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July 6, 2021

Mr. Brian Begley
Federal Facility Agreement Manager
Division of Waste Management
Kentucky Department for Environmental Protection
300 Sower Boulevard, 2nd Floor
Frankfort, Kentucky 40601

PPPO-02-10011704-21B

Mr. Victor Weeks
Federal Facility Agreement Manager
U.S. Environmental Protection Agency, Region 4
61 Forsyth Street
Atlanta, Georgia 30303

Dear Mr. Begley and Mr. Weeks:

TRANSMITTAL OF THE OPERATION AND MAINTENANCE PLAN FOR THE NORTHWEST PLUME GROUNDWATER SYSTEM INTERIM REMEDIAL ACTION AT THE PADUCAH GASEOUS DIFFUSION PLANT, PADUCAH, KENTUCKY (DOE/LX/07-2469&D1, PREVIOUSLY DOE/OR/07-1253&D4/R7)

References:

1. Letter from T. Duncan to B. Begley and V. Weeks, "Transmittal of the Operation and Maintenance Plan for the Northwest Plume Groundwater System Interim Remedial Action at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/OR/07-1253&D4/R7," (PPPO-02-10008325-21B), dated November 23, 2020
2. Letter from B. Begley to T. Duncan "RE: Submittal of Comments to the Operation and Maintenance Plan for the Northwest Plume Groundwater System Interim Remedial Action at the Paducah Gaseous Diffusion Plant (DOE/LX/07-1253&D4/R6), Paducah Site, Paducah, McCracken County, Kentucky #KY8-890-008-982," dated October 8, 2020
3. Letter from T. Duncan to B. Begley and V. Weeks, "Paducah Federal Facility Agreement—Signed Memorandum of Agreement for Resolution of the Informal Dispute Concerning U.S. Environmental Protection Agency and Kentucky Department for Environmental Protection Requirements for Additional Actions or Modifications Regarding the CY 2018 *Five-Year Review for Remedial Actions at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-2426&D2," (PPPO-02-10006452-20), dated July 7, 2020

Please find enclosed the subject document. This Northwest (NW) Plume Operation and Maintenance (O&M) Plan updates the previous revision, which was submitted to the Kentucky Department for Environmental Protection (KDEP) and the U.S. Environmental Protection Agency (EPA) on November 23, 2020. A redline version of the document, which highlights changes made to the previous version of the document, also is enclosed. Consistent with the U.S. Department of Energy's November 23, 2020, letter and the comment response summary (CRS) that was enclosed with the letter, the revisions address KDEP's October 8, 2020, comments that were not related to the above-referenced memorandum of agreement. An updated CRS also is enclosed with this submittal.

In addition to the revisions made in response to KDEP's October 8, 2020, comments, Decision Rule 10 in Table 2 in the NW Plume O&M Plan was revised so that the technitium-99 evaluation is consistent with the trichloroethylene evaluation on the western boundary of the Water Policy Box. The agreement among the Federal Facility Agreement parties on the revision to Decision Rule 10 is documented in e-mails dated April 27, 2021, and May 3, 2021.

Please note that a new Portsmouth/Paducah Project Office Lexington document number has been assigned to the document, which replaces the previous Oak Ridge document number.

If you have any questions or require additional information, please contact David Dollins at (270) 441-6819.

Sincerely,

Tracey L. Duncan

Digitally signed by Tracey L. Duncan
Date: 2021.07.06 09:22:19 -05'00'

Tracey Duncan
Federal Facility Agreement Manager
Portsmouth/Paducah Project Office

Enclosures:

1. *Operation and Maintenance Plan for the Northwest Plume Groundwater System Interim Remedial Action at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-2469&D1—Clean
2. *Operation and Maintenance Plan for the Northwest Plume Groundwater System Interim Remedial Action at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-2469&D1—Redline
3. KDEP CRS

Administrative Record File—(NWP PT-PD) Post-decision File for Northwest Plume Pump and Treat IRA

cc w/enclosures:
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DOE/LX/07-2469&D1
Secondary Document
(Previously DOE/OR/07-1253&D4/R7)

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

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Secondary Document
(Previously DOE/OR/07-1253&D4/R7)

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

Date Issued—June 2021

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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FIGURES

TABLES

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ACRONYMS

DMIP	Data Management Implementation Plan
DOE	U.S. Department of Energy
DQO	data quality objective
EMS	Environmental Management System
EPA	U.S. Environmental Protection Agency
EQ	equalization
ESD	explanation of significant differences
EW	extraction well
FFA	Federal Facility Agreement
GAC	granular activated carbon
HASP	Health and Safety Plan
IRA	interim remedial action
ISMS	Integrated Safety Management System
KPDES	Kentucky Pollutant Discharge Elimination System
LRGA	lower regional groundwater aquifer
MRGA	middle regional groundwater aquifer
MW	monitoring well
NWPGS	Northwest Plume Groundwater System
O&M	Operations and Maintenance
PGDP	Paducah Gaseous Diffusion Plant
PLC	programmable logic controller
QA	quality assurance
QC	quality control
ROD	Record of Decision
TCE	trichloroethene
URGA	upper regional groundwater aquifer
VOC	volatile organic compound
WMP	Waste Management Plan

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EXECUTIVE SUMMARY

This Operations and Maintenance (O&M) Plan has been prepared to serve as a guide and reference for the O&M of the Northwest Plume Groundwater System (NWPGS) constructed as an interim remedial action (IRA) for the Northwest Plume at the Paducah Gaseous Diffusion Plant (PGDP), near Paducah, Kentucky. The IRA is consistent with the U.S. Department of Energy (DOE) Environmental Restoration Division *Record of Decision for Interim Remedial Action of the Northwest Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/OR/06-1143&D4 (DOE 1993) (ROD), which was signed in July 1993.

As stated in the ROD, "The primary objective of this interim remedial action is to initiate a first phase remedial action, as an interim action to initiate control of the source and mitigate the spread of contamination in the Northwest plume."

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. A site investigation was conducted and it was determined that the principal contaminants of concern in the off-site groundwater were technetium-99 (^{99}Tc), a radionuclide, and TCE, an organic solvent.

The ROD initiated an interim remedial measure that included the construction and operations of the NWPGS. The NWPGS as originally constructed and operated consisted of four extraction wells (EWs) in two well fields, a groundwater treatment system, including an air stripper for removal of TCE, and four ion exchange units for removal of ^{99}Tc. To evaluate the effectiveness of the IRA, monitoring wells were installed in the vicinity of the EWs.

The NWPGS treatment goals, as specified in the ROD, are 5 ppb for TCE and 900 picoCuries per liter (pCi/L) for ^{99}Tc. These values for TCE and ^{99}Tc are set as project-specific operational goals (not regulatory levels) for the effluent before discharge, they are not goals or regulatory levels for aquifer cleanup. The system effluent discharges to Kentucky Pollutant Discharge Elimination System-permitted Outfall 001. A fixed-based contract laboratory performs sample analyses.

Consistent with a 1996 Explanation of Significant Differences (ESD) to the 1993 ROD, the treatability study included in the ROD was not executed, and the sequence of groundwater treatment steps described in the ROD was reversed to route groundwater through the air stripper first, and then through ion exchange resin (DOE 1996).

