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Secondary Document

Operation and Maintenance Plan for the Northeast Plume Containment System Interim Remedial Action at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky

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Operation and Maintenance Plan for the Northeast Plume Containment System Interim Remedial Action at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky

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U.S. DEPARTMENT OF ENERGY
Office of Environmental Management

Prepared by
FOUR RIVERS NUCLEAR PARTNERSHIP, LLC,
managing the
Deactivation and Remediation Project at the
Paducah Gaseous Diffusion Plant
under Contract DE-EM0004895

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ACRONYMS

ARAR	applicable or relevant and appropriate requirement
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
DQO	data quality objective
EMP	Environmental Monitoring Program
EPA	U.S. Environmental Protection Agency
EQ	equalization
ESD	Explanation of Significant Differences
EW	extraction well
FFA	Federal Facility Agreement
HASP	health and safety plan
IRA	interim remedial action
ISMS	Integrated Safety Management System
KPDES	Kentucky Pollutant Discharge Elimination System
MOA	Memorandum of Agreement
MW	monitoring well
NEPCS	Northeast Plume Containment System
NWPGS	Northwest Plume Groundwater System
O&M	operation and maintenance
PGDP	Paducah Gaseous Diffusion Plant
PLC	programmable logic controller
PZ	piezometer
QAPP	Quality Assurance Project Plan
QC	quality control
RAWP	remedial action work plan
RGA	Regional Gravel Aquifer
ROD	record of decision
TU	treatment unit
VFD	variable frequency drive
VOC	volatile organic compound

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EXECUTIVE SUMMARY

This Operation and Maintenance (O&M) Plan has been prepared to serve as a guide and reference for operation of the Northeast Plume Containment System (NEPCS) constructed as an interim remedial action (IRA) at the Northeast Plume at the Paducah Gaseous Diffusion Plant (PGDP). The IRA is consistent with the U.S. Department of Energy's (DOE) *Record of Decision for Interim Remedial Action at the Northeast Plume, Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (ROD), which was signed in June 1995, and modified by the *Explanation of Significant Differences to the Record of Decision for the Interim Remedial Action of the Northeast Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-1291&D2/R2 (DOE 2016a) (ESD). As stated in the ROD, "the primary objective of this interim remedial action is to implement a first-phase remedial action as an interim action to initiate hydraulic control of the high concentration area within the Northeast Plume that extends outside the plant security fence."

In August 1988, volatile organic compounds and radionuclides were detected in private wells north of PGDP. In response, DOE and the U.S. Environmental Protection Agency (EPA) entered into an Administrative Consent Order under Sections 104 and 106 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). DOE then implemented a PGDP Water Policy to reduce the current risk to potential human exposure (i.e., potentially affected residences and businesses). The CERCLA site investigations discovered trichloroethene (TCE)-contaminated groundwater within the Regional Gravel Aquifer northeast of the plant. This plume is referred to as the Northeast Plume. Additional information detailing the activities that led to the construction of the NEPCS is outlined in the Northeast Plume ROD.

The Northeast Plume ROD initiated an IRA that included installation of the NEPCS, which has been in operation since 1997. This O&M Plan revision provides the NEPCS operators with background information; program organization; reporting requirements; O&M requirements and guidelines; training requirements; and PGDP emergency response guidelines.

The intent of this O&M plan revision is to provide an updated plan that can be used to guide operation of the optimized NEPCS. The ESD and the *Remedial Action Work Plan for Optimization of the Northeast Plume Interim Remedial Action at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-1280&D2/R3 (DOE 2016b), document optimization of the NEPCS with a new extraction well (EW) field, additional treatment capacity, and other system changes.

The *Memorandum of Agreement for Resolution of Formal Dispute of the Explanation of Significant Differences to the Record of Decision for the Interim Remedial Action of the Northeast Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky (DOE/LX/07-1291&D2), and Remedial Action Work Plan for Optimization of the Northeast Plume Interim Remedial Action at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky (DOE/LX/07-1280&D2)* (MOA for Resolution), signed by the Federal Facility Agreement (FFA) parties on July 31, 2015, states the following:

> The resolution documents the Parties' agreement that an optimization of the existing Northeast (NE) Plume Interim Action (namely relocation of the two extraction wells up-gradient and operation of two treatment units) is warranted to increase trichloroethylene (TCE) mass removal and to enhance control of NE Plume migration at the eastern edge of the PGDP industrial facility. The Parties have reached consensus that the optimized extraction wells installed under the NE Plume Explanation of Significant Differences (ESD) should not cause or contribute to the undesired migration of Technetium-99 (Tc-99) contamination from the source area(s) (e.g., C-400 Building and Northwest (NW) Plume)

and that actions (as further described below) may be undertaken to prevent any undesirable expansion of Tc-99 and TCE within the NE Plume (DOE 2015).

This O&M plan revision also addresses system modifications resulting from optimization activities, primarily that of replacing the C-614 EWs (EW331 and EW332) with two new EWs (EW234 and EW235) at locations near the eastern edge of the PGDP industrial facility and installing a secondary treatment unit (TU) to increase NEPCS capacity. The C-637 Cooling Towers, used as the primary treatment method since February 1997, were shut down June 2013 when the United States Enrichment Corporation ceased uranium enrichment operations. Installation of the first TU as an alternate treatment method to the C-637 Cooling Towers was completed, and resulted in a new CERCLA outfall (CERCLA Outfall 001) discharge point located downstream of Kentucky Pollutant Discharge Elimination System Outfall 002. The optimized NEPCS consists of the two new EWs (EW234 and EW235), the two associated TUs, and installation of 14 monitoring wells (MWs) and 8 piezometers to evaluate performance and effectiveness of the optimized EWs. Included in the system of 14 MWs, with single screens, are 7 new Regional Gravel Aquifer MWs in a north-south transect located approximately 600 ft east of the C-400 Building. Sampling results from the transect MWs will be used to establish baseline TCE and technetium-99 concentrations in the area of their installation and to assess impacts of the EWs on contaminant migration from source areas, including impacts to the groundwater divide east of the C-400 Building. Existing EWs, pipelines, and facilities not utilized as part of the optimized NEPCS will be placed into a standby condition. EW331 and EW332 will be kept in good working condition until the FFA parties agree that maintenance no longer is necessary, and final disposition (including well abandonment) has been determined.

1. EQUIPMENT STARTUP AND OPERATOR TRAINING

1.1 GENERAL NORTHEAST PLUME CONTAINMENT SYSTEM DESCRIPTION

The Northeast Plume Containment System (NEPCS) is designed to recover groundwater contaminated by trichloroethene (TCE) from the Northeast Plume and deliver it to two treatment units (TUs), designated as C-765 and C-765-A, for air stripping. The optimized NEPCS consists of two new extraction wells (EWs) (EW234 and EW235), each of which is equipped with a submersible pump, drop pipe, and electrical service. After extraction, water is pumped through transfer lines to the TUs. Each of the EW transfer lines is configured such that each TU is dedicated to one of the EWs and capable of being operated independently. The C-765 TU is operated to treat water extracted from EW234, and the C-765-A TU is operated to treat water extracted from EW235. Each unit consists of bag filters and an air stripper to support groundwater treatment. Bag filters remove suspended solids (if necessary) as a pretreatment to the air stripper, which is designed to remove TCE. The treatment system is contained within a weathertight enclosure and includes a system control panel. The treated groundwater then is discharged to Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Outfall 001, located downstream of Kentucky Pollutant Discharge Elimination System (KPDES) Outfall 002.

Existing NEPCS components [EW331, EW332, equalization (EQ) tank, ancillary piping, system control panel, and power distribution panel] are located at an equipment pad designated as C-614. When operated, extracted groundwater from EW331 and EW332 is pumped through a transfer line to the EQ tank. A transfer pump moves the groundwater from the EQ tank through approximately 5,800 linear ft of underground transfer piping to the C-765 TU. Existing EWs, pipelines, and facilities not utilized as part of the optimized NEPCS will be placed into a standby condition. EW331 and EW332 will be kept in good working condition until the Federal Facility Agreement (FFA) parties agree that maintenance no longer is necessary, and final disposition (including well abandonment) has been determined. Further detail regarding maintenance requirements for existing NEPCS system components placed in standby is discussed in Section 5.

The layout of the new transfer piping, treatment system, and discharge piping is detailed in Section 7. Groundwater discharge will be in accordance with applicable or relevant and appropriate requirements (ARARs). A process flow diagram and more detailed system information are contained in Section 7.

1.2 INITIAL NEPCS STARTUP GUIDELINES

Startup activities will be performed to test the new treatment system and ancillary components. This will include, but not be limited to, system interlocks, instrumentation, alarms, air stripper performance, and overall treatment system operation. Functional testing of EWs and TUs will be accomplished by the following checks:

- Inspect visually all modified electrical and communication wiring connections.
- Perform voltage testing of all modified wiring connections.
- Perform calibration checks/verification on installed process instrumentation.
- Conduct rotational checks on pump and blower motors.
- Conduct operational checks of automated valves.

- Simulate system alarm conditions, including emergency stops, to verify proper system interlocks and responses.

- Establish stable system operating parameters at target system flow rates.

Batch testing will be performed at the maximum designed flow rate of 200 gpm for approximately 2.5 hours to ascertain that the air stripper is reducing the TCE concentration in effluent to levels consistent with outfall discharge criteria (see Question/Goal #2 of Table 3). The batch testing will be performed after construction acceptance and integrated testing of the TUs, but prior to operational start up. Air stripper performance will be evaluated based on TCE samples from the influent/effluent of the air stripper.

One batch test will be performed at the C-765 TU. Based on EW step test results, the maximum operational pumping rate for EW235 will be lower than that of EW234. The ratio of air-to-water flow through the air stripper controls the removal rate of the contaminant; an increase in the air-to-water ratio will result in greater removal rates. Because the newly installed TU (C-765-A) is comprised of the same treatment equipment as the C-765 TU and the maximum operational pumping rate for EW235 will be lower than that of EW234, removal efficiency by the C-765-A air stripper will be greater than that of the C-765 TU. Also, analytical sampling results indicate groundwater concentrations in the area of EW234 (C-765 TU) are greater than the groundwater concentrations in the area of EW235 (C-765-A TU); therefore, batch testing of the C-765 TU will be the "worst case" operating conditions with respect to the air stripper's performance for both TUs.

Upon initiation of the batch test, the treatment system will operate for approximately 30 minutes before any samples are pulled. After the initial 30 minutes has elapsed, samples will be collected at the TU influent and effluent sample points. The system then will continue to operate for approximately 30 minutes before a second set of samples will be pulled from the same sample locations. This process will be repeated until a total of four influent samples and four effluent samples is collected. After the requisite samples are collected, the system will be shut down until the laboratory analysis is received, and it is determined that the TU is operating as designed. Once both systems are fully operational, routine monitoring will confirm operational efficiency.

Temporary modification of the TU effluent piping will be required to allow for installation of flexible hose to the temporary storage tanks. Treated water will be captured, during batch run(s), in two temporary storage tanks (each with a nominal capacity of 16,000 gal) and sampled to ascertain that the air stripper is reducing the TCE concentration in the effluent to levels consistent with the CERCLA Outfall discharge criteria.

