Commonwealth of Kentucky

Environmental Oversight Report 2021
Paducah Gaseous Diffusion Plant

Kentucky Division of Waste Management
300 Sower Boulevard
Frankfort, Kentucky 40601
502-782-6317

This 2021 Environmental Oversight Report, finalized in December 2022, was prepared by the Kentucky Division of Waste Management to report activities under the U.S. Department of Energy Federal Facility Agreement (FFA) and Agreement in Principle (AIP) grants, covering the period from Jan. 01, 2021, to Dec. 31, 2021. This report summarizes activities undertaken by the Commonwealth of Kentucky (Kentucky) to oversee environmental restoration activities at the Paducah Gaseous Diffusion Plant (PGDP). Copies of the report are available from the Hazardous

Waste Branch, Division of Waste Management, 300 Sower Blvd., Frankfort, Kentucky 40601, phone 502-782-6317.

Acknowledgment: This material is based upon work supported by the Department of Energy under Grant Numbers DE-EM-0005187 and DE-EM-0005189.

Table of Contents

TABLES

FIGURES

ACRONYMS

Above Mean Sea Level	AMSL
Agreement in Principle	AIP
Below Ground Surface	bgs
Cabinet for Health and Family Services	CHFS
Calendar Year	CY
Citizens Advisory Board	CAB
Comprehensive Environmental Response, Compensation, and Liability Act	CERCLA
Comprehensive Site Operable Unit	CSOU
Decontamination and Decommissioning	D&D
Dense Non-Aqueous Phase Liquid	DNAPL
Department of Energy (US)	DOE
Depleted Uranium Hexafluoride	DUF_6
Depleted Uranium Hexafluoride (DUF_6) Footprint Underlying Soils	DUFUS
Division for Air Quality	DAQ
Division of Water	DOW
Dye-Enhanced Laser Induced Fluorescence	DyeLIF
Electrical Resistance Heating	ERH
Energy and Environment Cabinet	EEC
Environmental Protection Agency (US)	EPA
Extraction Well	EW
Federal Advisory Committee Act	FACA
Federal Facilities Agreement	FFA
Fiscal Year	FY
Gallons Per Minute	gpm
Geographical Area	GA
Kentucky Department for Environmental Protection	KDEP
Kentucky Pollutant Discharge Elimination System	KPDES
Little Bayou Creek	LBC
Membrane Interface Probe	MIP
Memorandum of Agreement	MOA
Minimum Detectable Activity	MDA
Monitoring Well	MW
Not Applicable	NA

Operable Unit	OU
Paducah Gaseous Diffusion Plant	PGDP
Parts Per Billion	ppb
Portsmouth/Paducah Project Office	PPPO
PPPO Environmental Geographic Analytical Spatial Information System	PEGASIS
Polychlorinated Biphenyl	PCB
Radiation Health Branch	RHB
Requires Further Investigation	RFI
Record of Decision	ROD
Regional Groundwater Aquifer	RGA
Remedial Investigation/Feasibility Study	RI/FS
Resource Conservation and Recovery Act	RCRA
Site Management Plan	SMP
Solid Waste Management Unit	SWMU
Solid Waste Management Unit Assessment Report	SAR
Technetium-99	Tc-99
Tennessee Valley Authority	TVA
Total Suspended Solids	TSS
Trichloroethene	TCE
Upper Continental Recharge System	UCRS
United States Enrichment Corporation	USEC
University of Kentucky Research Consortium for Energy and the Environment	KRCEE
Volatile Organic Compound	VOC
West Kentucky Wildlife Management Area	WKWMA
Work Plan	WP

Introduction

In July 2013, the Paducah Gaseous Diffusion Plant (PGDP) ended over 60 years of continuous uranium enrichment production. Today, the United States Department of Energy (DOE) oversees environmental cleanup activities at the site, including environmental management, waste management, depleted uranium hexafluoride conversion, deactivation, decontamination, and decommissioning. The PGDP is located on a 3,556-acre federal reservation in northwestern McCracken County, Kentucky. Most of the historical and ongoing operations at the PGDP occur within a footprint the size of approximately 750 acres. This area is surrounded and bounded by the West Kentucky Wildlife Management Area (WKWMA) to the north, east and west. Since construction, the PGDP has been owned by the DOE or its predecessor U.S. government agencies. The United States Enrichment Corporation (USEC) was responsible for the operation and maintenance of the PGDP production facilities from July 1993 to October 2014. Although DOE retains ultimate responsibility for environmental restoration and waste management, DOE has employed a series of support contractor teams to assist with the implementation of various activities at the site. Four Rivers Nuclear Partnership was the deactivation and environmental remediation contractor during calendar year (CY) 2021.

A variety of environmental concerns have been identified at the site since 1988. Historical PGDP activities have adversely affected soil, sediment, surface water and groundwater. Groundwater sampling and analyses have detected concentrations of primarily trichloroethene (TCE) and technetium-99 (Tc-99), a radioactive by-product of historic PGDP process operations. Soil and sediment sampling analyses have detected the presence of polychlorinated biphenyls (PCBs) and uranium. In addition, historic surface water studies have documented polychlorinated biphenyl (PCB) concentrations in fish collected from both, Bayou Creek to the west of the site, and Little Bayou Creek to the east of the site.

Site cleanup activities are prioritized and sequenced in the fiscal year (FY) 2021/2022 Site Management Plan (SMP). Activities focus on environmental investigations to determine if any impacts or releases have occurred to the environment within the 750-acre Paducah Site that have yet to be investigated or were previously inaccessible. Field

activities associated with the C-400 Complex Operable Unit (OU) pertaining to the Remedial Investigation/Feasibility Study (RI/FS) Work Plan (WP), was the primary environmental focus during 2021.

At the Paducah Site, media-specific operable units (OU) were established by developing a site conceptual risk model for each solid waste management unit (SWMU) and Area of Concern (AOC). This process included a qualitative evaluation of contaminant types and concentrations, release mechanisms, likely exposure pathways, estimated points of exposure, and potential receptors. Potential receptors included current and reasonably foreseeable future land-use assumptions in the evaluation.

The OUs (based on the 2021/2022 SMP) identified for the Paducah Site are:

- C-400 Complex OU
- Groundwater OU
- Surface Water OU
- Soils OU
- Soils and Slabs OU (note: contains 17 Geographical Areas (GA))
- Burial Grounds OU
- Decontamination and Decommissioning OU (Remaining Balance of Facilities)
- Lagoons OU
- Depleted Uranium Hexafluoride (DUF_6) Footprint Underlying Soils OU (DUFUS)
- CERCLA Waste Disposal Alternatives Operable Unit
- Comprehensive Site Operable Unit (CSOU)

A final CSOU evaluation will occur at PGDP following completion of the remaining OUs.

Public Engagement

Citizens Advisory Board

The Paducah Citizens Advisory Board (CAB) is a stakeholders' board that provides advice and recommendations to DOE regarding environmental management programs at the Paducah Site. It is their responsibility to represent and communicate the views of their community as well as keep the public informed on key issues, upcoming decisions and

board recommendations. Kentucky's Division of Waste Management (DWM) and Cabinet for Health and Family Services (CHFS) are non-voting (ex-officio) members that serve as advisors and inform the CAB on their respective agencies' policies and views. The CAB is a local board organized under the umbrella charter of the Office of Environmental Management Site-Specific Advisory Board, whose activities are governed by the Federal Advisory Committee Act (FACA). The website for the Paducah CAB can be found at: https://www.energy.gov/pppo/pgdp-cab/paducah-citizens-advisory-board.

Full board CAB meetings and CAB educational meetings are held on alternating months, the third Thursday of every month. Multiple representatives from Kentucky (AIP and FFA) routinely attend these meetings. The full board and educational meetings allow for meaningful interaction between the CAB board members and any members of the general public that choose to attend. Four CAB meetings were conducted in 2021. The first three of these meetings were held virtually due to covid-19 concerns. During the meeting on March 18, 2021, recent accomplishments at the site (including the installation of a dry hybrid fire suppression system) were outlined, and discussions were held regarding developing a guide for DOE to augment outreach programs and creating a 10-year vision of expectations for EM to interact with the local community and stakeholders. This theme was further expanded upon in the meeting held June 17, 2021, when suggestions were made for improving stakeholder interactions by developing a groundwater treatment success story and developing metrics to identify removal of contamination while downsizing site infrastructure. During the meeting on September 29, 2021, plans were made for developing the CAB 2022 Work Plan. During the November 29, 2021 meeting a Draft Groundwater Contamination Treatment Storyboard was unveiled.

Oversight Newsletter

The Kentucky Department for Environmental Protection (KDEP) Paducah Site Section releases periodic newsletters titled *Oversight News*. The newsletters are an effort to better inform the public and stakeholders about available resources and significant updates at the Paducah Site. Major features in the newsletters cover topics such as communication efforts by DOE and Kentucky's Energy and Environment Cabinet (EEC), Radiation Health Branch (RHB) monitoring, updates on the northwest and northeast

plumes, historical actions and future planning for the C-400 Complex, and activities held at the WKWMA surrounding the PGDP. The newsletter also features Paducah Site Section staff changes whenever applicable.

During 2021, no editions of Oversight News were issued. Due to the pandemic, delays and slowdown of work at the site, no reports were generated during 2021.

Kentucky's Oversight Program

The Commonwealth of Kentucky (Kentucky) is responsible for overseeing the environmental cleanup of the PGDP and protecting human health and the environment. The EEC has designated the Hazardous Waste Branch (HWB) within the Division of Waste Management (DWM) to serve as the lead agency to coordinate this oversight and to implement both the Agreement in Principle (AIP) and the Federal Facility Agreement (FFA) federal grant programs for Kentucky. The CHFS RHB has radiation authority for Kentucky and serves a critical role in implementing these two oversight programs. State agencies and other organizations assisting the HWB and RHB with various types of activities and oversight responsibilities include:

- Division of Waste Management (DWM)
- Division of Water (DOW)
- Division for Air Quality (DAQ)
- Office of Legal Services (OLS)
- Kentucky Department of Fish and Wildlife Resources (KDFWR)
- University of Kentucky Research Consortium Energy and Environment (KRCEE)
- Division of Environmental Program Support Lab
- Radiation Health Branch Radiation/Environmental Monitoring Section
- Program Planning and Administration Branch

For the purposes of this report, all references to activities conducted by the Paducah Gaseous Diffusion Plant (Paducah Site) Section, within the DWM, will be referred to as Kentucky. References to activities by other state government agencies that are not part of the EEC (and in some cases, not part of DWM) will be specified as appropriate.