During the last quarter of calendar year 2009, the NWP IRA Optimization project was implemented to increase volatile organic compound (VOC) mass removal and enhance capture in the vicinity of the original south well field of the NWPGS. The NWP IRA System Optimization included installation of two new EWs (EW232 and EW233), installation of piping and leak detection monitoring stations, construction of an overhead feeder to provide electrical power to the new EWs, and instrumentation and control modifications. The wells were installed in the vicinity of the original south well field. Groundwater is extracted from each well at a rate of approximately 100 gpm. The piping and leak detection system transfer the extracted groundwater to the C-612 Treatment Facility. The original north EWs, EW228 and EW229, were taken out of service. The original south wells, EW230 and EW231, were taken off line, but remain in stand-by mode. An ESD to the 1993 ROD was completed in 2010 and documents these NWPGS optimization measures (DOE 2010a).

This O&M Plan provides the NWPGS operators with background information; and references to plans and procedures required to maintain and operate the treatment system to meet DOE, EPA, and Commonwealth of Kentucky policies and statutes. References herein to any plan or procedure refer to the most recent version of the plan or procedure in effect as of the date of this O&M Plan or to the revised version of such plans and procedures if revised subsequent to the date of this plan.

1. EQUIPMENT STARTUP AND OPERATOR TRAINING

1.1 GENERAL NORTHWEST PLUME GROUNDWATER SYSTEM DESCRIPTION

In August 1988, volatile organic compounds (VOCs) and radionuclides were detected in private wells north of Paducah Gaseous Diffusion Plant (PGDP). In response, U.S. Department of Energy (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. A site investigation was conducted, and it was determined that the principal contaminants of concern in the off-site groundwater were technetium-99 (^{99}Tc), a radionuclide, and trichloroethene (TCE), an organic solvent. The *Record of Decision for Interim Remedial Action of the Northwest Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/OR/06-1143&D4, (ROD) was signed in July 1993 (DOE 1993). As stated in the Declaration for the ROD, "The primary objective of this interim remedial action is to initiate a first phase remedial action, as an interim action to initiate control of the source and mitigate the spread of contamination in the Northwest Plume."

Consistent with a 1996 the Explanation of Significant Differences (ESD) to the 1993 ROD, the treatability study included in the ROD was not executed, and the sequence of groundwater treatment steps described in the ROD was reversed to route groundwater through an air stripper first and then through ion exchange resin (DOE 1996).

The ROD initiated an interim remedial measure that included the construction and operations of the Northwest Plume Groundwater System (NWPGS). The NWPGS construction was completed in May 1995, with system testing and shakedown through August 27, 1995. The NWP interim remedial action (IRA) System began routine pump-and-treat operations on August 28, 1995.

The NWPGS facility is located at PGDP near Paducah, Kentucky. The groundwater treatment system is housed in a pre-engineered metal building and trailer located in the northwest portion of the PGDP. The NWPGS is designed to recover and treat contaminated groundwater, to generate data to determine the treatment efficiency for the extracted groundwater, and to evaluate the effect of extraction on the Regional Gravel Aquifer.

The purpose of this Operations and Maintenance (O&M) Plan is to provide information on operation of the NWPGS and to provide data management and reporting requirements to assist in evaluating the effectiveness of the interim remedial action. References herein to any plan or procedure refer to the most recent version of the plan or procedure in effect as of the date of this O&M Plan or to the revised version of such plans and procedures if revised subsequent to the date of this plan.

The groundwater recovery system includes two extraction wells (EWs) as shown in Figure 1. The extracted groundwater is transferred through secondary containment dual wall piping to the treatment facility. The treatment system is designed to remove TCE and ^{99}Tc using air stripping and ion exchange technologies, respectively. The off-gas from the air stripper passes through granular activated carbon prior to discharge to the atmosphere. The treated groundwater is discharged to a Kentucky Pollutant Discharge Elimination System (KPDES)-permitted outfall.

During the last quarter of calendar year 2009, the NWP IRA Optimization project was implemented to enhance capture and increase VOC mass removal in the vicinity of the original south well field of the NWPGS. The NWP IRA Optimization project was initiated as a result of observations and recommendations documented during several reviews and assessments conducted since 2003. In 2010, an ESD to the 1993 ROD was completed to document the optimization of the NWPGS (DOE 2010a). Refer

to the *Remedial Action Work Plan for the Northwest Plume Interim Remedial Action Optimization at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/LX/07-0339&D1, for more detail regarding the basis for the NWP IRA Optimization project (DOE 2010b).

The NWP IRA System Optimization included installation of two new EWs (EW232 and EW233), installation of piping and leak detection monitoring stations, construction of an overhead feeder to provide electrical power to the new EWs, and instrumentation and control modifications. The wells were installed in the vicinity of the original south well field. Groundwater is extracted from each well at a rate of approximately 100 gpm. The pipeline transfers the extracted groundwater to the C-612 Treatment Facility. The original north EWs, EW228 and EW229, were taken out of service. The original south wells, EW230 and EW231, were taken off-line, but remain in stand-by mode. The locations of the original NWPGS EWs and the new EW232 and EW233 are illustrated in Figure 1.

1.2 OPERATOR TRAINING

Training is performed for new operations staff when significant changes are made to procedures/work instructions or when system modifications are implemented. General training requirements regarding health and safety and PGDP requirements for work on-site are listed in CP2-ER-0067, *Health and Safety Plan for the Paducah Plumes Operations and C-613 Sediment Basin, Paducah, Kentucky* (HASP). This document can be found on the Public Documents website (https://pubdocs.pad.pppo.gov/).