1.3 OPERATOR TRAINING

Personnel training activities regarding operational work instructions will be completed and documented during the system start-up period. New personnel are required to complete system training before performing work at NEPCS. General training requirements regarding health and safety and Paducah Gaseous Diffusion Plant (PGDP) requirements for work on-site are documented in the training position descriptions and the most recent revision of the *Health and Safety Plan for the Paducah Plumes Operations, Paducah, Kentucky*, CP2-ER-0067 (HASP) (FPDP 2015a). Training position descriptions and personnel training records are maintained by the U.S. Department of Energy (DOE) Prime Contractor training department.

2. DESCRIPTION OF NORMAL OPERATION AND MAINTENANCE

2.1 OPERATION AND MAINTENANCE

The NEPCS is operated and maintained in accordance with this plan and the most recent revision of operating procedures developed for the NEPCS. Changes made to operating conditions as a result of implementing the optimized NEPCS are incorporated into the affected operating procedures. Control, distribution, use, and maintenance of controlled documents and forms are performed in accordance with the most recent revision of CP3-OP-0025, *Document Control Process*.

2.2 OVERVIEW OF OPERATIONAL STRATEGY, SYSTEM CONTROL, AND CONDUCT OF OPERATIONS

2.2.1 Operational Strategy

As stated in the Record of Decision (ROD), "the primary objective of this interim remedial action is to implement a first-phase remedial action as an interim action to initiate hydraulic control of the high concentration area within the Northeast Plume that extends outside the plant security fence." The *Explanation of Significant Differences to the Record of Decision for the Interim Remedial Action of the Northeast Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-1291&D2/R2, (ESD) was developed to document the necessary changes made to optimize the Northeast Plume interim remedial action (IRA) (DOE 2016a). The *Memorandum of Agreement for Resolution of Formal Dispute of the Explanation of Significant Differences to the Record of Decision for the Interim Remedial Action of the Northeast Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky (DOE/LX/07-1291&D2), and Remedial Action Work Plan for Optimization of the Northeast Plume Interim Remedial Action at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE/LX/07-1280&D2) (MOA for Resolution) signed by the FFA parties on July 31, 2015, states the following:

> The resolution documents the Parties' agreement that an optimization of the existing Northeast (NE) Plume Interim Action (namely relocation of the two extraction wells up-gradient and operation of two treatment units) is warranted to increase trichloroethylene (TCE) mass removal and to enhance control of NE Plume migration at the eastern edge of the PGDP industrial facility. The Parties have reached consensus that the optimized extraction wells installed under the NE Plume Explanation of Significant Differences (ESD) should not cause or contribute to the undesired migration of Technetium-99 (Tc-99) contamination from the source area(s) (e.g., C-400 Building and Northwest (NW) Plume) and that actions (as further described below) may be undertaken to prevent any undesirable expansion of Tc-99 and TCE within the NE Plume (DOE 2015).
>
> 1. The NE Plume ESD and Remedial Action Work Plan (RAWP) will be revised to include language similar to that found in the 1995 IROD and Draft Final (D2) RAWP for the NE Plume stating that pumping at the optimized extraction wells may result in changes to groundwater flow direction that may impact contaminant (i.e. TCE and/or Tc-99) migration from source areas (e.g. C-400 Building). The NE Plume ESD and RAWP will state that the modified NE Plume interim remedial action will include installation (at a minimum) of five new RGA monitoring wells in a north-south transect approximately 600 feet east of C-400 Building (exact locations to be determined by the FFA parties as part of the finalization of the RAWP). These transect monitoring wells will be used to assess the impact of

groundwater extraction wells on contaminant migration from source areas, including impacts to the groundwater divide east of C-400 Building.

Based on EW step test results, EW234 is anticipated to operate between 100 to 200 gpm, and EW235 is anticipated to operate between 75 and 150 gpm, with a total system flow rate of no more than 300 gpm for the optimized NEPCS. Adjustments can be made to operate at higher or lower flowrates, as design parameters allow, to achieve the goals of the NEPCS optimization. During system operations, TU process controls monitor system flow rates and adjust pumping speeds to maintain desired flow rates. Further discussions regarding specific optimized NEPCS component operating capabilities are detailed in Section 7. The optimized Northeast Plume Interim Remedial Action will include installation of 14 wells (MWs) and 8 piezometers (PZs) to evaluate performance and effectiveness of the optimized EWs. Seven of these MWs will be located in a north-south transect located approximately 600 ft east of C-400 Building. Samples from these transect MWs will be used to assess the impact of groundwater EWs on contaminant migration from source areas, including impacts to the groundwater divide east of C-400 Building. The MOA for Resolution includes actions that may be undertaken to prevent any undesirable expansion of Tc-99 and TCE within the Northeast Plume.

2.2.2 Overall System Control

The NEPCS is an automated system with failure alarms and interlocks that will shut down the system when required by certain alarm conditions. During normal operations, the system has the capability to operate with minimal operational support. General control of the NEPCS is maintained by locally mounted instruments and controls for each major process operation. Key process variables and controls are linked to system control panels. The system is controlled through these control panels.

2.2.3 Conduct of Operations

Conduct of operations for the NEPCS is governed by the site's Integrated Safety Management System Program. The conduct of operations program ensures that activities and facility operations are managed, organized, and conducted in a manner that assures an appropriate degree of rigor in performance and, therefore, contributes to safe and reliable operations. The program is based on DOE Order 422.1, *Conduct of Operations*.

2.3 OVERVIEW OF TREATMENT TECHNOLOGY (PROCESS THEORY)

The extracted Northeast Plume groundwater, contaminated with volatile organic compounds (VOCs), is treated using air stripping by passing the contaminated groundwater through a shallow tray air stripper. Air stripping is a proven technology for the removal of VOCs from contaminated groundwater through liquid-gas mass transfer. Air is forced upward through the unit as the contaminated groundwater flows downward through the system. The counter current flow of air and water causes TCE to be stripped from the water and transferred to the air stream as a gas, which subsequently is destroyed by ultraviolet light (i.e., sunlight).

2.4 OPERATING PROCEDURES

The NEPCS is operated in accordance with the most recent approved procedures, equipment manuals, and sound engineering practices. Additional work control documents are developed, as necessary, for NEPCS operations. Latest versions of operating procedures can be accessed through the plant's computer network. Control, distribution, use, and maintenance of controlled documents and forms are performed in accordance with the most recent revision of CP3-OP-0025, *Document Control Process*.

2.5 OPERATOR CHECKS

NEPCS personnel conduct equipment inspections and system checks of key process variables to record system operational data and ensure effective and safe system operation. As stated in Section 2.2.2, process information can be accessed locally by the system control panels. Such information includes system flow rates, alarm conditions, tank levels, and pump status. Various system component set points also may be adjusted locally or remotely. Other information such as pressure readings, flow totals, and other data can only be obtained by accessing locally mounted instrumentation at the system equipment. Daily system inspections and operational data collection are conducted in accordance with the most recent revision of procedure, CP4-ER-0017, *Northwest/Northeast Plume Operations Daily Operational Data Collection and Maintenance*. Latest version of this procedure can be accessed through the plant's computer network. Control, distribution, use, and maintenance of controlled documents and forms are performed in accordance with the most recent revision of CP3-OP-0025, *Document Control Process*.

2.6 SYSTEM MAINTENANCE AND CALIBRATION

NEPCS maintenance (corrective and preventive) and calibration are performed in accordance with equipment manufacturer's recommendations and sound engineering practices. Detailed information on maintenance activities is included in the most recent revision of CP2-ER-0046, *Paducah Plume Operations Maintenance, Calibration, and Testing Plan.* Latest version of this plan can be accessed through the plant's computer network. Control, distribution, use, and maintenance of controlled documents and forms are performed in accordance with the most recent revision of CP3-OP-0025, *Document Control Process*.

2.7 COMMUNICATION

The following are the current NEPCS communication equipment used by NEPCS personnel:

- Cellular telephones,
- Telephone system, and
- Two-way radios.

NEPCS personnel maintain some form of communication at all times.

The NEPCS utilizes a dedicated automatic telephone dialer (autodialer) for calling designated on-call personnel when system alarm conditions occur. Abnormal operating conditions trigger alarms in the main control system. The autodialer, upon receipt of an alarm signal from the programmable logic controller (PLC), dials on-call personnel and delivers an alarm message. If the autodialer is not answered or if the alarm is not properly acknowledged, it continues to dial the programmed numbers in succession until the alarm is properly acknowledged. The autodialer operates over standard telephone equipment.

Emergency telephone numbers for police, fire, medical emergencies, and PGDP interplant emergency lines are provided in the HASP (FPDP 2015a).

2.8 WASTE MANAGEMENT

Other than the treatment system effluent, the NEPCS system generates minimal waste, primarily protective clothing associated with sampling. Waste is handled and disposed of in accordance with the most recent revision of CP2-ER-0012, *Waste Management Plan for the Paducah Plume Operations at the Paducah*

Gaseous Diffusion Plant, Paducah, Kentucky (FPDP 2015b). This waste management plan addresses the management of waste produced at the NEPCS from the point of generation until custody is relinquished from the NEPCS. Minor waste streams may include bag filters, personal protective equipment, sampling materials, etc. The latest version of this plan can be accessed through the plant's computer network.

The major waste stream will be the treatment system effluent (i.e., treated groundwater), which will be discharged to CERCLA Outfall 001, located downstream of KPDES Outfall 002. This discharge will be monitored at the outfall against outfall discharge criteria, as indicated in Table 1.

Table 1. Outfall Discharge Criteria

Effluent Characteristic	**Discharge Limitations**		
	Yearly Average	Monthly Average	Daily Maximum
Flow (mgd)	N/A	Record	Record
Total suspended solids (mg/L)	N/A	30	60
Oil and grease (mg/L)	N/A	10	15
Total residual chlorine (mg/L)	N/A	0.011	0.019
Temperature (ºF)	N/A	N/A	89
Trichloroethene (µg/L)	N/A	30	N/A
Chronic toxicity (TU_c)	N/A	N/A	1.00
pH	N/A	6 (min)	9
1,1-Dichloroethene (µg/L)	N/A	7,100	N/A

This table is excerpted from Table 3 of the ESD (DOE 2016a).

3. DESCRIPTION OF POTENTIAL OPERATING PROBLEMS

This section describes shutdown and operational emergency conditions. This section is limited to the major shutdown and operational emergency conditions and is not all-inclusive.

3.1 CAUSES FOR NEPCS SHUTDOWN

The NEPCS will shut down when initiated by an operator or automatically as a result of system alarms. Operator-initiated shutdowns may be performed during situations such as routine maintenance, severe weather, personnel injury, or fire. The system will shut down automatically due to adverse conditions such as electrical failure.

Automatic shutdown of the NEPCS components will occur when certain alarm conditions exist. Table 2 lists probable system condition(s) related to each alarm condition.

Table 2. Alarm Conditions and Probable System Condition(s)

Alarm Condition	Probable System Condition(S)
1. PLC off-line	Fault(s) in the PLC, Input/Output module, or scanner module.
2. Low flow from EW	EW pump(s) may have shut off on low or high pressure.
3. Low or high pressure at the treatment system	System has shut down due to a low or high pressure in the transfer line.
4. Air stripper basin level high	TU effluent pump may have shut down or the flow rate may be inadequate to maintain preset level in basin. EW pumps will shut off automatically.
5. Air stripper high differential pressure	Air stripper trays may be collecting sediment from extracted groundwater.
6. Air stripper blower low pressure	Loss of power, obstruction of intake/effluent.

Note: Shutdown of individual components may lead to complete system shutdown.

