determining the subsurface soil conditions and the presence and relative concentration of VOCs in the UCRS, the RGA, and the RGA/Upper McNairy interface. The RDSI, conducted in accordance with *Remedial Design Support Investigation Characterization Plan for the Interim Remedial Action for the Volatile Organic Compound Contamination at the C-400 Cleaning Building at the Paducah Gaseous Diffusion Plant, Paducah Kentucky,* DOE/OR/07-2211&D2, (DOE 2005b) was completed in August 2006, using MIP technology. MIP technology readily collected soil conductivity profiles and VOC data from the UCRS, the RGA, and the McNairy with minimal generation of investigation derived waste. Figure E.3 shows locations of the MIP borings around the C-400 facility. Soil conductivity logs of each boring were used to determine lithology. When the conductivity indicated that the probe entered the McNairy, the boring was considered complete. In one instance where conventional drilling techniques were utilized instead of direct push technology (DPT), gamma ray logging was performed to determine lithologic intervals. Additional detail concerning the MIP data interpretation is provided in Appendix A of the *Remedial Design Report, Certified for Construction Design Drawings and Technical Specifications Package, for the Groundwater Operable Unit for the Volatile Organic Compound Contamination at the C-400 Cleaning Building at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0005&D2 (DOE 2008) (RDR).

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[4] MW408 is a multiport well, capable of supporting low-flow sampling, but inadequate to provide any appreciable groundwater or DNAPL recovery. TCE trends in MW408 indicate that pooled DNAPL accumulated within the basal sample interval of MW408 (completed within the McNairy Formation) for a period of four months during the Six-Phase Heating Treatability Study. Subsequent sampling of the basal sampling port in MW408 has recovered TCE concentrations indicative of residual DNAPL occurrence.

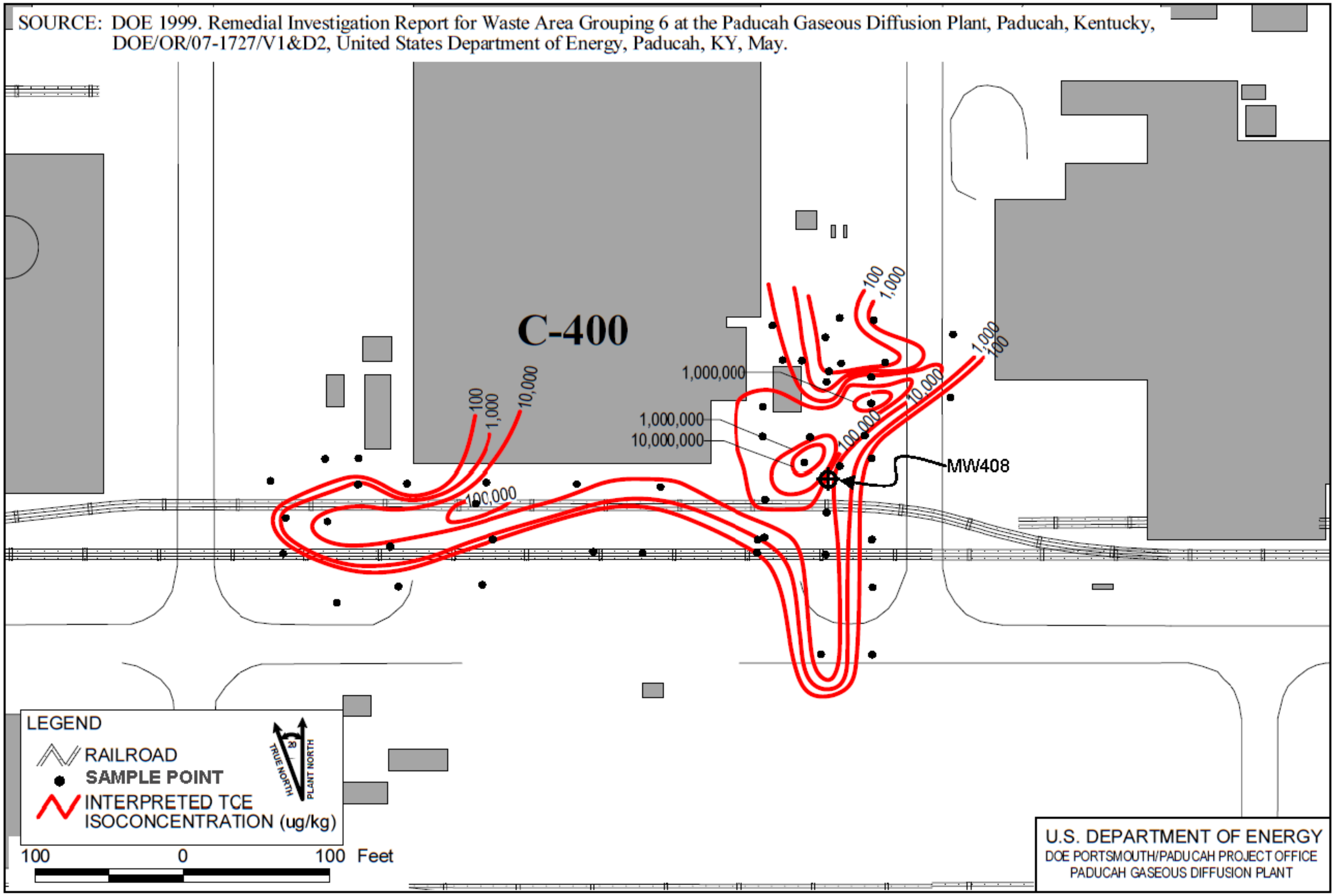

Figure E.2. Contour Map of Maximum TCE Concentration Detected in UCRS Soil

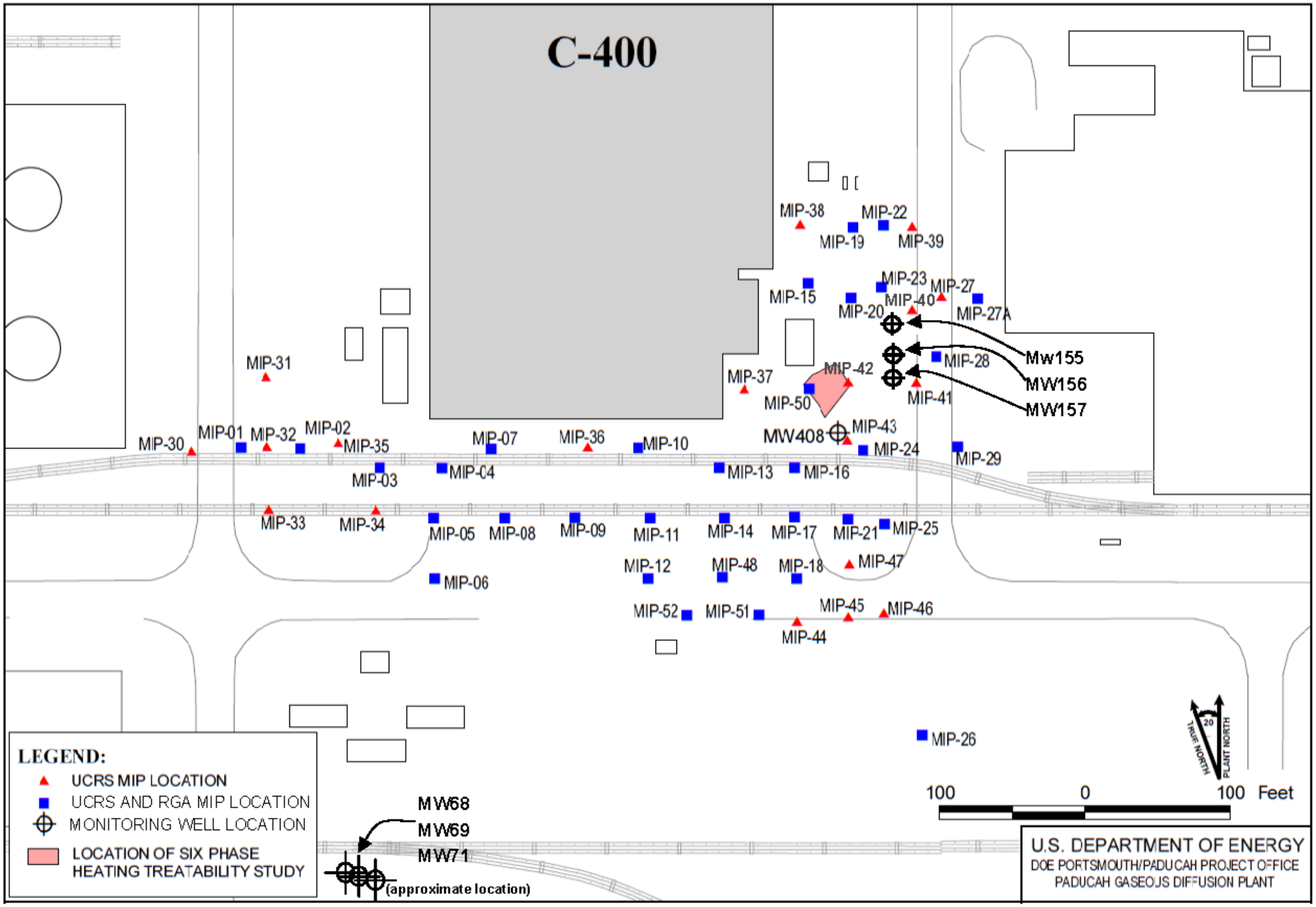

Figure E.3. C-400 MIP and Monitoring Well Locations

Geoprobe DPT soil sample rigs were used to deploy the MIP probes. For the RDSI, the Geoprobe rods were equipped with a shock damper to lessen stress on the MIP probe. Initial attempts with the MIP probe/Geoprobe system met refusal at depths ranging from 20 ft to 40 ft. In attempting innovative methods to accomplish the RDSI, the investigation drillers found that standard Geoprobe rods with a slightly smaller diameter than that of the MIP probe and without the shock damper could be used to "pre" probe the sample locations to the planned depth. Thereafter, the investigation team was able to drive the MIP probe to the planned depths in "pre" probed soil borings at all locations. The MIP characterization data from the "pre" probed borings showed unambiguous response on all three organic chemical detectors (all three detectors demonstrated significant correlative response to suspected increasing VOC concentrations within the range of delineation of each detector) and dynamic soil conductivity measurements. Intervals of high chemical detector response frequently presented significant detail with variations correlated to changes in lithology as defined by the soil conductivity log (as anticipated in minimally disturbed soils). The detailed responses, assumed to be correlated to lithologic changes, provided assurance that the "pre" probe process was not smearing DNAPL downward within the boreholes.

Damage to MIP tooling (i.e., the MIP probe and carrier gas tubing) sometimes occurred during characterization of the RGA due to the extended stress on MIP tooling that was required to penetrate the geology encountered in the RGA. When equipment failures were encountered, advancement of the boring was terminated immediately. The failure then was evaluated to determine if tooling withdrawal was required to correct the problem. Often the problem could be corrected without withdrawing the MIP tooling from the boring. This sometimes was accomplished by reversing the airflow through the carrier gas tubing to remove obstructions that may have entered the system. When this approach was unsuccessful or other problems existed (i.e., heater failure, torn membrane, etc.) that couldn't be repaired from ground surface, the tooling had to be withdrawn and repaired. Once repaired, the tooling was advanced back to the depth interval where the problem began. Characterization of the subsurface then was reinitiated at that depth interval. No negative impact to the quality of the MIP data is suspected to have occurred as a result of the withdrawal/repair process. MIP tooling advanced into the subsurface was irretrievable in five separate locations and had to be abandoned in place.

A MIP probe consists of a heating element and permeable membrane. VOCs diffusing through the MIP probe membrane are routed through tubing containing a carrier gas to a service truck at land surface containing organic chemical detectors. Detectors utilized in the RDSI included an electron capture detector (ECD), a flame ionization detector (FID), and a photoionization detector (PID). Each detector's response is reported in microvolts (μV). All three detectors responded to soil contamination by chlorinated solvents (such as TCE) to varying degrees. The ECD is the most sensitive of the detectors to chlorinated solvents, but also was the first detector to become saturated, which made it unable to differentiate higher levels of contamination. As used in the RDSI, the ECD's effective response ranged up to 1.3×10^7 μV (apparently equivalent to approximately 2.7×10^5 μV on the PID in the saturated zone at C-400). An FID typically is suited to nonchlorinated organics like methane and butane and generally proved to be the least responsive to soil contamination by chlorinated solvents. The FID response in the saturated zone commonly was approximately one half that of the PID. The PID is commonly used for investigation of soil contamination resulting from gasoline-related spills, but also is sensitive to chlorinated solvents[5] and appeared to yield the best characterization of the primary TCE DNAPL-suspect zones. Example logs illustrating conductivity profiles [milliSiemens/meter (mS/m)] and PID response (μV) are shown in Figure E.4 for MIP locations MIP-04 and MIP-07. The electrical conductivity of the UCRS and McNairy matrix is higher than that of the RGA. This contrast allows for identification of lithologic units (i.e., sharp shift in electrical conductivity between the UCRS and RGA interface and again

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[5] The PID detector is sensitive to chlorinated solvents when the detector is protected from humidity interferences and fitted with the proper energy source for the contaminant of concern.

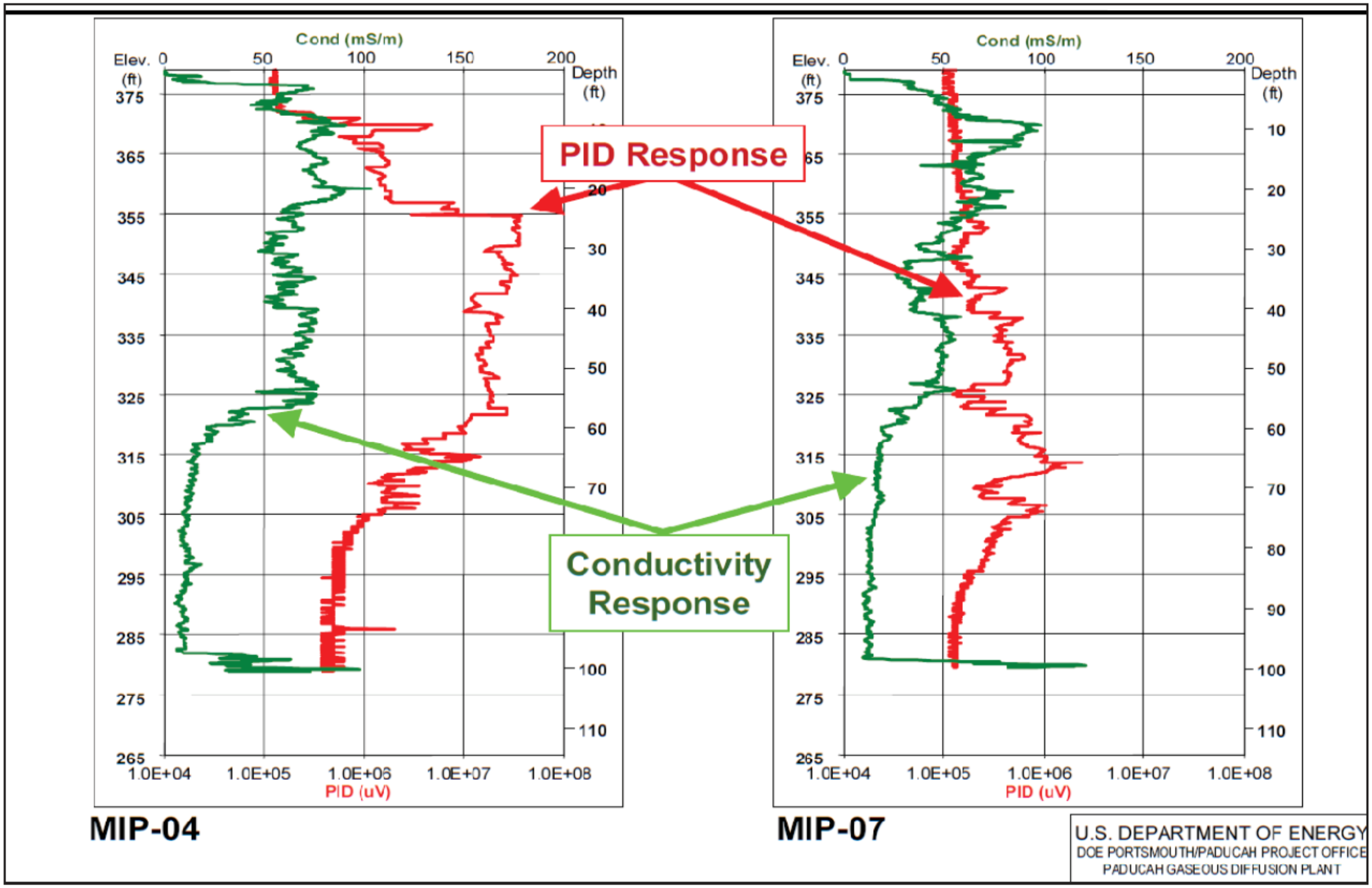

Figure E.4. Example MIP Log Showing PID and Conductivity Responses between the RGA and McNairy). Figure E.5 shows the lithologic intervals selected based on conductivity readings from the MIP logs. Note that the contact with the RGA/Upper McNairy interface is clearly distinguishable by the sudden increase in conductivity response at approximately 100 ft depth.

During the RDSI, 18 MIP borings were completed through the UCRS to a depth of approximately 55 ft (16.7 m) below ground surface (bgs) and 33 MIP borings were completed to the base of the RGA at an approximate depth of 100 ft (30.5 m) bgs. The RDSI Characterization Plan (DOE 2005b) optimized the location and depth of the MIP borings to complement the soil and groundwater data from the WAG 6 RI (DOE 1999). Four of the 33 MIP borings that extended to the base of the RGA were contingency borings completed to assess uncertainties within the RGA in accordance with the RDSI Characterization Plan (DOE 2005b). These contingency borings are shown on Figure E.3 as MIP-48, MIP-50, MIP-51, and MIP-52. Contingency boring MIP-50 assessed residual VOC levels in the RGA in the area of the Six-Phase Treatability Study.

The other three contingency borings delineated the southern extent of a suspected basal RGA DNAPL pool in the area southeast of building C-400. In total, the MIP borings characterized 4,200 ft of soil column.

Figure E.6 shows the locations for MIP borings in a three-dimensional aspect that displays the vertical extent of the MIP borings. Also shown on Figure E.6 is the color-coded PID response at each of the MIP borings.

To evaluate MIP data, the maximum PID response values over five ft depths were contoured in intervals of 1×10^6 µV. Review of the PID contour maps for the vadose zone (i.e., the 20 to 25 ft and 25 to 30 ft depth intervals) and comparison of results to the conceptual site model developed using WAG 6 RI data indicated that the contours of 2×10^6 µV (PID) appeared to delineate DNAPL occurrence. Similarly, a review of the PID contour maps for the saturated zone (five ft intervals between 30 ft and 100 ft bgs) and comparison of results to the conceptual site model developed using WAG 6 RI data indicated that the contours of 9×10^6 µV (PID) defined areas of DNAPL in the saturated zone. The PID criteria used to define DNAPL zones were 2×10^6 µV for the unsaturated zone and 9×10^6 µV for the saturated zone.