Coordination with Kentucky's government agencies, federal agencies and citizen's groups is another important function of the Paducah Site Section. Kentucky regularly cooperates and interacts with the U.S. DOE, the U.S. Environmental Protection Agency (EPA), and the Paducah CAB. Kentucky is an active participant in federal facility DOE inter-governmental groups associated with the National Governor's Association Federal Facilities Task Force, the National Conference of State Legislatures' State and Tribal Government Working Group, the Environmental Council of the States, and the EPA's Federal Facilities Forum.

Federal Facility Agreement (FFA) / Site Management Plan (SMP)

The FFA is a three-party agreement between DOE Portsmouth/Paducah Project Office (PPPO), EPA Region 4, and the KDEP. The FFA was developed to ensure compliance with, and to avoid duplication between, the cleanup provisions of the Resource Conservation and Recovery Act (RCRA) and those of CERCLA. Moreover, the FFA outlines regulatory structure and guides interactions between the three parties. The FFA allows Kentucky and EPA to address contaminated areas at the PGDP that are not subject to permitting but nonetheless require investigation and remediation. The FFA also provides a framework for project management, investigation, dispute resolution, and remediation.

The SMP establishes the clean-up priorities, planning dates, and enforceable milestones for the current fiscal year (FY) and the next two FYs. The SMP is evaluated and scoped annually. Once approved it becomes part of the FFA as an appendix. If the three parties to the FFA cannot agree on the current year's SMP, then the last approvable SMP remains in effect. The SMP also documents the three-party prioritization strategy for the complete remediation of the PGDP in a life-cycle baseline and life-cycle plan. The FFA parties meet to scope revisions for the document in the months leading up to DOE's annual transmittal deadline on November 15.

In early August 2017, the senior managers of DOE PPPO, EPA Region 4, and KDEP signed a Memorandum of Agreement (MOA) to reconfigure the sequence of all environmental remediation work at the Paducah Site. DOE identified and initiated resequencing efforts in April/May 2016. While several factors influenced DOE's

conclusion, the main factor was that DOE regained control of the Gaseous Diffusion Plant facilities in 2014, making the C-400 building accessible to investigate and clean-up.

The C-400 building has long been understood as the main source of the two ~four-mile long TCE groundwater (dissolved phase) contamination plumes, commonly identified as the Northeast and Northwest Plumes. These groundwater plumes are the longest known contamination plumes leaving any DOE property within the United States and therefore constitute the main risk to human health and the environment associated with the Paducah Site. In 1989 DOE established an administrative geographical boundary called the Water Policy Box. Within this geographic area, DOE offered free hookups to the municipal water supply. To clean up contamination associated with the C-400 Complex Operable Unit (OU), a comprehensive investigation of the area beneath and around the C-400 building must be performed. This investigation set out in 2020 to define all sources of contamination and how each contaminant is distributed spatially (vertically and laterally) beneath the C-400 Complex OU.

In order to accomplish a comprehensive investigation of the C-400 Complex OU, the senior managers of the FFA agreed that the C-400 building would be demolished to slab by the first quarter of 2019. The plan being that once the building was down, then the area would be more accessible to heavy drilling equipment. Multiple documents for demolishing the C-400 building were submitted by DOE, which were not approved by the EPA. Multiple meetings occurred regarding the characterization of existing contamination within the multiple basement areas that exist in the C-400 building.

The C-400 MOA was not signed until August 2017 and at that time the senior managers agreed not to finalize a 2017 SMP, but instead to concentrate efforts toward a 2018 SMP. The draft 2018 SMP was scoped over several meetings with an independent technical facilitator to capture and guide discussions. The draft 2018 SMP was rewritten to incorporate the pre-GDP OUs with the post-GDP OUs. The C-400 Complex OU was one of the new OUs created. The draft 2018 SMP was scoped by all three parties without the benefit of a DOE-Headquarters approved Life Cycle Baseline (LCB). This resulted in an initial draft 2018 SMP that consisted of >90% of all out-year planning dates labelled as TBD (To Be Determined). Once DOE received permission from their own headquarters

to reveal dates in their LCB, the PGDP project completion date slid from 2032 to >2065. All remaining environmental projects, except the C-400 Complex OU and the area directly north of the C-720 “Machine Shop” Building, referred to as SWMU 211-A, were moved out decades into the future.

The C-400 building is the main source of the two four-mile long TCE groundwater contamination plumes, commonly identified as the Northeast and Northwest Plumes. In order to clean up contamination at the C-400 complex, an exhaustive investigation of the nature and extent of contamination was needed to set the parameters for, and delineate the cleanup project area, beneath and surrounding the C-400 building. Scoping meetings for the investigation work plan, to be completed in a Remedial Investigation / Feasibility Study (RI/FS) Work Plan, began in 2018 and concluded in 2019. During the scoping process, sample locations were identified; concepts and data needs were determined; technical exchanges of investigation methods were discussed; and concerns relating to RI/FS Work Plan development were resolved.

Through meetings, discussions, and correspondence during the scoping process the DOE, EPA, and KDEP were able to mutually agree to the scope of the RI/FS Work Plan which received final approval from EPA and KDEP on October 7, 2019. The DOE announced implementation of the RI/FS Work Plan fieldwork on November 7, 2019. Initial field activities in the C-400 Complex OU included gamma walkover surveys, maintenance/redevelopment of existing monitoring wells, obstacle/infrastructure removal at designated sampling locations, and ground marking of drill locations and underground utilities. Installation of new monitoring wells began on March 3, 2020, and borings for soil samples commenced on March 10, 2020. Field activities were completed on December 3, 2021, with ~800 soil samples collected, ~130 groundwater samples collected, and 18 monitoring wells installed.

On December 5, 2019, DOE issued for review and comment the Remedial Action Work Plan for the SWMU 211-A Enhanced In-Situ Bioremediation for Volatile Organic Compounds. Following a review and resolution of comments on this document, KDEP issued concurrence for the RAWP on May 27, 2020. DOE entered informal dispute resolution due to conditions of approval from EPA on the RAWP about the area of

contamination, on-site disposal, and radiological effluent limits. Negotiations to resolve the informal dispute continued through 2021 with KDWM granting approval of the final revision to the RAWP on December 17, 2021.

Site Management Plan Documents Reviewed In 2021

FY 2021 Site Management Plan (2450&D1), dated November 6, 2020. Kentucky and the EPA approved the D1 on November 6 and November 16, 2020, respectively.

Agreement in Principle (AIP)

Under the AIP program, Kentucky conducts independent environmental monitoring activities and oversees DOE monitoring activities and procedures. Additionally, the program serves to disseminate information relevant to ongoing site cleanup activities to concerned citizens and the public in general. During 2021, AIP personnel wrote and distributed the 2021 Annual Strategic Environmental Sampling Plan and submitted both the 2019 Environmental Oversight Annual Report and the 2014-19 Environmental Oversight 5-Year Summary Grant Close-Out Report. Electronic copies documents listed above are available at https://eec.ky.gov/Environmental-Protection/Waste/hazardous-waste/Pages/paducah-gaseous-diffusion-plant.aspx. A fundamental task of the AIP program allows Kentucky to conduct independent and impartial assessments of the potential environmental impacts of past, present, and future DOE activities at the PGDP.

Kentucky AIP Program Sampling for 2021

One of the primary goals of the AIP is to monitor and evaluate current site activities through sampling and observation, as well as to identify possible threats to human health and the environment. The secondary goal is to independently verify data collected by DOE contractors to ensure data quality. To achieve these goals, AIP staff routinely observe DOE facilities and operations to identify environmental issues or concerns. Any resulting observations or findings of significant conditions or practices are brought to DOE's attention for review.

AIP staff collect independent environmental samples (soil, surface water, air, and groundwater) and split samples with DOE contractors. Over the years, AIP staff has also worked with organizations, such as the University of Kentucky, in conducting scientific research apart from DOE cleanup and monitoring efforts. Some of the research involved collecting environmental samples. Samples collected by AIP, and by independent researchers working with AIP, are routinely sent to laboratories under contract to the AIP program (all laboratories are independent of US DOE) or, in the case of independent researchers, selected by the researcher. AIP sampling includes the collection of groundwater samples (at the request of nearby property owners) from private residential

wells to inform the public of current groundwater conditions. AIP personnel also splits environmental media samples (primarily groundwater) to independently validate DOE's sampling results. Historically, AIP has split tissue samples collected from animals living near the PGDP to monitor any potential impact to the biota.

During 2021, AIP independently contracted with TestAmerica Laboratories located in Earth City, Missouri, McCoy & McCoy Pace Analytical Laboratories located in Madisonville, KY, and used two State Laboratories - the Kentucky Department for Environmental Protection Laboratory and the Cabinet for Health and Family Services' Radiation Health Branch Laboratory, both of Frankfort, Kentucky. All three laboratories are independent (of DOE) laboratories. The CHFS RHB laboratory analyzes groundwater samples, as well as air and surface water samples for gross alpha and gross beta concentrations, and gamma spectroscopy. If trigger levels for gross alpha and/or gross beta are exceeded, then CHFS will analyze the sample for isotopic radionuclides. AIP staff directly receives all analytical data from TestAmerica, McCoy & McCoy Pace Analytical, the KDEP Laboratory, and CHFS. The results are verified and shared formally by Kentucky AIP staff electronically in the formats specified by the DOE and their contractors. DOE developed a public website to share environmental data with the public. Analytical results collected by Kentucky AIP and DOE contractors can be searched, viewed spatially, and downloaded on the PPPO Environmental Geographic Analytical Spatial Information System, referred to as PEGASIS.

AIP Groundwater Investigations

Groundwater Sampling

During 2021, AIP staff collected 102 samples from 91 different monitoring wells and 4 samples from different residential wells. The 2021 AIP monitoring wells and seep sampling locations map (Figure 1) and residential well sampling map (Figure 2) shows all groundwater related locations sampled during the 2021 reporting period. Most of the wells sampled were located within two miles from PGDP groundwater plumes and/or less than two miles from the PGDP property boundary. Kentucky AIP environmental sampling results provide a line of evidence that supports validation of DOE data collection procedures and confirms that DOE analytical laboratory results are accurate,

reproducible, and independently verifiable. AIP independent oversight of DOE's groundwater sampling program also helps to ensure that analytical results used to construct contaminant plume maps are accurate.