3.2 RESPONSE AND NOTIFICATION PROCEDURE FOR NEPCS SHUTDOWN

To troubleshoot and correct system problems, personnel follow the most recent revision of appropriate procedures, plans, manufacturer's equipment manuals, and seek any necessary outside technical assistance. NEPCS operators record events, actions taken, and other pertinent information in accordance with the most recent revision of CP4-ER-0017, *Northwest/Northeast Plume Daily Operational Data Collection and Maintenance*. The NEPCS operations manager reports required information to the appropriate personnel and/or government agencies. [See Section 6.3.4 of the RAWP (DOE 2016b).]

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4. DESCRIPTION OF ROUTINE MONITORING AND LABORATORY TESTING

4.1 INTRODUCTION

Groundwater and process monitoring is conducted to ensure proper facility operation and compliance with the following documents:

- *Record of Decision for Interim Remedial Action at the Northeast Plume, Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/06-1356&D2 (DOE 1995);

- *Memorandum of Agreement for Resolution of Formal Dispute of the Explanation of Significant Differences to the Record of Decision for the Interim Remedial Action of the Northeast Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky (DOE/LX/07-1291&D2), and Remedial Action Work Plan for Optimization of the Northeast Plume Interim Remedial Action at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky (DOE/LX/07-1280&D2)* signed by the FFA parties on July 31, 2015 (DOE 2015);

- *Explanation of Significant Differences to the Record of Decision for the Interim Remedial Action of the Northeast Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-1291&D2/R2 (DOE 2016a); and

- *Remedial Action Work Plan for Optimization of the Northeast Plume Interim Remedial Action at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-1280&D2/R3 (DOE 2016b).

The data quality objective (DQO) process was used by the NEPCS team to ensure collection of data of appropriate quality and quantity to meet the NEPCS objective. DQOs are periodically evaluated and data collection and analysis revised as necessary.

4.2 DATA QUALITY OBJECTIVES

4.2.1 Problem Statement

The problem to be addressed by the Northeast Plume Optimization Project is the presence and continued migration of TCE-contaminated groundwater beyond the plant security fence in concentrations above the maximum contaminant level for TCE.

4.2.2 Principal Study Questions, Decision Rules, and Data Needs

Table 3 outlines the principal study questions, decision rules, and data needs required to effectively monitor the operation of the NEPCS and meet the objectives stated in the ROD, the ESD, and in the *Remedial Action Work Plan for Optimization of the Northeast Plume Interim Remedial Action at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-1280&D2/R3 (DOE 2016b).

Table 3. Principal Study Questions, Decision Rules, and Data Needs

	Question/Goal	Decision Rule	Data Needs
1	Is NEPCS retarding the migration of the highest concentration volume of the TCE Groundwater plume?	If field results[a] from MWs and analytical results from groundwater samples indicate that the EWs are not effectively retarding the migration of the highest concentration volume of the plume, then operation of the EW will be reevaluated and adjustments made as necessary.	TCE and Tc-99 samples will be collected from MWs. Water level data and pumping rates will be recorded for the EWs. Water level data will be collected for the MWs.
2	Is the treatment system (air stripper) effectively stripping the TCE from the contaminated groundwater?	If TCE levels in discharge effluents exceed 75% of the 30 µg/l discharge limit (22.5 µg/L), then operational conditions will be investigated and appropriate adjustments made as necessary.	TCE samples will be collected from the air stripper effluent.
3	Is the treatment system affecting environmental performance at CERCLA Outfall 001?	If any pollutant exceeds the criteria listed in Table 1, then the possible contributions to that exceedance by the NEPCS will be investigated and operations will be altered or suspended as necessary.	Data from CERCLA Outfall 001 will be evaluated.
4	What levels of TCE are being discharged into the atmosphere from the groundwater extraction process?	If air emissions of TCE from the NEPCS, as a single source or as a contributor to site emissions, exceed the regulatory guidelines, then the operating status will be reviewed and revised as necessary.	Emissions will be calculated based on TCE samples taken from the EWs and air stripper effluent and evaluating associated pump rates.
5	Is NEPCS meeting the requirements stated in the Facility and Nuclear Safety evaluation?[b]	If TCE or Tc-99 levels exceed the levels used in assumptions serving as the basis for safety, environmental, or operating limiting conditions, then system operation will be suspended until the impacts can be evaluated and appropriate operating conditions can be reestablished.	TCE and Tc-99 samples will be taken from MWs and EWs.
6	Is NEPCS running efficiently in terms of operation and maintenance (O&M)?	If system components are not operating within the manufacturer's specified performance criteria,[c] then system operation will be evaluated.	Operational data will be recorded to include flow rates from pumps; pressure readings; maintenance data; and pipeline and system integrity.
7	Is the risk pathway to residents for NEPCS contaminants eliminated as a result of the current Water Policy Boundary?	If the TCE levels exceed the MCL at the eastern boundary of the Water Policy, then reevaluate the boundary location. Tc-99 is addressed by other questions/goals and decision rules.	TCE samples will be collected from selected MWs and residential wells near the eastern boundary of the Water Policy (see Figure 1).

[a] MW groundwater sampling will be performed under the Environmental Monitoring Plan. Refer to Section 4.4 of this document and Section 1.2 of the RAWP for additional details (DOE 2016b). Field measurements and samples will be collected quarterly as follows:

- Field Measurements—depth to water, dissolved oxygen, pH, specific conductance, temperature, redox, and turbidity.
- Sample analytical parameters—TCE and Tc-99.

[b] The current safety basis for the NEPCS is contained in the sitewide industrial preliminary hazard screening PHS-PH-INDSTRL-0067/R3, July 2016 (FPDP 2016a). Refer to Appendix D, QAPP Worksheet #10, of the RAWP for additional details (DOE 2016b).

[c] Section 7 provides additional details on the manufacturer's performance criteria for the various system components. Refer to Sections 2.6, 2.7, and 3.2 for additional details. Refer to Appendix B, Air Dispersion Analysis of the RAWP, which identifies that the design criteria of the treatment systems is the same as the assumed maximum TCE inlet concentration for air dispersion modeling (1,000 ppb for both) (DOE 2016b).

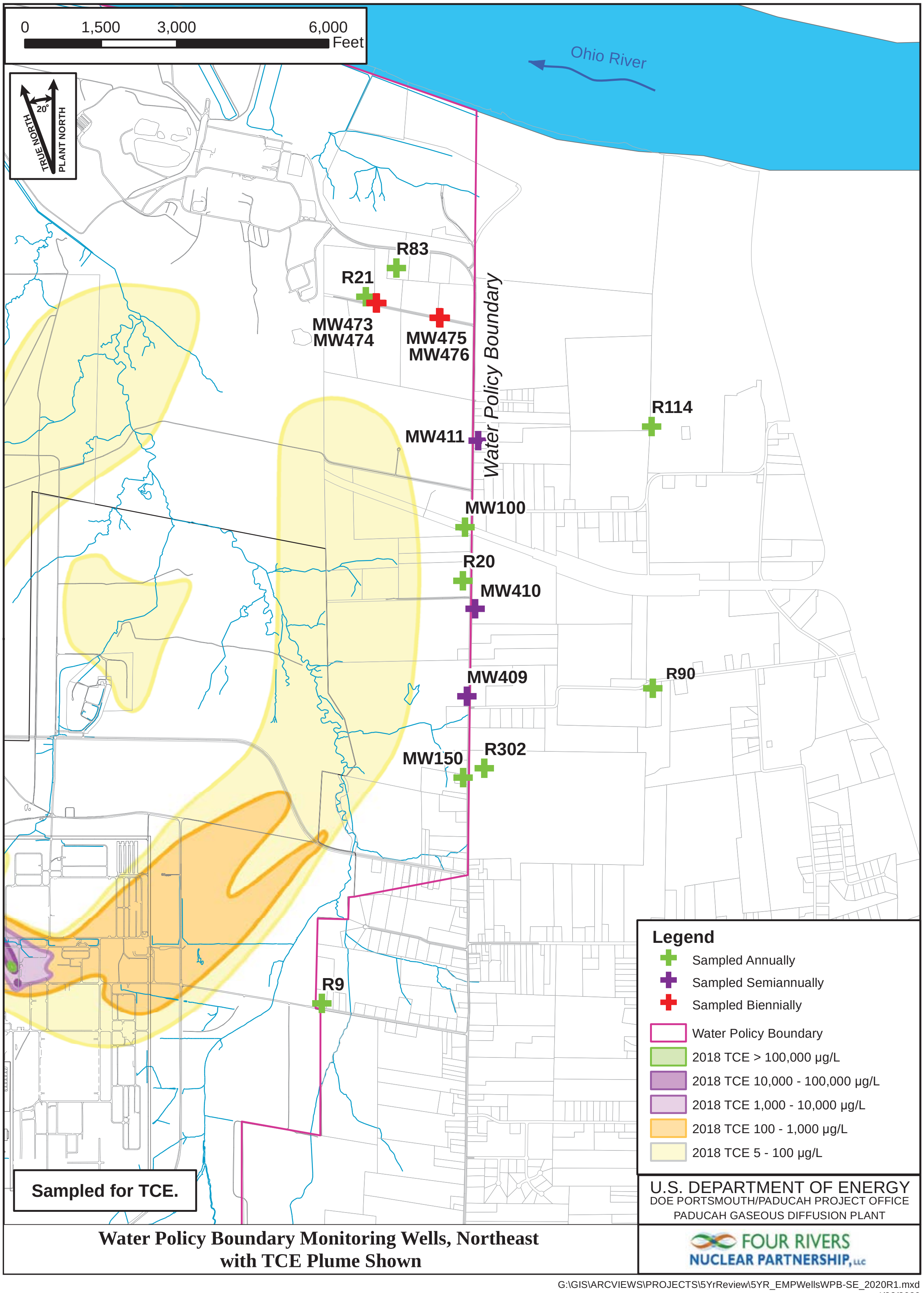

Figure 1. Water Policy Boundary Monitoring Wells, Northeast with TCE Plume Shown

4.3 EVALUATION OF EXTRACTION FIELD EFFECTIVENESS

The purpose of the extraction wellfield effectiveness monitoring is to acquire, collect, and maintain an adequate database of the hydrogeological conditions in the Northeast Plume to enable changes to be made in extraction rates that will optimize remediation and containment. This section describes hydraulic and chemical monitoring intended to support an evaluation of the performance of the NEPCS.

The network of new MWs, when combined with existing MWs, will provide both hydraulic and chemical performance information that can be used to assess the following:

- Effectiveness of capturing the Northeast Plume contamination by the optimized EW locations; and

- Potential contaminant migration impacts to the Northwest Plume by the optimized Northeast Plume EWs.

The goals of the effectiveness monitoring are to determine TCE mass removal rates and assess TCE capture zone effectiveness. The general approach to hydraulic and chemical monitoring and analysis will follow methods described in "A Systematic Approach for Evaluating Capture Zones at Pump and Treat Systems" (EPA 2008). Tc-99 is monitored in the transect wells in accordance with the MOA.

Section 2.5 of the RAWP provides additional details regarding goals of the Northeast Plume Optimization Project monitoring program, the monitoring approach (i.e., hydraulic or chemical monitoring), and identification of the wells and piezometers that will be included in each monitoring approach (DOE 2016b).