This criterion (9×10^6 µV) closely matched the experience of the MIP subcontractors who reported that areas with TCE contamination characterized as 1×10^7 µV by the PID commonly were DNAPL zones. Figure E.7 shows examples of the interpreted DNAPL source zones on MIP logs from vadose and saturated soils at location MIP-04 compared to readings for MIP-07 in which no DNAPL source zones were identified based on the previously-mentioned criteria for DNAPL source zone delineations. Although the MIP data indicate zones of likely DNAPL detection, they do not correlate to DNAPL saturation values, thus making an accurate estimate of TCE mass difficult. Soil and groundwater samples collected in selected zones based on MIP data are better suited to aid in mass estimates. Based on the MIP results and interpreted DNAPL source zones, a three-dimensional presentation of DNAPL source zones was defined as shown in Figure E.8. Figure E.9 shows the three-dimensional DNAPL source zone in relation to the C-400 Cleaning Building. This DNAPL source zone delineation, interpreted using data collected during the RDSI coupled with data from previous investigations, allowed the design team to optimize placement of ERH electrodes, vapor recovery wells, and other subsurface components.

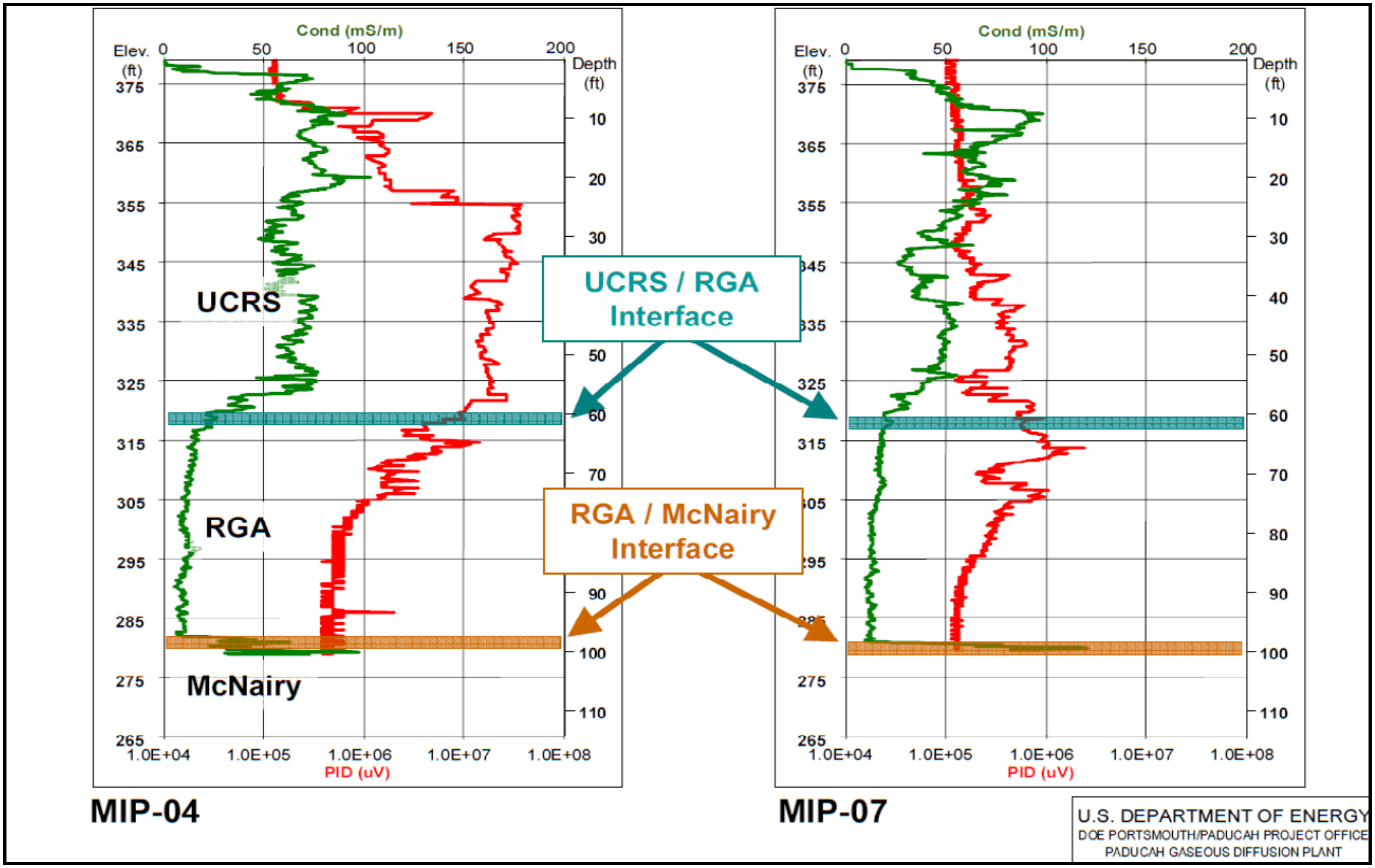

Figure E.5. Example MIP Log Showing Formation Interfaces

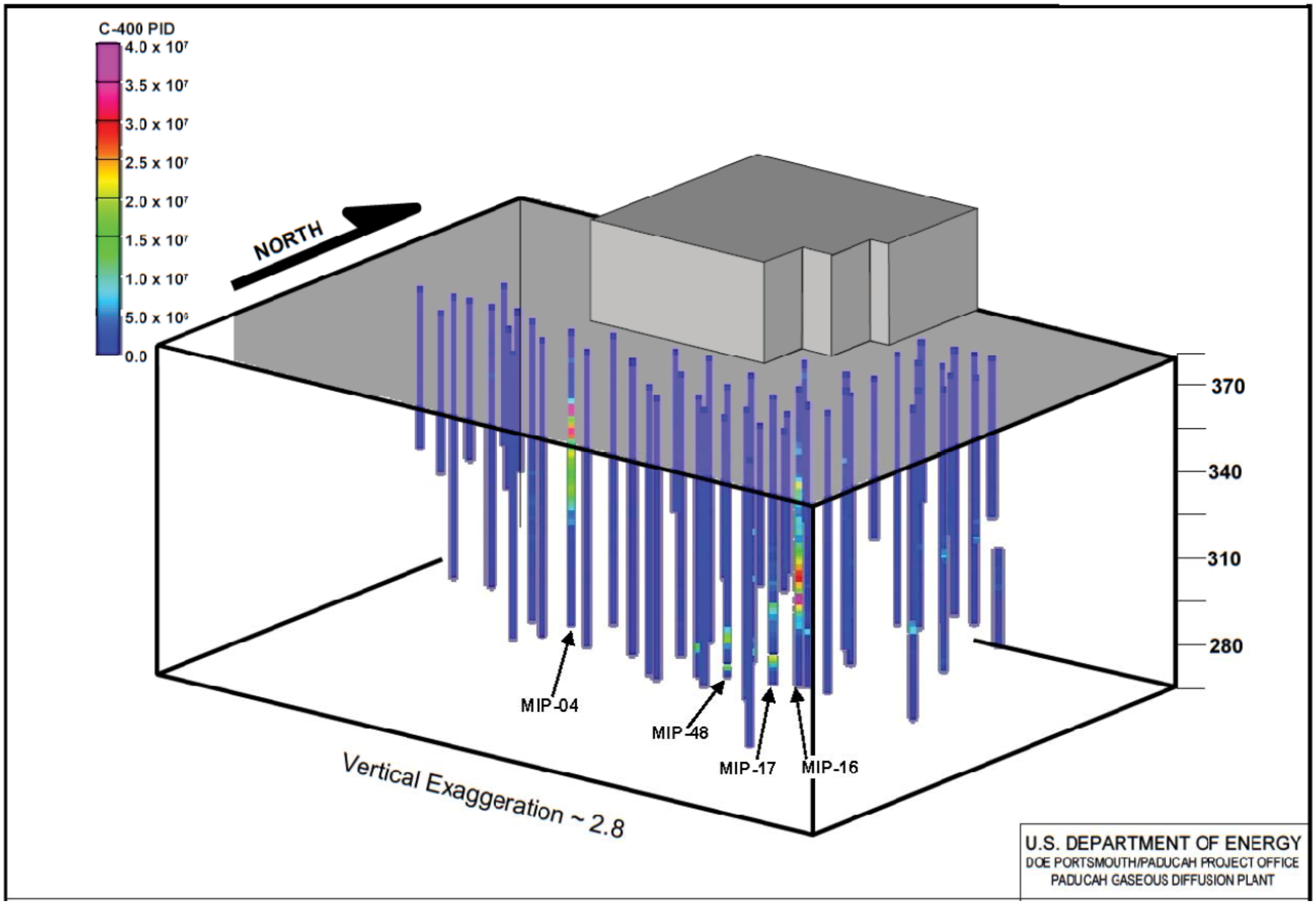

Figure E.6. C-400 MIP PID Response

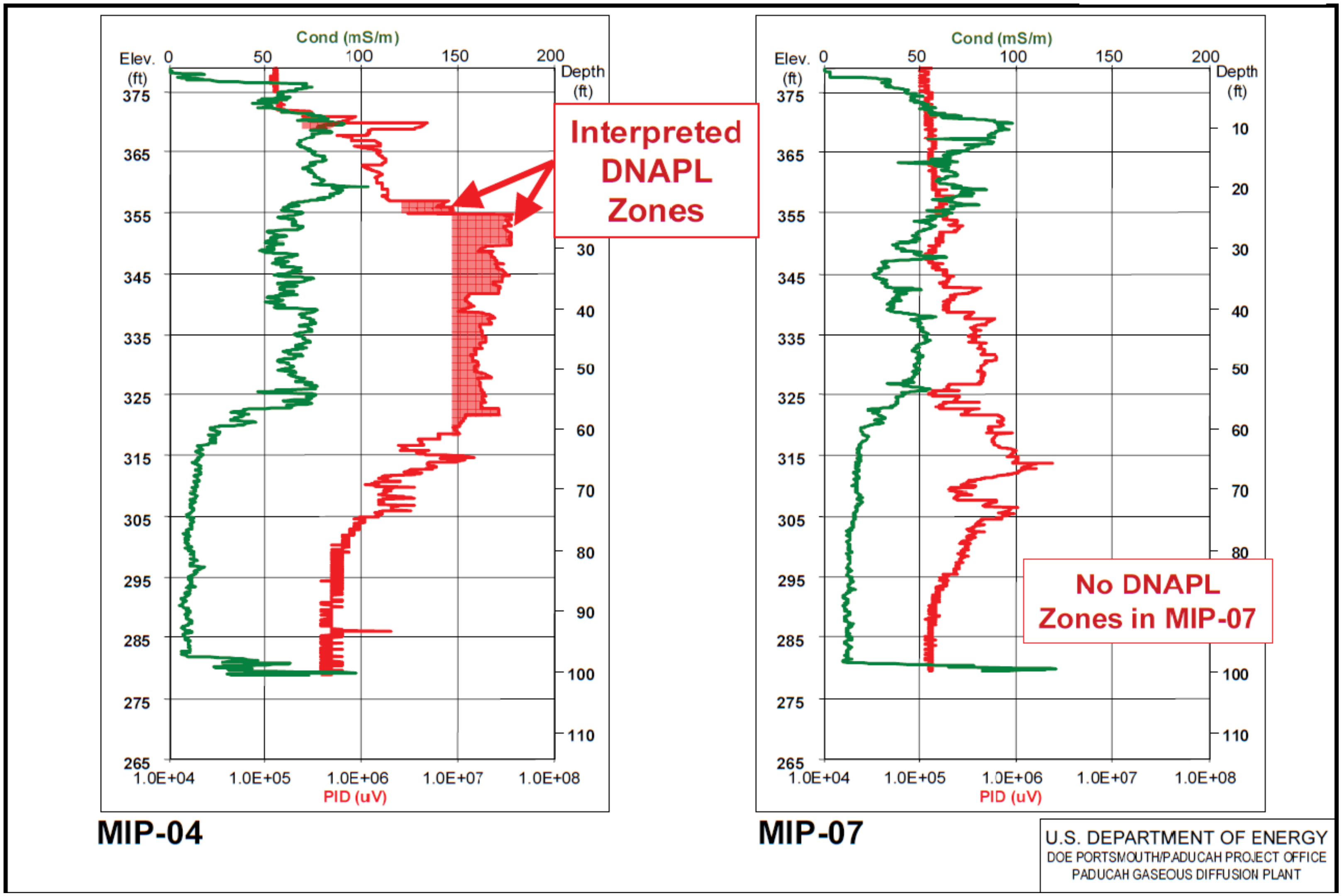

Figure E.7. Example MIP Log Showing Interpreted DNAPL Zones

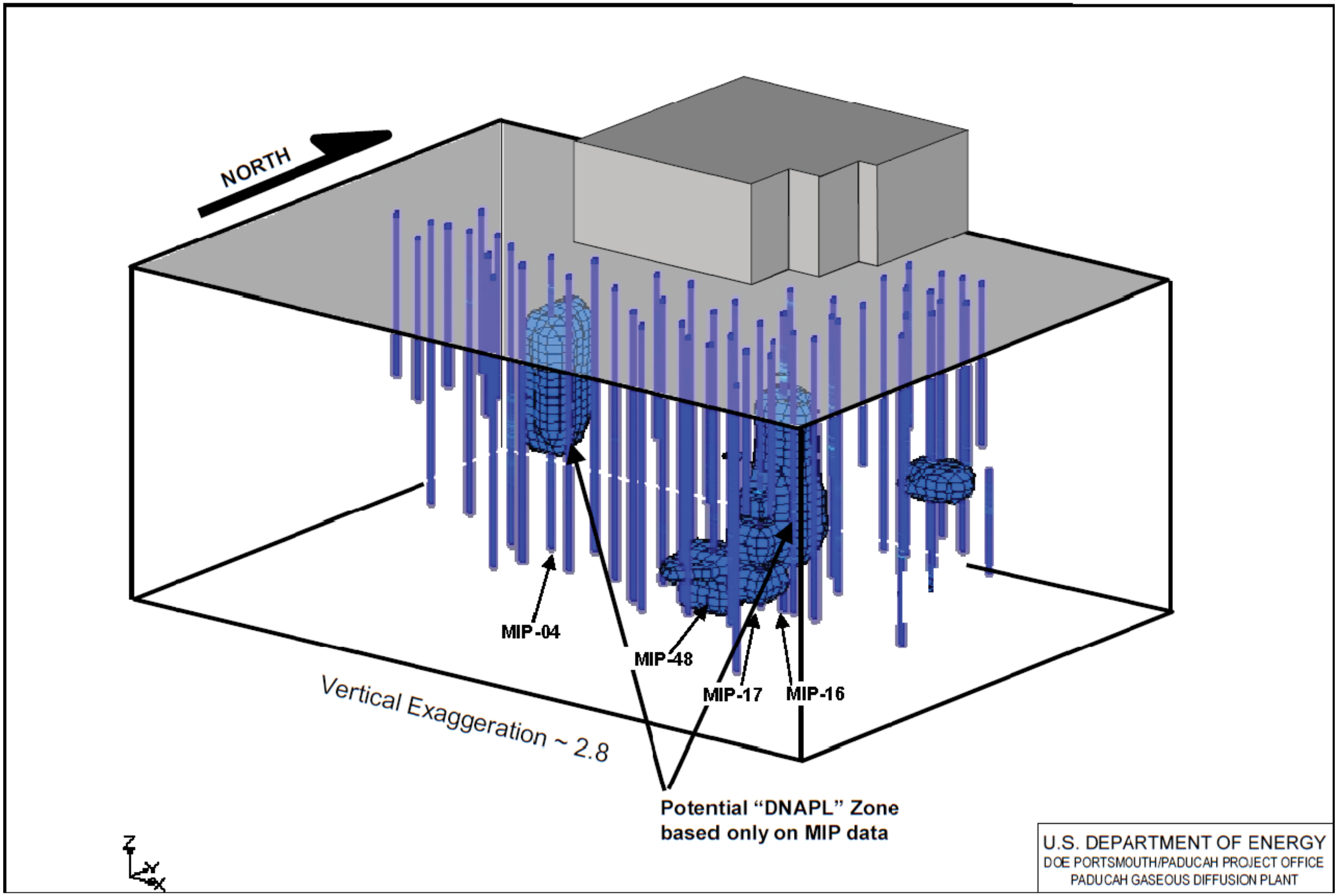

Figure E.8. Potential DNAPL Zone with MIP Borings

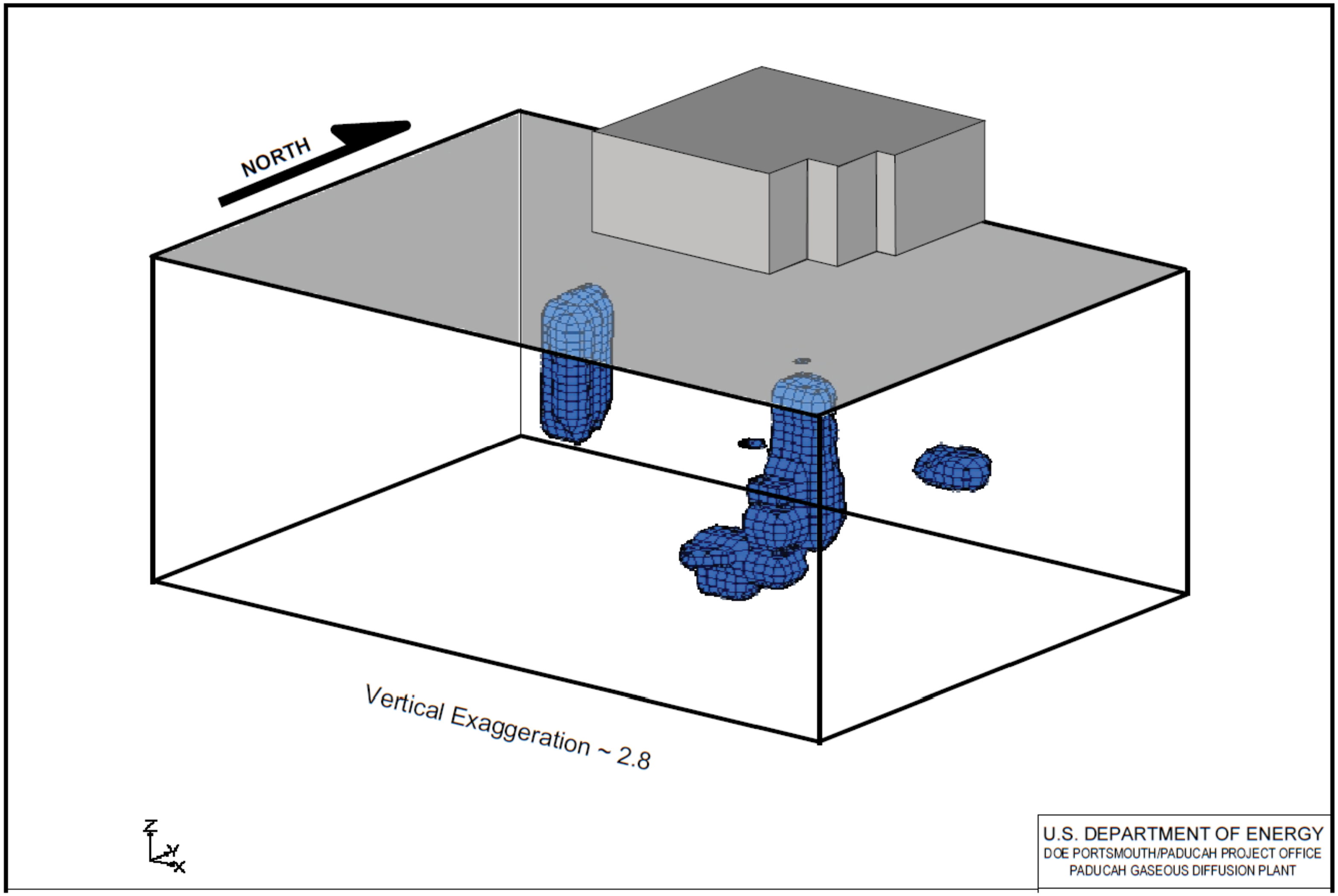

Figure E.9. Potential DNAPL Zone (Uncertain–based on MIP logs)

MIP results from the RDSI were used to delineate the extent of TCE soil contamination. The results were critical to interpreting the distribution of TCE DNAPL and the topography of the base of the Continental Deposits (base of the RGA) south of the C-400 Building. These data were thought to characterize the three-dimensional aspects of the TCE DNAPL source zones and to demonstrate that the residual TCE distribution was consistent with the conceptual model from the WAG 6 RI (DOE 1999). Moreover, the data was interpreted to show that the vertical extent of the DNAPL did not extend downward appreciably (0–1 ft) into the McNairy Formation below the primary RGA DNAPL pool at the base of the RGA.