In 2021, AIP staff split water samples with DOE Contractors from 20 monitoring wells. Also, an additional two field replicates were split with DOE Contractors. In most cases, AIP staff arranged to split groundwater samples with DOE during their scheduled sampling activities. These sampling events were conducted to evaluate and substantiate that DOE contractors are following their own sampling procedures and to verify the quality and accuracy of their laboratory analyses. AIP also reviews DOE Contractor procedures to insure they are scientifically sound and in compliance with EPA guidance. AIP samples were shipped to independent analytical laboratories (not affiliated with DOE) and split-sampling results demonstrated a general similarity between those samples collected and analyzed by independent laboratories and those collected and analyzed by DOE Contractors (Table 1). Of the 20 monitoring well samples split between AIP and DOE Contractors in 2021, most had similar trichloroethene (TCE) and Technetium 99 (Tc-99) concentrations (Table 1).

Seeps Sampled by Kentucky AIP

At the beginning of 2021, 7 seeps in Little Bayou Creek were a part of Kentucky's sampling program. These seeps are located where groundwater is observable (upwelling) in a channelized portion of LBC. The locations of the seeps can move by several feet over time and have been known to even disappear for long periods of time. The base flow in LBC is comprised primarily of discharges from plant outfalls. These seeps are located downstream of the Paducah Site, approximately two miles south from the plant and approximately two miles from northeast of the confluence of LBC and the Ohio River. AIP staff check the LBC seep area monthly for any migrating and/or new seeps.

During an AIP walk down of LBC in July 2021, AIP Staff reported changes of the LBC seep area rendering LBCSP8 (Seep 8) inaccessible. TCE concentrations in the seeps, sampled simultaneously, ranged from < 0.593 ug/l to 1.36 ug/L. Tc-99 concentrations in the seeps ranged from < 9.42 pCi/L to 12.7 pCi/L. Samples from Seep 8 were not

obtained in 2021 due to the seep shifting from a near surface location within the creek bed to a deeper location within the creek.