4.3.1 Hydraulic Monitoring[1]

Hydraulic monitoring is conducted to assess the following:

- Hydraulic performance of the system with regard to capture zone development; gradient manipulation and plume trajectory;

- Effects due to changes in external hydraulic stresses; and

- Potential impacts on adjacent plumes.

The monitoring activities described in this section will be performed during a shutdown and restart event scheduled within 4 months of start-up of the NEPCS EWs, EW234 and EW235. Hydraulic monitoring will consist of water level measurements made in a network of MWs and PZs prior to and during the system shutdown and restart event. The hydraulic monitoring of NEPCS will include (1) pre-shutdown monitoring, (2) phased shutdown/restart monitoring, and (3) limited, long-term monitoring, as needed. Objectives and anticipated duration for each phase, not including long-term monitoring, to support hydraulic monitoring is as follows:

- Pre-shutdown monitoring to determine hydraulic gradients during EW234 and EW235 operations will commence a minimum of three days prior to system shutdown. Reference Section 4.3.1.1 for additional detail of this phase.

[1] Durations listed in this section are approximations and may be adjusted as field conditions warrant.

- EW234 and EW235 will be shutdown (Phase I) to monitor wellfield aquifer response for a minimum of four days prior to commencement of EW235 pumping test. Reference Section 4.3.1.2 for additional detail of this phase.

- Restart of EW235 (Phase II) will commence after Phase I has been completed to monitor near-field aquifer response for a minimum of eight days prior to shutdown of EW235. Reference Section 4.3.1.2 for additional detail of this phase.

- Shutdown of EW235 (Phase III) will commence after Phase II has been completed to monitor near-field aquifer response for a minimum of four days prior to restart of EW234. Reference Section 4.3.1.2 for additional detail of this phase.

- Restart of EW234 (Phase IV) will commence after Phase III has been completed to monitor near-field aquifer response for a minimum of eight days prior to shutdown of EW234. Reference Section 4.3.1.2 for additional detail of this phase.

- Shutdown of EW234 (Phase V) will commence after Phase IV has been completed to monitor near-field aquifer response for a minimum of four days prior to restart of EW234 and EW235. Reference Section 4.3.1.2 for additional detail of this phase.

- Restart of EW234 and EW235 (Phase VI) will commence after Phase V has been completed to monitor overall wellfield aquifer response for a minimum of eight days. Reference Section 4.3.1.2 for additional detail of this phase.

4.3.1.1 Pre-shutdown hydraulic monitoring[2]

An initial hydraulic monitoring event for the Northeast Plume will be conducted prior to system shutdown to characterize the hydraulic conditions in the aquifer under operational conditions. Hydraulic monitoring locations and the method of data collection during shutdown and restart are listed in Table 4 and depicted in Figure 2. Water levels in 7 of the MWs (MW200, MW533, PZ534, PZ535, PZ541, PZ553, and PZ554) and the 2 EWs will be recorded continuously throughout system shutdown and restart (Figure 2 and Table 4). Continuous monitoring with data loggers will begin a minimum of 3 days prior to system shutdown. A synoptic measurement of MWs scheduled to be measured manually will be conducted within 24 hours prior to system shutdown. System shutdown will be conducted during a period that is not anticipated to be subject to significant precipitation (more than 0.30 inches of rainfall in 24 hours). Precipitation during system shutdown and restart will be noted.

[2] Durations listed in this section are approximations and may be adjusted as field conditions warrant.

Table 4. Northeast Plume Groundwater System
Hydraulic Monitoring Wells

Monitoring Well ID	Completion Interval[a]	Screened Interval (ft above mean sea level)	Continuous Logger/ Manual Measurements for EW System Test	Relative Wellfield Location
PZ110	URGA	312.4/302.4	Manual	Distant Observation Well
MW145	URGA	293.1/283.1		
MW155	LRGA	292.1/287.1		
MW163	LRGA	289.8/284.8		
MW165A	URGA	315.2/310.2		
MW205	URGA	312.2/307.2		
MW255	LRGA	292.5/287.8		
MW256	LRGA	281.9/277.2		
MW258	LRGA	292.0/287.3		
MW260	LRGA	289.8/285.1		
MW288	LRGA	290.0/280.0		
MW292	LRGA	286.1/276.1		
MW341	MRGA	302.0/292.0		
MW355	LRGA	290.4/285.4		
MW480	LRGA	294.1/284.1		
MW495	LRGA	278.6/268.6		
MW496	LRGA	277.6/267.6		
MW524	MRGA	308.7/298.7		
MW525	MRGA	310.6/300.6		
MW526	MRGA	311.8/301.8		
MW528[b]	LRGA	301.4/291.4		
MW529	LRGA	298.9/288.9		
MW530	LRGA	295.1/285.1		
MW531	LRGA	277.3/267.3		
PZ532	LRGA	295.7/285.7		
MW533*	LRGA	292.0/282.0	Continuous	Near-field Well to EW234
PZ534*	LRGA	293.7/283.7		
PZ535*	LRGA	290.9/280.9		
MW537	LRGA	287.1/277.1	Manual	Near-field Well to EW234
MW539	LRGA	291.4/281.4		Near-field Well to EW235
PZ540	LRGA	289.5/279.5		Near-field Well to EW235
PZ541*	LRGA	287.0/277.0	Continuous	Near-field Well to EW235
PZ553*	LRGA	289.2/279.2		
PZ554*	LRGA	289.2/279.2		
PZ555	LRGA	290.1/280.1	Manual	Distant Observation Well
MW556	LRGA	288.8/278.8		
Background Monitoring Well				
MW200*	MRGA	304.6/299.6	Continuous	Distant Observation Well

[a] Definitions of completion intervals are as follows:
URGA = Upper RGA
MRGA = Middle RGA
LRGA = Lower RGA
[b] MW527 and MW528 are collocated wells. Hydraulic monitoring for the area of these collocated wells is provided by MW528. Figure 4 of the RAWP presents locations of MWs and PZs included in the hydraulic monitoring network (DOE 2016b).
*Denotes a continuously monitored well, with a recording interval of 1 minute for the initial 12 hours of each test phase.

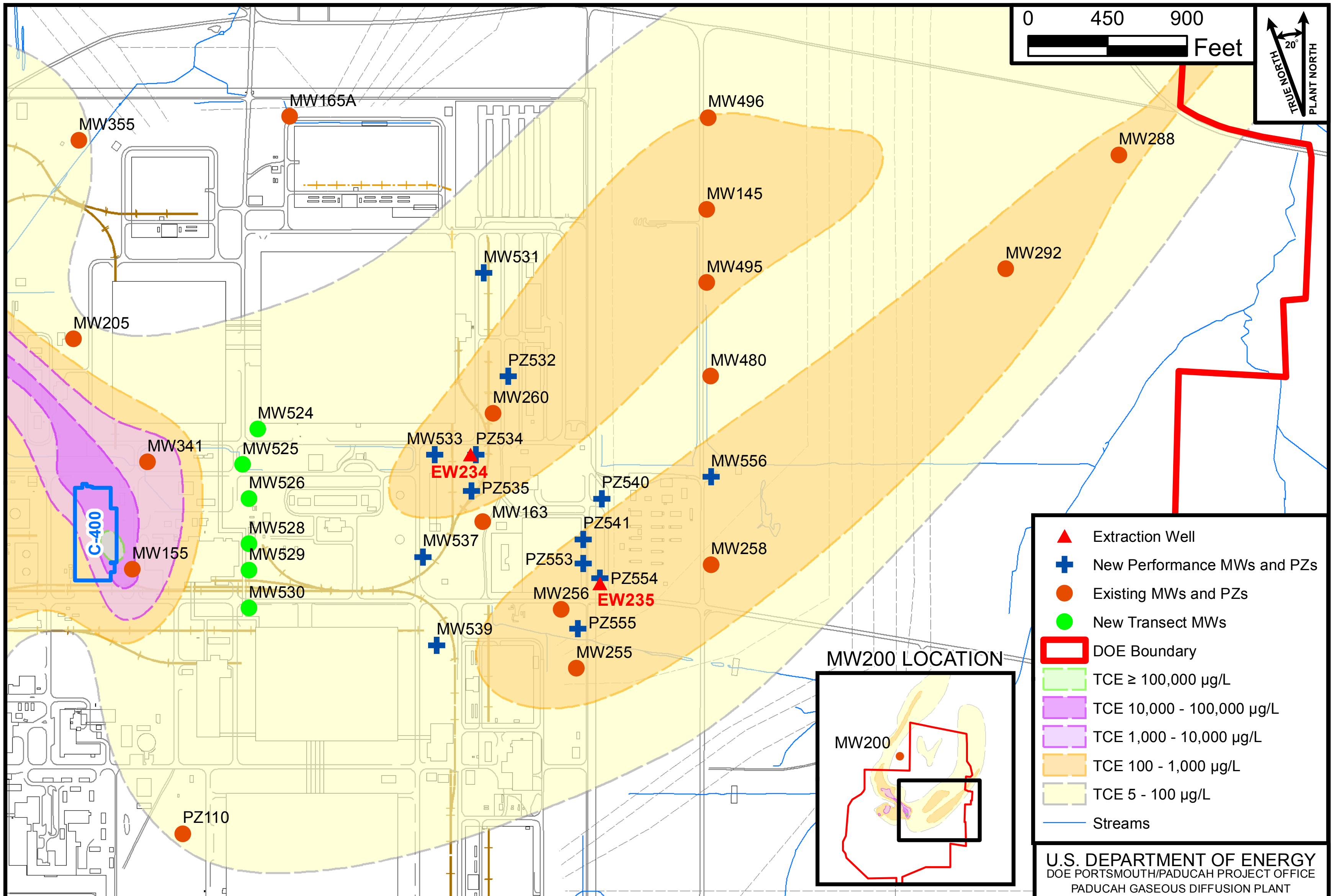

Figure 2. Hydraulic Monitoring Network

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Hydraulic monitoring will be conducted in 36 MWs and PZs in the vicinity of the EWs and in 1 background MW (located north of the PGDP industrial complex and away from the areas of pumping) during the shutdown and restart events.

4.3.1.2 System shutdown and restart monitoring[3]

System shutdown and monitoring restart will be conducted to obtain information that can be used to characterize aquifer properties and to evaluate the response of the aquifer to hydraulic stresses imposed by operational pumping. Continuous water level measurements will be collected with data loggers, and periodic manual monitoring of water levels will be taken using water level meters (for wells not equipped with data loggers). The primary objective of the shutdown/restart monitoring is to support current and future evaluations of the capture zones of the EWs. The following is the planned testing sequence.

Phase I—Shutdown of NEPCS Operation: At a predetermined time, wellfield operations will be halted, allowing the aquifer to return to ambient conditions, a near equilibrium period to which the aquifer potentiometric surface rebounds when not subjected to anthropogenic activities (i.e., well pumping). The system will be shut down 4 days[4] to ensure full recovery to ambient (unstressed) conditions. Monitoring includes continuous monitoring using data loggers with manual water level measurements for confirmation of the data logger measurements. The background well (MW200) also will be measured. Wells and piezometers designated for manual measurement will be measured daily for the first 4 days and approximately every 2 days thereafter, if needed, until water levels have fully recovered. Near steady-state conditions, a period of active EW pumping when water levels stabilize to a rate of change of less than 0.05 ft within an hour, will be confirmed from water levels in MWs and PZs equipped with data loggers. For the purposes of this test, near steady-state conditions will be achieved when the water level change is less than 0.05 ft within an hour at continuously monitored MWs and PZs near the EW locations. Following determination of steady-state conditions, a final manual measurement of all water levels of the EWs, MWs, and PZs in the hydraulic network will be conducted prior to system restart.