E.3. CONCEPTUAL SITE MODEL

The WAG 6 RI (DOE 1999) and GWOU FS (DOE 2001) established the basis of the conceptual site model for the TCE contamination of the south end of the C-400 Building for the RDR. Refer to Figure E.10 for an illustration of this conceptual model. Results from the WAG 6 RI (DOE 1999) and GWOU FS (DOE 2001) were used in the development of the map of the area to be addressed by the ROD (DOE 2005a). This area is defined by the hatched area on Figure E.11.

Soil analyses for the WAG 6 RI (DOE 1999) document that the primary organic compounds in the DNAPL source zones and other areas of contaminated soil are TCE and degradation products of TCE. TCE is the most common soil contaminant in UCRS soil samples and the dominant dissolved contaminant in RGA water samples.

Combined data from the WAG 6 RI (DOE 1999) and the RDSI were interpreted to identify two main TCE DNAPL-suspect source zones and four other areas of TCE soil contamination in the area of the south end of the C-400 Building. In each of the main TCE DNAPL-suspect zones, the DNAPL mass was thought to have migrated downward through the UCRS. An illustration of this process is shown in Figure E.10. The larger of the two DNAPL-suspect source zones is thought to be associated with leaking piping of a TCE transfer pump near the southeast corner of C-400. This leak has affected a large area, potentially including the UCRS soils below C-400. A large mass of DNAPL associated with the leak was interpreted to have traveled to the southwest in the shallow UCRS soils until encountering a pathway for downward migration in the vicinity of RDSI boring MIP-16.[6] It is suspected that repeated spills from the TCE transfer pump provided enough spill mass that DNAPL penetrated to the base of the RGA and formed a DNAPL pool at the contact of the RGA and underlying McNairy Formation. A depression in the RGA/McNairy Formation contact may have created a structural trap for a DNAPL pool in the area of RDSI borings MIP-13, MIP-14, MIP-17, and MIP-48.[7] The attachment presents representative MIP logs of the suspected DNAPL area southeast of the C-400 Building. Because the RGA/McNairy Formation contact slopes southward on the south side of the C-400 Building, pooled DNAPL at the base of the RGA, from spills associated with the TCE transfer pump, should not have migrated under the C-400 Building.

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[6] Groundwater flow is known to be near vertical in response to the large downward hydraulic gradient that is common at PGDP. Conversely, the TCE DNAPL is not a "wetting" fluid in the soil-groundwater-DNAPL system and cannot readily penetrate downward in soils with small water-saturated pore spaces. Although DNAPL moves in response to gravity, vertical flow is strongly controlled by the water saturation and size and connection of soil porosity. The DNAPL moved laterally in a horizon of DNAPL-permeable soil until it encountered a deeper zone of increased permeability that allowed vertical migration.

[7] Figure E.7 of Appendix A in the RDR presents a structure contour map of the base of the Continental Deposits (base of the RGA).

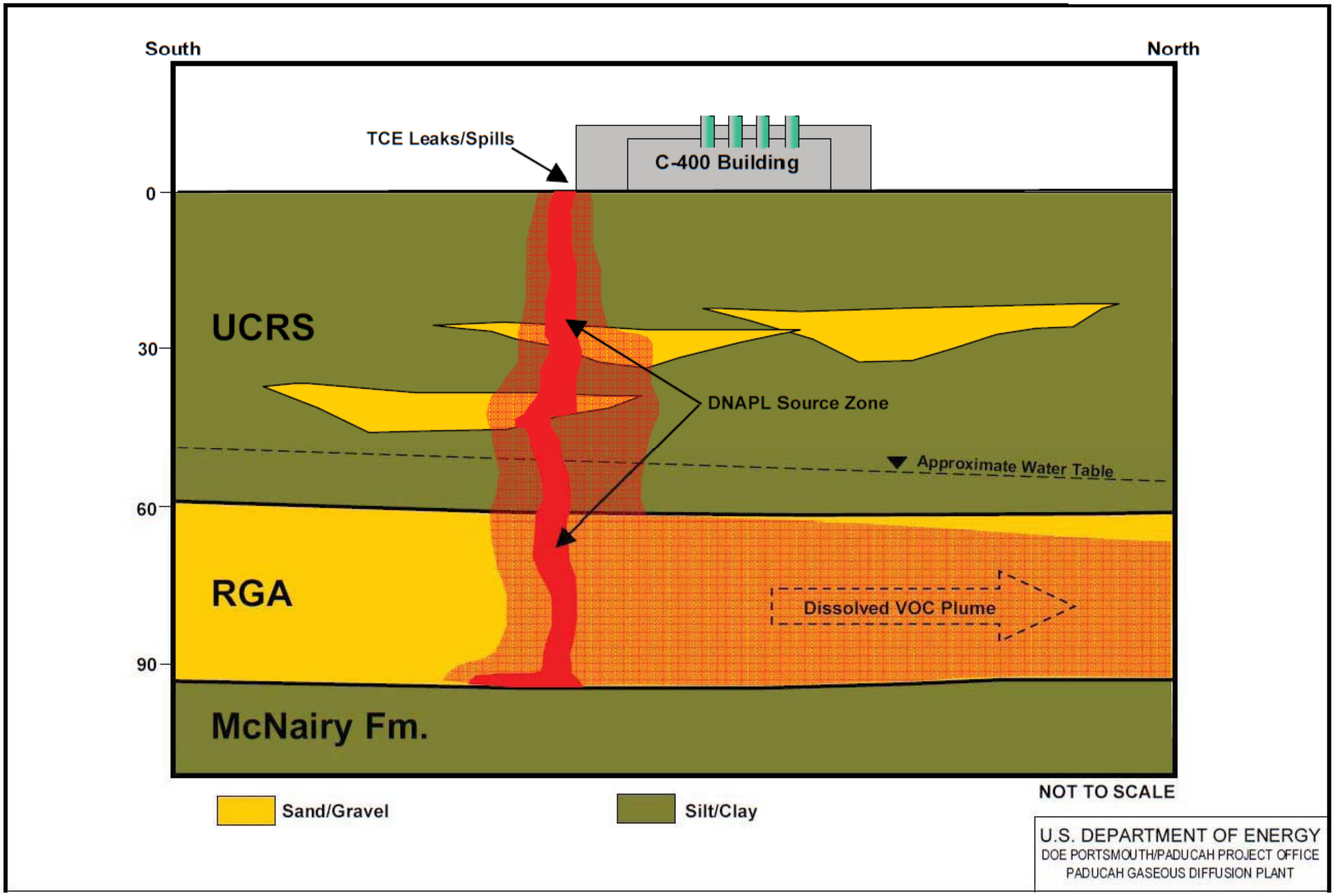

Figure E.10. C-400 Conceptual Site Model

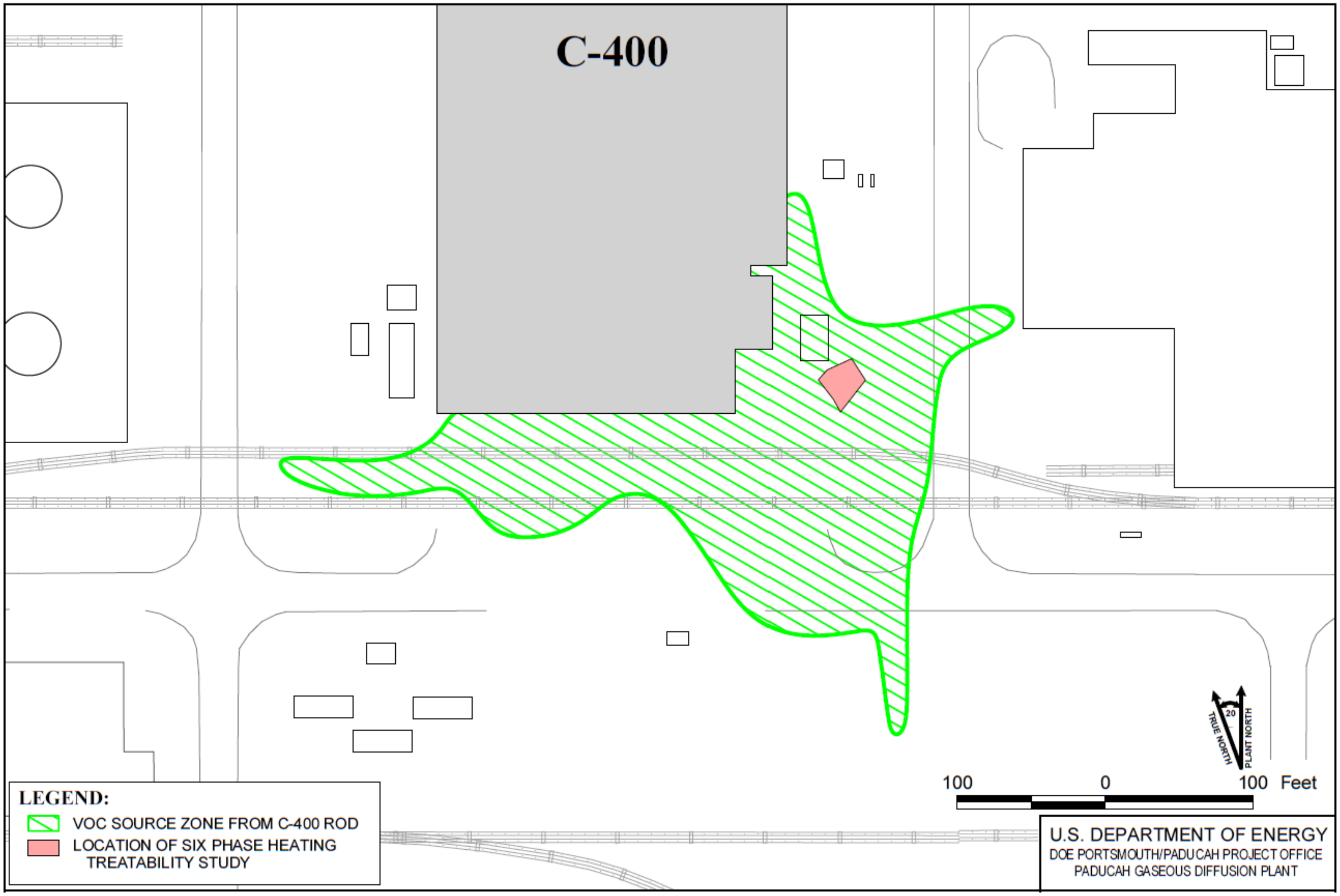

Figure E.11. Contaminant Source Zones from the C-400 ROD

The other suspected DNAPL source zone was associated with a storm sewer system that served the west side of C-400 in the southwest area. WAG 6 RI soil analyses and RDSI soil boring logs were interpreted to indicate that DNAPL migrated through the bedding material of the storm sewer that served the west side of C-400 and penetrated underlying soils in the area of boring MIP-04. The DNAPL zone was thought to extend through the UCRS, but had insufficient TCE mass for the DNAPL to penetrate the RGA. Subsequent results of Phase I of the IRA have determined that this conceptual model of DNAPL occurrence was incorrect for the area.

Additional areas of TCE-contaminated soil include an East Treatment Area containing the Solid Waste Management Unit (SWMU) 11 TCE Leak Site, 400-016 Area (WAG 6), 400-163 Area (WAG 6), and TCE Tank Area. SWMU 11 is the location of a former breach in a storm sewer on the east side of C-400.

Effluent from a sump in the vicinity of a large TCE degreaser in the C-400 Building inadvertently was piped to the storm sewer, possibly beginning in the early 1950s. Repeated releases created a DNAPL pool in the storm sewer backfill beneath the breach in the storm sewer based on observations from a subsequent soil removal action. This DNAPL was able to penetrate only the soils immediately adjacent to the storm sewer. Site construction uncovered the TCE leak in 1986.

A subsequent removal action excavated approximately 9,200 ft^3 of TCE-contaminated soil and bedding material. The main excavation area measured approximately 20 ft wide (east to west) by 40 ft long (north to south). A 10-ft wide trench, centered on the storm sewer, was dug 16 ft deep to expose the pipe, which lay 13 ft below original grade. The remainder of the excavation was 7 ft deep. Concern for the stability of nearby structures (11th Street and a TCE tank pad) limited the extent and depth of the excavation. PGDP backfilled the excavated area with clean fill material and capped the area with a layer of clay after excavation activities were completed. The fill material and clay cap approximate the textures of the area shallow soils.

The SWMU 11 removal action recovered a significant portion of the DNAPL. Forty 55-gal drums were used to containerize excavated contaminated soil. TCE concentrations were as high as 700,000 µg/kg in soil samples collected adjacent to and below the storm sewer line. Note that this contamination concentration is reported as representative of both the excavated soil adjacent to the storm sewer and the soils remaining below the storm sewer after the excavation. Some contaminated soil is known to have been left in place. MIP results document the presence of a discrete DNAPL zone at the base of the UCRS that is associated with SWMU 11 (currently being addressed by the East Treatment area). Figure E.12 shows the location of the source zones discussed herein, which were delineated based on results from the RDSI and WAG 6 RI (DOE 1999). The Phase I IRA treatment of the SWMU 11 area recovered approximately 278 gal of TCE. (The RDR estimated 250 gal of TCE were present.)

DNAPL MASS ESTIMATE

The MIP profiles are a qualitative measure of VOCs with an uncertain relationship to TCE concentrations, but provide a basis for the site-specific conceptual model of DNAPL occurrence and the definition of extent of the DNAPL-suspect source zones. The RDR presents the measurements and assumptions that were applied to the conceptual models to estimate the DNAPL volumes that are present in the ERH area. Table E.1 summarizes the estimated DNAPL volumes from the RDR.

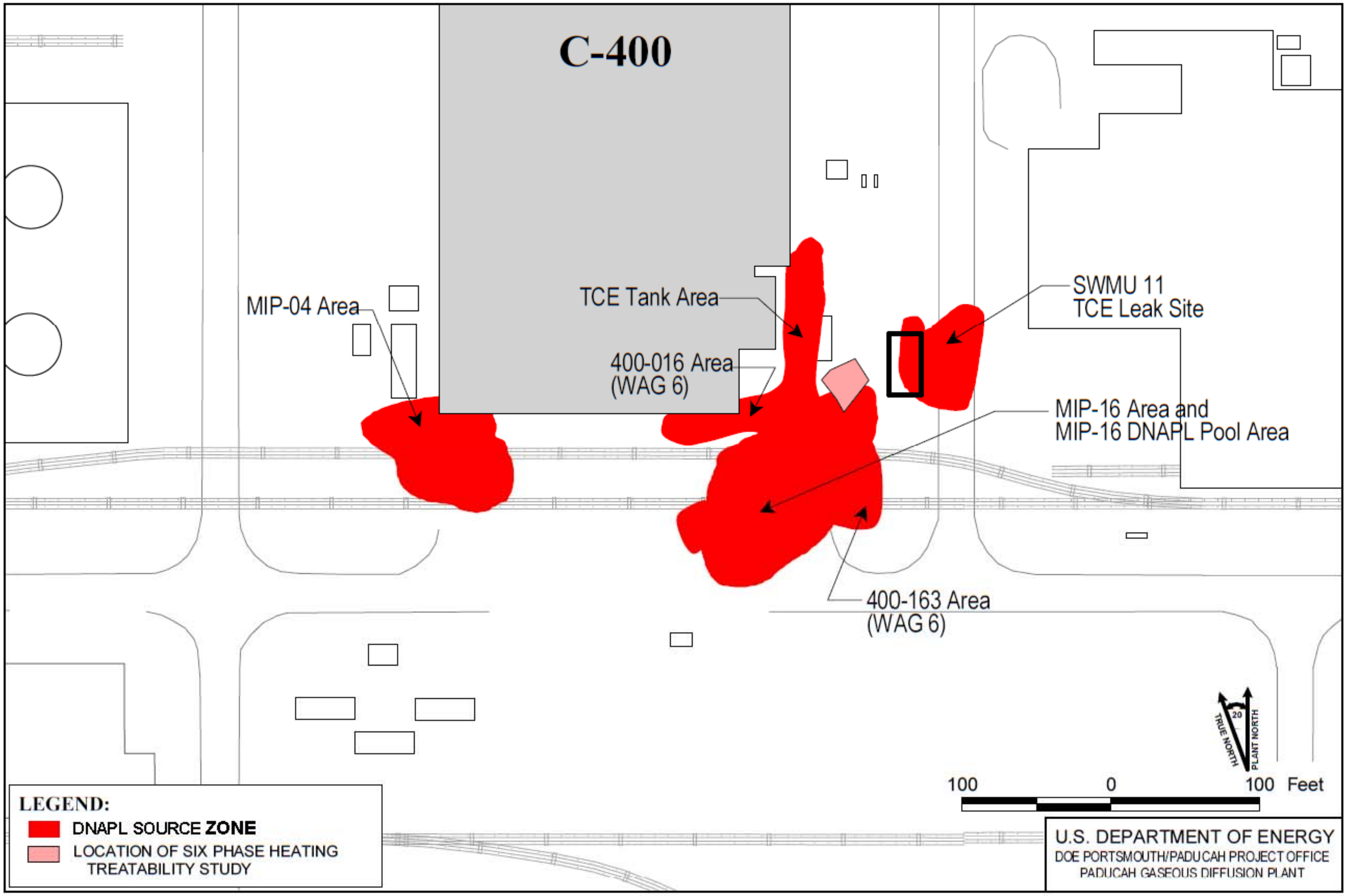

Figure E.12. DNAPL Source Zone Delineations from RDSI and WAG 6 Results

Table E.1. Summary of Estimated DNAPL Volumes from the Remedial Design Report

DNAPL Area	General Location	Maximum Area (ft^2)	Depth (ft bgs)	Estimated DNAPL Volume (gal)
MIP-04 Area	Northwest RDSI area	6,000	20–70	23,100
MIP-16 Area	East–central RDSI area	5,300	20–80	29,681
MIP-16 DNAPL Pool Area	East–central RDSI area	4,800	84–97	22,049
SWMU 11 TCE Leak Site	East RDSI area	775	28–32	250
TCE Tank Area	East side C-400	1,700	20–60	49
400-016 Area	South side C-400	2,000	16–34	1
400-163 Area	Southeast RDSI area	1,400	8–48	22

Additional detail concerning the DNAPL mass estimate is provided in the RDR (DOE 2008).