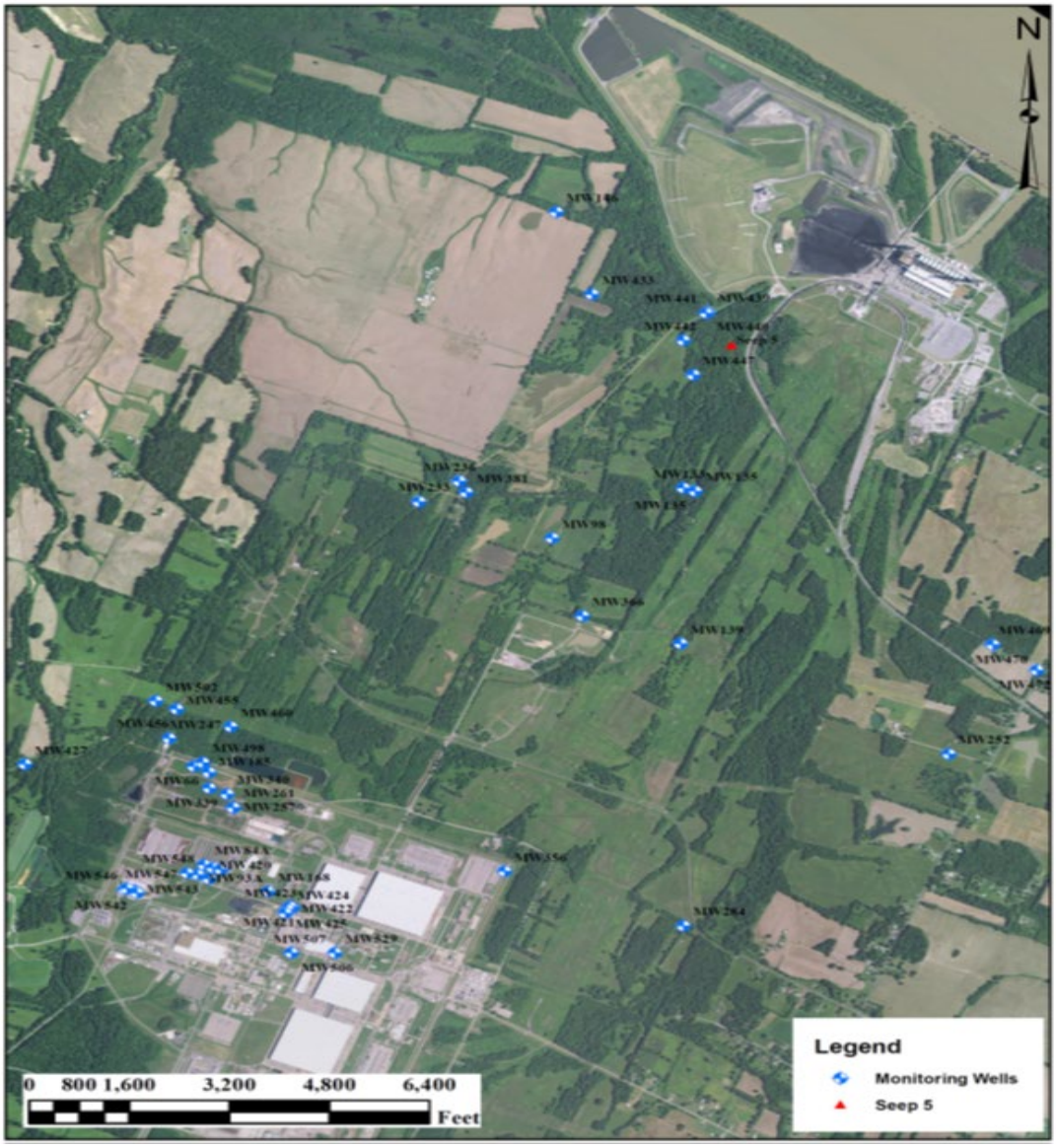

Figure 1. AIP 2021 MWs and Seep Sampling Locations

Figure 2. AIP 2021 Residential Well Sampling Locations

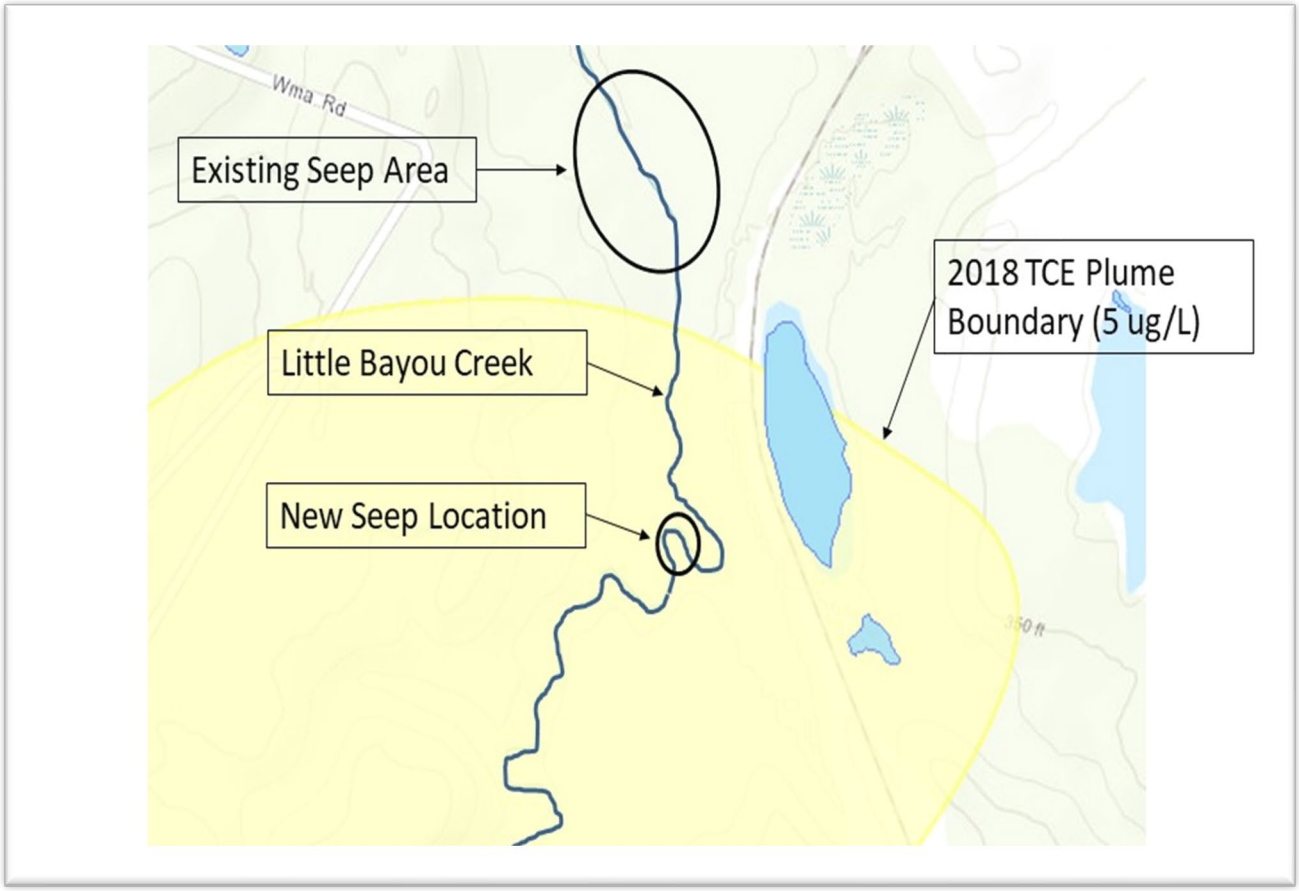

Figure 3: Location of Newly Discovered Seep #8

		AIP: TCE µg/L		DOE: TCE µg/L		AIP: Tc-99 pCi/L		DOE Tc-99 pCi/L	
Well #	Sample Date	Value and/or Qualifier	DL	Value and/or Qualifier	DL	Value and Uncertainty	MDA	Value and Uncertainty	MDA
MW455	3/16/21	23.3	0.5	24.1	1	N/A	N/A	7.91 +/- 7.02 (U)	11.7
MW456	3/16/21	4.31	0.5	5.33	1	N/A	N/A	-0.0413 +/- 6.71 (U)	11.6
MW161	5/11/21	230	100	248	5	7.90 +/- 1.18	3.72	-1.38 +/- 9.17 (U)	16
MW557	7/8/21	5,620	0.5	N/A	N/A	-6.60 +/- 1.22	4.17	N/A	N/A
MW558	7/8/21	1,330	0.5	N/A	N/A	8.64 +/- 1.31	4.17	N/A	N/A
MW559	7/8/21	1,230	0.5	N/A	N/A	43.2 +/- 1.50	4.17	N/A	N/A
MW559X	7/8/21	1,140	0.5	N/A	N/A	42.5 +/- 1.50	4.17	N/A	N/A
MW563	7/8/21	12,700	0.5	N/A	N/A	N/A	N/A	N/A	N/A
LBCSP5	8/12/21	0.704	0.5	0.54 (U)	1	-5.00 +/- 1.18	4.01	N/A	N/A
LBCSP5X	8/12/21	0.688	0.5	0.66 (U)	1	-4.77 +/- 1.18	4.01	N/A	N/A
MW339	9/21/21	567	5	1,840	20	24.8 +/- 1.41	4.19	44 +/- 9.4	14.1
MW66	9/21/21	814	5	845	10	226 +/- 2.22	4.19	263 +/- 13	12.8
MW572	10/20/21	716	12.5	N/A	N/A	107 +/- 1.67	3.62	N/A	N/A
MW574	10/20/21	1,850	25	N/A	N/A	657 +/- 3.31	3.62	N/A	N/A
MW573	10/20/21	8,120	50	N/A	N/A	71.6 +/- 1.51	3.62	N/A	N/A
MW566	10/20/21	585	12.5	N/A	N/A	61.1 +/- 1.45	3.62	N/A	N/A
MW567	10/20/21	3,500	25	N/A	N/A	25.1 +/- 1.26	3.62	N/A	N/A
MW568	10/20/21	4,230	25	N/A	N/A	54.2 +/- 1.42	3.62	N/A	N/A
MW84A	11/29/21	6,560	50	N/A	N/A	120 +/- 1.74	3.69	258 +/- 17.8	20
MW84AX	11/29/21	7,240	50	N/A	N/A	195 +/- 2.04	3.69	249 +/- 17.2	19.4
MW87A	11/29/21	2,060	50	N/A	N/A	12.1 +/- 1.20	3.69	11.6 +/- 10.9 (U)	18.2
MW90A	11/29/21	167	0.5	N/A	N/A	13.9 +/- 1.21	3.69	15.7 +/- 11 (U)	18.1
MW420	11/29/21	1,650	5	N/A	N/A	N/A	N/A	12.4 +/- 11.2 (U)	18.8
MW93A	11/29/21	2,920	50	N/A	N/A	12.5 +/- 1.20	3.69	10.6 +/- 11.1 (U)	18.5

In Tc-99 samples, +/- represents the uncertainty in the measurement.

Kentucky samples were analyzed by TestAmerica of St. Louis and the Kentucky Radiation Health Branch.

[1]A field replicate was also analyzed. The higher of the two results is shown.

DL – Detection Limit

J – Estimated Quantitation

MDA – Minimum Detectable Activity

NA – Not applicable. Technetium-99 was not analyzed because the following criteria were not met:

Gross Alpha ≥ 5 pCi/L and Gross Beta ≥ 9 pCi/L

NS – Not sampled

U – TCE: Not detected; Tc-99: Value reported is <MDA and/or TPU.

Table 1: 2021 Split-Sampling Results between EEC AIP & DOE

NW and NE Plume Extraction Wells Area of Influence / Cone of Depression Assessments

Northwest Plume Extraction Wells

AIP personnel did not collect independent water levels surrounding the Northwest Plume Extraction Wells during 2021. The most recent AIP cone of depression interpretation, based off AIP groundwater levels surrounding the Northwest Plume, is presented as Figure 4. EW232 and EW233 went online in August 2010, after being relocated further east from their dormant predecessors EW230 and EW231. The optimized EW232 and EW233 were moved to account for an observed eastward shift of the high concentration portion of the NW plume. The optimized extraction wells each have 20-foot screens with the intake pumps located roughly 8 feet below the top of each well screen. The depth below ground surface for the pump intake at EW232 is 74.5ft and for EW233 it is 81.5ft. The lowest portion of the Regional Groundwater Aquifer (RGA) at EW232 is 88.8ft and at EW233 it is 95.7ft. AIP has conducted the water level monitoring for the last several years to evaluate the potential for high concentration TCE bypass under and around EW232 and/or EW233. TCE concentrations in the RGA (upper, middle, lower), surrounding the extraction wells were also evaluated. Four of these monitoring wells are compared in Figure 5. These four monitoring wells illustrate that overall concentrations are decreasing over the period from 2009 - 2019. Concentrations of TCE have risen slightly in MW261 and MW339 in both 2020 and 2021. Concentrations of TCE slightly decreased in MW498 in 2020 and then rose to above 2019 concentrations in 2021. Concentrations of TCE in MW340 decreased significantly in 2020, but in 2021 rebounded to approximately the same concentrations as detected in 2019.

Generally, TCE concentrations in the NW Plume monitoring wells near the extraction wells have stabilized in the last two to four years. In 2021, the NW plume extraction wells pumped 102,440,547 gallons of water. On the west side of the NW plume, MW248, MW250, and MW456 have shown decreasing TCE concentrations. Over the same period, TCE concentrations in proximal deep downgradient wells also appear to be trending down. AIP has speculated that the higher concentrations of TCE (dissolved phase) are by-passing the extraction wells. DOE conducted their own evaluation of the

two NW Plume extraction wells in a white paper entitled *Evaluation of TCE Trends in MW460* where they independently concluded "that the likely condition is that the Northwest Plume is bypassing the EW232/EW233 well field within the lower RGA." The same white paper provided an alternative explanation for elevated TCE concentrations in MW460 as being residual downgradient TCE concentrations being pulled upgradient. The white paper also noted that higher concentrations (centroid) of TCE have shifted towards the east since 2010.