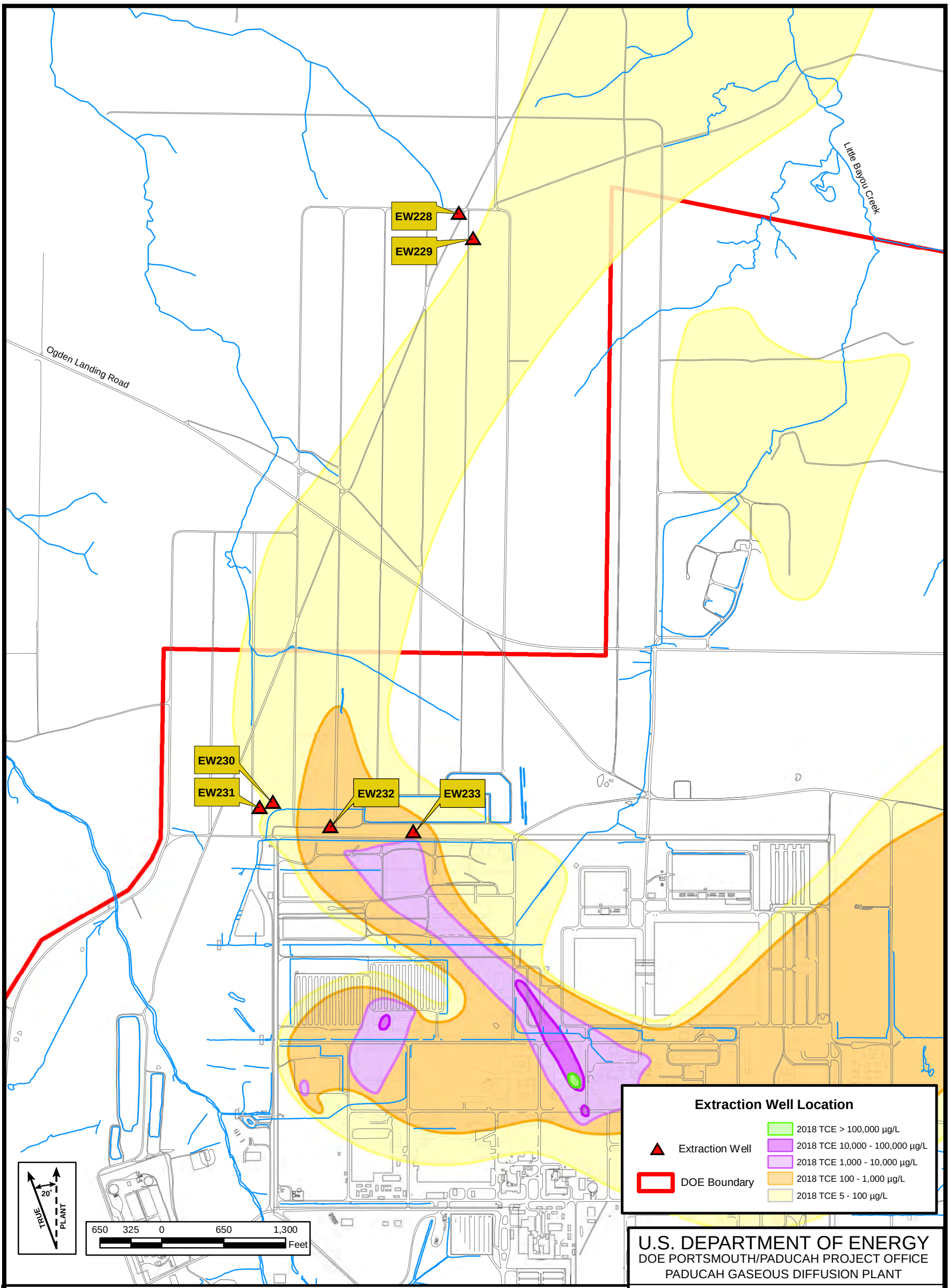

Figure 1. Northwest Plume Extraction Wells

MAP SOURCE INFORMATION

Map Generation Date and Location: G:\GIS\ARCVIEWS\JP3_Projects\NW_Plume\EW_Locations_20210408.mxd
Extraction Well Layer: G:\GIS\iPEGASIS.gdb\Locations
Streams Layer: G:\GIS\iPEGASIS.gdb\streams
Road Layer: G:\GIS\iPEGASIS.gdb\roadrow
DOE Boundary Layer: G:\GIS\iPEGASIS.gdb\doebnd
2018 TCE Plume Layer: G:\GIS\SHAPES\PLUMES\2018\TCE_100000.shp, ...\TCE_10000.shp, ...\TCE_01000.shp, ...\TCE_00100.shp, ...\TCE_00005.shp
Facilities Layer: G:\GIS\ARCVIEWS\geodatabases\Paducah_site.gdb\usec, ...\doe, ...\uds, ...\Common

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2. DESCRIPTION OF NORMAL O&M

2.1 O&M

The NWPGS is operated and maintained in accordance with this O&M Plan and associated plans and procedures referenced herein. If, in the future, safety or efficiency improvements can be incorporated into these associated plans and procedures, then they will be revised and followed by the pump-and-treat Operations Manager and staff. Administrative changes, such as a new DOE contractor, may result in revision to these associated plans and procedures. The most current version of these plans and procedures can be found on the Public Documents website (https://pubdocs.pad.pppo.gov/).

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

2.2.1 Operational Strategy and System Control

NWPGS operations are conducted to meet the primary objectives of the ROD (DOE 1993). System operating parameters (such as EW flow rates) are based on treatment system, EW, and MW data. The NWPGS is designed to operate 24 hours per day, 7 days per week to meet the objectives of the IRA as stated in the ROD (DOE 1993). The system is staffed during normal business hours for routine operational data collection, sampling, calibration activities, and preventative maintenance. The system is monitored and controlled 24 hours per day by a programmable logic controller (PLC). The PLC controls flow through the system and monitors system instrumentation for nonroutine operating conditions. Operations personnel are notified via auto-dialer in the event of off-normal conditions.

2.2.2 Conduct of Operations

NWPGS conduct of operations will be performed in accordance with the HASP; CP2-ER-0046, *Paducah Plume Operations Maintenance, Sampling and Analysis, and Calibration and Testing Plan*; CP2-ER-0012*, Paducah Plume Operations Waste Management Plan Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (WMP); along with applicable procedures and work instructions. Responsibilities and actions that affect the quality of the O&M of the NWPGS are described in the Data Management Implementation Plan (DMIP), as described in Section 10 of the *Remedial Action Work Plan for the Northwest Plume Interim Remedial Action Optimization at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/LX/07-0339&D1 (DOE 2010b).

Changes to system components are controlled by the DOE Prime Contractor's engineering procedure, CP3-EN-0203, *Design Change Process*.

2.3 OVERVIEW OF TREATMENT TECHNOLOGY (PROCESS THEORY)

The two primary treatment technologies used at the NWPGS are air stripping and ion exchange. These process technologies are briefly described below. Process technologies secondary to the primary contaminant removal technologies at the NWPGS include suspended solids removal by filtration, solids dewatering, and gas-phase activated carbon adsorption.

2.3.1 Air Stripping

The Northwest Plume TCE-contaminated groundwater is pumped from an equalization (EQ) tank through sand filters for solids removal and then to the top of the air stripping unit. Air is drawn upward through the unit as the contaminated groundwater flows downward through the system. The countercurrent flow of air and water causes TCE to be stripped from the water and transferred to the air stream. The air stream is then passed through granular activated carbon (GAC) to remove TCE before it is released into the atmosphere. The spent GAC is removed from the treatment system every six months and is sampled for characterization. The characterization data is then evaluated, and based on the evaluation, the spent GAC either is sent to a regeneration facility where it is reactivated and returned to the NWPGS for reuse or disposed of as waste.

2.3.2 Ion Exchange

^{99}Tc exists in the Northwest plume groundwater as the pertechnetate ion (TcO_4), which can be removed by ion exchange technology. During the first two years of pilot operation, four types of ion exchange resin were evaluated for performance. Based on cost and effectiveness, Purolite A-520-E was selected as the preferred resin.