Phase II—EW235 Pumping Test: EW235 will be operated at the design rate and monitored for a minimum of 8 days to approximate the single well steady-state drawdown effects under operational conditions. Heads in the hydraulic MW and PZ network will be monitored to assess aquifer response to the pumping stress. As in Phase I testing, MWs and PZs designated for manual measurement will be measured daily for the first 4 days, and approximately every 2 days afterward, if necessary, until steady-state conditions are reached. Near steady-state is considered to be achieved when the log-time versus drawdown for the observation MWs and PZs plots linearly on a semi-log plot, or the water level change in distant observation wells (Table 4) is less than 0.05 ft for a 1-hour period in continuously monitored MWs and PZs.

Phase III—EW235 Shutdown: As in Phase I, EW235 wellfield operations will be halted, allowing the aquifer to return to ambient conditions, and water level monitoring will be conducted for a period of approximately 4 days for water levels to fully recover.

Phase IV—EW234 Pumping Test: EW234 will be operated at the design rate and monitored for a minimum of 8 days to approximate the single well, steady-state drawdown effects under operational conditions. Heads in the hydraulic MW and PZ network will be monitored to assess aquifer response to the pumping stress. As in Phase II testing, MWs and PZs designated for manual measurement will be measured daily for the first 4 days and approximately every 2 days afterward, until steady-state conditions are reached.

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[3] Durations listed in this section are approximations and may be adjusted as field conditions warrant.
[4] Longer if required.

Phase V—EW234 Shutdown: As in Phase III, EW234 wellfield operations will be halted, allowing the aquifer to return to ambient conditions, and water level monitoring will be conducted for a period of approximately 4 days for water levels to fully recover.

Phase VI—Full NEPCS Restart: Both EW234 and EW235, will be operated at the design rate and monitored for a minimum of 8 days to approximate the composite steady-state drawdown effects under operational conditions. Heads in the hydraulic MW and PZ network will be monitored to assess aquifer response to the pumping stress. As in Phase II and IV testing, MWs and PZs designated for manual measurement will be measured daily for the first 4 days and approximately every 2 days afterward, until steady-state conditions are reached. After Phase VI of testing is complete, no system shutdown is proposed, and the system will continue operational phase pumping at design flow rates.

Data logger recording intervals will be every 5 minutes for most of the testing period, with the exception of loggers in near-field MWs and PZs, where the recording interval will be 1-minute for the first 12 hours of each phase of the test (Table 4). Following this period, data collection will occur at 5 minute intervals. Precipitation in the area during the test periods will be recorded daily. The water level monitoring will be conducted in accordance with applicable technical procedures.

To provide regional water level variation during the shutdown-restart test, MW200 will be monitored periodically as the background well (Table 4). Because this well is far removed from the EWs, it is anticipated that the time for pumping stresses to propagate through the aquifer to this remote location will be longer than the time required to reach steady-state in the remaining well network. Data from the background MW will be used to assess regional trends during the test. Following Phases I, II, and IV monitoring, water levels collected at hydraulic monitoring locations will be used to construct potentiometric surface maps and determine hydraulic gradient direction and magnitude of drawdown in the vicinity of the hydraulic MW and PZ network.

4.3.1.3 Long-term hydraulic monitoring

Depending on longevity of the remedial system, additional synoptic measurements may be necessary to characterize flow directions and system performance. Water level measurements associated with chemical monitoring under the Environmental Monitoring Program (EMP) will provide continuing data to assess gradient development and potential changes in hydraulic stress over time.

4.3.2 Chemical Monitoring

Chemical monitoring of NEPCS will focus on several areas within and near the Northeast Plume to achieve the monitoring objectives. The chemical monitoring prescribed in this section is intended to provide a basis for determining if the objectives of the ROD are being met. Table 5 lists the MWs selected for the chemical monitoring and the monitoring frequency for each well. Due to the potential continuing source of TCE to the Northeast Plume from the vicinity of C-400 Building and the Northwest Plume, the chemical monitoring will focus on both upgradient areas and downgradient areas to the EWs (Figure 3).

4.3.2.1 Baseline monitoring

Several wells in the chemical monitoring network with a significant sampling history currently are monitored under the EMP. Graphs of TCE concentrations in these wells are contained in *U.S. Department of Energy Paducah Gaseous Diffusion Plant Federal Facility Agreement Semiannual Progress Report*

Table 5. Northeast Plume Groundwater System
Chemical Monitoring Wells

Monitoring Well ID	Completion Interval[a]	Monitoring Frequency[b]
MW124	LRGA	Existing MWs—quarterly sampling to begin during the 4th quarter sampling event of east C-400 transect MWs
MW126	MRGA	
MW144	LRGA	
MW145	URGA	
MW155	LRGA	
MW156	URGA	
MW163	LRGA	
MW255	LRGA	Existing MWs—semiannual sampling
MW256	LRGA	
MW258	LRGA	Existing MWs—quarterly sampling to begin during the 4th quarter sampling event of east C-400 transect MWs
MW260	LRGA	
MW283	LRGA	
MW288	LRGA	
MW291	LRGA	
MW292	LRGA	
MW293A	MRGA	
MW341	MRGA	
MW478	URGA	
MW479	URGA	
MW480	LRGA	
MW495	LRGA	
MW496	LRGA	
MW524	MRGA	East C-400 transect MW—quarterly sampling began October 2016
MW525	MRGA	
MW526	MRGA	
MW527	MRGA	
MW528	LRGA	
MW529	LRGA	
MW530	LRGA	
MW531	LRGA	MWs to be installed as part of Northeast Plume Optimization Project—quarterly sampling to begin prior to start of EW234 and EW235 operations
MW533	LRGA	
MW536	MRGA	
MW537	LRGA	
MW538	MRGA	
MW539	LRGA	
MW556	LRGA	

[a] Definitions of completion intervals are as follows:
URGA = Upper RGA
MRGA = Middle RGA
LRGA = Lower RGA
[b] For MWs designated for quarterly sampling, each MW will be sampled for eight quarters following EW startup, at a minimum.

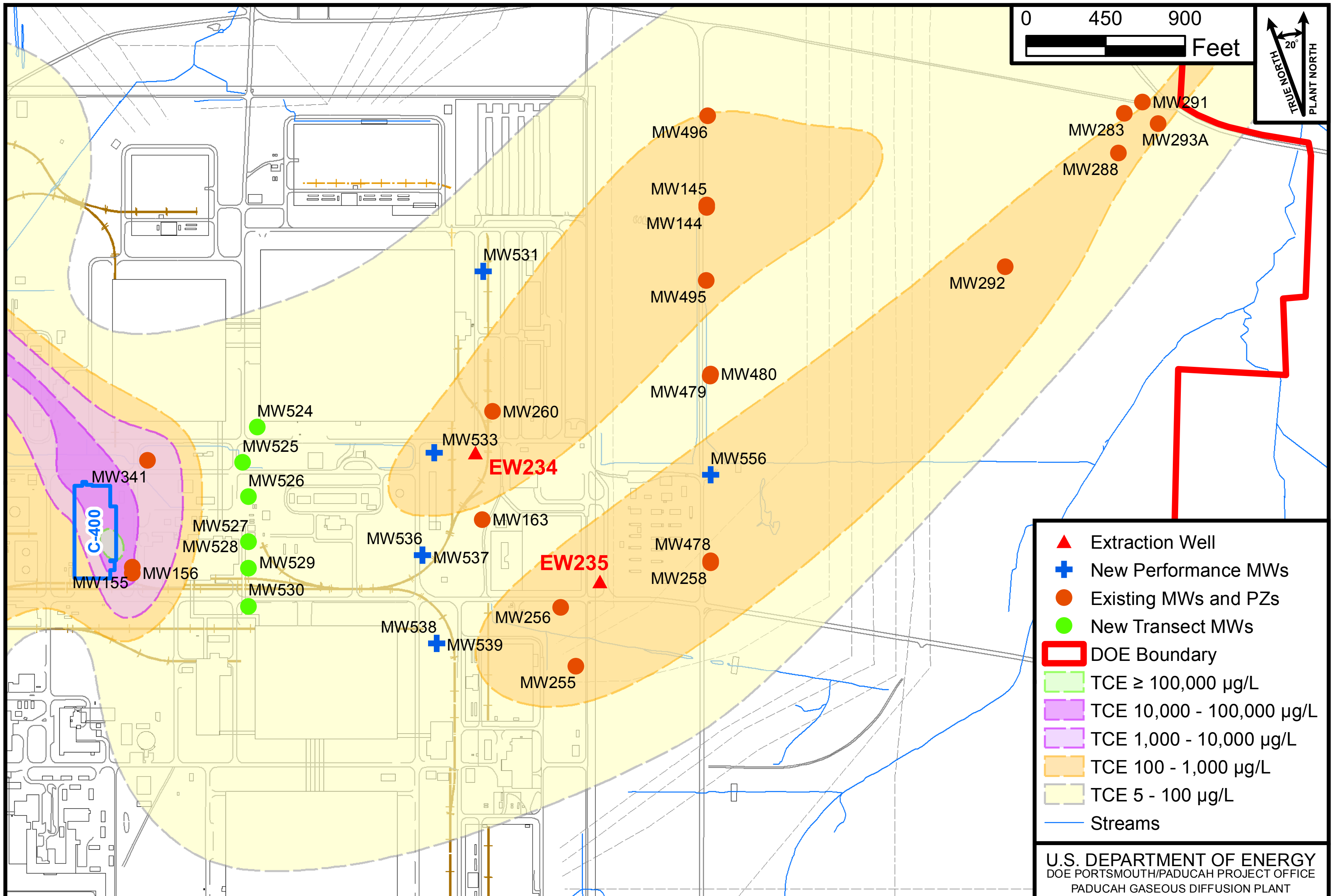

Figure 3. Chemical Monitoring Network

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for the Second Half of Fiscal Year 2016, Paducah, Kentucky, DOE/LX/07-2404/V2 (DOE 2016c). These graphs indicate that concentrations are relatively stable over time and trends are readily identifiable.

Based on the relative stability of concentration trends in individual wells, a pre-startup baseline sampling event is not proposed. The baseline concentration at each MW will be taken from the most recent TCE sample result from the well in the 6 months prior to startup of EW234 and EW235. Any well in the chemical monitoring network that has not been sampled for TCE within this 6 month time frame will be sampled prior to startup of the EWs.

4.3.2.2 Long-term monitoring

Periodic monitoring of the well network will be performed to characterize the Northeast Plume and help determine the effectiveness of system performance. Each MW included in chemical monitoring will be sampled quarterly for the first two years following EW startup: the beginning of quarterly monitoring is staged by well group (Table 5). Revisions to future monitoring frequency may be proposed to the FFA parties for discussion and concurrence after two years following EW startup. Tri-party agreements to change the monitoring frequency will be documented in an errata to the approved Northeast Plume O&M Plan and the subsequent revision of the Environmental Monitoring Plan.

EWs will be sampled at startup and monthly thereafter. EWs will be sampled at sampling ports under normal operating conditions.

4.4 DATA EVALUATION

This section discusses the methods and techniques that are planned for use in evaluating the effectiveness of the remedial system.