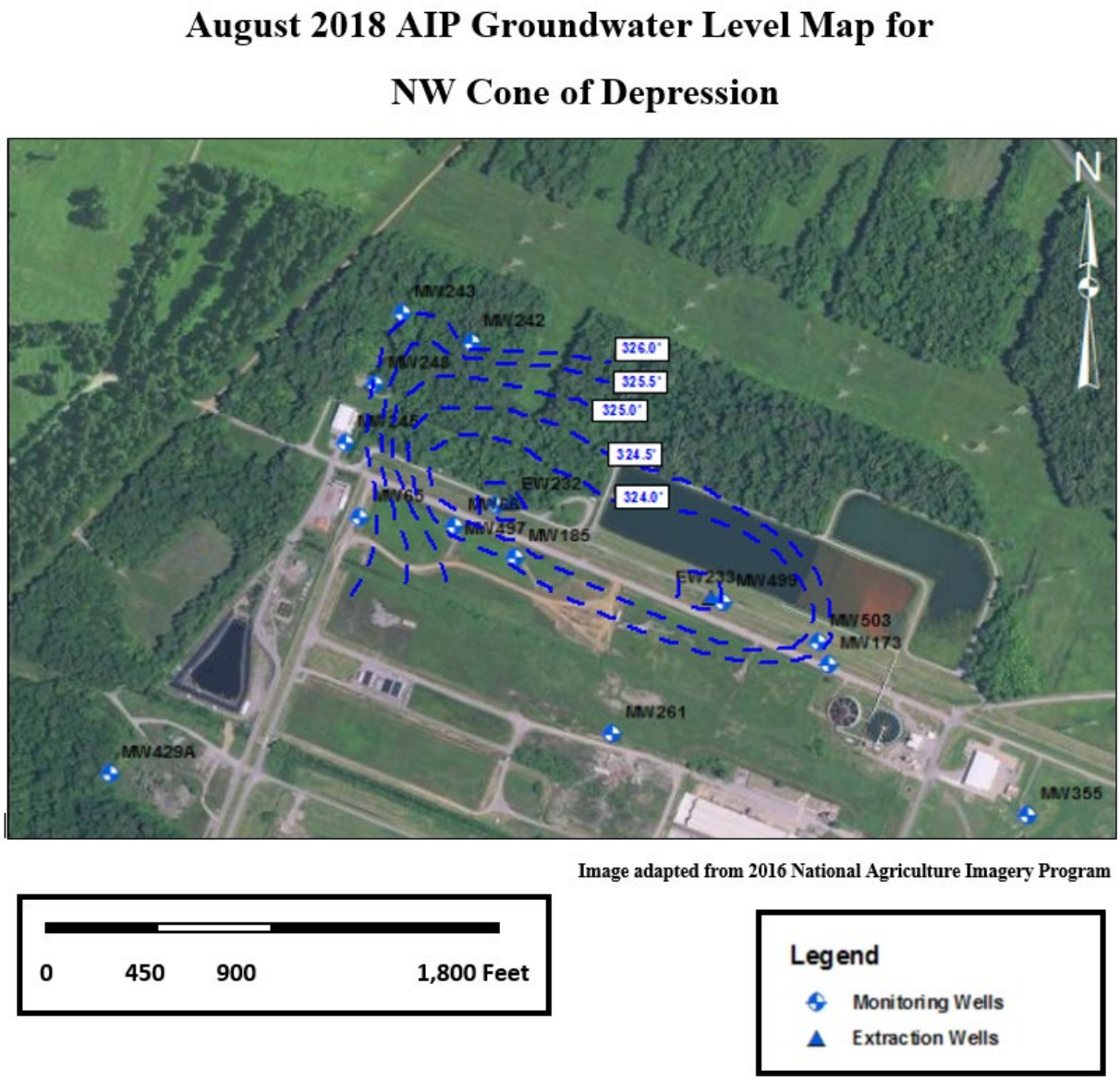

Figure 4. Northwest Groundwater Cone of Depression

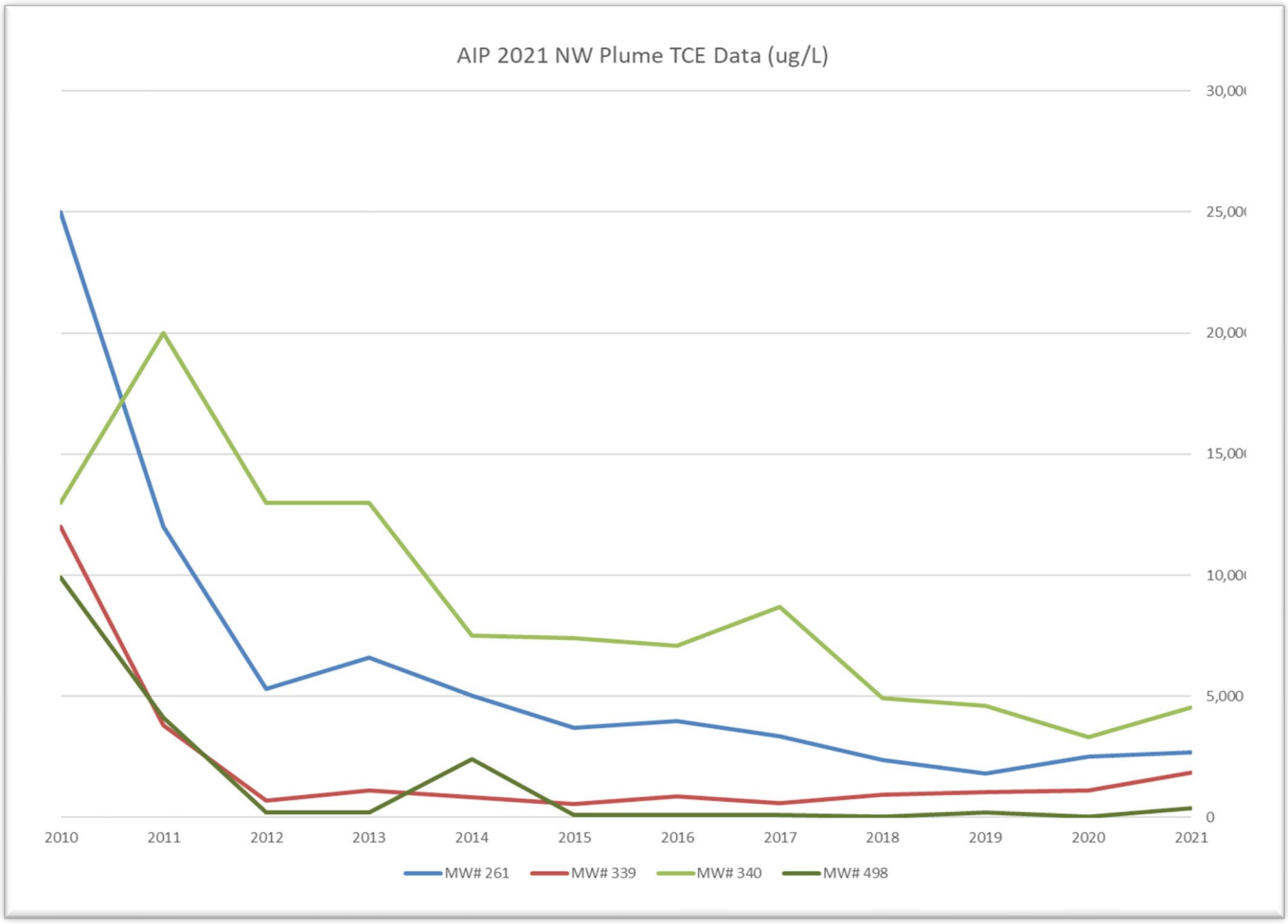

Figure 5. Northwest Plume TCE Data

Northeast Plume Extraction Wells

During the 2021 reporting period, the Northeast extraction wells (EW234 and EW235) removed 82,053,413 gallons of water and 2,096,226,038 gallons since becoming operational. AIP personnel did not complete a comprehensive water level synoptic event surrounding the Northeast extraction well field during 2021, but the most recent synoptic water level measurements, collected by AIP personnel, is presented as Figure 6. Water elevation measurements (August 2018) were plotted to visualize the cone of depression present around EW234 and EW235 extraction wells.

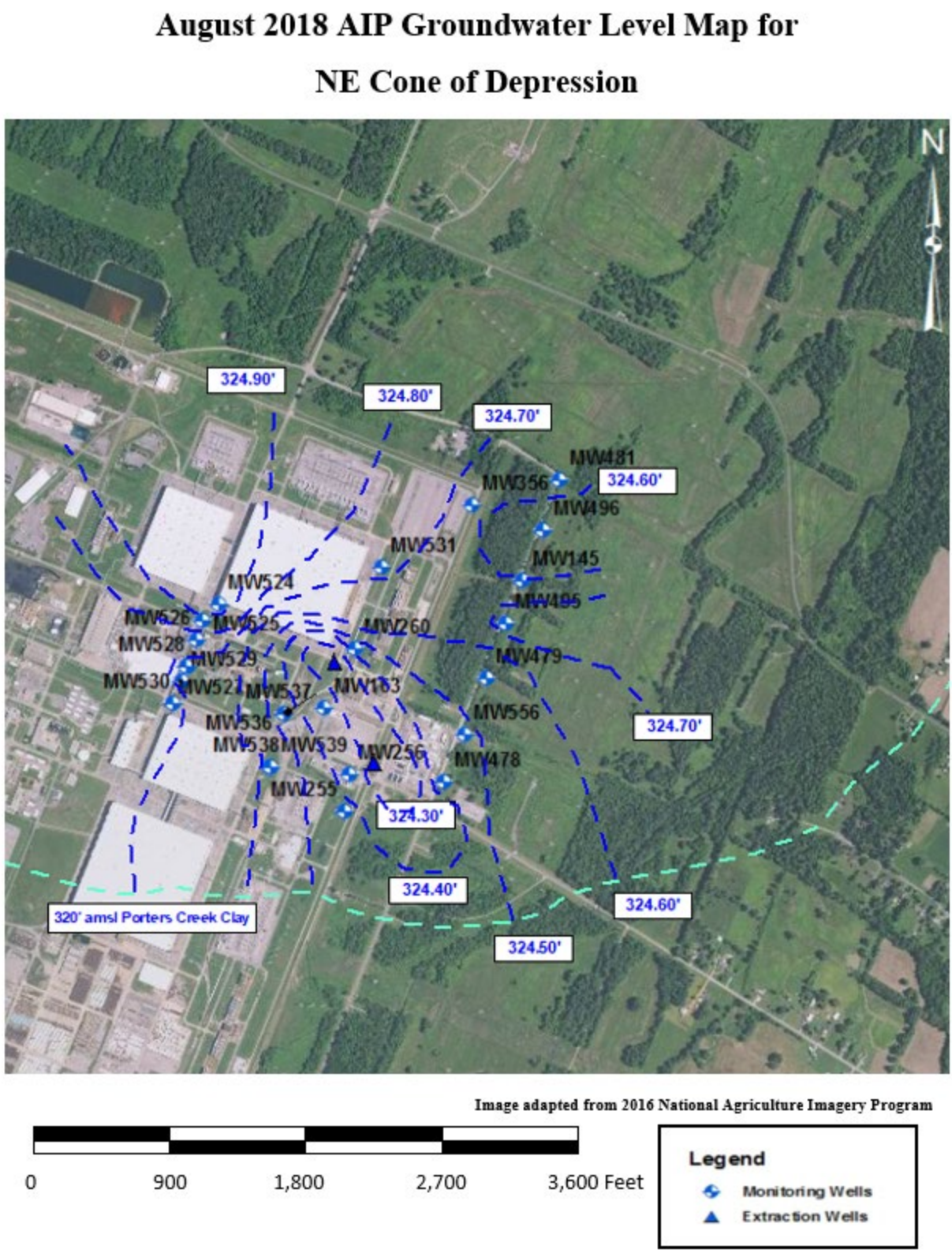

Figure 6. Northeast Groundwater Cone of Depression

EW234 and EW235 were installed as an optimization effort to the northeast system and officially started pumping October 10, 2017. The original wells EW331 and EW332 were placed in stand-by mode. The new extraction wells were installed to increase TCE mass removal, enhance control of the northeast plume migration at the eastern edge of the facility, and reduce further offsite migration.

Sampling results for several of the northeast plume transect monitoring wells, located ~800 ft east of the C-400 Building revealed increasing TCE concentration trends in 2018. Once increasing TCE trends were observed, DOE consulted with KDEP and EPA which resulted in a reduction to pumping rates on June 14, 2018. TCE increased in MW526 from the established baseline concentration of 267 µg/L to 2,790 µg/L in 2018, then drastically decreased in 2019 where it fluctuated between 1,250 µg/L and 1,460 µg/L. Results from four sampling events from MW526 during 2020 yielded results of 3,180 µg/L, 2,520 µg/L, 2,800 µg/L and 2,680 µg/L, in chronological order. Quarterly sampling results collected in 2021 yielded results of 2,890 µg/L, 2,950 µg/L (duplicate of 2,820 µg/L), 2,750 µg/L, and finally 1,940 µg/L. These results can be interpreted as generally stable compared to 2020 results apart from the last sample results being a significant reduction. Similarly, TCE levels in MW529 (baseline concentration of 130 µg/L) increased to 3,070 µg/L in 2018, continued to increase to 6,380 µg/L, and then peaked at 8,320 µg/L in July 2019. On the last quarterly sampling event in 2019, MW529 experienced a 50% reduction in TCE concentrations with a result of 4,150 µg/L. The four samples collected in 2020, chronologically, yielded results of 4,020 µg/L, 5,880 µg/L, 3,240 µg/L and 3,180 ug/L, an overall trend of reduction from 2019 results. The reduction in concentration trends continued in 2021, with concentrations of 3,230 µg/L, 4,730 µg/L, 3,650 µg/L, 2,560 µg/L (KY AIP) and 2,400 µg/L being detected. MW530 concentrations rose from 88.5 µg/L in early 2018 to 808 µg/L in June 2018. Results steadily dropped during the remainder of 2018 and throughout 2019 to a low of 269 µg/L. Results continued to steadily decline during each sampling event in 2020, with an early year concentration of 171 µg/L and a last sampling event yielding a result of 80.1 µg/L. The trend of reducing concentrations continued in 2021, with concentrations of 60.1 µg/L, 66.4 µg/L, 59.5 µg/L, and 39.2 µg/L being detected.

The reduced extraction system pumping rates initiated in mid-2018 appear to be mostly favorable in reducing the eastern migration of TCE from the C-400 Building Complex. Concentrations of TCE in MW526 were higher during all sampling events in 2020 than they were in 2019, and concentrations detected during 2021 were generally stable compared to those detected in 2020. Concentrations of TCE in MW529 peaked in July 2019 and exhibited a declining trend in concentration that continued through2021. Concentrations of TCE in MW530 showed a steady decline beginning in June 2018, and the decline continued through2021. Sampling results from MW529 and MW530 support the effectiveness of the lowered pumping rates in inhibiting mobilization of TCE from the C-400 Building Complex area. While concentrations in MW529 did peak in July 2019, this could be explained by a lag period where TCE had already mobilized eastward from the C-400 area prior to the reduction in pumping. Quarterly sampling of the transect wells by DOE contractors will continue to be monitored and pumping rates in one or both EWs can be further modified should future trends indicate continued mobilization.