Phase I IRA treatment recovered only approximately 160 gal from the MIP-04 (Southwest) Area. The DNAPL estimate for the MIP-16 Area, to be treated in Phase II of the IRA, is based on MIP logs with similar-scaled PID responses and a similar conceptual model. Note that the DNAPL estimate of the MIP-16 DNAPL Pool Area derives from a different conceptual model (much higher DNAPL saturation).[8]

E.4. DATA GAPS

The primary data gaps associated with characterization of TCE[9] in the area southeast of building C-400 are as follows.

- TCE concentrations in soil in the Phase II area have not been characterized sufficiently to optimize the Phase II treatment system design.[10]
- The occurrence and location of TCE DNAPL zones have not been adequately characterized.
- The volume of the TCE DNAPL zones and the mass of TCE remain poorly defined.

E.5. SAMPLING MEDIA AND METHODS

E.5.1 MIP CORRELATION FIELD SAMPLING PLAN

The field crew will perform sampling work in accordance with LATA Kentucky-approved procedures and work instructions. Procedures related to the sample collection are listed below. Additional general activities governed by procedures are referenced in Table E.2.

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[8] The DNAPL saturation of the MIP-16 Area conceptual model ranges from an average of 6.5% in the RGA to 8.8% in the UCRS, compared to the DNAPL saturation of the MIP-16 DNAPL Pool Area, which is assumed to be 50%.

[9] The recovered DNAPL from the Phase I ERH Southwest Area did not match the estimate of DNAPL mass for the area based on MIP logs of the area and a conceptual site model. This disparity produces uncertainty for the interpretation and estimate of DNAPL mass for the Phase II ERH.

[10] Design elements that are based on TCE concentrations in the soil include optimized placement of electrodes and the selection and sizing of ERH vapor treatment components.

- PAD-ENM-0018, *Sampling Containerized Waste*
- PAD-ENM-0021, *Temperature Control for Sample Storage*
- PAD-ENM-0023, *Composite Sampling*
- PAD-ENM-2300, *Collection of Soil Samples*
- PAD-ENM-2303, *Borehole Logging*
- PAD-ENM-2700, *Logbooks and Data Forms*
- PAD-ENM-2702, *Decontamination of Sampling Equipment and Devices*
- PAD-ENM-2704, *Trip, Equipment, and Field Blank Preparation*
- PAD-ENM-2708, *Chain-of-Custody Forms, Field Sample Logs, Sample Labels, and Custody Seals*
- PAD-ENM-5003, *Quality Assured Data*
- PAD-ENM-5004, *Sample Tracking, Lab Coordination, & Sample Handling Guidance*
- PAD-ENR-0020, *Direct Push Technology (DPT) Sampling*
- PAD-WD-9503, *Off-Site Shipments by Air Transport*

Table E.2. General Activities Governed by Procedures

Activity	Applicable Procedure
Accident/Incident Reporting	PAD-SH-1007, *Incident/Event Reporting*
Calibration of Measuring and Test Equipment	PAD-QA-1020, *Control and Calibration of Measuring and Test Equipment*
Collection of Samples	PAD-IH-5560, *Workplace Industrial Hygiene Sampling*
Conducting Assessments	PAD-QA-1420, *Conduct of Assessments*
	PAD-REG-0003, *Performing Environmental Compliance Assessments and Identification and Reporting of Environmental Issues*
Construction Equipment Inspection	PAD-SM-0006, *Construction Equipment Inspection and Maintenance*
Data Verification and Validation	PAD-ENM-5102, *Radiochemical Data Verification and Validation* PAD-ENM-5105, *Volatile and Semivolatile Data Verification and Validation*
Decontamination of Large Equipment	PAD-DD-2701, *Large Equipment Decontamination*
Document Control	PAD-PD-1107, *Development, Approval, and Change Control for Performance Documents*
Documenting and Controlling	PAD-WC-0021, *Work Execution*
Field Changes to Approved Plans	PAD-ENG-0027, *Field Change Request (FCR), Field Change Notice (FCN), and Design Change Notice (DCN) Process*
Evaluations for Suspect/Counterfeit Items	PAD-QA-1009, *Identification, Control, and Disposition of Suspect/Counterfeit Items*
Fall Prevention	PAD-SH-2004, *Fall Prevention and Protection*
Field Engineering Inspections and Surveys	PAD-ENG-0001, *Field Engineering Inspections and Surveys*
Graded Approach	PAD-QA-1650, *Graded Approach*
Handling, Transporting, and Relocating Waste Containers	PAD-WD-0661, *Transportation Safety Document for On-site Transport within the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*
Hoisting and Rigging Operations	PAD-ENG-0012, *Hoisting and Rigging Operations*
Inspection and Test Plans and Review of Vendor/Supplier QA Program	PAD-QA-1208, *Supplier Selection and Evaluation*
Issue Management (includes corrective action)	PAD-QA-1210, *Issues Management Program*
Nonconforming Items and Services	PAD-QA-1440, *Control of Nonconforming Items and Services* PAD-SH-2001, *Identifying Defective Equipment*
Powered Industrial Trucks	PAD-SH-0005, *Industrial Motorized Trucks (Forklifts)*

Table E.2. General Activities Governed by Procedures (Continued)

Activity	Applicable Procedure
Activity	**Applicable Procedure**
Quality Assurance Program	PAD-PLA-QM-001, *LATA Environmental Services of Kentucky, LLC Quality Assurance Program and Implementation Plan for the Paducah Environmental Remediation Project*
Radiation Protection	PAD-PLA-HS-002, *LATA Environmental Services of Kentucky, LLC Radiation Protection Program Paducah Environmental Remediation Project*
Records Management	PAD-RM-1009, *Records Management, Administrative Record, and Document Control*
Revisions to Procedures or Work Packages	PAD-PD-1107, *Development, Approval, and Change Control Performance Documents*
	PAD-WC-0018, *Work Management Program for the Paducah Environmental Remediation Project*
	PAD-WC-0021, *Work Execution*
Subcontract Management	PAD-CP-0008, *Receipt and Evaluation of Proposals*
Suspend/Stop Work	PAD-SH-2018, *Stop/Suspend Work (Safety Related)*
Temperature Extremes	PAD-IH-5134, *Temperature Extremes*
Training	PAD-TR-0702, *Conduct of Training*
	PAD-TR-0710, *Assignment of Training*
	PAD-TR-0750, *Required Reading*
Transmission of Data	PAD-ENM-1001, *Transmitting Data to the Paducah Oak Ridge Environmental Information System (OREIS)*
Waste Management and Disposition	PAD-WD-0016, *Waste Handling and Storage in DOE Waste Storage Facilities*
	PAD-WD-0437, *Waste Characterization and Profiling*
	PAD-WD-3010, *Waste Generator Responsibilities for Temporary On-Site Storage of Regulated Waste Materials at Paducah*
Worker Safety and Health	PAD-PLA-HS-001, *LATA Environmental Services of Kentucky, LLC Worker Safety & Health Plan Paducah Environmental Remediation Project*

E.5.1.1 Purpose

This FSP describes the characterization of subsurface contaminant conditions at four locations using MIP technology and the collection of soil and groundwater samples at an additional four locations in the area southeast of the C-400 Building to support the following: a development of predictive relationships of previous and proposed MIP responses to current TCE concentrations, delineation of TCE DNAPL zones, and assessment of TCE DNAPL mass and volume.

The primary means to confirm and develop the predictive relationships for the MIP logs will be a comparison of the MIP responses to soil and groundwater sample results in collocated borings. This FSP targets soil samples in the UCRS and McNairy and groundwater samples in the RGA.[11] These samples will undergo standard analysis for concentrations of VOCs at a fixed-based laboratory. In addition to predetermined vertical intervals and sampling slightly above and slightly below lithology changes, field scans of VOC levels in the UCRS and McNairy soil cores (via hand-held PID) will be used to identify zones with higher levels of contamination for targeted sampling.

In addition to the collection of VOC data, this FSP specifies collecting natural oxidant demand (NOD) and microbial samples and measuring groundwater flow rates via passive flux meters to assist management with the evaluation of other remedial alternatives to, or in conjunction with, ERH technology. These technologies include *in situ* chemical oxidation, bioaugmentation, and pump-and-treat.

[11] The collection of representative soil samples from the RGA is problematic. As RGA soil samples are extracted, the escaping water column in the sample system tends to "wash" the soil samples.

- NOD samples will be collected to evaluate the RGA for the presence of naturally occurring reduced materials (e.g., reduced metals, primarily iron and manganese, and organic matter) that increase the amount of oxidant required to effectively treat contaminants in the subsurface.

- Bio-trap samplers will be deployed in select MWs in the vicinity of the C-400 area to evaluate microbial populations in the UCRS and RGA and quantify the abundance of specific bacterial groups involved in reductive dechlorination (e.g., Dehalococcoides). The information collected will assist site management with future remedial decision strategies.[12]

- Passive flux samplers will be deployed in the proposed upgradient 3-well cluster MW. The passive flux samplers will be positioned to collect velocity data in the upper, middle, and lower RGA. The velocity data will be used to reevaluate groundwater flow rates in the RGA in close proximity to the C-400 area.

E.5.1.2 The Data Quality Objective Process

The data quality objective (DQO) process is a strategic planning approach based on the scientific method to prepare for a data collection activity. It consists of the seven key elements listed as follows:

- State the Problem
- Identify Decisions
- Identify Inputs
- Specify Boundaries
- Define Decision Rules
- Specify Error Tolerances
- Optimize Sample Design

The DQO Process, as it applies to this FSP, is summarized in the following text.

State the Problem:

The problem statement is as follows:

> Significant technical uncertainty exists regarding the use of MIP logs to estimate DNAPL mass in the area southeast of C-400 Building. Previous interpretation of MIP logs led to DNAPL mass assumptions, which appear to be overestimated. MIP technology should be used to identify likely DNAPL zones because of its high speed, high vertical resolution, and low cost, but MIP data must be used in combination with other sampling techniques to provide a robust estimate of mass. In order to better understand the performance of the MIP in contaminated sediments at this site, soil and groundwater samples adjacent to previous and new MIP borings will be collected and analyzed. These data will be used to determine the best method to estimate the mass in the environment. The role of lithology, specifically fine-grained sediments, in controlling the distribution of DNAPL in the UCRS, RGA, and McNairy will be evaluated.

[12] Enhanced biodegradation may be stimulated by several methods. The optimal approach will require additional characterization of the microbial and chemical environment.

Although chemical oxidation and enhanced biodegradation are common remedial actions for VOC-contaminated soil and groundwater, little data exist to assess the application of either remedial measure at C-400. The collection of some preliminary characterization data to support potential alternative analyses is prudent. The application of either technology would require significantly more characterization, likely in the format of a treatability study.

Both soil and groundwater are useful media for the characterization of VOC presence and concentrations in the treatment area. Soil samples taken from the DNAPL zone offer the best characterization of the mass of DNAPL present in the fine-grained matrix of the UCRS and McNairy [TCE will be present in the soil samples in all phases as aqueous, as gas (in the unsaturated zone), as sorbed mass, and as free or residual-phase DNAPL contained in the soil pores]; however, the collection of representative soil samples from the coarse-grained RGA is problematic. As the coarse sand and gravel samples of the RGA are recovered from depth, the overlying water column in the sampling system tends to "wash" the soil sample as it is withdrawn. This problem will tend to bias low the estimate of DNAPL mass that is present in RGA soil samples.

Within the treatment area, the mass of VOCs dissolved in groundwater is limited by the solubility of the VOC constituents and other dissolved constituents in water and may not be representative of the mass of DNAPL present; however, TCE concentrations measured in water samples at different depths may provide a reasonable assessment of the presence of DNAPL in the vicinity of the water samples.

As such, comparison of MIP logs and vertical profiles of TCE concentrations in collocated borings, in soil samples of the UCRS and McNairy and in groundwater samples of the RGA, should establish a predictive relationship for the MIP responses. [It is anticipated that the methods of developing the predictive relationships between MIP responses and soil and groundwater TCE levels will be similar to those developed for the U.S. Army Corps of Engineers (COE 2002).] Moreover, the TCE soil sample analyses can provide a direct indication of the presence of DNAPL and a measure of the mass of DNAPL.

The analytes for soil and groundwater samples that will directly support this assessment are TCE and the TCE intermediate, reductive dechlorination[13] degradation products (*cis*-1,2-DCE; *trans*-1,2-DCE; and vinyl chloride). These analyses will be performed using method SW-846, with a reporting limit of 10 µg/kg per analyte for soils and 5 µg/L per analyte for groundwater.

Analyses of NOD and microbial populations are useful screening-level data to assist in the assessment of the implementability of chemical oxidation and enhanced microbial degradation of the VOC contamination, respectively. These samples can be readily collected from proposed soil borings and existing MWs with minimal level of effort. The velocity of RGA groundwater in the C-400 area remains a key uncertainty that impacts design of remedial measures. This investigation will install a 3-well cluster upgradient of the southeast C-400 DNAPL zone, with MWs screened in the upper, middle, and lower RGA, to be used in measuring groundwater flow velocity with passive flux meters. The passive flux meters will be filled with soluble tracers: the loss of the tracer over time is an indirect measure of groundwater flow velocity.

Sample analyses for this investigation will be planned through the Paducah Sample Management Office (SMO). The samples will be sent to a SMO-approved laboratory that has been audited under the DOE–

[13] Reductive dechlorination is not expected to be an active process in the aerobic groundwater of the treatment areas; however, lesser concentrations of these VOCs have been detected in samples of soil and groundwater from south of the C-400 Building. Intermediate products of other degradation pathways typically are short-lived.

Consolidated Audit Program, and if required, is certified by Kentucky Department for Environmental Protection to perform the requested analyses.

Identify Decisions:

The principal study question and associated alternative actions and decision rules typically are identified in this section; however, decisions within the scope of the IRA will not be based solely upon the data. Rather, the data will be analyzed to verify that sufficient DNAPL is present in the UCRS in the Phase II treatment area to justify use of the designed vapor treatment system and to develop predictive relationships of MIP responses to on-site environmental occurrences of TCE; therefore, only a principal study question will be defined in this section. It is inappropriate to define either Alternative Actions or a Decision Statement when no decisions are to be made with the data. The principal study question associated with this project is as follows:

> What is the relationship of MIP responses to the presence of TCE mass in the southeast C-400 Cleaning Building Area?

Identify Inputs:

The study inputs are the site geology, previous and proposed MIP borehole logs and identification and quantification of VOCs in groundwater and soils (primarily TCE and its degradation products) in the area southeast of the C-400 Cleaning Building area prior to the implementation of ERH for Phase II of the IRA.

Specify Boundaries:

The boundaries of the study are the soils and groundwater associated with the area southeast of the C-400 Cleaning Building. Soil boreholes extending down to 1 ft into the McNairy Formation[14] will be sampled, where possible, collocated with previous and proposed MIP boreholes. The general vertical boundaries for each of the media are further defined below:

- MIP, UCRS (~20–60 ft bgs), RGA (~60–95 ft bgs), and the upper 1 ft of the McNairy Formation.
- Soils, UCRS (~20–60 ft bgs), and the upper 1 ft of the McNairy Formation (~ 95 ft bgs).
- Groundwater, RGA (~60–95 ft bgs).

The temporal boundaries related to this FSP are the beginning date of the previous MIP survey (July 2006) and the conclusion of collection of these samples (prior to installation of ERH for Phase II of the C-400 IRA).

Define Decision Rules:

The primary parameters of interest in this study are the TCE analyses of soil and groundwater and MIP responses in collocated borings. Soil analyses will be used as a direct measure of the amount of TCE (including DNAPL) present. Groundwater analyses will be indicative of the aqueous TCE mass and the potential presence of TCE DNAPL. Water sample analyses will be compared to a standard of 1,400 ppm TCE (aqueous solubility of TCE) to evaluate the presence of DNAPL. Analyses of NOD and microbial population are for screening-level assessment, only; no standard is strictly applicable.

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[14] The McNairy samples are anticipated to be collected in the area or vicinity of a DNAPL pool. The limit of the depth of penetration into the McNairy is a prudent measure to limit downward spread of DNAPL.

Because no direct decision will be made regarding this data, it is inappropriate to define decision rules.

Specify Error Tolerances:

This step of the DQO process includes the development of statistical hypotheses, decision rules, and the definition of appropriate error rates. The overall effectiveness of the MIP technology will be evaluated by comparing the value of previous and proposed MIP responses with soil or groundwater TCE analyses of collocated samples.

Many factors may negatively influence the relationship. Although the interrogated media in the collocated boreholes are anticipated to be similar, the samples will be separated by several ft (linearly) and several years, in some cases. DNAPL occurrence may respond to minute changes in lithology, which are anticipated over short distances in the UCRS, RGA, and McNairy. The previous MIP logs were generated in July and August 2006. Higher saturations of DNAPL potentially remain mobile and may have migrated since 2006. Moreover, lower TCE concentrations in soil may have been subject to significant dissolution and degradation since 2006.