Ion exchange is carried out in a pressurized vessel that contains a bed of ion exchange resin composed of small, spherically-shaped beads. Effluent from the air stripper flows through a header at the top of the vessel, flows downward to a lateral collection assembly at the bottom of the vessel, and exits the ion exchange vessel. As contaminated water flows downward through the resin bed, anions are exchanged for chloride ions on the resin beads. Pertechnetate ions passing through the ion exchange bed are removed until the available exchange sites are filled, after which these ions will begin to "leak" through the ion exchange columns and appear in the effluent stream. This "leaking" is defined as breakthrough, which is determined from sampling data. Pertechnetate ions have a greater affinity for some resins than other anions in the groundwater (sulfates, chlorides, nitrates, etc.); thus, pertechnetate ions tend to preferentially adsorb onto the surface of the resin beads (DOE 1993, Section 3.1).

2.4 OPERATING PROCEDURES

The NWPGS is operated in accordance with the DOE Prime Contractor's procedures/work instructions, equipment manuals, and sound engineering practices. Additional procedures/work instructions will be developed, as necessary, for NWPGS operations.

2.5 OPERATOR CHECKS

The operations staff conducts equipment inspections and records process data to ensure effective and safe system operations. Information such as system flow rates, alarm conditions, tank levels, pump status, pressure readings, and other data are collected and reviewed regularly. Daily system inspections and operational data collection are conducted in accordance with procedure CP4-ER-0017, *Northwest/Northeast Plume Daily Operational Data Collection and Maintenance.* This procedure can be found on the Public Documents website (https://pubdocs.pad.pppo.gov/).

2.6 SYSTEM MAINTENANCE AND CALIBRATION

NWPGS maintenance (corrective and preventive) is performed in accordance with equipment manufacturers' recommendations and sound engineering practices. Detailed information on maintenance

activities is included in CP2-ER-0046, *Paducah Plume Operations Maintenance, Sampling and Analysis, and Calibration and Testing Plan*. This plan can be found on the Public Documents website (https://pubdocs.pad.pppo.gov/).

2.7 COMMUNICATION

Below is the current communications equipment used by NWPGS personnel.

- Cellular telephones
- Landline telephone system
- Two-way radios

Operators maintain two forms of communication at all times.

The NWPGS contains a dedicated automatic telephone dialer (autodialer) for calling designated on-call personnel when system alarm conditions occur at the facility. Abnormal operating conditions trigger alarms in the main control system. The autodialer, upon receipt of an alarm signal from the PLC, dials on-call personnel and delivers an alarm message. NWPGS operations personnel notify the pump-and-treat Operations Manager of all call-outs. If the autodialer is not answered or if the alarm is not properly acknowledged, it continues to dial the programmed numbers of responsible parties in succession until the alarm is properly acknowledged. The autodialer operates over standard telephone equipment.

Emergency telephone numbers for reporting spills, fires, and other emergencies are provided in the HASP.

2.8 WASTE MANAGEMENT

Waste generated, as a result of O&M activities at the NWPGS, includes spent ion exchange resin, filter press solids, sample containers, personal protective equipment and possibly spent GAC. After evaluating characterization data for spent GAC, the spent GAC is either sent to a regeneration facility, where it is reactivated and then returned to the NWPGS for reuse, or disposed of as waste. The WMP addresses the management of waste produced at the NWPGS from the point of generation until custody is relinquished from the NWPGS. The WMP can be found on the Public Documents website (https://pubdocs.pad.pppo.gov/).

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3. DESCRIPTION OF POTENTIAL OPERATING PROBLEMS

This section describes operating problems that cause the shutdown of the NWPGS. It is limited to major problems and is not all-inclusive.

3.1 CAUSES FOR NWPGS SHUTDOWN

The NWPGS will shut down automatically as the result of certain nonroutine operating conditions. System shutdowns are initiated by programmed system interlocks that respond to the nonroutine operating condition and active system alarms. System alarms are the means by which the PLC communicates with the NWPGS operator. There are numerous alarm conditions; however, the alarms listed in Table 1 result in the activation of the NWPGS autodialer followed by an operator call-out. Table 1 lists system conditions and probable cause(s) related to each alarm condition.

Table 1. Alarm Conditions

Alarm No.	Alarm condition	System condition	Probable cause
1	EQ pump shutdown	Automatic system shutdown has occurred	Extraction well pump(s) shut down because of high/low pressure, high/low current, or a leak detection alarm
2	Sump level high	Automatic system shutdown has occurred	Faulty sump level detector or ruptured or leaking vessels
3	Manhole leak	Automatic shutdown of extraction wells serviced by the alarmed manhole has occurred	Infiltrated groundwater or system pipeline leak
4	High TCE in the effluent	System continues to operate until the operator manually shuts it down (if required) when responding to the call-out	TCE concentration in effluent exceeds “set point” or on-line analyzer is operating incorrectly

3.2 RESPONSE AND NOTIFICATION PROCEDURE FOR NWPGS SHUTDOWN

To troubleshoot and correct system problems, personnel follow appropriate procedures/work instructions and manufacturers’ equipment manuals, and seek any necessary outside technical assistance. NWPGS operators record all shutdown events, actions taken, and other pertinent information on daily operational data collection forms. NWPGS operations personnel notify the pump-and-treat Operations Manager of system shutdowns.

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4. DESCRIPTION OF MONITORING AND LABORATORY TESTING

4.1 INTRODUCTION

Groundwater and process monitoring is conducted to ensure proper facility operation and compliance with the ROD (DOE 1993). The data quality objective (DQO) process is used by the NWPGS team to ensure collection of data of appropriate quality and quantity to meet NWPGS objectives.

4.2 DATA QUALITY OBJECTIVES

4.2.1 Problem Statement

As stated in the ROD, "The primary objective of this interim remedial action is to initiate a first phase remedial action, as an interim action to initiate control of the source and mitigate the spread of contamination in the Northwest plume." Groundwater contaminated with TCE and ^{99}Tc is extracted from the Northwest Plume and is pumped to the C-612 Treatment Facility. The treatment system removes TCE by air stripping and ^{99}Tc by ion exchange. The treated water is discharged into the DOE KPDES Outfall 001.

4.2.2 Principal Study Questions, Decision Rules, and Data Needs

Table 2 outlines the principal study questions, decision rules, and data needs required to effectively monitor the operations of the NWPGS and meet the objectives stated in the ROD.

4.3 EFFECTIVENESS MONITORING

The purpose of the well effectiveness monitoring is to create and maintain an adequate database on the hydrogeologic situation in the Northwest Plume and to enable changes to be made in extraction/injection that will optimize remediation and containment (DOE 1993). This section describes hydraulic and chemical monitoring intended to support an evaluation of the performance of the NWPGS. Data collection and analysis will be conducted in the context of the remedial action objectives of the ROD, as stated above.

The goals of the effectiveness monitoring are to determine trends for TCE concentrations, primarily downgradient of pumping wells, determine mass removal rates, provide data for model recalibration, if necessary, and confirm capture zone development in accordance with model predictions. 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).

4.3.1 Hydraulic Monitoring

Hydraulic monitoring is conducted to verify the hydraulic performance of the system with regard to capture zone development, gradient manipulation and plume trajectory, assessment of effects due to changes in system operations or external hydraulic stresses, assessment of potential impacts on adjacent plumes, provide a basis for groundwater flow model refinement and/or recalibration, and refinement and optimization of system operation, if necessary.