TCE concentrations in the monitoring wells downgradient of EW234 and EW235 (MW145, MW478, MW479, MW495, and MW556) have varied. TCE concentrations in MW145 have fluctuated but remained within a range of 30 µg/L during the 2018-2021 period. Since April 2019, concentrations of TCE in MW478 have hovered around the 300 µg/L mark, and this trend continued through most of 2021 until concentrations rose to 380 µg/L in a sample collected in December. An overall reduction of concentrations trend in MW479 that began in late 2019 continued through 2021. All concentrations detected during 2021 were less than 2.2 µg/L. Results of five samples collected from MW495 during 2021 ranged from 222 µg/L to 257 µg/L, which was the first year since 2013 that TCE had not been detected above 300 µg/L. Samples were collected at four separate dates during 2021 from MW556, and concentrations of TCE in all four samples were lower than the lowest concentration detected during 2020. Monitoring of downgradient wells will continue to be performed by DOE field contractors on a routine basis. KY AIP staff will continue to observe, split, and independently sample MWs associated with the northeast plume monitoring well network.

C-400 Monitoring Wells Sampled by Kentucky AIP

Since July 2009, the AIP has monitored the effectiveness of various groundwater actions taken at C-400 by sampling all functional depths of the following downgradient multi-port monitoring wells: MW421, MW422, MW423, MW424 and MW425. These monitoring wells are in the vicinity of the northwest corner of the C-400 building and are used to compare TCE concentrations over time. Each of the monitoring wells contain three screened intervals corresponding to the upper (shallow), middle, and lower (deep) RGA zones. The AIP has collected samples from these downgradient wells since 2009 and tracked the associated chemical data to chart downgradient impact of the remediation efforts.

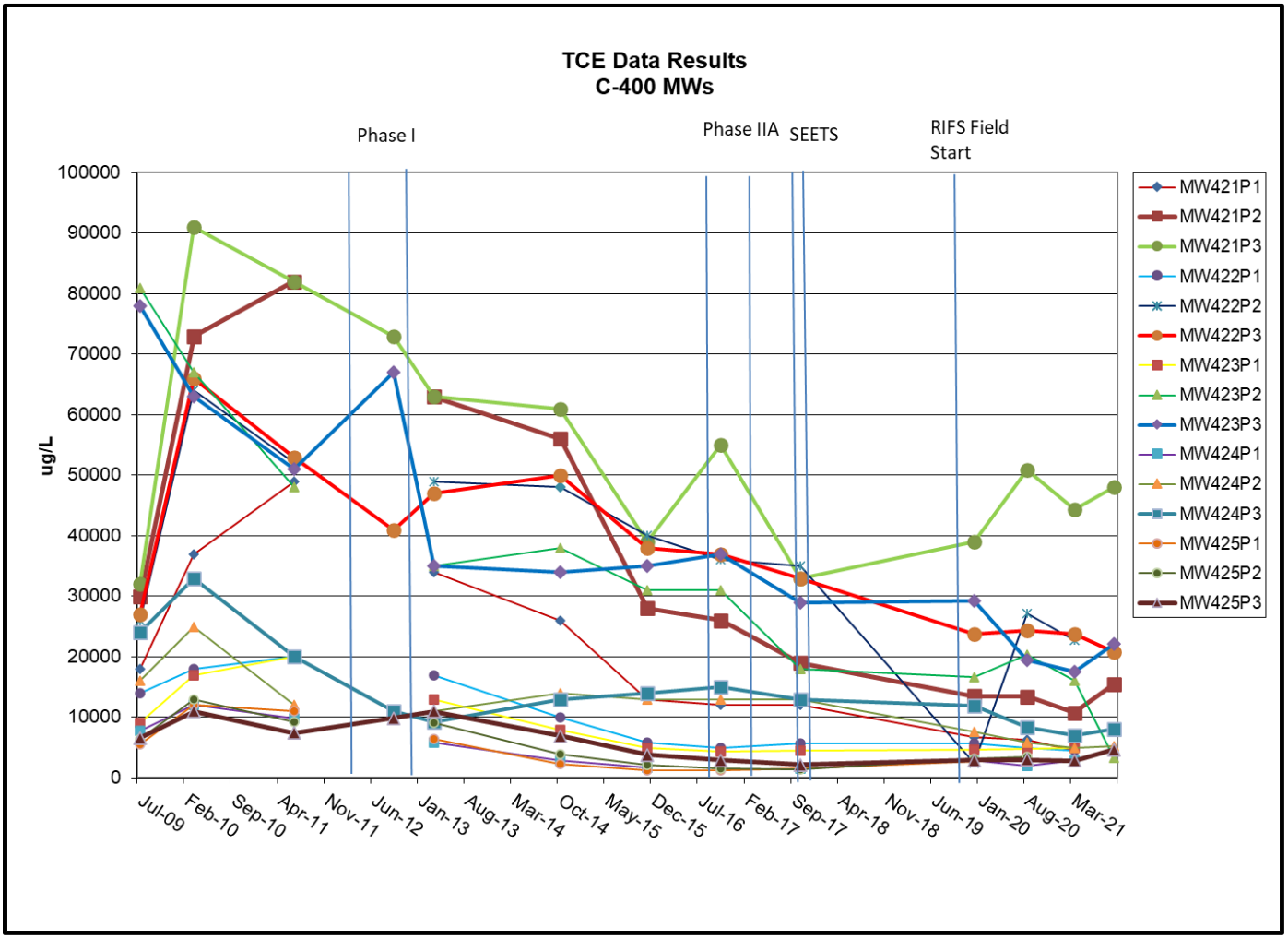

Figure 7. C-400 Monitoring Well TCE Data

AIP last collected split samples with DOE contractors from monitoring well clusters MW506 and MW507 in 2020. This well cluster is located hydraulically upgradient (south) of the C-400 remedial groundwater actions, (discussed in more detail below), taken to date. Each of the monitoring wells has a unique screened interval corresponding to the shallow, middle, and deep RGA zones. This monitoring well cluster provides a comparison to several downgradient multi-port monitoring wells.

Sampling efforts of both up- and down-gradient monitoring well clusters will resume in AIP's 2022 sampling schedule to monitor contaminant mobilization that will likely occur during implementation of C-400 Complex OU RI field activities. The C-400 RI field activities installed ~112 soil borings of multiple depths, ~18 monitoring wells, and ~50 contingency borings designated by consensus as a Membrane Interface Probe (MIP) or Dye-enhanced laser induced fluorescence system (DyeLIF) boring.

Several remedial actions have historically occurred around the C-400 Building to extract TCE from the subsurface. In 2003 a treatability study was conducted utilizing six-phase heating, a form of electrical resistance heating (ERH) which removed ~1,900 gallons (22,000 lbs.) of TCE. Phase I ERH became operational on March 29, 2010, and ran for seven months, removing ~535 gallons (6,525 lbs.) of TCE along the southern portions of the C-400 building. TCE concentrations in all downgradient wells showed a decline after the Phase I operational period. During Phase 2a, TCE totaling ~1,137 gallons (13,871 lbs.) was removed during ERH operation (Jan. 1 through Oct. 9, 2014). TCE concentrations also generally declined downgradient during the months and years following Phase 2a. In 2016 a treatability study utilizing steam enhanced extraction was conducted upgradient from the Phase IIb area and no extraction component was utilized. Increasing concentrations of TCE were observed in upgradient monitoring well cluster MW506 and MW507. The increase in TCE concentrations in the middle and lower RGA wells is suspected to be inadvertent mobilization, from southern portions of the Phase IIb area, during the Steam Enhanced Extraction Treatability Study in 2016. Concentrations leveled off in 2017 and trended downward through 2019. Sample results for MW506 and MW507 in 2020 maintained similar concentration levels since 2019.

Concentrations in the majority of downgradient C-400 monitoring wells continue to decline over time or remain relatively constant. An increase in concentration was noted in MW421

P3 in 2016, then decreased in 2017, and steadily increased throughout 2020. MW421 P3 is screened at a depth of 83 to 85 feet below ground surface (bgs). DOE data from 2011, 2012 and 2013 was used to supplement AIP data in this analysis. Only the deep wells, designated by P3, were sampled in 2012.

PGDP Sitewide Groundwater Flow Model

Groundwater models are used to help evaluate hydrogeologic systems to simulate and predict aquifer conditions and travel times. A groundwater model is a simplified mathematical representation of the subsurface hydrogeologic flow conditions at a site. The Paducah Gaseous Diffusion Plant (PGDP) Sitewide Groundwater Flow Model was created to develop a tool that can assist in evaluating potential remedies. The Groundwater Model Working Group is comprised of technical experts that work collaboratively to develop, discuss, evaluate, refine, modify, and make recommendations in support of potential groundwater related projects.

In a series of meetings, DOE, EPA, Kentucky, and their associated contractors worked together to revise the PGDP groundwater model to determine if additional data needs are necessary to support the evaluation of potential groundwater remedies. The first groundwater flow model at the PGDP was designed in 1990 and revised several times through 1997. A transport model was developed in 1997 and 1998. The next major revision to the model did not occur until 2008. That revision was developed to assist in determining additional data needs, evaluating potential remedies, calculating cleanup criteria, and developing inputs to design selected remedies. The model was further refined in 2012 to evaluate how potential variability in anthropogenic recharge rates (e.g., leaking water from plant utility lines) can influence groundwater flow and extraction well capture zone performance. Revisions to the 2016 model included revisions to the southern model boundary, refinement of anthropogenic recharge rates within the industrial area, upgradient Terrace Gravel recharge refinement, optimization of calibration periods by utilizing more complete synoptic water level datasets, refinement of lithologic/stratigraphic/hydrostratigraphic thickness intervals, and changing drain cells to river boundary cells in the lower reaches of Bayou and Little Bayou Creeks.

The PGDP groundwater model simulates flow within the Regional Gravel Aquifer (RGA)

and essentially ignores flow in both the Upper Continental Recharge System (UCRS) and the McNairy Formations - which are the units above and below the RGA, respectively. The UCRS conveys natural and anthropogenic recharge vertically to the RGA and an evaluation was conducted to identify UCRS lithologic areas with less than 2-ft of clay above the RGA, which also was near suspected areas of elevated anthropogenic recharge. The underlying McNairy Formation is represented in the model as a no-flow boundary. The model includes an upgradient zone which accounts for recharge (upgradient input) to the model along Terrace Gravel deposits.

Prior to 2010 water elevations collected at PGDP were collected during routine sampling events which typically occurred over several months. Water level elevations fluctuated over time which introduced uncertainty into all water level potentiometric surface interpretations/maps prior to 2010. In August 2010, DOE initiated synoptic water level events on an annual basis. A synoptic water level event occurs over a relatively short time period (1-3 days) when atmospheric conditions are expected to remain consistent. Subsequent revisions to the groundwater model include multiple sets of synoptic water level elevation events to test model predictions against actual recorded conditions.