This investigation will generate MIP logs at four locations; at least two will be collocated borings at previous MIP locations. The collocated MIP and soil/groundwater borings will allow a direct comparison of MIP profiles and support development of predictive relationships of MIP responses to soil and groundwater TCE concentrations, The MIP and analytical data will be regressed in an attempt to develop predictive equations specific to differing settings of water saturation and lithology, similar to methods developed by the U.S. Army Corps of Engineers (COE 2002). Data will be graphed to show the scatter of the data and best fit solution, and an equation will be developed for the relationship. It is anticipated that the data set of MIP and soil and groundwater analyses will contain outliers. The experience and skill of the analyst will be relied upon to identify the outliers to be excluded from the data base for development of the predictive equations. The documentation for the predictive equations will include identification of data that were excluded.

Optimize Sampling Design:

This step is used to optimize sampling design. MIP boring locations originally were distributed across the treatment area based on professional judgment and biased to provide uniform sample "coverage." Collocated proposed MIP logs will be generated for the previous MIP boreholes MIP-13 and MIP-16. Two other locations to be determined in the primary DNAPL zone also will be MIP logged. If the proposed MIP-13 and MIP-16 logs mirror the previous logs at the locations, the two additional new MIP boreholes will be used to fill gaps in the MIP borehole coverage: if the proposed MIP-13 and MIP-16 logs differ significantly from the previous logs, the two additional new MIP boreholes will be used to reassess other MIP borehole logs.

Locations for the collocated soil borings (this FSP) are being biased to two areas: (1) to MIP borings with highest MIP response and (2) to a setting that is perimeter to the suspected DNAPL zone(s). The previous locations with highest MIP responses (supposed DNAPL-scale response) are MIP-13, MIP-14, MIP-16, MIP-17, MIP-21, MIP-43, and MIP-48. Collocated borings will be sampled at each of these locations. In addition, perimeter location MIP-44 will be sampled to characterize an area of lesser MIP response (Figure E.13).

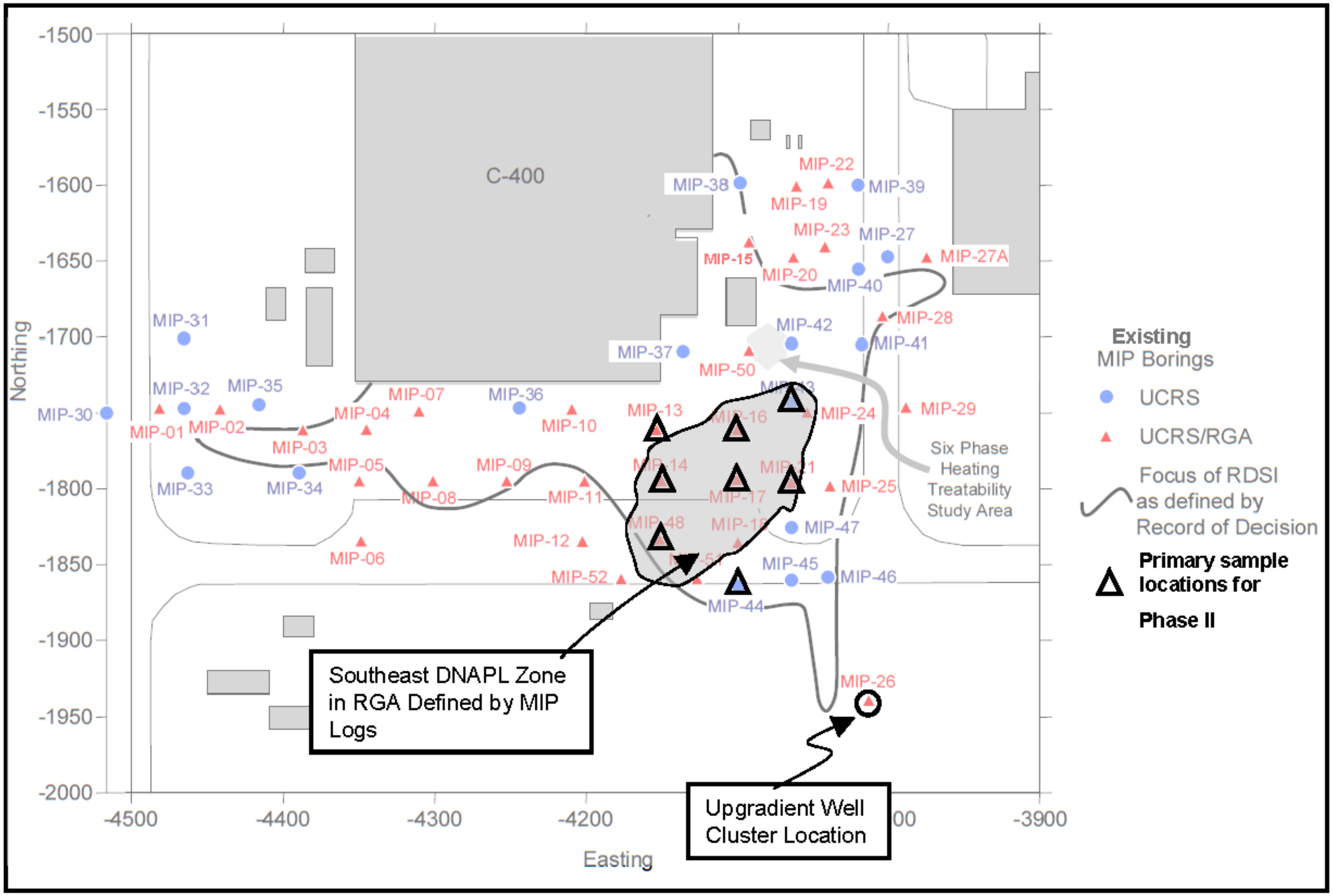

Figure E.13. Sample Locations for the MIP Confirmation Study

The distribution of DNAPL in subsurface soils can be extremely heterogeneous and may vary in response to depositional/erosional structures; textures resulting from subsequent chemical, physical, and biological processes; and the location, mass, and timing of the DNAPL release(s). TCE was the primary contaminant released into the soils south of the C-400 Cleaning Building. Subsequent degradation has resulted in lesser concentrations of other VOCs within the DNAPL. It is anticipated that VOC concentrations in the soil and groundwater samples of the collocated borings will vary significantly within each boring and across the area. For soil sample analyses (which will be purposely biased high during sample collection), the analyses will be compared with the maximum PID response in the collocated MIP log for the 1 ft interval centered on the depth of the sample. For groundwater analyses (which tend to be more diffused by the sampled medium), the groundwater sample will be compared with the average of the PID response in the collocated MIP log for the 1 ft interval centered on the depth of sample. Separate predictive relationships between soil VOC concentrations and the MIP will be made for the unsaturated UCRS, saturated UCRS, and McNairy Formation. Also, a separate predictive relationship will be made for the groundwater sample concentrations in the RGA. The MIP response to VOC concentration has proven to differ significantly between saturated and unsaturated formations (Costanza *et al*., 2002). A better predictive relationship between concentration and MIP response is expected in the saturated zone.

E.5.1.3 Locations

A primary goal of the proposed investigation to collect soil and groundwater samples is to compare the existing VOC concentrations (in the environmental samples) with preexisting and current MIP logs. Because slight variations in soil texture may bias significantly the presence of DNAPL and textures of the UCRS and RGA matrix change over short distances, samples collected as close as possible to the previous and proposed MIP boreholes provide the best possible basis for comparison. However, concern exists that the immediate environment of the borehole may be biased by any previous MIP sampling activity, specifically vertical mobilization of DNAPL and the influence of the borehole grout. In an effort to balance the benefit of sampling closely collocated boreholes with the potential bias introduced by the previous MIP investigation, the proposed sample boreholes will be uniformly spaced 2 ft removed from the collocated MIP boring. The field crew has freedom to position the borehole anywhere on a 2-ft radius of the collocated MIP boring to optimize the location of the drill/DPT rig. For locations with previous and proposed MIP boreholes, the collocated soil borehole will be constrained to one of the two points located 2 ft from both MIP boreholes.

E.5.1.3.1 MIP

Continuous MIP logs will be obtained from four borings completed with DPT through the RGA. Experience has shown that a direct push of the MIP in the RGA is difficult. Moreover, the MIP contains electronic and mechanical equipment that may be damaged due to excessive hammering; therefore, the MIP log will be completed in stages. First, the MIP contractor will advance the MIP probe through the UCRS to the top of the RGA. Second, the MIP contractor will retract the MIP probe and push a pilot hole through the RGA with a DPT probe of smaller diameter than the MIP tool, to near the anticipated depth of the MIP borehole. Then, once the targeted depth of the pilot hole is reached, the MIP contractor will pull out the DPT probe and insert the MIP tool, collecting readings through the RGA and 1 ft into the top of the McNairy, as determined by the MIP's soil conductivity log. If the MIP contractor cannot advance the MIP probe through the UCRS as planned, the UCRS may be "pre" probed similar to the RGA.

The MIP probe transmits data through a cable to a MIP controller and/or other field instruments that are enclosed in a separate field vehicle. A gas chromatograph (GC) equipped with FID, PID, and ECD, supports the MIP system. The MIP contractor will calibrate the MIP probe and GC detectors consistent with the manufacturer's operating manuals. (The GC contains a radioactive source to support its function.)

After MIP sampling is complete, the hole above the RGA will be backfilled with bentonite grout using a tremie pipe to within 2 ft of ground elevation. The remaining 2 ft of borehole will be backfilled with the surface material of the borehole area. Additional procedural details of DPT sampling are in PAD-ENR-0020, *Direct Push Technology (DPT) Sampling*.

E.5.1.3.2 Soil

The field crew will perform soil sampling in accordance with procedure PAD-ENM-2300, *Collection of Soil Samples.* This sampling effort will rely upon a hollow stem auger (HSA) drill rig or DPT system to collect the soil samples. The HSA drill rig or DPT system will collect the soil core in a plastic liner using either a Macro-Core® or DT22® sampler. Field crew members will cut open the plastic liner for soil subsampling once the liner has been extracted.

In two locations of the suspected DNAPL zone (MIP-13 and MIP-16), soil samples will be collected from each 1-ft depth interval of the UCRS and from the top 1 ft of the McNairy. In six other locations of the suspected primary DNAPL zone (see Table E.3), soil samples will be collected from 2-ft depth intervals in the UCRS and from the top of the McNairy in four of the locations. In addition to predetermined vertical intervals, sampling will be conducted slightly above and slightly below the basal contact of the main sand and gravel unit of the UCRS and at the base of the RGA. The exact sample depths will be biased to characterize zones of highest VOC concentration, as determined by field monitoring instruments (i.e., hand-held PID). The field crew will use En Core® samplers (25 gram size) to collect a grab sample from the selected sample depth as soon as possible after the core liner is cut open, without compositing a sample. Table E.3 summarizes the anticipated depths of sampling based on the soil conductivity logs from the MIP boreholes (where available) and the number of samples. While the soil conductivity log is expected to determine accurately the top of the McNairy, the depth of the bottom of the UCRS is less well defined by the conductivity log and will be determined by examination of the soil core. The field crew will develop a continuous log of the UCRS soil core consistent with PAD-ENM-2302, *Borehole Logging*, and will, likewise, describe the base-of-RGA/top-1-ft-of-McNairy core. (Other than the top and bottom of the RGA, the RGA interval will not be logged in the collocated soil borings.) **The field crew will not sample any deeper than 1 ft into the McNairy in the suspected DNAPL zone** to minimize the potential of mobilizing DNAPL deeper into the McNairy.

In one upgradient location (MIP-26), the investigation will install a 3-well RGA MW cluster. The field crew will collect continuous core through the UCRS and RGA intervals and log the lithology without collecting a soil sample for analysis unless field monitoring with a hand-held PID indicates the presence of significant soil contamination (50 ppm TCE or greater as measured by the PID).[15] If contamination is noted, the field crew will collect samples for laboratory VOC analysis within the identified contamination area only, using a 1 ft vertical spacing of samples and up to four additional samples from slightly above and slightly below lithology changes. The field crew will collect seven samples for NOD analysis from the soil core of this well cluster: one each from the Hydrogeological Unit 1 (HU1), HU2, and HU3 intervals of the UCRS; one each from the upper, middle, and lower RGA; and one from the top 1 ft depth of the McNairy.

After each soil boring is completed, the hole above the RGA will be backfilled with bentonite grout using a tremie pipe to within 2 ft of ground elevation. The remaining 2 ft of borehole will be backfilled with the surface material of the borehole area. Because the upgradient location may be impacted by remedial actions in the RGA, each of the three wells of the 3-well cluster will be constructed with stainless steel screen and riser pipe and a cement-bentonite annular seal grout.

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[15] This criterion is based on field experience with drilling investigations at PGDP.

This FSP anticipates the collection of approximately 316 soil samples for analysis of VOCs, not including sample requirements for quality control.

Table E.3. Anticipated Soil Sample Depths

LOCATION	SOIL BORING	DEPTH (ft)		VERTICAL SPACING OF SAMPLES (ft)		SAMPLE QUANTITIES	
		BASE OF UCRS	TOP OF McNairy	UCRS	RGA	SOIL	GROUND-WATER[16]
Internal to Suspected DNAPL zone	MIP-13	65.1	95.4	1	5	66	6
	MIP-14	55.5	96.8	2	5	29	8
	MIP-16	62.2	94.1	1	5	63	7
	MIP-17	64.9	96.2	2	5	33	6
	MIP-21	57.2	94.6	2	5	29	8
	MIP-43	NA	NA	2	None	32[17]	None
	MIP-48	61.4	94.2	2	5	32	7
Perimeter	MIP-44	NA	NA	2	None	32[17]	None
	AVERAGE	**61.0**	**95.2**		**TOTAL[18]**	**316**	**42**

E.5.1.3.3 Groundwater

Groundwater samples will be collected as grab groundwater samples from the effluent stream of a pump that is positioned below a pneumatic packer placed near the bottom of the hollow stem augers. The field sample crew may use a pneumatic positive displacement pump, submersible piston pump, or electric submersible pump that is constructed and fitted with materials suitable for the sampling of VOCs and TCE DNAPL. Prior to collection of the sample, the field sample crew will purge a volume of water equivalent to 3X the volume of water present in the hollow stem augers below the pneumatic packer. The groundwater sample will be collected from a side stream of the effluent purge stream, without a break in pumping once the required purge volume has been pumped. The flow rate of the side stream during sampling should not exceed 100 mL/minute[19] and will be field-filtered. No measurement of field parameters will be required to establish the representativeness of the sample stream prior to sample collection. The evacuation of 3X the volume of the bottom of the auger should be sufficient to yield a representative sample for TCE.

Groundwater samples will be collected for analysis of VOCs in 40-mL glass vials with Teflon-lined closure, filled so no headspace remains in the vial. Samples will be preserved with hydrochloric acid to a potential of hydrogen (pH) of less than 2 and cooled to 4 °C ± 2 °C. Not including sample requirements for quality control, this FSP anticipates the collection of 42 groundwater samples for VOC analysis.

The field crew will place passive samplers, such as the Bio-Trap Sampler® of Microbial Insights, in three C-400 vicinity MWs to assess microbial populations in UCRS and RGA groundwater. Wells MW69 (UCRS), MW68 (lower RGA), and MW71 (upper RGA) (see Figure E.3) or three alternatives will be prepared by removing the dedicated sample pumps and purging a minimum of 3X the initial volume of

[16] The basal groundwater sample will be collected immediately above the interface of the RGA/McNairy contact.
[17] Thirty-two is the derived number of soil samples for an average measured thickness of the UCRS.
[18] Additional samples will be required to characterize VOC concentrations immediately above and below lithology changes.
[19] The flow rate of the sample stream may not exceed 100 mL/minute: the purge rate may be up to 2 gal/minute as long as the pump does not cavitate.

water in the wells (pumping at variable depths to clean the whole length of the well screen) to provide a gross cleaning of the well screen interval. The purge rate should be sufficient to stress the capacity of the well, but should not exceed 2 gal/minute. **The wells will not be purged at a rate that draws the water level down into the well screen interval.** After the water column has been allowed to settle for a minimum of 24 hours, the field crew will lower and secure the samplers near the midpoint of the well screen interval and leave the samplers in place for 30 days.

After this investigation installs and develops the 3-well RGA MW cluster at upgradient location MIP26, the field crew will install passive samplers, such as those available from EnviroFlux®, across each well screen interval. The matrix of the samplers will be saturated with soluble tracers, such as alcohols, and left in the well screen intervals for a period recommended by the vendor of the passive sampler. Comparison of the percentage of the mass of tracer lost at discrete depths in each screen interval over a set time will be a direct measure of the relative rate of groundwater flow at those sample depths. The mass of tracer lost over the time that the tracer was placed in the well will provide data to bound the groundwater flow rate. The vendor of the passive sampler will be consulted for the appropriate means to interpret the data.

E.5.1.3.4 DNAPL

The effort to collect groundwater samples may yield a significant volume of DNAPL. If pumping produces DNAPL, as evidenced by high VOC concentrations in the effluent stream (>500 ppm TCE on a hand-held PID) or observation of a separate liquid phase, the field crew will adjust the pumping rate to 1 Liter/minute or less, in an attempt to sustain the production of DNAPL. The field crew will collect the "water" sample as soon as possible after DNAPL is indicated, regardless of the purge volume, and continue pumping to recover DNAPL.

In the case where a sample interval produces 100 Liters (26 gal) or more of DNAPL, the field crew must consult with the Project Manager to optimize a pumping strategy. Pumping will continue with the intent to recover as much DNAPL as possible. Any recovered DNAPL will be managed in accordance with the instructions and procedures outlined in the RAWP. The Phase I ERH treatment system provides storage facilities for DNAPL.

E.5.1.3.5 Assessment of DNAPL mass

The end use of the MIP correlation sampling is to substantiate the DNAPL mass estimate of the RDR or to support an independent mass assessment. If trends in the MIP log data conform to trends of soil and groundwater analyses, then the predictive relationship between MIP and analytical results will be examined, and the data will be analyzed to determine if significant predictive equations can be developed relating MIP and analytical results over the range of these data and with limited extrapolation. The DNAPL mass will be reassessed using method similar to that of the RDR. In the case where the trends of MIP log data do not conform to trends in the soil and groundwater analyses, then the MIP logs will be considered of lesser value and the analytical data will be the primary basis for DNAPL mass estimate.

Soil analyses will be related to DNAPL saturation by the equation:

DNAPL saturation (as a decimal fraction) = $\left(2.056 \times TCE\right) \Big/ \left(0.5256 - 0.1656 \times TCE\right)$

where TCE is the TCE concentration as a decimal fraction.

The above equation assumes that all measured TCE mass is accounted as DNAPL (i.e., any sorbed, aqueous, or gas phase TCE is lumped into the NAPL phase), the density of TCE is 1.46 g/cubic centimeter, the soil consists of quartz with a density of 2.65 g/cubic centimeter, the porosity of the soil matrix is 0.36 (36%), the soil sample is taken from below the water table, and the density of groundwater is 1.00 g/cubic centimeter.