4.4.1 Hydraulic Data

Evaluation of hydraulic data will include an analysis of pre-shutdown, shutdown, and restart data. Analytical evaluation of hydraulic data will be conducted to determine aquifer transmissivity, and potentiometric maps will be contoured to determine observed hydraulic gradient direction and magnitude.

4.4.1.1 Shutdown and restart hydraulic data

Pre-shutdown (operational) hydraulic data will be compiled and analyzed to develop a potentiometric map of hydraulic head under pumping conditions. Hydraulic gradient direction and magnitude will be displayed on the map. Vertical gradients under operational conditions will be tabulated at nested monitoring locations.

Hydraulic data from system startup monitoring and testing will be compiled and analyzed using a variety of methods, including the following:

- Hydrograph and gradient analysis,
- Time vs. drawdown and distance-drawdown analyses, and
- Delineation of drawdown.

Groundwater hydrographs are useful for illustrating the sensitivity of different aquifer intervals to pumping. Aquifer response is quantified at the fundamental level by examining hydrographs (e.g., water level changes in individual wells as a function of time). After heads have stabilized, maps of drawdown will be prepared to show the geometry of the zone of influence of the extraction system.

Horizontal and vertical gradients will be calculated based on MW and PZ data collected prior to and during system startup. This data will be used to evaluate the hydraulic stress in the aquifer due to system operation. Flow rate calculations will be made to help verify that the pumping rates of the EWs are appropriate to capture the groundwater flux across the plume extent.

In addition, capture zone width calculations will be performed using analytical methods for each well based on pumping rates, hydraulic gradient, and observed and modeled hydraulic conductivity values. The analytical solution of Javandel and Tsang (1986) will be used to delineate the capture zone for the EWs, using site-specific parameters. The Javandel and Tsang (1986) method is an analytical solution suitable for a fully penetrating well in an isotropic aquifer.

Hydraulic conductivity values will be calculated based on observed hydraulic response in nearby existing and new MWs and PZs during aquifer testing. Several analytical solutions are applicable for a pumping test in a confined/semiconfined aquifer like the one at PGDP, including the following:

- Theis (1935)—applicable for a fully penetrating pumping well;
- Cooper and Jacob (1946)—applicable for a fully penetrating pumping well;
- Hantush and Jacob (1955)—applicable for a leaky confined aquifer;
- Moench (1985)—applicable for a leaky confined aquifer.

A time-drawdown analysis will be conducted for each continuously monitored observation MW and PZ to derive estimates of hydraulic conductivity. A distance-drawdown analysis may be used for all the observation MWs and PZs at once. In an ideal homogeneous aquifer, a straight-line method (Jacob's approximation solution) can be used in a distance-drawdown graph to derive an overall transmissivity (Cooper and Jacob 1946). This value for overall transmissivity then will be compared with the transmissivities derived from each individual well by the time-drawdown analysis.

4.4.2 Chemical Data

Chemical data will be evaluated to identify TCE and Tc-99 trends for wells in the monitoring network. The results of periodic and long-term contaminant monitoring, conducted prior to and after system startup will be tabulated and provided to stakeholders for review semiannually, as described in Section 4.5. These tables will be designed to facilitate observation of trends over time. Graphs showing changes over time also will be developed, as needed. TCE mass capture from system operation will be calculated based on EW samples and flow rates.

Statistical analyses may be used to compare data sets or to assess trends over time, including calculation of summary statistics and determining the significance of trends. These statistical techniques may include comparative analyses, multivariate comparison, trend analysis, linear regression, variable correlation, and multivariate correlation. These analyses often are problem specific and may or may not be relevant to addressing the objectives of NEPCS effectiveness monitoring. Regardless, the data density from the proposed monitoring network is sufficiently robust to provide the data necessary, should a statistical analysis be required.

Operational adjustments to maximize the efficiency of the remedial systems may be recommended based partially on a review of influent concentrations and mass capture results. The long-term monitoring data will be used to assess potential issues of long-term plume fate that may be related to potential long-term optimization efforts. As part of data evaluation, the monitoring network will be reevaluated periodically to ensure that the objectives of the effectiveness monitoring program are being obtained.

4.5 REPORTING SUMMARY

Section 1.2, Section 6.3.4, and Appendix D, Quality Assurance Project Plan (QAPP) of the RAWP identifies the formal reporting requirements (DOE 2016b). Analysis of hydraulic and chemical data will be presented in FFA Semiannual Progress Reports in accordance with the RAWP (DOE 2016b). The first semiannual report will include a summary of system operational history for the period, in-plant effectiveness at treating the extracted groundwater, and future proposed sampling frequencies. The status of the shutdown/restart hydraulic monitoring and quarterly/semiannual chemical monitoring results for the first 6 months of operation will be presented in a semiannual report within 1-year of system startup. Revisions to future monitoring frequency may be proposed to the FFA parties for discussion and concurrence after two years following EW start-up. Tri-party agreements to change the monitoring frequency will be documented in an errata to the approved Northeast Plume O&M Plan and the subsequent revision of the Environmental Monitoring Plan.

4.6 SAMPLING, ANALYSIS, AND DATA COLLECTION

To ensure that all DQOs are met, a summary table of sampling, analysis, and data collection was formulated and is presented in Table 6. Figure 4 identifies the location of treatment system components and physical sample locations for the Northeast Plume Optimization Project. The air stripper effluent sample point for performance monitoring of TCE removal efficiency is in the same general location inside both the C-765 (servicing EW234 and shown in Figure 4) and C-765-A (servicing EW235) TUs. Figure 4 identifies that CERCLA Outfall 001 is the sample collection point for compliance with ARARs that occurs prior to comingling with other waters. Refer to Section 6 and Figures 6 and 7 of the RAWP for additional information (DOE 2016b).

4.6.1 Quality Assurance and Quality Control

The Northeast Plume Optimization Project maintains a quality sample and data management program to verify the integrity of data generated. Each aspect of the monitoring program, from sample collection to data reporting, must comply with quality requirements and assessment standards identified in the Northeast Plume Optimization QAPP (Appendix D of the RAWP) (DOE 2016b).

4.6.2 Sampling and Analysis

Analytical data consist of definitive data based on data needs determined in the project-specified DQOs. TCE, as well as other analyses, satisfy decision rules in Table 3. These analyses are performed using approved EPA methods under 40 *CFR* § 136, Table 1, or other approved methods that meet the requirements of modified methods discussed in 40 *CFR* § 136.6. (See Appendix D in the project QAPP of the RAWP) (DOE 2016b).

Specific quality control (QC) samples are collected to monitor the effectiveness of the sampling procedures and laboratory methods. QC samples are collected as needed for this project. They include field blanks, duplicates, equipment rinseates, and trip blanks.

Table 6. Summary of Sampling, Analysis, and Data Collection

Decision Rule (refer to Table 3)	Sample point(s)	Parameters	Frequency[a]
#1	EW234 and EW235	Pumping Rates	Daily
		TCE	Monthly
		Water Level	Weekly
	MWs	TCE and Water Level	Quarterly
	PZ Wells	Water Level	Quarterly
#2	Air Stripper Liquid Effluent	TCE	Weekly
#3	CERCLA Outfall	Flow; Total Suspended Solids; Oil and Grease; Total Residual Chlorine; pH; Temperature; TCE; and 1,1-DCE	Weekly
		Chronic Toxicity	Quarterly
#4	EW234 and EW235	Pumping Rates	Daily
		TCE	Monthly
	Air Stripper Liquid Effluent	TCE	Weekly
#5	EW234 and EW235	TCE, Tc-99	Monthly
	MWs	TCE, Tc-99	Quarterly
#6	EW234 and EW235	Operational Data	Daily
	TU	Operational Data	Daily

Note: This table specifies only data needed to establish basis for Decision Rules identified in Table 3. Additional sampling may be required that is identified in the Project Specific QAPP. Sampling may be increased temporarily to support operational troubleshooting. Sampling will be suspended temporarily when the facility is shut down or if other operation conditions exist that would make sampling impractical. Refer to Section 4.3.2.2 for long-term monitoring requirements.

[a] Frequency definitions are as follows:
Daily refers to normally manned operations, excluding weekends, holidays, or days when the facility is shut down.
Weekly—1 sample per calendar week.
Monthly—1 sample per calendar month.
Quarterly—1 sample every 3 months, not to exceed 4 months.
Annually—1 sample each fiscal year.

4.6.3 Corrective Action Procedures

Project personnel are responsible for identifying conditions adverse to quality and informing the NEPCS Operations Manager. Corrective action procedures require that conditions adverse to quality be identified and documented, with the appropriate corrective action(s) taken and verified in accordance with the most recent revision of procedure CP3-QA-3001, *Issues Management*.

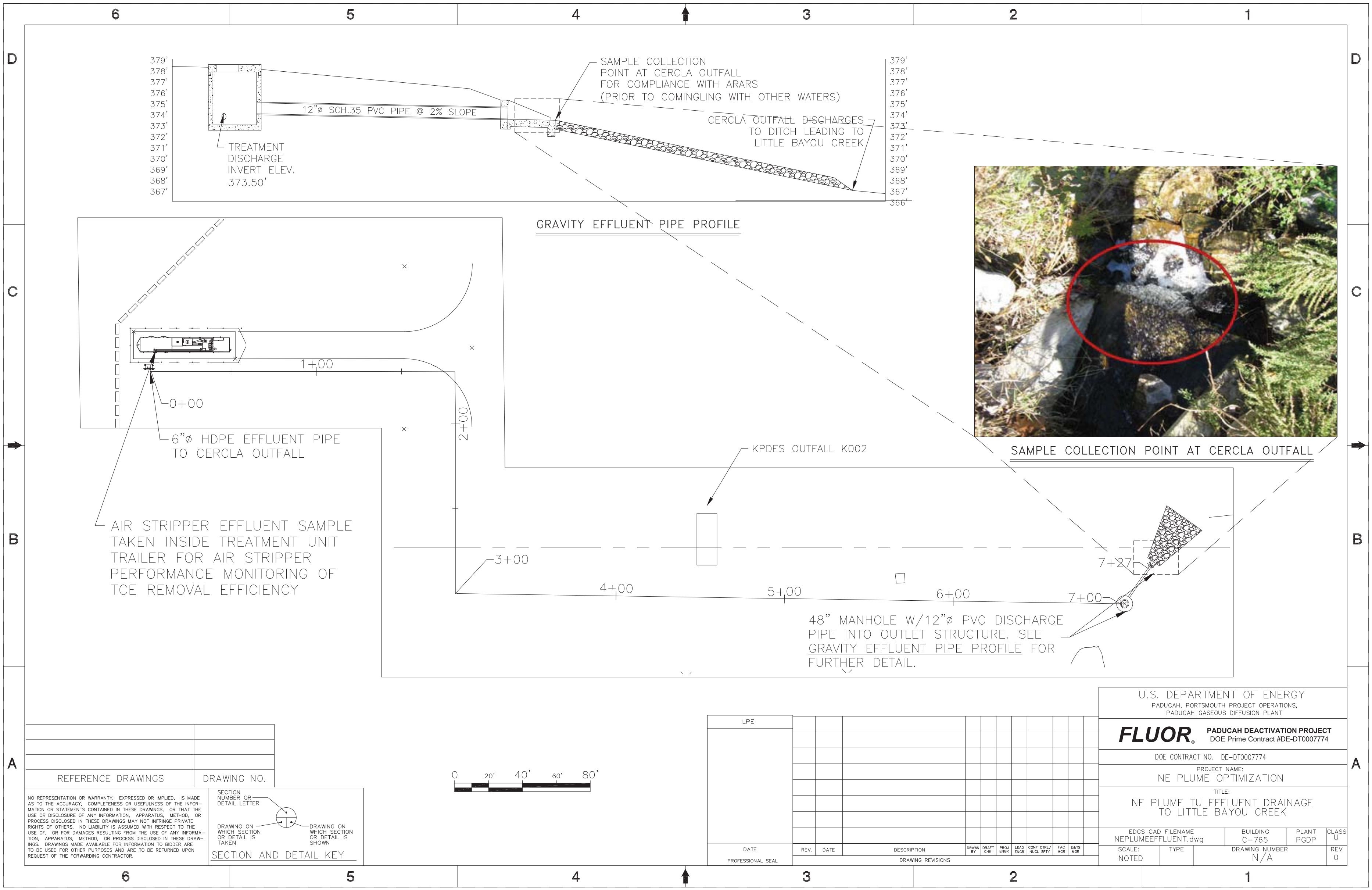

Figure 4. Northeast Plume TU Effluent Drainage to Little Bayou Creek

5. DESCRIPTION OF ALTERNATE OPERATIONS AND MAINTENANCE

After operational acceptance testing of the optimized NEPCS is complete, EW331 and EW332, EQ tank, transfer pump, and all infrastructure associated with C-614 facility is to be shut down and placed in standby mode. MW network data collected during operation of the optimized NEPCS will be evaluated in accordance with the DQOs referenced in Table 3.