DOE submitted the 2016 update of the PGDP Sitewide Groundwater Flow Model document to the regulators in April 2017, even though it is not subject to regulatory review and approval under the Federal Facilities Agreement (FFA). The 2016 update was the result of a collaborative approach and process undertaken by all three parties to the FFA, with an objective to represent and reflect groundwater flow conditions of the past, present, and future. The intent of the model update is to provide FFA decision makers with a tool that can predict how contamination will migrate in the RGA over time. Both Kentucky and EPA reviewed and provided comments and recommendations to be considered in the next groundwater model revision effort. The model will continue to be evaluated and updated periodically, as warranted. The Groundwater Modeling Group met virtually on a quarterly basis during 2020.

Efforts to collect additional water level data (based on recommendations) to refine the groundwater model proceeded in 2018. For the first time, fifteen monitoring wells belonging to and located on Tennessee Valley Authority (TVA) property were collected

by Kentucky AIP field staff as part of the sitewide synoptic water elevation monitoring event. The water level elevations (Table 2) were collected in 2021 by Kentucky AIP to enhance the DOE synoptic water level event that occurred during the same week. In 2019, Kentucky AIP discovered two more TVA wells, bringing the total of TVA wells to seventeen. TVA abandoned monitoring well TVA-D8A during the installation of the sheet-pile wall in August 2021. Synoptic water level events occurred in February, May, and November of 2021. TVA notified AIP Staff of elevation changes in multiple TVA monitoring wells that would impact the measurements collected during the August 2021 synoptic water level event. The water level measurements collected during the August was removed from the data set to preserve the integrity of the groundwater model. The data collected during the 2021 events was officially transmitted to DOE where it will be combined with the Paducah Site wells. The water level data will likely be used to refine future iterations of the groundwater model.

Well	OREIS Name	Measuring Point	Measured GW Elevation	Water Level	Date	Barometric Pressure (inHg)
TVAGW-6D	TVAGW-6D	368.8	320.08	48.72	2/22/2021	30.06
			321.42	47.38	5/24/2021	29.71
		372.77	318.43	54.34	11/16/2021	29.61
TVAGW-5D	TVAGW-5D	368.5	319.72	48.78	2/22/2021	30.06
			321.95	46.55	5/24/2021	29.71
		372.55	318.27	54.28	11/16/2021	29.61
TVAGW-4D	TVAGW-4D	365.8	319.7	46.10	2/22/2021	30.06
			323.98	41.82	5/24/2021	29.71
		369.26	318.16	51.10	11/16/2021	29.61
TVAGW-3D	TVAGW-3D	363.8	319.71	44.09	2/22/2021	30.05
			321.89	41.91	5/24/2021	29.71
		366.9	318.18	48.72	11/16/2021	29.61
TVAGW-2D	TVAGW-2D	370.0	324.46	45.54	2/22/2021	30.07
			326.66	43.34	5/24/2021	29.71
		372.82	323.12	49.70	11/16/2021	29.61
TVAGW-1D	TVAGW-1D	370.1	320.05	50.05	2/22/2021	30.05
			322.40	47.70	5/24/2021	29.72
		374.94	318.79	56.15	11/16/2021	29.61

TVA-D8A	SHF-D8A	331.82	317.42	14.4	2/22/2021	30.05
			325.32	6.50	5/24/2021	29.73
			Abandoned	N/A	August 2021	N/A
TVA-D75B	SHF-D75B	353.08	310.89	42.19	2/22/2021	30.05
			310.83	42.25	5/24/2021	29.67
			308.64	44.44	11/16/2021	29.51
TVA-D74B	SHF-D74B	332.16	309.90	22.26	2/22/2021	30.04
			308.79	23.37	5/24/2021	29.69
			307.76	24.40	11/16/2021	29.51
TVA-D30B	SHF-D30B	324.36	305.41	18.95	2/22/2021	30.04
			301.67	22.69	5/24/2021	29.69
			302.37	21.99	11/16/2021	29.52
TVA-D17	SHF-D17	365.43	317.00	48.43	2/22/2021	30.04
			319.27	46.16	5/24/2021	29.72
			315.67	49.76	11/16/2021	29.52
TVA-D11B	SHF-D11B	321.79	308.21	13.58	2/22/2021	30.05
			307.96	13.83	5/24/2021	29.70
			302.29	19.50	11/16/2021	29.52
TVA-D10	SHF-D10	351.74	311.76	39.98	2/22/2021	30.04
			307.79	43.95	5/24/2021	29.67
			304.86	46.88	11/16/2021	29.51
SHF-201C	SHF-201C	323.75	308.05	15.7	2/22/2021	30.03
			309.75	14.00	5/24/2021	29.71
			304.77	18.98	11/16/2021	29.53
SHF-201B	SHF-201B	323.75	308.20	15.55	2/22/2021	30.03
			309.79	13.96	5/24/2021	29.71
			305.00	18.75	11/16/2021	29.53
SHF201A	SHF201A	323.75	307.96	15.79	2/22/2021	30.03
			309.73	14.02	5/24/2021	29.71
			304.86	18.89	11/16/2021	29.53
SHF-102G	SHF-102G	362.85	319.11	43.74	2/22/2021	30.03
			322.95	39.90	5/24/2021	29.71
			319.34	43.51	11/16/2021	29.53
Ohio River Elevation			303.4	N/A	2/22/2021	30.02
			298.8	N/A	5/24/2021	29.66
			300.4	N/A	11/16/2021	29.51

Table 2. 2021 AIP Synoptic Water Level Events

AIP staff assisted DOE and Contractors on reconnaissance efforts along Metropolis Lake to search for suitable locations for placement of a semi-permanent measuring stick to gauge fluctuations in lake levels more precisely. AIP personnel also worked with the Kentucky Nature Preserves Permitting Program Department to understand their expectations and concerns, which were passed along to DOE and their contractor. AIP personnel also learned that TVA maintains and monitors an Ohio River gauging station (Table 2), which was shared with DOE and the groundwater modeling group project team.

Sediment Basin Sampling

The C-613 Northwest Storm Water Control Facility (a.k.a. the C-613 Sediment Basin) was constructed as part of the first phase of the scrap metal removal project. The sediment basin began operation in March 2003, has a capacity of 4.5 million gallons and was specifically designed to collect surface water runoff from the facilities' 61-acre northwest watershed, which includes the 27-acre former scrap yard area. The sediment basin collects storm water runoff and allows suspended sediments time to settle, after which the storm water is discharged through the Kentucky Pollutant Discharge Elimination System (KPDES) Outfall 001 into Bayou Creek. The Outfall 001 regulatory discharge limits are defined in the Division of Water (DOW) Permit as: Total Suspended Solids (TSS) will not exceed 30 mg/L averaged over a 30-day period and shall not exhibit a pH outside the range of six to nine standard units.

The AIP C-613 Sediment Basin sampling regimen began in October of 2002. The C-613 Sediment Basin sampling regimen has been significantly modified twice. Frequent, non-periodic samples were collected from 2003 to 2007. These sample results identified specific contaminants of concern, provided baseline analyte concentrations and allowed trends to be determined. After sufficient information was collected, sampling was reduced to a quarterly sampling regimen that was established during the first quarter of 2008. This quarterly regimen was performed from 2008 to 2011. Due to budgetary constraints and the fact that analyte concentrations had stabilized, the sampling regimen was again modified in the first half of 2012, when the frequency of sample collection was again reduced from quarterly to semi-annually. The semi-annual sampling regimen, continued through 2021, includes one non-discharge sampling event per year to continue assessment of changes in contaminant concentrations that sediment basin releases may have on West Kentucky Wildlife Management Area (WKWMA) receptors.

The semi-annual sampling regimen for 2021 is as follows:

First Semi-Annual Sampling Event:

Sediment Basin Inlet, KPDES Outfall 001 and Iron Bridge Sampling Points

Purpose: The first semi-annual event collects samples from the basin inlet (Sediment Basin), outlet (Outfall 001) and at a point (Iron Bridge) where WKWMA recreators can be exposed to Bayou creek water. Samples are always collected during a Sediment Basin discharge event.

Figure 8. AIP Surface Water 2021 Sampling Locations

Second Semi-Annual Sampling Event:

Part 1) Sediment Basin Inlet, KPDES Outfall 001 and Iron Bridge Sampling Points

Purpose: The second semi-annual event collects samples from the basin inlet (Sediment Basin), outlet (Outfall 001) and at a point (Iron Bridge) where WKWMA recreators can be exposed to Bayou creek water. Samples are collected during a Sediment Basin discharge event.

Part 2) KPDES Outfall 001 and Iron Bridge Sample Points (Annual)

Purpose: This annual sample is collected to determine analyte concentrations when there is no active discharge from the Sediment Basin. This sample is referred to as a non-discharge event. This sample is collected during the second semi-annual event as it has historically been a period of both steady rainfall and stream flow. This sampling event was designed to be representative of an average WKWMA recreator's possible contaminant exposure during normal stream flow.

Each sample is analyzed for the following analytes:

Total Suspended Solids (TSS)

Metals, including Uranium and Mercury

Gross Alpha and Beta activity

Isotopic Uranium (U-234, U-235 and U-238)

Results: TSS and pH

During the 2021 reporting period, neither the TSS concentrations nor the pH limits exceeded DOW KPDES Outfall 001 permit requirements. Flocculent, a material used to enhance particulate precipitation, was not used during 2021; and the last flocculent treatment was in December of 2007. After the Scrap Metal Removal project was completed in March of 2007, DOE's service contractor planted and continues to maintain a well-developed grass cover over the (former) Scrap Yards area. Observations indicate the vegetative cover stabilizes the soil, reduces sediment flow into the basin and allows for greater absorption of rainfall. This results in low sediment basin turbidity

measurements and low TSS sample results. Based on a comparison of these sample results and the Outfall 001 discharge requirements, AIP concludes that the sediment basin continues to perform its primary design function, which is to comply with DOW KPDES requirements.