Hydraulic monitoring consists of water level measurements made in a network of monitoring wells (MWs). The spatial distribution of the wells was determined in part using the three-dimensional groundwater flow

Table 2. Principal Study Questions, Decision Rules, and Data Needs

	Question/Goal	Decision rule	Data needs
1	Are we mitigating the spread of the highest concentration portions of the plume?	If field data from the NWPGS well field and mathematical modeling of the plume indicate that the NWPGS is not mitigating the spread of the highest TCE and ^{99}Tc concentration portions of the Northwest Plume, then NWPGS operations will be evaluated and appropriate actions taken.	Field data will be collected from the NWPGS well field.[a]
2	Are we effectively meeting operational goals of 5 ppb or less TCE and 900 pCi/L or less ^{99}Tc discharging from C-612?	If discharge levels of TCE exceed 5 ppb or discharge levels of ^{99}Tc exceed 900 pCi/L, then NWPGS operations will be evaluated and appropriate actions taken.	TCE and ^{99}Tc samples will be collected from the NWPGS effluent (HV-171).
3	Are we satisfying the regulatory limit of 81 ppb or less for TCE at Outfall 001?	If 81 ppb or greater of TCE is detected at the C-612 effluent, then operations will be shut down, the system will be evaluated, and the appropriate actions taken.	TCE samples will be collected at HV-171.
4	What levels of TCE are being discharged into the atmosphere?	If the NWPGS exceeds its allocated portion of TCE emissions for environmental remediation activities, NWPGS operations will be evaluated and appropriate actions taken.	TCE samples will be collected from the NWPGS influent (HV-082) and effluent (HV-171). Mass balance calculations will be performed using the above data.
5	What levels of ^{99}Tc are being discharged to the atmosphere?	These data are required to be collected for annual National Emissions Standards for Hazardous Air Pollutants calculations.	Technetium-99 samples will be collected from the NWPGS influent (HV-82), air stripper effluent (HV-014), and effluent (HV-171).
6	Are we meeting the requirements stated in the Facility and Nuclear Safety evaluation?	If TCE or ^{99}Tc levels, flow rates, or operating system conditions exceed levels or change from the current safety evaluation, then immediate action will be taken followed by a system evaluation and other appropriate actions.	TCE and ^{99}Tc samples will be collected from the NWPGS influent (HV-082). Daily NWPGS flow rates will be calculated from operational data.

Table 2. Principal Study Questions, Decision Rules, and Data Needs (Continued)

	Question/Goal	Decision rule	Data needs
7	Is the system running efficiently?	If system components are not operating within the manufacturers' specified performance criteria, then system operations will be evaluated and maintenance performed. Otherwise, operation of the NWPGS will continue as outlined in this O&M Plan and applicable maintenance and calibration specifications.	Operational data (such as flow rates, pressure readings, and tank levels) will be collected. Operational samples will be collected and analyzed. The collected data will be reviewed to determine system performance. Details on operational data collection and operational samples will be maintained as records in accordance with Section 8.
8	What groundwater volumes/flow rates are we extracting from the NWPGS extraction wells?	If the daily withdrawal volume exceeds 432,000 gal (per the Water Withdrawal Permit[b]), then the NWPGS system flow rate will be adjusted below this level.	Pumping volumes and flow rates will be recorded on a daily basis, excluding holidays and weekends, from each of the operating NWPGS extraction wells.
9	Is waste properly characterized for storage and/or disposal?	If waste is not properly characterized for storage and/or disposal, then additional sampling and analyses will be performed.	Data will be collected in accordance with applicable waste management procedures.
10	Is the risk pathway to residents for NWPGS contaminants eliminated as a result of the current Water Policy Boundary?	If the TCE levels exceed 5 ppb and/or there are upward trends in Tc-99 concentrations at the western boundary of the Water policy, then reevaluate the boundary location (DOE 2021, EPA 2021, KDWM 2021).	TCE and Tc-99 samples will be collected from selected MWs and residential wells between the water Policy affected area and the western boundary of the Water Policy (see Figure 2).

[a] Monitoring well groundwater sampling will be performed in accordance with Section 4.3, Effectiveness Monitoring.
[b] A Kentucky Water Withdrawal Permit (1345) was issued in 1995; the permit was rescinded in 2010 because of the exemption under 42 U.S.C. § 9621.