Shutdowns of the NEPCS are handled in the quickest possible manner to ensure minimum downtime and prevent adverse effects on equipment. The system is designed so that continuous operation of the NEPCS is possible when only one of the two EWs is functional.

C-614 system components that are placed in standby may require routine maintenance to ensure good working order if EW331 and EW332 are returned to service. Maintenance actions and inspections will be performed in accordance with equipment manufacturer's recommendations and sound engineering practices, as applicable.

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6. HEALTH AND SAFETY PLAN

A HASP was developed for the NEPCS using pertinent information about the site, potential contaminants and hazards that may be encountered, and hazards inherent to routine activities performed during NEPCS operations. A copy of the HASP can be accessed through the plant's computer network (FPDP 2015a). Control, distribution, use, and maintenance of controlled documents and forms are performed in accordance with the most recent revision of CP3-OP-0025, *Document Control Process*.

An Integrated Safety Management System (ISMS) is implemented into all work performed at NEPCS. The ISMS process integrates environment, safety, and health controls into management and work practices at all levels. This is achieved by the implementation of five safety management functions into all phases of work. These functions consist of defining the scope of work, analyzing hazards, developing and implementing controls, performing work, and providing feedback and continuous improvements. The ISMS is a fundamental element in the safety program for the NEPCS.

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7. DESCRIPTION OF EQUIPMENT

7.1 EQUIPMENT AND PROCESS DESCRIPTION

7.1.1 Plant-Specific Operations

This section provides the process description, design criteria, modes of operation, instrumentation description, and process control for the major components of the NEPCS. A system process flow diagram for NEPCS is presented in Figure 5. Detailed information on system configurations and equipment specifications can be found in the system's "as-built" drawings and manufacturer's equipment manuals.

7.1.2 Groundwater Extraction Wells and Associated Equipment

The NEPCS is comprised of two TUs and two EWs. The C-765 TU will be used for EW234 and the C-765-A TU will be used for EW235. The location of the two EWs and associated NEPCS equipment relative to PGDP is presented in Figure 6. For hydraulic control, EW234 is expected to operate at a range of between approximately 100 to 200 gpm, and EW235 is expected to operate at a range of between approximately 75 to 150 gpm. The groundwater EWs supply influent groundwater for NEPCS TUs. The air stripper for each NEPCS operation trailer is capable of 1-250 gpm operation, but will be limited by the PLC controls to ensure the system flow rate is maintained within the operational capabilities of each system. Each well is housed inside a concrete vault for maintenance and access to the well head.

The discharge piping from the concrete EW vaults to the NEPCS operation trailers is constructed of high-density polyethylene. Each EW contains an electric-driven centrifugal submersible well pump that pumps groundwater through the discharge piping to the NEPCS TUs. The wellhead piping; sample tap; pressure gauge; and manual flow control valve are located below grade in a secured equipment vault at each well location.

Each groundwater EW pump operates continuously in either a HAND or AUTO mode. When a well pump is in HAND, it supplies water continually to the NEPCS operation trailer until the switch is released. When a well pump is in AUTO, it operates automatically on signals generated by the system PLC.

Each groundwater EW vault drains to a sump and a sump pump. The sump pump is a small, electric-driven submersible pump with the discharge connected to the EW discharge piping. Water collected in the sump is monitored by a float switch; when activated, it pumps any water from the sump into the water discharge piping to be treated at the NEPCS operation trailers.

7.1.3 Control/Instrumentation Description

Main power to the EW pumps is supplied from a local overhead line that supplies power to power distribution panel boards. Each well pump has a local control panel and VFD (variable-frequency drive) for optimum control and adjustment of the groundwater extraction rate. The local control panel has a well pump selector switch, a sump pump selector switch, and indicator lights.

Each well has a manual control valve, pressure gauge, sample tap, and a VFD. Once all alarm conditions have been cleared, the well pumps can be restarted at the PLC.

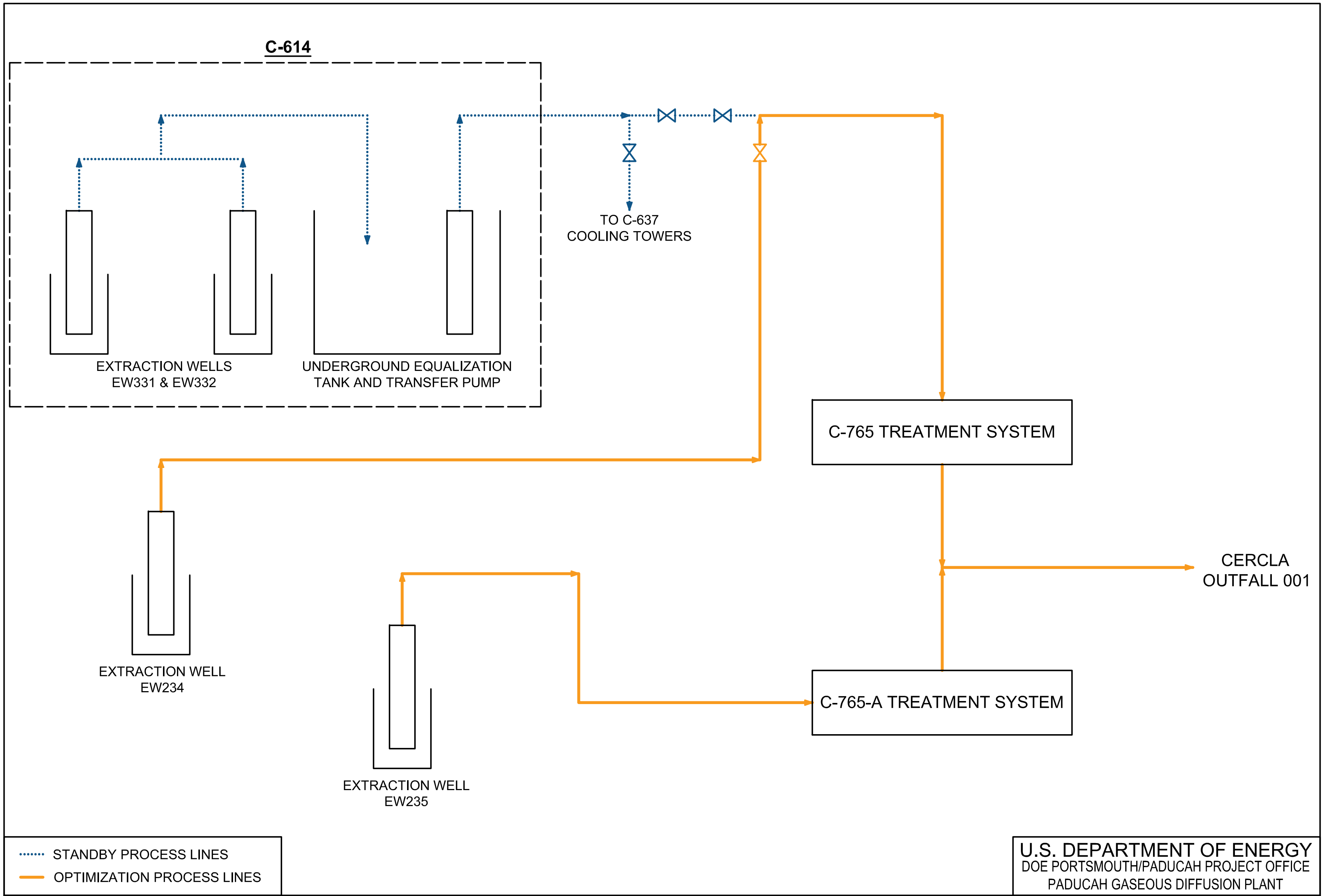

Figure 5. System Process Flow Diagram for NEPCS

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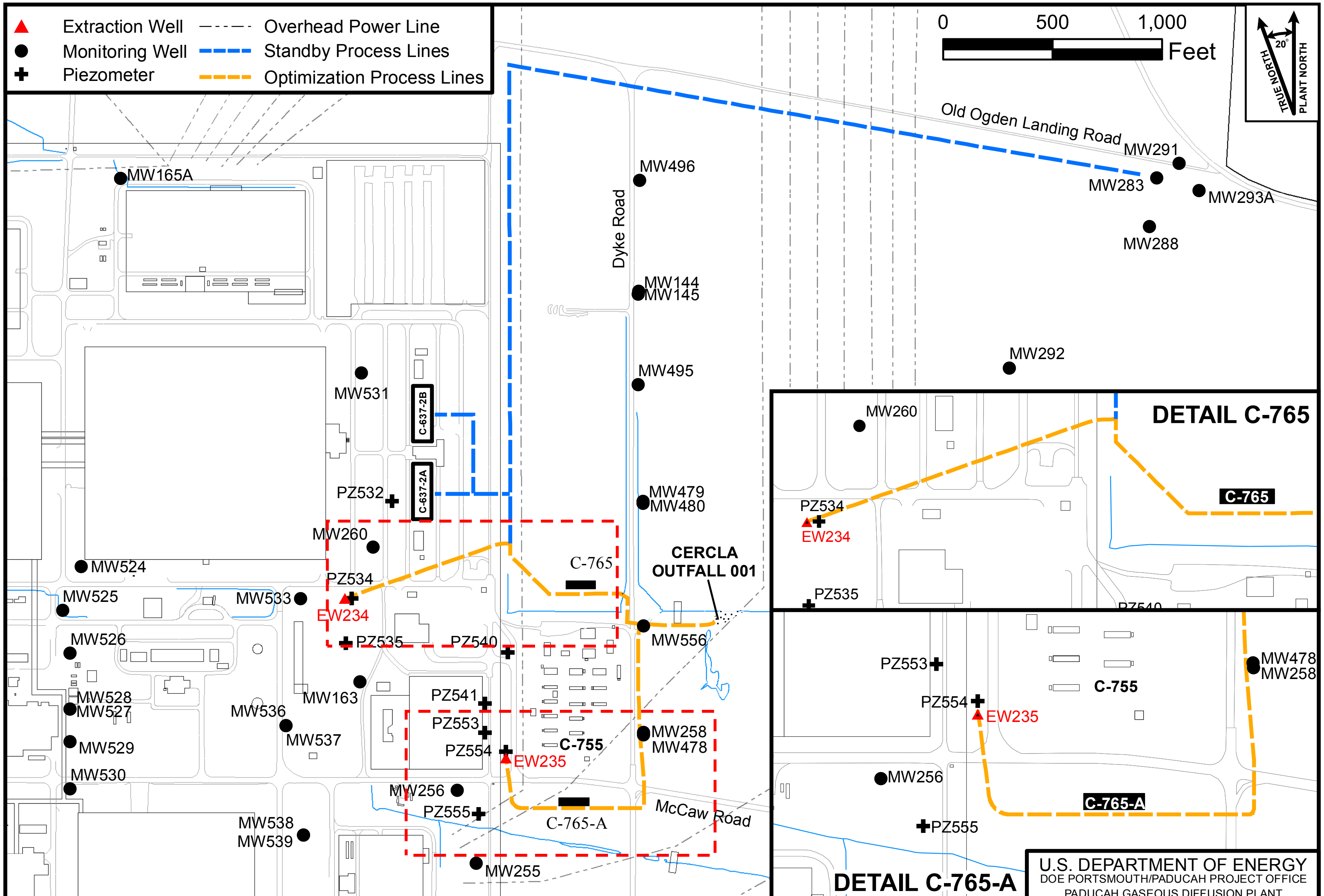