The relationship of groundwater analyses to DNAPL saturation is less straightforward because TCE reaches saturation in pure water at 1,400 mg/L. For groundwater, a value of 140 mg/L will be interpreted as the presence of 10% DNAPL saturation. Because DNAPL is mobile at saturations exceeding residual saturation and the sampling method is not ideal for capture of DNAPL, the presence of a small amount of DNAPL in a water sample will be interpreted as 20% saturation. If 10% or more of the sample is DNAPL, the DNAPL saturation will be interpreted to be 50% for that vertical sampling interval.

For purposes of the DNAPL mass estimate, the TCE concentrations will be averaged over 5-ft thick intervals (e.g., 70–75 ft bgs, 75–80 ft bgs, etc.) and interpolated and extrapolated consistent with the RDR (DOE 2008) to define the area of 1% and greater DNAPL saturation. The DNAPL mass will be assumed to be the average of the TCE concentrations applied over the volume defined by 1% and greater DNAPL saturation.

If the trends in the MIP logs do not conform to the trends in soil and groundwater analyses, then the MIP logs will be considered of lesser value and the analytical data will be the primary basis for DNAPL mass estimate. Depending upon the complexity of the TCE trends, the data may be averaged over hydrogeologic units and interpolated/extrapolated based on a conceptual model or the mass may be inferred from volumetric modeling using a computer program such as Environmental Visualization System (EVS).

It is important to remember that estimating a nonuniformly distributed DNAPL mass in heterogeneously distributed sediments based on a finite number of samples is difficult at best. It is not unlikely that the estimates of DNAPL mass may be off by an order of magnitude or more. Posttreatment sampling, along with all previous sampling and sensing investigations, will provide a better, but not perfect, assessment of the initial and remaining mass of contaminant.

E.6. SAMPLE ANALYSIS

The sample analyses for this investigation will characterize soil, groundwater, and project-generated waste materials. Analytical requirements, methods, and procedures applicable to this FSP are identified in Section 8 of the RAWP (DOE 2009). Specific analytical requirements, methods, and procedures for VOCs are described in the Quality Assurance Project Plan, Chapter 9 of the *Remedial Action Work Plan for the Interim Remedial action for the Volatile Organic Compound Contamination at the C-400 Cleaning Building at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0004&D2/R2 (DOE 2009) (RAWP).

E.7. SAMPLING PROCEDURES

With the exception of the groundwater grab samples, fieldwork and sampling will be conducted in accordance with LATA Kentucky-approved, medium-specific work instructions, or procedures. Section 5.1.3.2 presents the requirements for collection of the groundwater grab samples. DOE or LATA

Kentucky will approve any deviations from these work instructions and procedures. LATA Kentucky will document changes on Field Change Request forms as detailed in the Quality Assurance Project Plan, Chapter 9 of the RAWP (DOE 2009).

E.8. DOCUMENTATION

Field documentation will be maintained throughout this investigation in various types of documents and formats including field logbooks, sample labels, sample tags, chain-of-custody forms, and field data sheets. The "Data Management Implementation Plan," Chapter 10 of the RAWP, provides the applicable guidelines for maintaining field documentation (DOE 2009). The data from this investigation will be used to evaluate the design for Phase II of the C-400 IRA.

E.9. SAMPLE LOCATION SURVEY

A survey of the previous MIP boreholes of interest to this project will be conducted to mark the reference locations at the site before any sampling is performed. Another survey of sampling locations will be conducted upon completion of field activities. The field sampling crew will make a thorough description of each location during sampling activities and will document the locations using field maps. This documentation will be used for the survey effort if sampling location markers are disturbed or if markers cannot be placed at the time of sampling. Where possible, temporary markers consisting of flagging or wooden or metal stakes or paint on concrete will be used to preserve the boring locations.

Each new sample point will be surveyed for its horizontal and vertical location using the PGDP coordinate system for horizontal control. Additionally, State Plane Coordinates will be provided using the U.S. Coast and Geodetic Survey North American Datum of 1983. The datum for vertical control will be the U.S. Coast and Geodetic Survey North American Vertical Datum of 1988. Accuracy for this work will be that of a Class 1 First Order survey. Work will be performed by or under responsible charge of a Professional Land Surveyor registered in the Commonwealth of Kentucky. Coordinates will be entered into Paducah Project Environmental Measurements System and will be transferred with the station's ready-to-load file to Paducah Oak Ridge Environmental Information System.

E.10. REFERENCES

COE (U.S. Army Corps of Engineers) 2002. *Tri-Service Site Characterization and Analysis Penetrometer System Validation of the Membrane Interface Probe*, ERDC/EL TR-02-16, U.S. Army Corps of Engineers, Engineer Research and Development Center, Vicksburg, MS.

Costanza, J., K.D. Pennell, J. Rossabi, and B. Riha 2002. *Effect of Temperature and Pressure on the MIP Sample Collection Process*, in proceedings of the Third International Conference, Remediation of Chlorinated and Recalcitrant Compounds, Monterey, CA, May 20-23.

DOE (U.S. Department of Energy) 1999. *Remedial Investigation Report for Waste Area Grouping 6 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1727&D2, U.S. Department of Energy, Paducah, KY, May.

DOE 2001. *Feasibility Study for the Groundwater Operable Unit at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1799&D2, U.S. Department of Energy, Paducah, KY, January.

DOE 2005a. *Record of Decision for Interim Remedial Action for the Groundwater Operable Unit for the Volatile Organic Compound Contamination at the C-400 Cleaning Building at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-2150&D2/R2, U.S. Department of Energy, Paducah, KY, July.

DOE 2005b. *Remedial Design Support Investigation Characterization Plan for the Interim Remedial Action for the Volatile Organic Compound Contamination at the C-400 Cleaning Building at the Paducah Gaseous Diffusion Plant, Paducah Kentucky,* DOE/OR/07-2211&D2, U.S. Department of Energy, Paducah, KY, December.

DOE 2008. *Remedial Design Report, Certified for Construction Design Drawings and Technical Specifications Package, for the Groundwater Operable Unit for the Volatile Organic Compound Contamination at the C-400Cleaning Building at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0005&D2/R1, U.S. Department of Energy, Paducah, KY, July.

DOE 2009. *Remedial Action Work Plan for the Interim Remedial action for the Volatile Organic Compound Contamination at the C-400 Cleaning Building at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0004&D2/R2, U.S. Department of Energy, Paducah, KY, September.

EPA (U.S. Environmental Protection Agency) 1998. *Federal Facility Agreement for the Paducah Gaseous Diffusion Plant,* U.S. Environmental Protection Agency, Atlanta, GA, February 13.

ATTACHMENT

REPRESENTATIVE MEMBRANE INTERFACE PROBE LOGS

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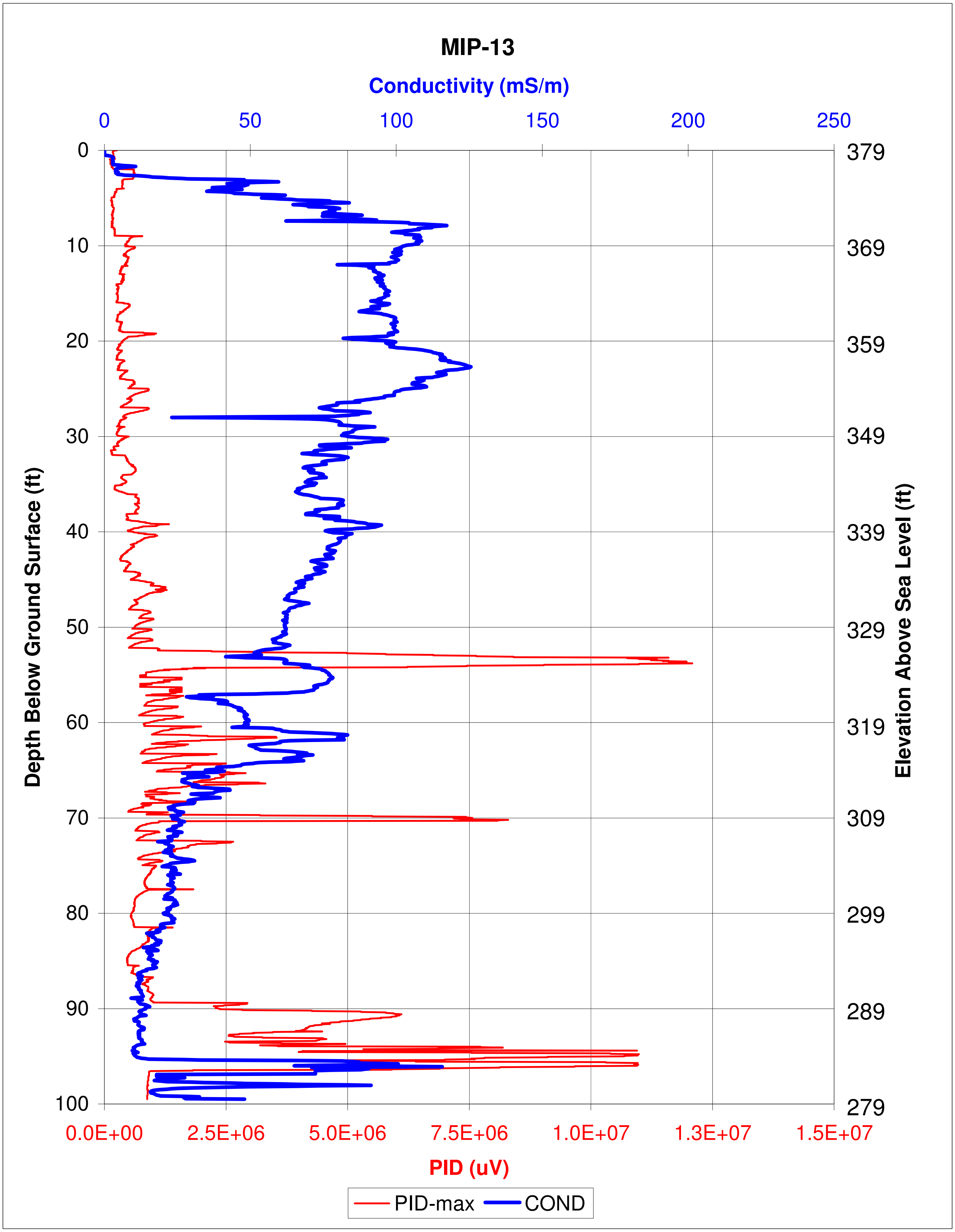
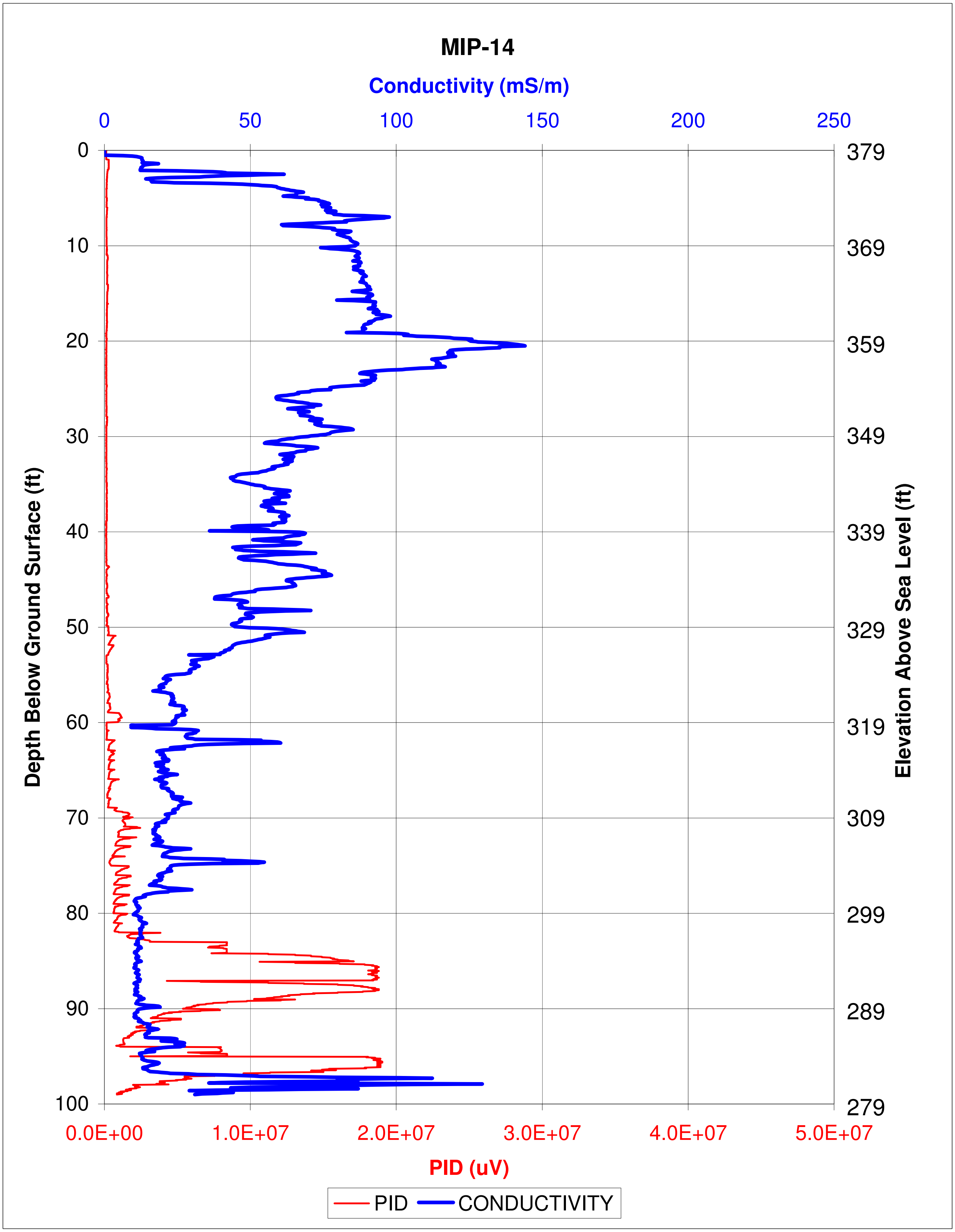


MIP-13
Conductivity (mS/m)
0
50
100
150
200
250
Depth Below Ground Surface (ft)
0
10
20
30
40
50
60
70
80
90
100
Elevation Above Sea Level (ft)
379
369
359
349
339
329
319
309
299
289
279
0.0E+00
2.5E+06
5.0E+06
7.5E+06
1.0E+07
1.3E+07
1.5E+07
PID (uV)
PID-max
COND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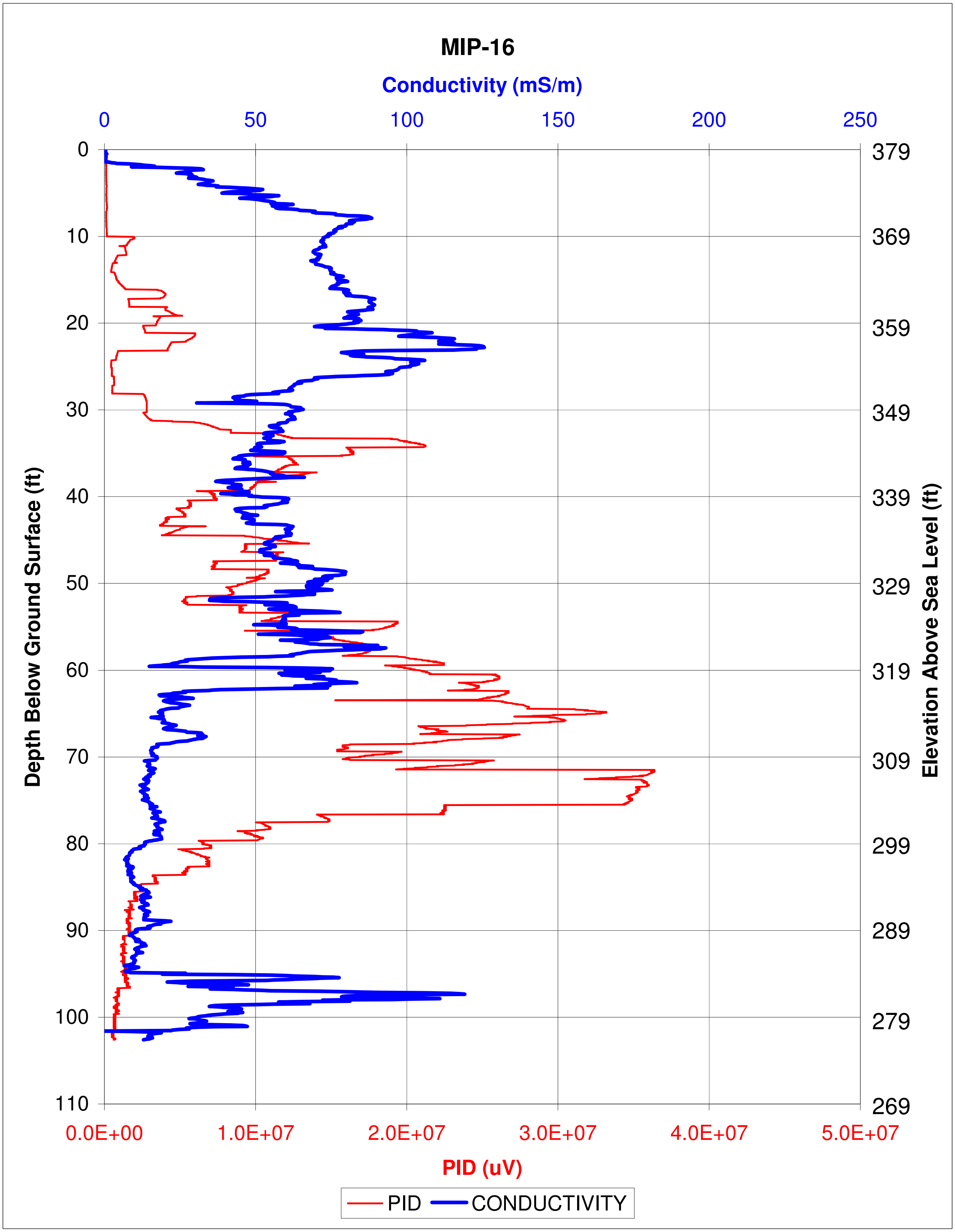
Conductivity (mS/m)
0
50
100
150
200
250
0
10
20
30
40
50
60
70
80
90
100
Depth Below Ground Surface (ft)
379
369
359
349
339
329
319
309
299
289
279
Elevation Above Sea Level (ft)
0.0E+00
1.0E+07
2.0E+07
3.0E+07
4.0E+07
5.0E+07
PID (uV)
PID
CONDUCTIVITY