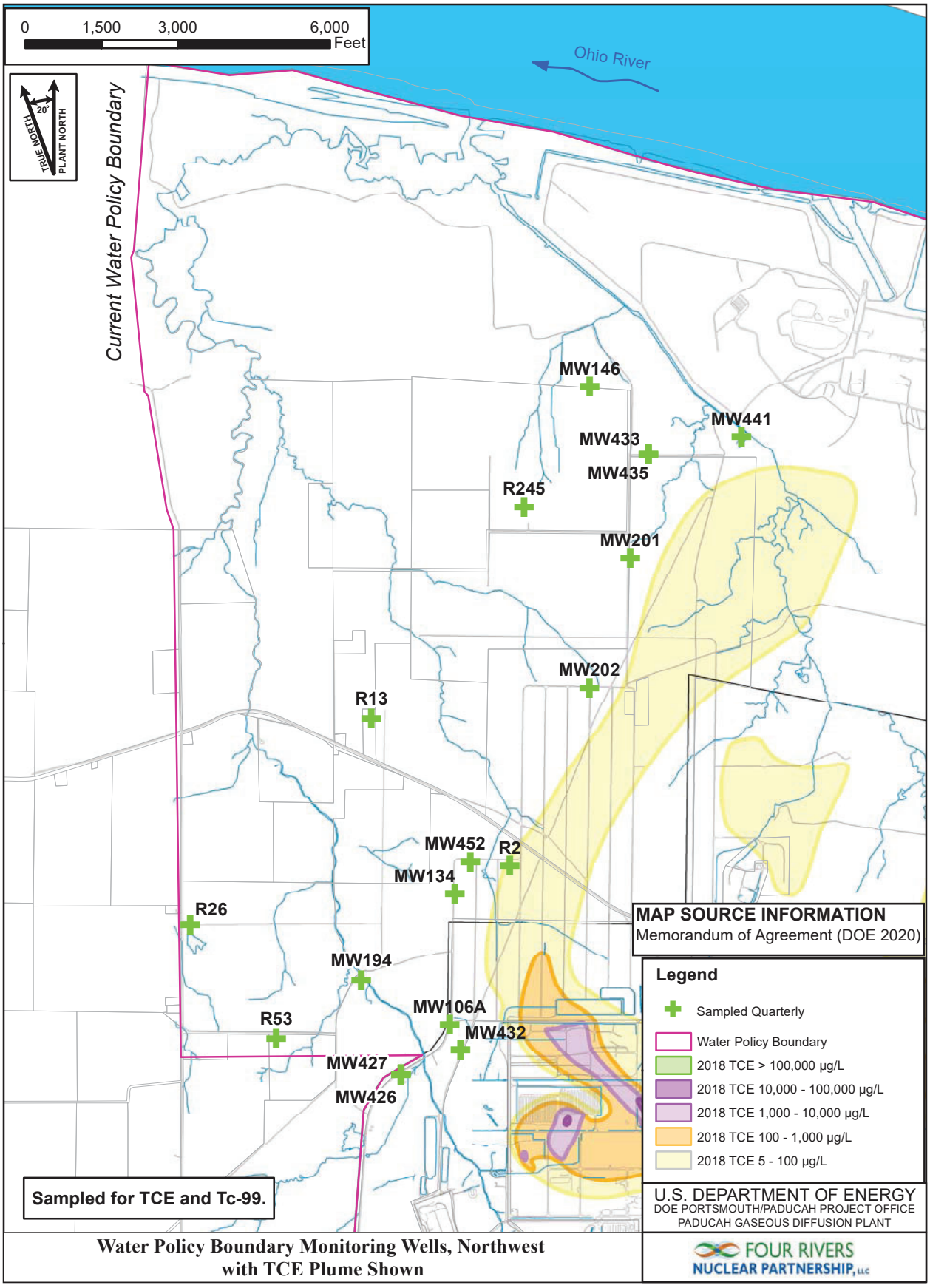

Figure 2. Water Policy Boundary Monitoring Wells, Northwest with TCE Plume Shown

model. The wells are distributed to provide sufficient water level and drawdown information to assess capture using analytical methods and to provide a three-dimensional distribution of groundwater elevations that are used to compare with the three-dimensional flow model.

Model predictions indicate that as water usage declines at the PGDP, lower rates of anthropogenic recharge will lessen the hydraulic gradient in the vicinity of the system, resulting in a larger capture zone, although flow trajectories are predicted to change. As water usage continues to decline, it may be necessary to reevaluate the potentiometric surface in relation to the remedial system and C-400 location to ensure that the ROD objectives are being met.

Water level measurements collected in accordance with the Environmental Monitoring Program will provide continuing data to assess gradient development and potential changes in hydraulic conditions over time.

4.3.2 Chemical Monitoring

Chemical monitoring of the NWPGS is conducted in accordance with the Decision Rules (see Table 2) and Section 4.6; it is intended to provide a basis for determining if the objectives of the ROD are being met. The MWs selected for chemical monitoring and the monitoring frequency for each well are identified in Section 4.6. Due to the continuing source of TCE and ^{99}Tc to the plume from the vicinity of C-400 Building, the bulk of the chemical monitoring will focus on areas downgradient of the EWs.

4.3.2.1 Baseline monitoring

All of the wells in the chemical monitoring network have a significant sampling history. Graphs of TCE concentrations in these wells are contained in the Federal Facility Agreement (FFA) semiannual progress report and indicate that concentrations are relatively stable over time, and that trends are readily identifiable.

4.3.2.2 Long-term monitoring

Periodic monitoring of the well network is performed to characterize the Northwest Plume and help determine the effectiveness of system performance. The monitoring frequency is summarized in Section 4.6. Wells generally are located upgradient of the EWs or peripheral to the system where TCE concentrations generally are not expected to fluctuate significantly as a result of system operation. EWs are sampled quarterly at sampling ports under normal operating conditions.

4.4 DATA EVALUATION

This section discusses the methods and techniques used in evaluating the data used to determine effectiveness of the remedial system.

4.4.1 Hydraulic Data

The hydraulic data were compared to model-predicted data and model recalibration was conducted as needed. Evaluation of hydraulic data has been conducted to determine aquifer transmissivity and potentiometric maps have been contoured to determine hydraulic gradient direction and magnitude.

Future changes in activities at the site of the former PGDP that may significantly affect flow patterns in the vicinity of the remedial system. At that time, measurement of water levels in the hydraulic MW network or

another set of appropriate wells may be required to determine flow trajectories and potential effects on system operation.

4.4.2 Chemical Data

Chemical data is reviewed as described in Section 4.6.1. through Section 4.6.4 and then evaluated to identify TCE concentration trends for wells in the monitoring network. The results of periodic and long-term contaminant monitoring are tabulated and provided to stakeholders for review semiannually, as described in Section 4.5. These tables are designed to facilitate observation of trends over time. Graphs showing changes over time also are developed. TCE mass capture from system operation are calculated based on EW sample data 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 NWGPS effectiveness monitoring. Regardless, the data density from the 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. Over time, changes in plume configuration or flow trajectories may require modification to the MW network to provide appropriate coverage.

4.5 REPORTING SUMMARY

Analysis of all chemical data is presented in the Semiannual Progress Reports in accordance with the *Federal Facility Agreement for the Paducah Gaseous Diffusion Plant*, DOE/OR/07-1707 (EPA 1998). Validated chemical data will be included in the semiannual progress reports, as available. If appropriate, the results of flow model revisions will be presented along with recommendations for revisions to the monitoring program or system operations.

4.6 SAMPLING AND ANALYSIS, QUALITY ASSURANCE AND QUALITY CONTROL

A summary table of sampling, analysis, and data collection is presented below in Table 3. A listing of Northwest Plume monitoring wells that are not associated with water policy boundary monitoring are presented in Table 4.

4.6.1 Sampling and Analysis

Analytical data consist of definitive data based on data needs determined in the project-specific DQOs. Analyses of TCE and of other analytes to satisfy the decision rules are performed using the modified EPA

Table 3. Summary of Sampling, Analysis, and Data Collection

Sample point(s)	Parameters	Frequency[a]	Decision rule (refer to Table 2)
Extraction wells EW232, EW233 (EW230 and EW231 if returned to service)	Pump Rates	Daily	#6
	Water Levels	Weekly	#6
	TCE, ^{99}Tc, Gross Alpha/Beta	Quarterly	#6
Monitoring Wells (refer to Table 4)	TCE, ^{99}Tc	Semiannually	#1
Water Policy Boundary Monitoring Wells (MW106A, MW134, MW146, MW194, MW201, MW202, MW426, MW427, MW432, MW433, MW435, MW441, MW452, R2, R13, R26, R53, and R245)	TCE, ^{99}Tc	Quarterly	#10
System influent (HV-082)	TCE	Monthly	#4, #6
	^{99}Tc	Monthly	#5, #6
	Si, Fe, Mn, VOCs	Quarterly[c]	NA
	Calcium hardness	Quarterly	NA
	Sulfates, Alkalinity	Semiannually	NA
System effluent (HV-171)	TCE	Weekly	#2, #3, #4
	^{99}Tc	Weekly	#2, #5
Air stripper effluent (HV-014)	^{99}Tc	Monthly[c]	#5
System ion exchange units	^{99}Tc	Monthly[d]	N/A
Operational data	Multiple[e]	Daily and weekly	#6, #7

[a] Frequency definitions are as follows:
Daily—one sample per day excluding weekends and holidays.
Weekly—one sample per calendar week.
Bimonthly—two samples per calendar month.
Monthly—one sample per calendar month.
Quarterly—one sample every 3 months, with samples no more than 4 months apart.
Semiannual—two samples each fiscal year
Annually—one sample each fiscal year no less than 3 months apart.

[b] These samples are necessary to identify changes in dissolved metal concentrations which may affect the operational performance of select unit processes (sand filters, air stripper, and ion exchange columns).

[c] This sample must be taken on the same date and approximate time as the monthly system influent sample (HV-082).