Figure 6. Location of Monitoring Wells, Extraction Wells, and the NEPCS Relative to PGDP

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Additionally, operators can use the PLC to shut down the well pump(s). After shutdown, the pump(s) are restarted at the PLC panel.

The system control panels at the EWs use local control panels utilizing switches and indicator lights while the treatment systems utilize graphical control panels, PLCs, and an autodialer for notifying NEPCS personnel of system shutdown. The control panels display the status of system components and alarm conditions found in Section 3.

7.1.4 Process Control

Groundwater EW flow rates are determined by the system's effects on the site hydrogeology. Groundwater MWs near the EWs are monitored and sampled routinely for contaminant parameters. The proposed frequency of well monitoring (includes sampling and other modeling parameters) is addressed in Section 4. As the results of this monitoring are assessed, the pumping rates from the groundwater EW may be modified to reflect changes in the site hydrogeology.

The flow from each groundwater EW is adjusted using the PLC control of each VFD and system valves as necessary to control each pump discharge and to confirm the flow rate by use of a flowmeter. The flow rate is adjusted to operate within the minimum and maximum design flow for each EW pump, while staying within the design flow rate of the air stripper and the target flowrate for the site hydrogeology.

7.1.5 C-765 Treatment System

The C-765 treatment system is the northern treatment system located north of C-755 complex inside a fence enclosed area to control access to the facility. It is contained within an approximate 8.5-ft by 53-ft weathertight enclosure, which includes bag filters, air stripper, and control panel. EW234 is connected to C-765 TU via Ethernet connection to enable communication between the two components. An inlet set of bag filters removes suspended solids as a pretreatment to the air stripper, which removes TCE. The bag filters are configured in parallel and have a clean bag filter in standby when the online filters begin to plug. Instrumentation is included to monitor the differential pressure across the filters and automatically change to the clean filter(s) before the bag(s) become plugged. The dirty filter bag(s) then is replaced and becomes the standby filter. After sufficient operating experience, bag filters may be taken offline and bypassed if suspended solids concentrations are low enough to meet CERCLA outfall criteria without their use and operational data indicate they are not needed to reduce maintenance on the air stripper trays. Once water has passed through the air stripper, removing TCE from the extracted groundwater, it is pumped from the air stripper basin to the outfall by the system effluent pump. Control of the effluent pump by the PLC is maintained by monitoring the water level in the air stripper basin and adjusting the effluent pump's VFD to maintain a consistent level within each air stripper basin. Additionally, the treatment system enclosure was designed with capacity for future treatment system components, if required, by changing groundwater conditions.

System component status, information, and associated alarms will be monitored via the treatment system control panel. Treated groundwater is discharged into CERCLA Outfall 001. EW331 and EW332 are connected to the C-765 treatment system, but are taken off-line and will remain in standby mode unless the alternative operations and maintenance, discussed in Section 5, are implemented.

7.1.6 C-765-A Treatment System

The C-765-A treatment system is the southern treatment system located south of C-755 complex inside a fence enclosed area to control access to the facility. It is contained within an approximate 8.5-ft by 53-ft weathertight enclosure, which includes bag filters, air stripper, and control panel. EW235 is connected to

C-765-A TU via Ethernet connection to enable communication between the two components. An inlet set of bag filters removes suspended solids as a pretreatment to the air stripper, which removes TCE. The bag filters are configured in parallel and have a clean bag filter in standby when the online filters begin to plug. Instrumentation is included to monitor the differential pressure across the filters and automatically change to the clean filter(s) before the bag(s) become plugged. The dirty filter bag(s) then is replaced and becomes the standby filter. After sufficient operating experience, bag filters may be taken offline and bypassed, if suspended solids concentrations are low enough to meet CERCLA outfall criteria without their use and operational data indicate they are not needed to reduce maintenance on the air stripper trays. Once water has passed through the air stripper, removing TCE from the extracted groundwater, it is pumped from the air stripper basin to the outfall by the system effluent pump. Control of the effluent pump by the PLC is maintained by monitoring the water level in the air stripper basin and adjusting the effluent pump's VFD to maintain a consistent level within each air stripper basin. Additionally, the treatment system enclosure was designed with capacity for future treatment system components, if required, by changing groundwater conditions.

System component status, information, and associated alarms will be monitored via the treatment system control panel. Treated groundwater is discharged into CERCLA Outfall 001.

7.2 MONITORING COMPONENTS

A mechanical flow rate/totalizer is installed in each NEPCS TU for recording flow rates and total volume pumped. Trailer effluent concentrations are measured at CERCLA Outfall 001 and for the liquid effluent of each trailer per the requirements of Section 4.

7.3 MAINTENANCE OF SITE EQUIPMENT

Equipment replacement, calibration, and maintenance are performed in accordance with the manufacturers' recommendations. Detailed information on required maintenance and calibration activities are documented in the most recent revision of CP2-ER-0046, *Paducah Plume Operations Maintenance, Sampling and Analysis, and Calibration and Testing Plan* (FPDP 2016b), and can be accessed through the plant's computer network. Control, distribution, use, and maintenance of controlled documents and forms operating procedures are performed in accordance with the most recent revision of CP3-OP-0025, *Document Control Process*.

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8. RECORDS AND REPORTING

8.1 LOGBOOKS AND LABORATORY RECORDS

Records are maintained by NEPCS personnel to document significant information involving NEPCS operations. Information includes routine operation, unusual occurrences, equipment malfunctions, spills, sampling events, visitors on-site, operational data records, and maintenance records.

8.2 DATA MANAGEMENT

To meet regulatory requirements for the acquisition of technically and legally defensible data, a traceable audit trail is established from the development of sampling through the archiving of information in accordance with DOE/OR/07-1595&D2, *Data and Documents Management and Quality Assurance Plan for Paducah Environmental Management and Enrichment Facilities* (DOE 1998), and the most recent revision of CP2-ES-0063, *Environmental Monitoring Data Implementation Plan at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (FPDP 2016c). This necessitates that each step or variation of the sampling and analytical process is documented. Quality assured data are obtained through appropriate planning, adequate sampling and laboratory QCs, and documented data review as outlined in the most recent revision of procedure CP3-ES-5003, *Quality Assured Data*.

8.3 PROGRAM REPORTING REQUIREMENTS

Routine O&M of the NEPCS and the MWs includes preparation of various operations and progress reports for submittal to EPA Region 4 and the Kentucky Department for Environmental Protection. In addition, various components of the NEPCS operation may require preparation of special work plans or reports.

8.3.1 NEPCS O&M Plan

This O&M Plan provides the NEPCS operators with background information, program organization, reporting requirements, and O&M requirements and guidelines. It also includes references to plans and procedures that aid in maintaining compliance with DOE, federal, and Commonwealth of Kentucky policies and statutes. Training requirements and PGDP emergency response and operating procedures are also referenced. It should be emphasized that the O&M Plan is a dynamic document. Modifications and improvements to NEPCS operational procedures and this O&M Plan will continue as methods are identified that improve the overall performance and efficiency of system operations.

8.3.2 Semiannual Progress Reports

Semiannual reports are prepared and issued to DOE within 30 days of the end of each six-month period, summarizing the data generated by activities associated with the NEPCS. DOE submits progress reports to the Kentucky Department for Environmental Protection and EPA. For this project, effluent discharge and other information will be summarized in semiannual reports. Such information may include, but not be limited to, TCE concentrations, maintenance performed, down time, TCE removed, effluent discharges in excess of those in Table 1, etc.

8.4 EMERGENCY PROCEDURES AND NOTIFICATIONS

The HASP provides guidance on emergency response and notification. The HASP is reviewed annually and made available for inspection by employees, their supervisors, health and safety personnel, and other government agencies having relevant responsibilities. The plan addresses all of the following:

- Personnel roles, lines of authority, and communication;
- Emergency recognition and prevention;
- Evacuation routes and procedures;
- Emergency medical treatment and first aid;
- Emergency alarm and response procedures;
- Hazardous material release; and
- Personal protective equipment and emergency equipment.

8.4.1 Existing Programs

The PGDP has a comprehensive program for emergency response. The NEPCS Operations Manager will ensure that personnel are trained to implement the site program. In the area of emergency response procedures, the NEPCS is considered a part of PGDP. NEPCS personnel will cooperate with emergency response personnel and may be asked to provide assistance in accounting for personnel, gathering at the safe refuge point, and reporting the status of the incident.

8.4.2 Accident/Incident Reporting

NEPCS personnel are required to immediately report any injury, regardless of severity, to their supervisor. Once informed, the supervisor will report the incident to management, who will make necessary notifications. In the event of a serious injury, personnel may seek immediate emergency medical assistance before notifying their supervisor.

Major incidents occurring at the NEPCS must be reported to DOE. Examples of reportable incidents include, but are not limited to, medical emergencies, spills, and major operational disruptions.

8.4.3 Emergencies

Personnel are trained during the PGDP site training to report emergencies. Emergencies are to be immediately reported to the Plant Shift Superintendent’s Office, located at C-300, using the fastest route possible. This could be a telephone call (441-6333), a radio network call to Alpha One, or an emergency call box activation (if possible, person will remain in the area to direct the responders).

9. OPERATIONS AND MAINTENANCE COST ESTIMATE

The costs associated with the O&M of the NEPCS and the NWPGS no longer are tracked separately. O&M of the two systems have been combined under the current contract. The average annual cost for O&M of both systems is approximately $1 million. This cost is a total project cost that includes, but is not limited to, the following:

- O&M of the systems, including corrective maintenance,
- Waste disposal,
- Sampling and analysis,
- Health and safety,
- Data management,
- Technical reporting, and
- Financial tracking.

NEPCS operating costs are expected to remain relatively stable; however, events that may impact costs include, but are not limited to, unscheduled maintenance events, document review cycles, and project scope changes generated during baseline planning.

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