MIP-16
Conductivity (mS/m)
0
50
100
150
200
250
Depth Below Ground Surface (ft)
0
10
20
30
40
50
60
70
80
90
100
110
Elevation Above Sea Level (ft)
379
369
359
349
339
329
319
309
299
289
279
269
0.0E+00
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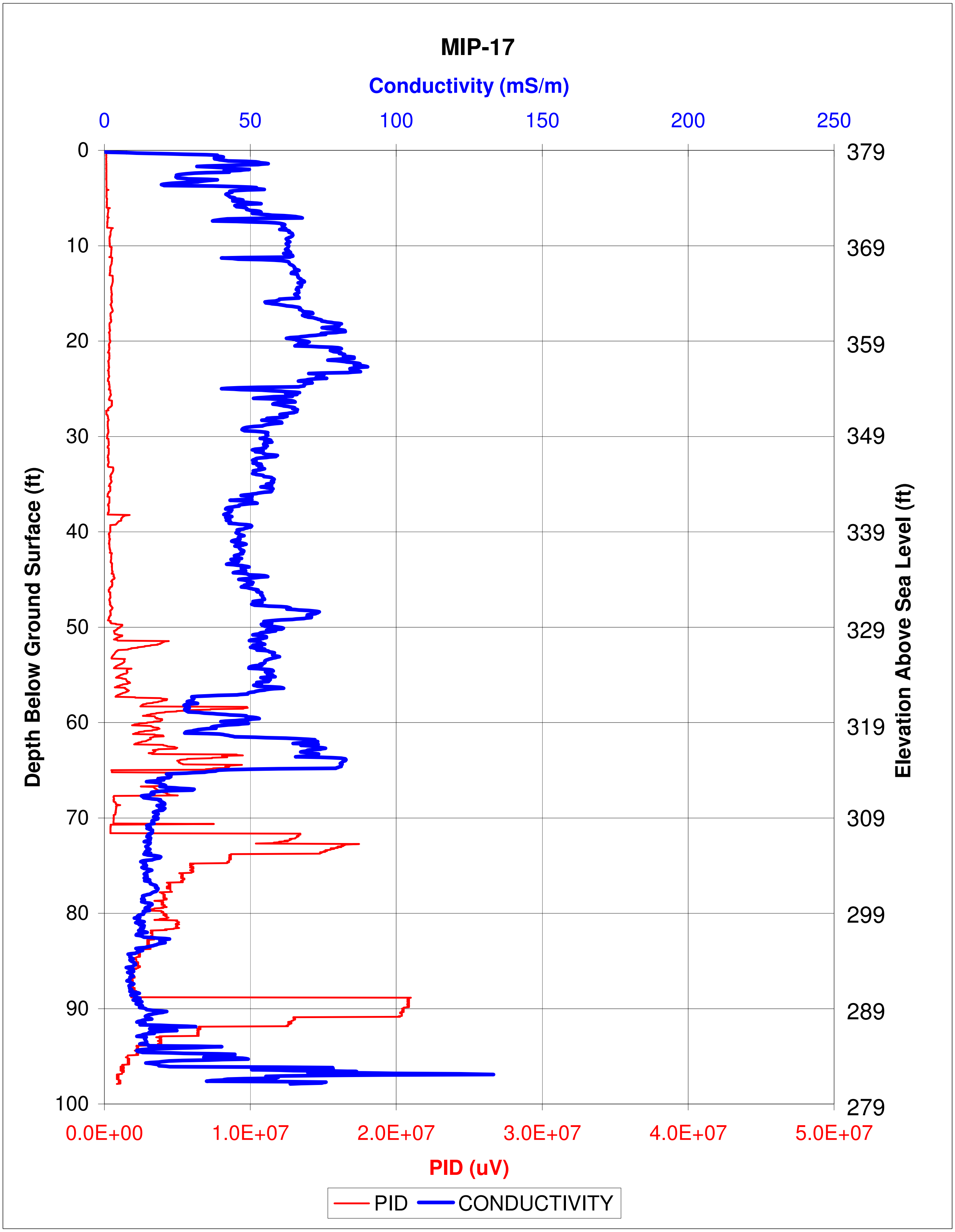
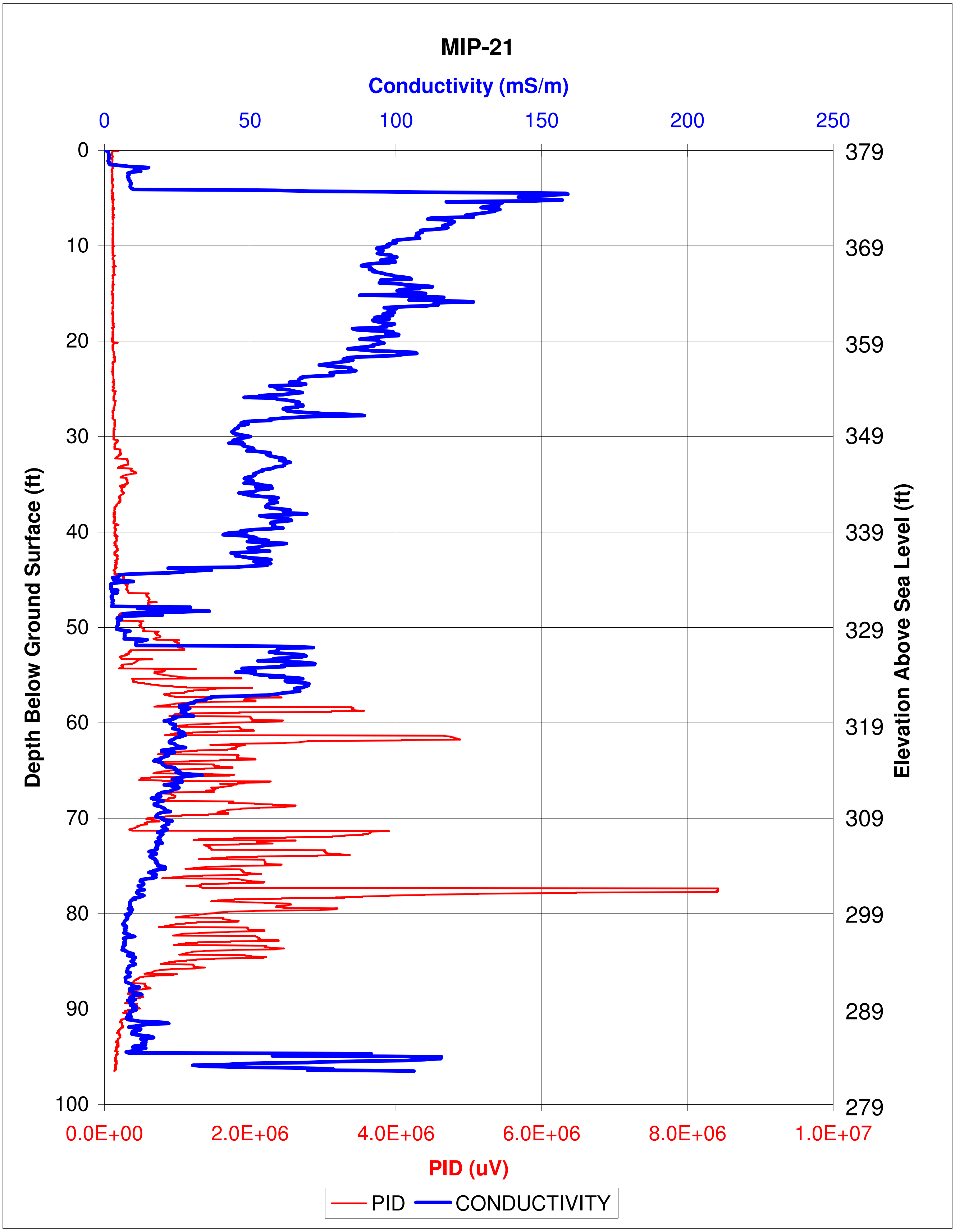
2.0E+07
3.0E+07
4.0E+07
5.0E+07
PID (uV)
PID
CONDUCTIVITY


MIP-17
Conductivity (mS/m)
0
50
100
150
200
250
Depth Below Ground Surface (ft)
0
10
20
30
40
50
60
70
80
90
100
Elevation Above Sea Level (ft)
379
369
359
349
339
329
319
309
299
289
279
0.0E+00
1.0E+07
2.0E+07
3.0E+07
4.0E+07
5.0E+07
PID (uV)
PID
CONDUCTIVITY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Conductivity (mS/m)
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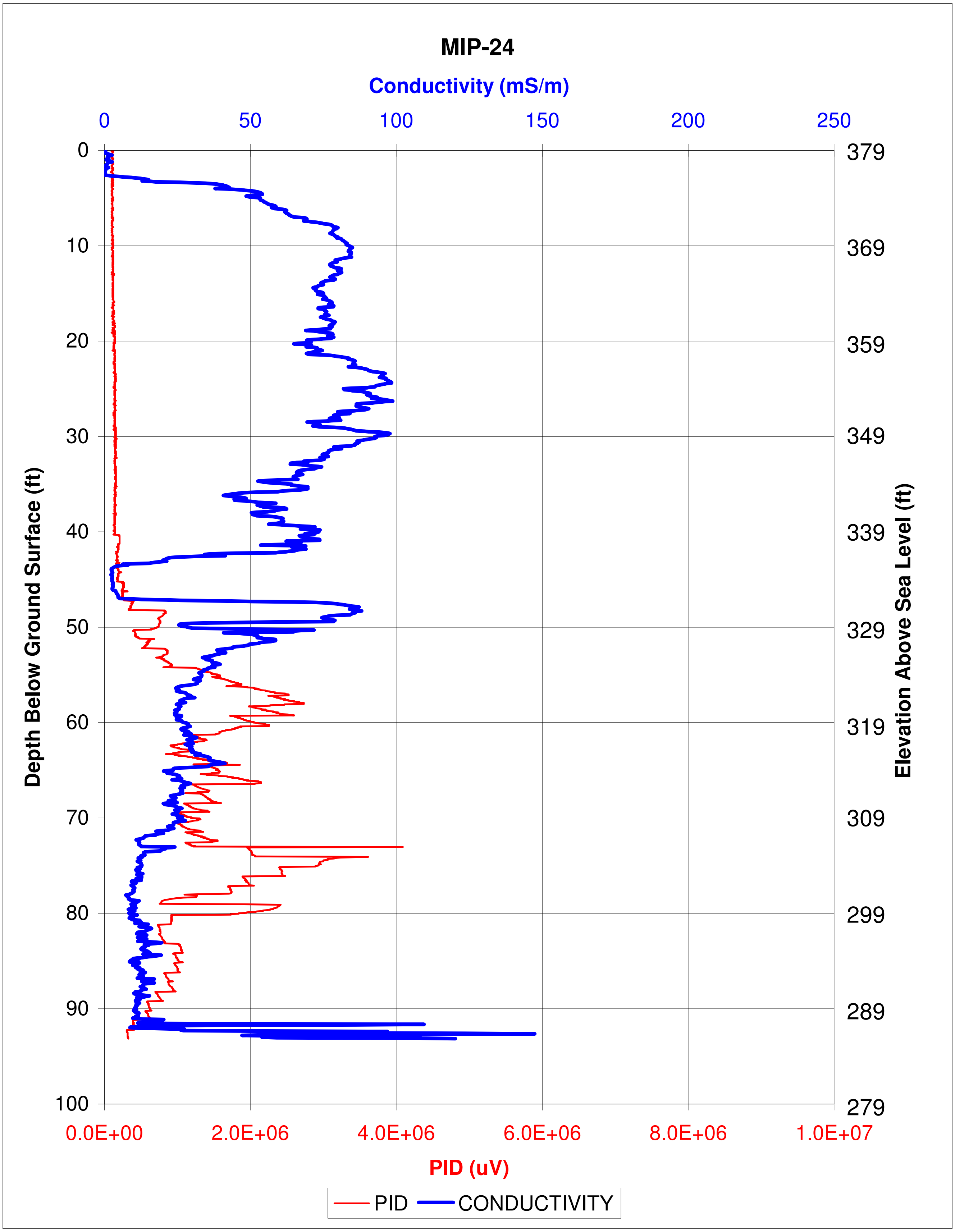
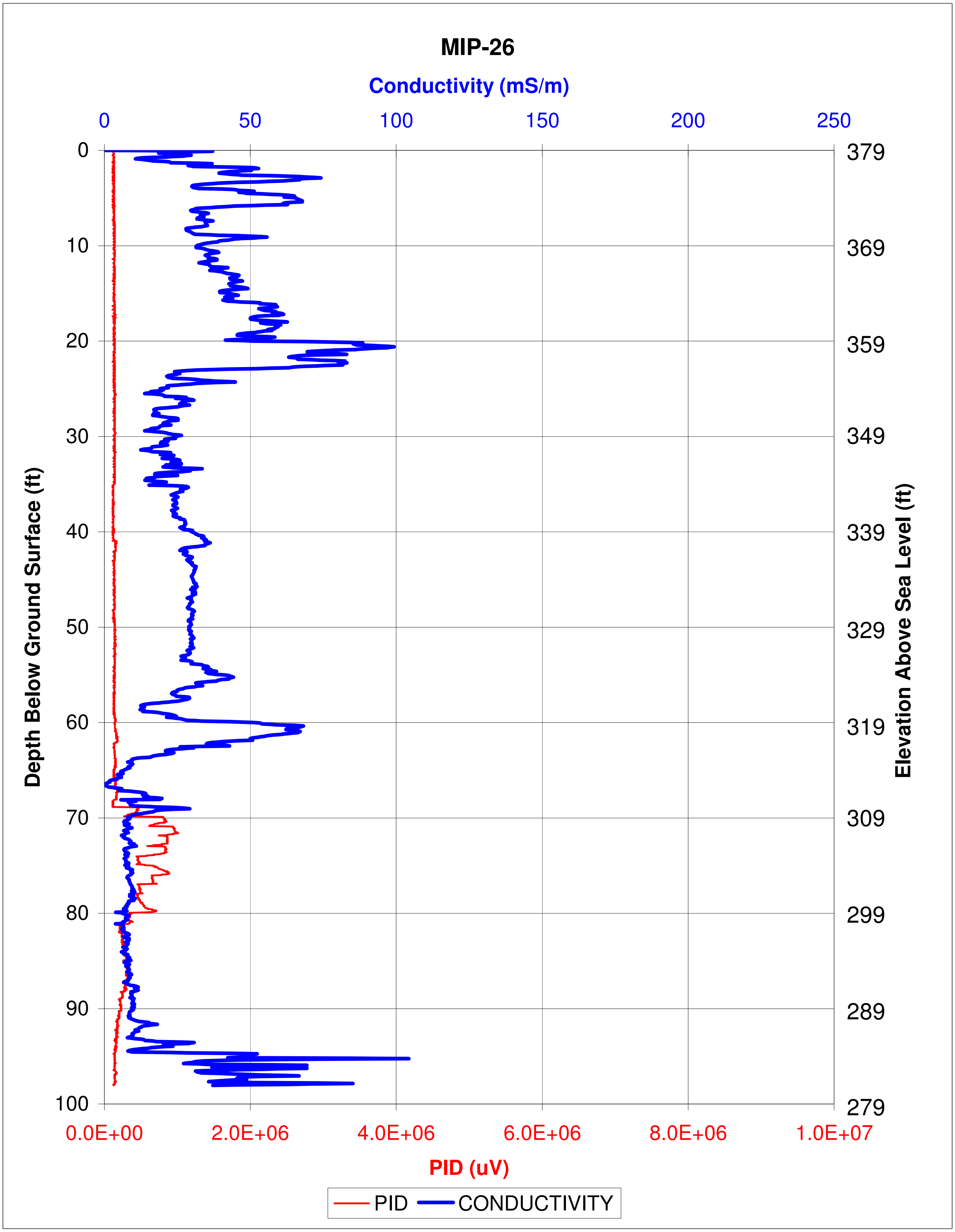
50
100
150
200
250
Depth Below Ground Surface (ft)
0
10
20
30
40
50
60
70
80
90
100
Elevation Above Sea Level (ft)
379
369
359
349
339
329
319
309
299
289
279
0.0E+00
2.0E+06
4.0E+06
6.0E+06
8.0E+06
1.0E+07
PID (uV)
PID
CONDUCTIVITY



MIP-24
Conductivity (mS/m)
0
50
100
150
200
250
Depth Below Ground Surface (ft)
0
10
20
30
40
50
60
70
80
90
100
Elevation Above Sea Level (ft)
379
369
359
349
339
329
319
309
299
289
279
0.0E+00
2.0E+06
4.0E+06
6.0E+06
8.0E+06
1.0E+07
PID (uV)
PID
CONDUCTIVITY



MIP-26
Conductivity (mS/m)
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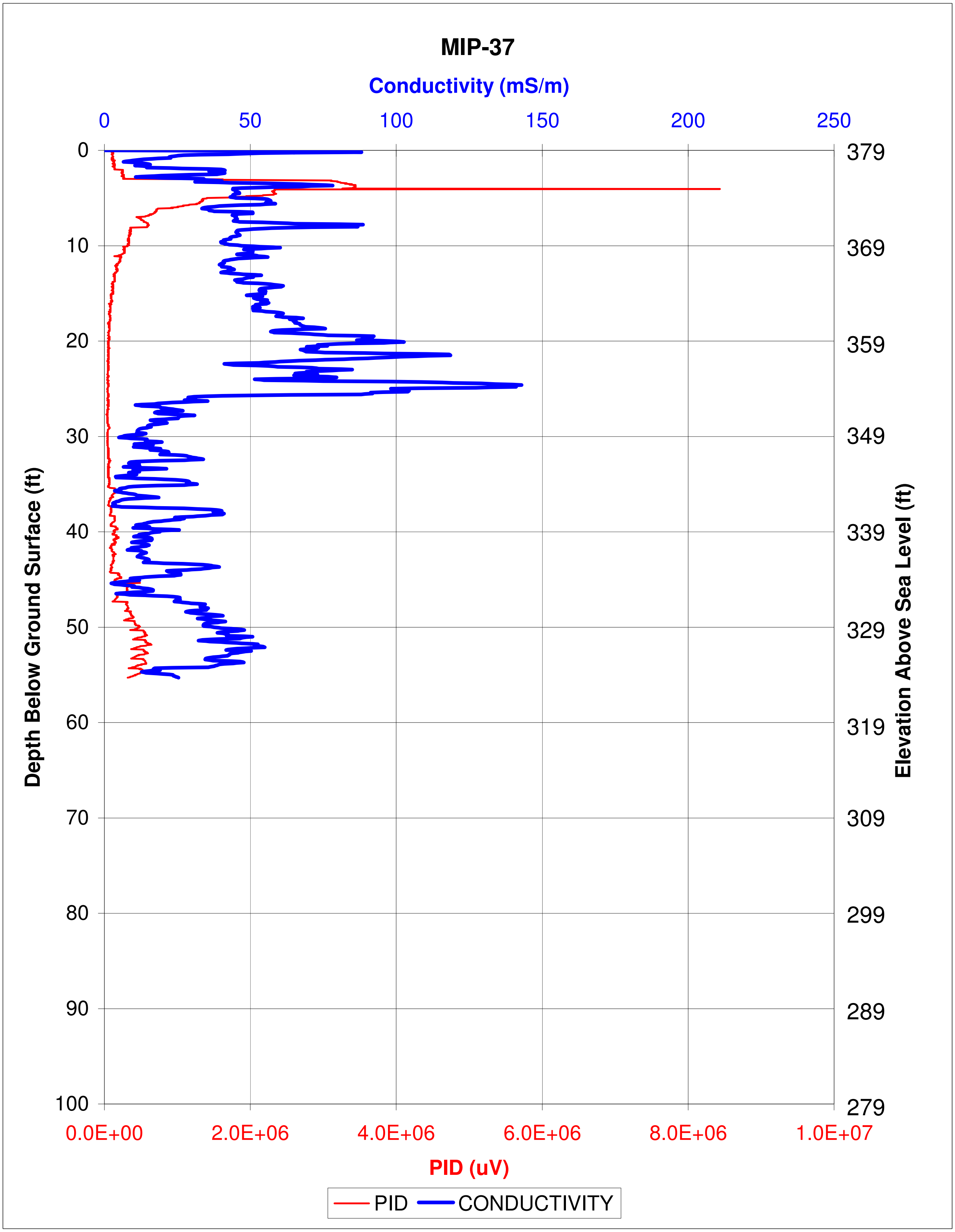
50
100
150
200
250
0
10
20
30
40
50
60
70
80
90
100
379
369
359
349
339
329
319
309
299
289
279
Depth Below Ground Surface (ft)
Elevation Above Sea Level (ft)
0.0E+00
2.0E+06
4.0E+06
6.0E+06
8.0E+06
1.0E+07
PID (uV)
PID
CONDUCTIVITY