[d] Samples will be collected from each lead column (two columns are in the lead position). The ^{99}Tc data generated will be used to forecast and determine breakthrough of the ion exchange resin.

[e] Operational data collection parameters include pressure, flow rates, tank levels, and others. For details, refer to procedure CP4-ER-0017, *Northwest/Northeast Plume Daily Operational Data Collection and Maintenance.*

Note: The pump-and-treat Operations Manager temporarily may increase sampling to support operational troubleshooting. Sampling will be temporarily suspended when the facility is shut down or other operational conditions exist that would make sampling impractical.

Table 4. Northwest Plume Monitoring Wells*

Monitoring Well ID	Completion Interval	Monitoring Frequency
MW63	Upper Regional Groundwater Aquifer (URGA)	Semiannually
MW65	Lower Regional Groundwater Aquifer (LRGA)	Semiannually
MW66	URGA	Semiannually
MW165A	URGA	Semiannually
MW173	URGA	Semiannually
MW242	Middle Regional Groundwater Aquifer (MRGA)	Semiannually
MW243	MRGA	Semiannually
MW244	MRGA	Semiannually
MW245	MRGA	Semiannually
MW248	MRGA	Semiannually
MW250	MRGA	Semiannually
MW339	LRGA	Semiannually
MW340	LRGA	Semiannually
MW355	LRGA	Semiannually
MW428	LRGA	Semiannually
MW429A	URGA	Semiannually
MW430	LRGA	Semiannually
MW455	URGA	Semiannually
MW456	LRGA	Semiannually
MW457	URGA	Semiannually
MW458	LRGA	Semiannually
MW459	URGA	Semiannually
MW460	LRGA	Semiannually
MW461	URGA	Semiannually
MW462	LRGA	Semiannually
MW497	URGA	Semiannually
MW498	LRGA	Semiannually
MW499	URGA	Semiannually
MW500	LRGA	Semiannually
MW501	URGA	Semiannually
MW502	LRGA	Semiannually
MW503	URGA	Semiannually
MW504	LRGA	Semiannually

*List does not include Water Policy Boundary MWs.

SW-846 methods as described in *Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods* (EPA 2014). Analyses of ^{99}Tc are performed using a liquid scintillation counter.

Specific quality control (QC) samples are collected to monitor the effectiveness of the sampling procedures and laboratory methods. QC samples are collected, as needed, which may include field blanks, duplicate

samples, equipment rinseates, and trip blanks. Additional information is provided in CP3-ES-5003, *Quality Assured Data*, and in the DMIP.

4.6.2 Data Review

The data review process consists of the verification, validation, and assessment of the analytical results received from the laboratory. Data verification is performed on all analytical data to ensure all requested information is received. This includes analytes requested, methods used, units, holding times, and reporting limits achieved. The data validation process determines whether proper QC methods are used and whether the results meet established QC criteria. Validation is performed in accordance with the DMIP at a target frequency of a minimum of 5% (1 out of every 20 data packages). Data verification, validation of laboratory data, and assessment is performed according to procedure CP3-ES-5003, *Quality Assured Data.* Sample Management Office personnel perform verification of 100% of laboratory data and NWPGS personnel perform data assessment on 100% of laboratory data. Data assessment consists of a review of DQOs and the O&M Plan requirements. Any problems found during the review process are documented and resolved.

4.6.3 Quality Assurance and Quality Control

Information pertaining to QA/QC, such as equipment calibration and maintenance, personnel responsibilities, training, and corrective actions, is discussed in CP2-QA-1000, *Quality Assurance Program Description for the Paducah Gaseous Diffusion Plant*.

4.6.4 Corrective Action Procedures

NWPGS O&M personnel are responsible for identifying conditions adverse to quality and informing the pump-and-treat operations manager. Corrective action procedures require that conditions adverse to quality be identified and documented, and corrective action should be taken and verified in accordance with CP2-QA-1000, *Quality Assurance Program Description for the Paducah Gaseous Diffusion Plant*.

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5. DESCRIPTION OF ALTERNATE O&M

The NWPGS is designed to operate 7 days per week and 24 hours per day. Shutdowns of the NWPGS are addressed in the quickest possible manner to ensure minimum downtime and prevent adverse effects on equipment. System program interlocks, mechanical protection devices (e.g., pressure relief valves), and the autodialer help protect against equipment damage and promote worker safety. Manufacturers' reference manuals, work plans, guidance documents (e.g., the HASP and CP2-ER-0046, *Paducah Plume Operations Maintenance, Sampling and Analysis, and Calibration and Testing Plan*), and procedures/work instructions provide guidance to NWPGS personnel so that operations will be conducted safely and efficiently. Because temporary shutdown of the NWPGS does not endanger workers, the public, or the environment, an alternate O&M Plan is not necessary.

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6. ENVIRONMENT, SAFETY, AND HEALTH PLAN

The HASP was developed for the NWPGS using pertinent information about the site, potential contaminants and hazards that may be encountered, and hazards inherent to routine activities performed during NWPGS operations. The HASP can be found on the Public Documents website (https://pubdocs.pad.pppo.gov/).

An Integrated Safety Management System (ISMS)/Environmental Management System (EMS) is implemented on all work performed at the NWPGS. The ISMS/EMS 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/EMS is a fundamental element in the safety and environmental protection program for the NWPGS.

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7. DESCRIPTION OF EQUIPMENT

This section describes equipment associated with the NWPGS, including monitoring components, as well as equipment maintenance and replacement. Figure 3 presents a schematic of the groundwater treatment system, including all major components.

7.1 EQUIPMENT IDENTIFICATION

The NWPGS is composed of several operating systems that are described in detail in the Northeast/Northwest Plumes Reference Manual. These systems include the following:

- Groundwater EWs, well pumps, and pipeline system
- EQ pump and tank
- Pretreatment and filter system
- Air stripper and vapor-phase carbon system
- Ion exchange and resin dewatering system
- Backwash supply and treated water discharge system
- Compressed air system
- Instrument and control systems
- Sump and building systems