MIP-37
Conductivity (mS/m)
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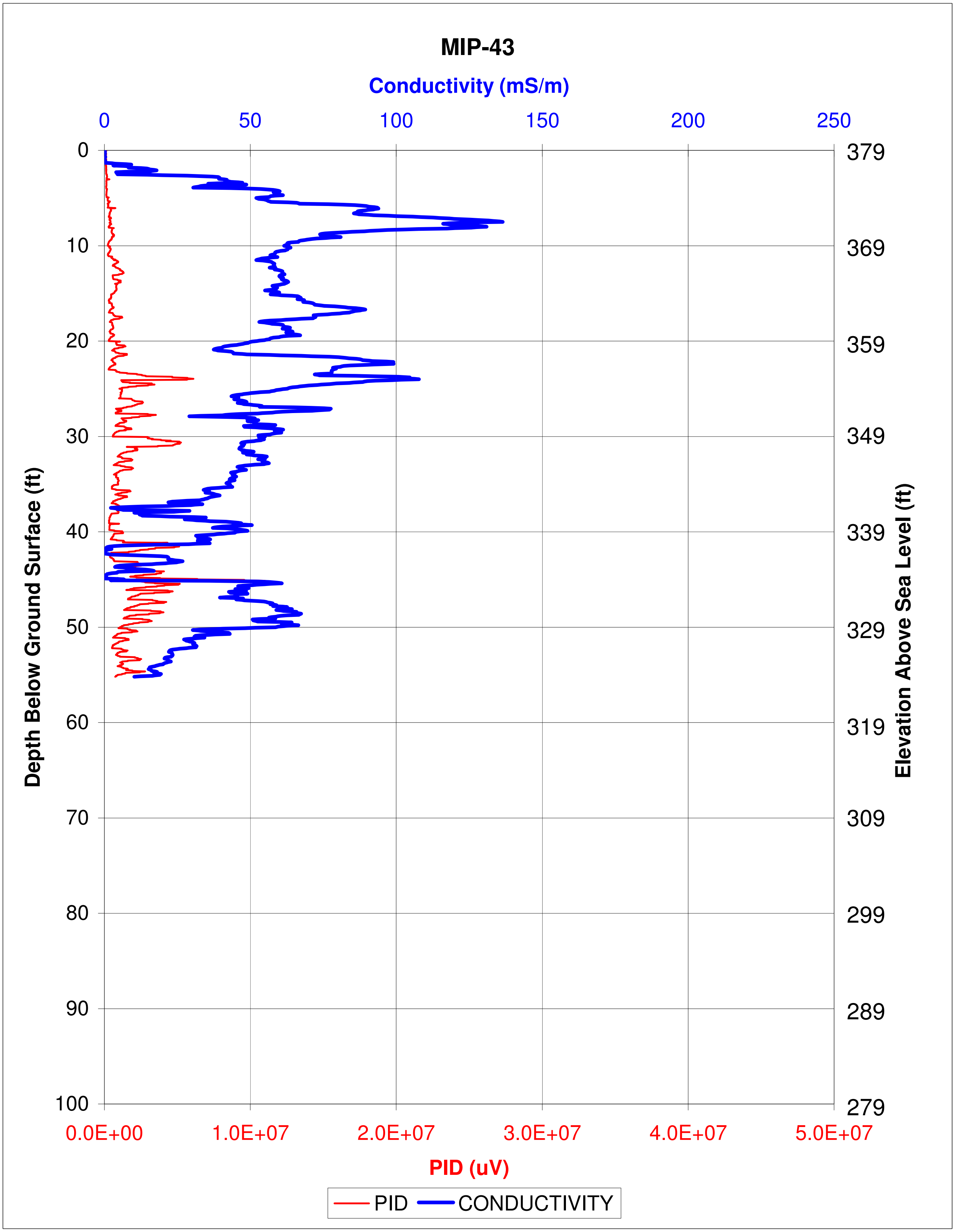
100
150
200
250
0
10
20
30
40
50
60
70
80
90
100
379
369
359
349
339
329
319
309
299
289
279
Depth Below Ground Surface (ft)
Elevation Above Sea Level (ft)
0.0E+00
2.0E+06
4.0E+06
6.0E+06
8.0E+06
1.0E+07
PID (uV)
PID
CONDUCTIVITY


MIP-43
Conductivity (mS/m)
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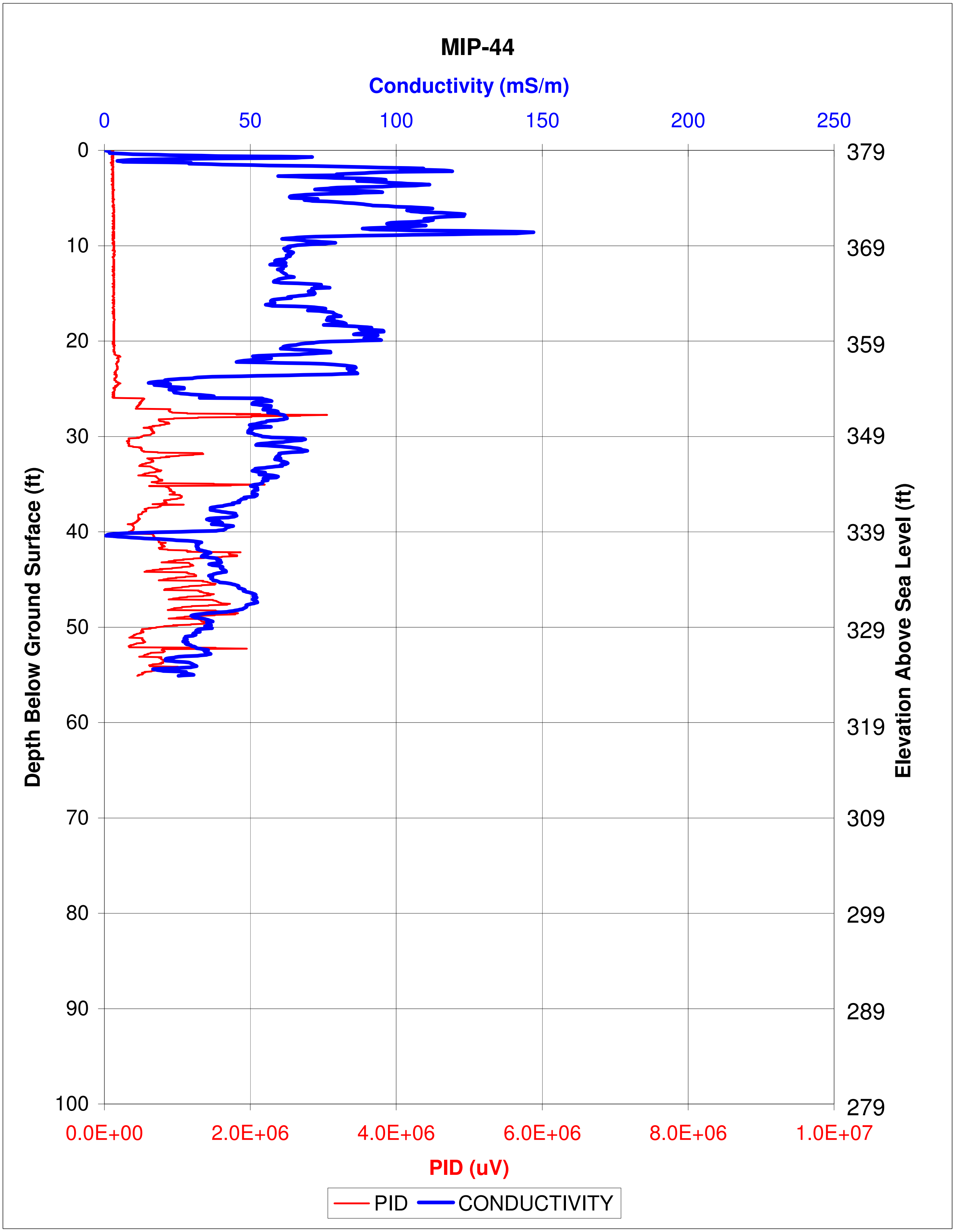
50
100
150
200
250
0
10
20
30
40
50
60
70
80
90
100
379
369
359
349
339
329
319
309
299
289
279
Depth Below Ground Surface (ft)
Elevation Above Sea Level (ft)
0.0E+00
1.0E+07
2.0E+07
3.0E+07
4.0E+07
5.0E+07
PID (uV)
PID
CONDUCTIVITY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Conductivity (mS/m)
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50
100
150
200
250
Depth Below Ground Surface (ft)
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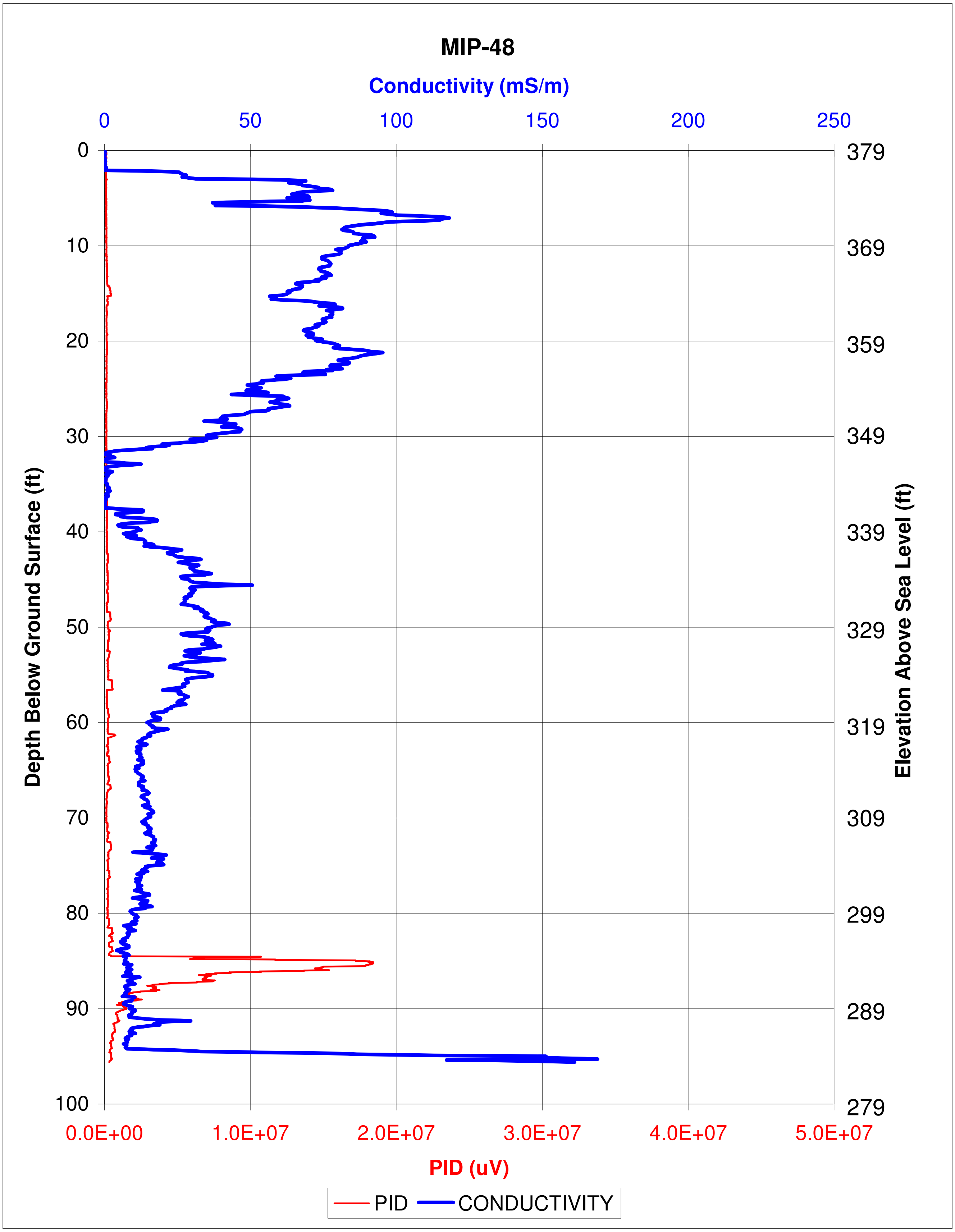
10
20
30
40
50
60
70
80
90
100
Elevation Above Sea Level (ft)
379
369
359
349
339
329
319
309
299
289
279
0.0E+00
2.0E+06
4.0E+06
6.0E+06
8.0E+06
1.0E+07
PID (uV)
PID
CONDUCTIVITY



MIP-48
Conductivity (mS/m)
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50
100
150
200
250
0
10
20
30
40
50
60
70
80
90
100
Depth Below Ground Surface (ft)
379
369
359
349
339
329
319
309
299
289
279
Elevation Above Sea Level (ft)
0.0E+00
1.0E+07
2.0E+07
3.0E+07
4.0E+07
5.0E+07
PID (uV)
PID
CONDUCTIVITY

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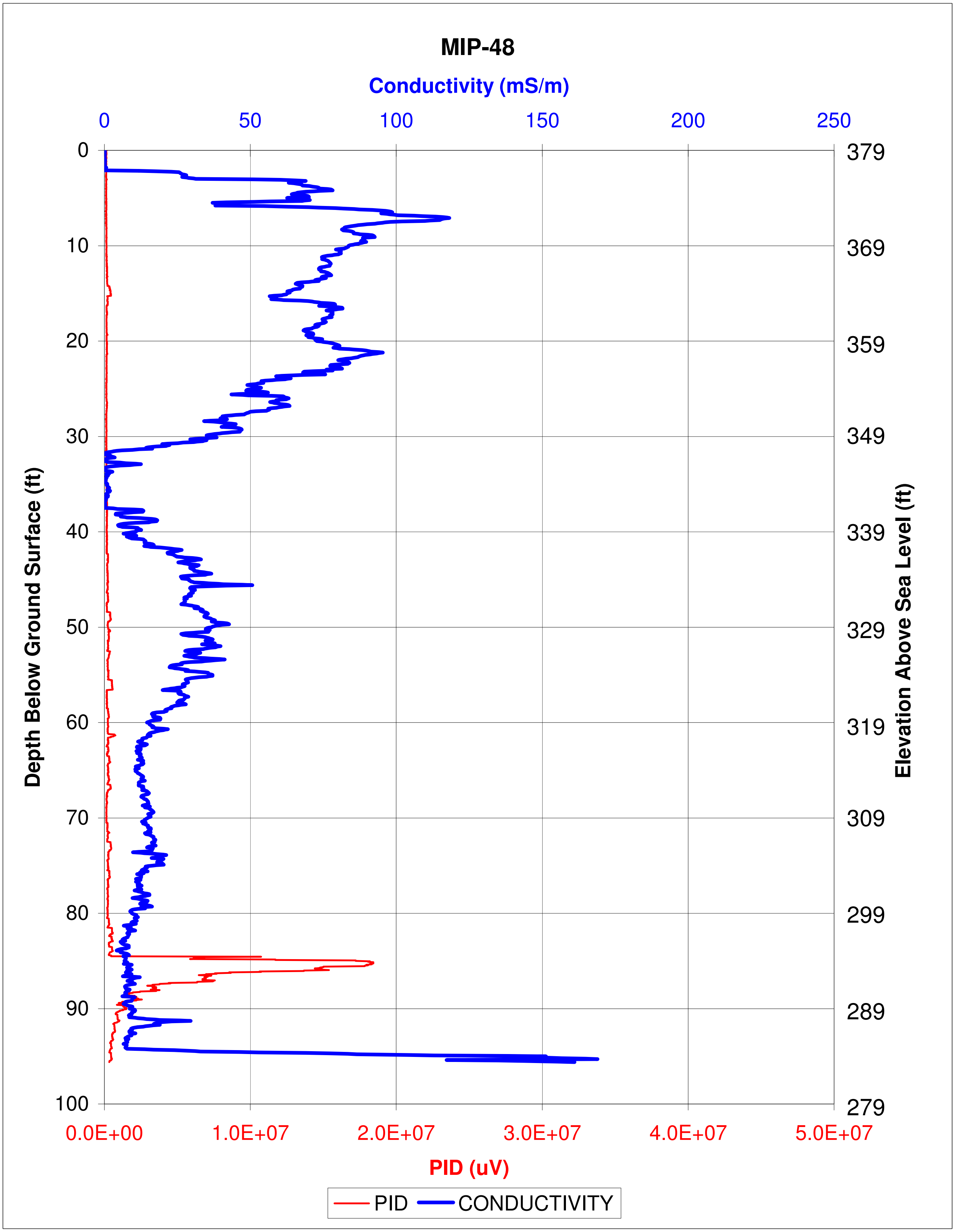

MIP-48
Conductivity (mS/m)
0
50
100
150
200
250
Depth Below Ground Surface (ft)
0
10
20
30
40
50
60
70
80
90
100
Elevation Above Sea Level (ft)
379
369
359
349
339
329
319
309
299
289
279
0.0E+00
1.0E+07
2.0E+07
3.0E+07
4.0E+07
5.0E+07
PID (uV)
PID
CONDUCTIVITY

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