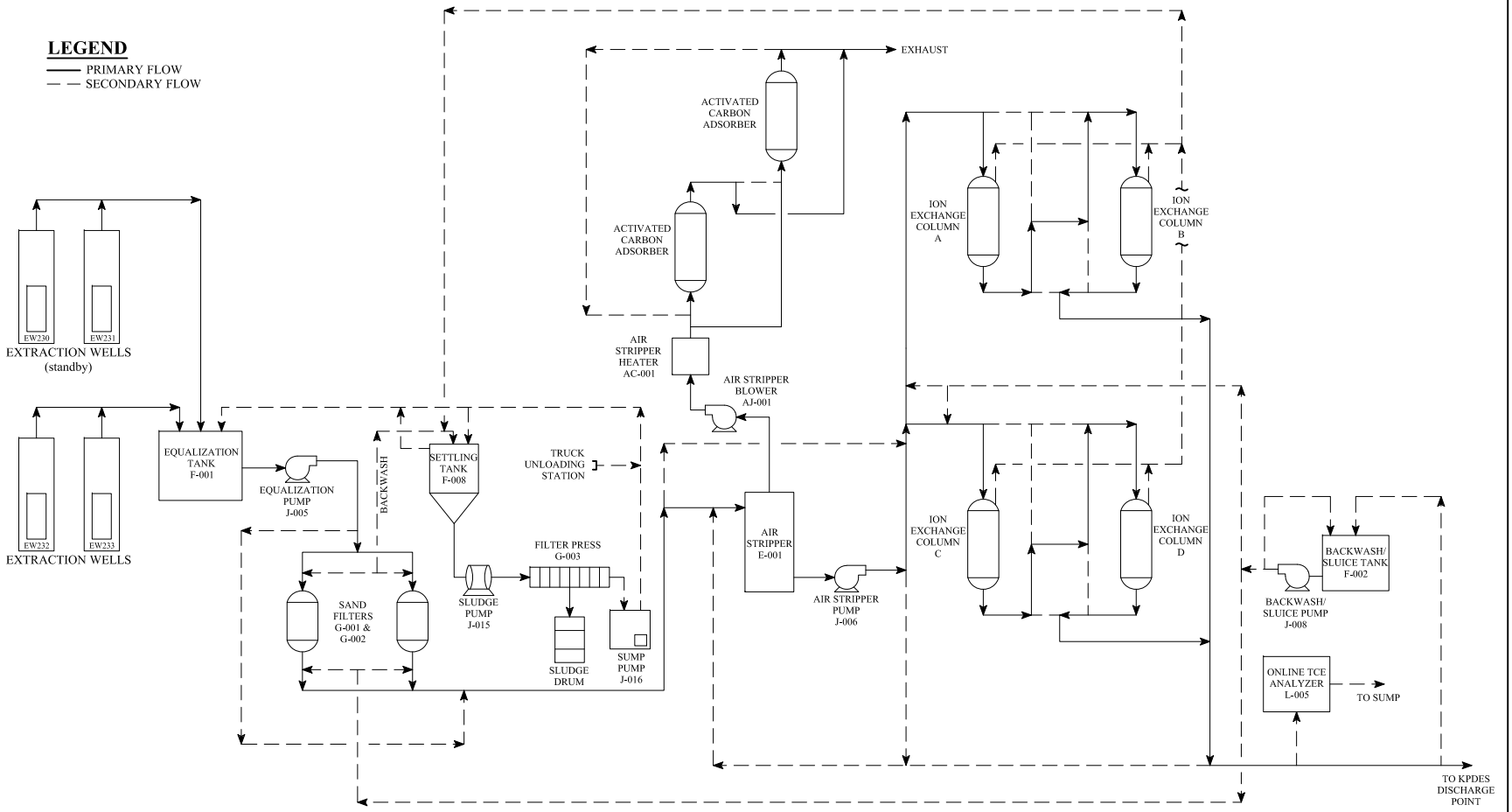
Groundwater from the EWs is transferred through a pipeline to the EQ tank at the NWPGS. Water is pumped from the EQ tank through the sand filters before being treated by the air stripper for TCE removal (see Figure 3). Vapors from the air stripper are passed through granular activated carbon for TCE removal before they are released into the atmosphere. Water from the air stripper discharge enters ion exchange columns for ^{99}Tc removal before being discharged to DOE KPDES Outfall 001.

7.2 MONITORING COMPONENTS

Five secured manhole monitoring stations, with leak detection probes, are located along the transfer line from the EWs. Should a leak occur, an alarm signal is displayed at the main system control panel and the corresponding EW pump(s) will shut down automatically.

Local control panels for system monitoring are located at each EW, the sand filter skid, and the air stripper skid. Each EW pump has a flowmeter/totalizer, pressure gauge, and HIGH and LOW pressure sensor that will initiate a shutdown of the pumps at pre-set pressure levels. Additionally, the PLC will shut down the pump(s) when manually prompted by the operator, when the EQ tank level is high, or when a leak is detected in the pipeline. After shutdown, the pump(s) are manually restarted at the main system control panel only after all alarm conditions have been cleared. The main system control panel is located inside the NWPGS facility and has a graphic display of the system, an operator interface unit, and the PLC. A TCE online analyzer is used to monitor effluent TCE concentrations and has a high-level alarm linked to the PLC.

NORTHWEST PLUME GROUNDWATER SYSTEM
PROCESS FLOW DIAGRAM



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

Figure 3. Northwest Plume Groundwater System Process Flow Diagram

FOUR RIVERS NUCLEAR PARTNERSHIP, LLC

U:\AutoCAD\FRNP CAD files\NW Plume\Fig.3 R0 - NW Plume Process Flow Diagram.dwg

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 included in CP2-ER-0046, *Paducah Plume Operations Maintenance, Sampling and Analysis, and Calibration and Testing Plan*.

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8. RECORDS AND REPORTING

8.1 PROJECT RECORDS

The NWPGS operations personnel are responsible for maintaining records pertaining to NWPGS operations. Information captured and maintained includes reports of routine operations, unusual occurrences, equipment malfunctions, spills, operational data records, and maintenance records.

8.2 DATA MANAGEMENT

To meet regulatory requirements for the acquisition of technically and legally defensible sampling and analytical data, a traceable audit trail is established from implementation of the approved sampling and analysis plan through the archiving of sample data in accordance with CP3-ES-5003, *Quality Assured Data*, and the DMIP. Each step or variation of the sampling and analytical process is documented. Quality assured data is obtained through appropriate planning, adequate sampling and laboratory quality controls, and documented data review.

8.3 PROGRAM REPORTING REQUIREMENTS

O&M information is reported to EPA and Kentucky Department for Environmental Protection in a semiannual progress report in accordance with the FFA (EPA 1998).

This O&M Plan was developed in accordance with the FFA (EPA 1998). It provides the NWPGS operators with background information and references to plans and procedures required to maintain and operate the treatment system to meet DOE, Federal, and Commonwealth of Kentucky policies and statutes. References herein to any plan or procedure refer to the most recent version of the plan or procedure in effect as of the date of this O&M Plan or to the revised version of such plans and procedures if revised subsequent to the date of this plan. It should be emphasized that the O&M Plan is a dynamic document. Modifications and improvements to this O&M Plan will continue as methods are identified that improve the overall performance and efficiency of system operation.

8.4 EMERGENCY PROCEDURES AND NOTIFICATIONS

The HASP provides guidance on emergency procedures and notification. The HASP is reviewed annually by NWPGS operators and made available for inspection by employees, supervisors, health and safety personnel, and other government agencies having relevant responsibilities. The plans address the following:

- Pre-emergency planning
- Personnel roles, lines of authority, and communication
- Emergency recognition and prevention
- Spill response
- Site security and control
- Evacuation routes and procedures
- Emergency alerting and response procedures
- Personal protective equipment and emergency equipment

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9. O&M COST ESTIMATE

The costs associated with the O&M of the Northwest Plume Groundwater System and the Northeast Plume Containment System are tracked in a single account. Based on fiscal year 2020 information, the annual cost for O&M of both systems is approximately $800,000.00. This cost is a total project cost that includes, but is not limited to, the following:

- O&M of the system
- Sampling and analysis
- Health and safety
- Data management
- Technical reporting
- Financial tracking

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