Results: Uranium Metal, Uranium radionuclides and alpha and beta

The following is a presentation of the 2021 analytical results for the C-613 Sediment Basin for the Discharge Event Samples Collected on April 21, 2021:

Table 3. 2021 First Semi-Annual Discharge Sampling Event:

Analyte	Basin Inlet	MDL / MDA	Total Uncertainty (2σ +/-)	Basin Outlet (Outfall 001)	MDL / MDA	Total Uncertainty (2σ +/-)	Iron Bridge	MDL / MDA	Total Uncertainty (2σ +/-)
Uranium Metal (µg/L)	**250.0**	0.40	N/A	**150.0**	0.40	N/A	**36.0**	N/A	N/A
Gross Alpha (pCi/L)	**44.94**	1.30	2.55	**31.41**	1.30	2.26	**9.05**	1.42	1.24
Gross Beta (pCi/L)	**162.15**	3.69	3.97	**97.11**	3.69	3.17	**31.91**	4.03	2.15
U-234 (pCi/L)	**43.7**	0.16	3.99	**30.5**	0.29	3.05	**5.07**	3.79	2.40
U-235 (pCi/L)	**3.09**	0.20	0.64	**2.48**	0.18	0.58	**0.23**	0.81	0.47
U-238 (pCi/L)	**83.6**	0.29	7.18	**51.6**	0.26	4.82	**12.7**	3.74	2.66

2021 Second Semi-Annual Sampling Event:

The non-discharge sample was collected at a time the Sediment Basin was not being actively discharged. Samples were collected at KPDES Outfall 001 (Outlet) and at the "Iron Bridge" sample point, which is representative of potential contaminant exposure to an average recreator, as this sample point borders the WKWMA. Several of the Basin Outlet and Iron Bridge radionuclide results indicate they were not analyzed. This means they were not analyzed for the analyte specified in the row. All samples are analyzed for gross alpha/gross beta utilizing gas flow proportional counters and for gamma emitting isotopes utilizing gamma spectrometry. Uranium and plutonium isotopes are not specifically analyzed for unless the gross alpha results from the screening are greater than or equal to 5.0 pCi/L. Technetium-99 will be analyzed if the gross beta results are equal to or exceed 9.0 pCi/L.

Part 1: Results from the Non-Discharge Event Samples collected on September 15, 2021:

Table 4. 2021 Second Semi-Annual Non-Discharge Sampling Event

Analyte	Basin Outlet (Outfall 001)	MDL / MDC	Total Uncertainty (2σ +/-)	Iron Bridge	MDL / MDC	Total Uncertainty (2σ +/-)
Uranium Metal (µg/L)	**1.2**	0.4	N/A	**0.5**	0.4	N/A
Gross Alpha (pCi/L)	**1.31**	0.63	0.55	**0.00**	0.63	0.36
Gross Beta (pCi/L)	**19.93**	1.64	1.04	**9.06**	1.64	0.79
U-234 (pCi/L)	N/A	N/A	N/A	N/A	N/A	N/A
U-235 (pCi/L)	-9.55	93.5	45.8	-16.8	91.2	40.4
U-238 (pCi/L)	N/A	N/A	N/A	N/A	N/A	N/A
Tc-99 (pCi/L)	**11.5**	4.00	1.28	**2.06**	4.00	1.20

Part 2: Results from the Discharge Event Samples collected on December 1, 2021:

Table 5. 2021 Second Semi-Annual Discharge Sampling Event:

Analyte	Basin Inlet	MDL / MDC	Total Uncertainty (2σ +/-)	Basin Outlet (Outfall 001)	MDL / MDC	Total Uncertainty (2σ +/-)	Iron Bridge	MDL / MDC	Total Uncertainty (2σ +/-)
Uranium Metal (µg/L)	**210.0**	0.4	N/A	**150.0**	0.4	N/A	**73.0**	0.4	N/A
Gross Alpha (pCi/L)	**83.97**	0.74	3.51	**56.79**	0.69	2.79	**27.59**	0.69	1.85
Gross Beta (pCi/L)	**161.82**	1.96	2.79	**116.66**	1.82	2.30	**52.05**	1.82	1.59
U-234 (pCi/L)	**43.4**	0.30	4.21	**28.6**	0.16	2.74	**13.0**	0.19	1.46
U-235 (pCi/L)	**3.09**	0.23	0.67	**1.64**	0.16	0.44	**0.68**	0.19	0.28
U-238 (pCi/L)	**77.1**	0.18	7.06	**50.0**	0.16	4.43	**22.5**	0.19	2.22
Tc-99	**34.9**	3.69	1.33	**26.7**	3.69	1.28	**12.1**	3.69	1.20

Sediment Basin sampling has been performed regularly since the Sediment Basin became operational in March of 2003. Discharge times, volumes and water quality parameters have been collected and compiled since November of 2004. The following data was compiled from 2003 to 2021 concerning average uranium concentrations (averaged from all results available for a given year) and the annual discharge through the Sediment Basin (in gallons). According to the National Oceanic and Atmospheric Administration (NOAA), the average yearly rainfall in the Paducah, Kentucky area is 49.1 inches. Average inlet and outlet Uranium metal (total) concentrations, Sediment Basin discharge volume, annual rainfall, and percentage of annual rainfall for each year from 2003 through 2021 are as follows:

2003: Inlet: 346.0 µg/L Outlet: 156.0 µg/L

Annual Discharge: Not Collected Rainfall: 47.84 inches (97% of Average)

2004: Inlet: 371.0 µg/L Outlet: 206.0 µg/L

Annual Discharge: Nov & Dec Only Rainfall: 40.66 inches (82% of Average)

2005: Inlet: 458.0 µg/L Outlet: 193.0 µg/L

Annual Discharge: 57,800,000 Gallons Rainfall: 37.45 inches (76% of Average)

2006: Inlet: 454.0 µg/L Outlet: 244.0 µg/L

Annual Discharge: 101,100,000 Gallons Rainfall: 67.11 inches (136% of Average)

2007: Inlet: 276.0 µg/L Outlet: 36.0 µg/L

Annual Discharge: 34,000,000 Gallons Rainfall: 43.33 inches (88% of Average)

2008: Inlet: 338.0 µg/L Outlet: 110.0 µg/L

Annual Discharge: 51,000,000 Gallons Rainfall: 53.69 inches (109% of Average)

2009: Inlet: 439.0 µg/L Outlet: 46.0 µg/L

Annual Discharge: 45,000,000 Gallons Rainfall: 55.60 inches (113% of Average)

2010: Inlet: 176.7 µg/L Outlet: 93.3 µg/L

Annual Discharge: 32,550,000 Gallons Rainfall: 36.67 inches (74% of Average)

2011: Inlet: 188.0 µg/L Outlet: 75.7 µg/L

Annual Discharge: 51,012,000 Gallons Rainfall: 74.85 inches (152% of Average)

2012: Inlet: 196.0 µg/L Outlet: 31.3 µg/L

Annual Discharge: 2,820,000 Gallons Rainfall: 30.06 inches (61% of Average)

2013: Inlet: 78.5 µg/L Outlet: 57.5 µg/L

Annual Discharge: 24,439,000 gallons Rainfall: 60.3 inches (122% of Average)

2014: Inlet: 93.0 µg/L Outlet: 100.0 µg/L

Annual Discharge: 30,663,000 gallons Rainfall: 46.84 inches (95% of Average)

2015: Inlet: 167.0 µg/L Outlet: 71.3 µg/L

Annual Discharge: 42,399,000 gallons Rainfall: 51.77 inches (105% of Average)

2016: Inlet: 218.0 µg/L Outlet: 111.0 µg/L

Annual Discharge: 37,760,800 gallons Rainfall: 49.24 inches (100% of Average)

2017: Inlet: 165.0 µg/L Outlet: 114.0 µg/L

Annual Discharge: 31,345,800 gallons Rainfall: 46.33 inches (94% of Average)

2018: Inlet: 155.0 µg/L Outlet: 50.5 µg/L

Annual Discharge: 45,670,800 gallons Rainfall: 59.46 inches (121% of Average)

2019: Inlet: 230.0 µg/L Outlet: 12.0 µg/L

Annual Discharge: 63,012,000 gallons Rainfall: 49.08 inches (100% of Average)

2020: Inlet: 167.5 µg/L Outlet: 89.0 µg/L

Annual Discharge: 38,828,500 gallons Rainfall: 58.28 inches (109% of Average)

2021: Inlet: 230.0 µg/L Outlet: 150.0 µg/L

Annual Discharge: 34,818,000 gallons Rainfall: 49.38 inches (100% of Average)

Observations:

The data reports that the concentration of uranium metal has historically decreased by roughly one-half to three-fourths between the C-613 Sediment Basin inlet and the KPDES Outfall 001 discharge point. The average reduction in uranium concentrations and radionuclide readings for 2021 was roughly 35%, a historical low. From 2003 to 2008, when active scrap metal removal was being performed, the average inlet concentration was 374.0 µg/L. From 2009 to 2021, after the scrap metal had been removed, concentrations of uranium metal at Outfall 001 have varied from a low of 12.0 µg/L (2019) to a high of 150.0 µg/L (2021).

- **C-613 Sediment Basin Inlet:**

The average inlet concentration in 2021 for uranium was 230.0 µg/L, which is above-average since 2009. The thirteen-year average inlet concentration from 2009 to 2021 was 192.6 µg/L. In 2005, the highest historically reported average inlet concentration was 458.0 µg/L and the lowest to date, in 2013, was 78.5 µg/L.

- **C-613 Sediment Basin Outlet (KPDES Outfall 001):**

The average outlet concentration of uranium metal in 2021 was 150.0 µg/L, which was significantly higher than the thirteen-year average of 77.0 µg/L from 2009 to 2021. The

highest reported average outlet concentration was 244.0 µg/L (2006), which was during the scrap metal removal project and before the growth of a vegetative cover. The lowest concentration, 12.0 µg/L, occurred in 2019.

- **Iron Bridge**

The average concentration of uranium metal at the Iron Bridge sampling point in 2021 during discharge sampling events was 32.8 µg/L. The concentration of uranium reported at the Iron Bridge non-discharge sampling event performed on September 15, 2021, was 0.5 µg/L. The Iron Bridge sampling point was first integrated into the sample regimen in 2007, and the average concentration of uranium metal in non-discharge events from 2007 to 2021 is 2.5 µg/L.

Conclusions:

The average 2021 discharge event inlet measurement for alpha particles in water was 64.45 pCi/L and the average outlet measurement was 44.1 pCi/L. The average 2021 inlet measurement for beta particles in water was 162.0 pCi/L and the outlet measurement was 106.9 pCi/L. Alpha and beta activity measurements showed an approximate 30-45% decrease between the C-613 Sediment Basin inlet and the KPDES Outfall 001 discharge point. As a percentage decrease in concentrations, these are the lowest recorded decreases since the Sed Basin became operational. The concentration of uranium metal decreased from an inlet average of 230.0 µg/L to an outlet average of 150.0 µg/L, an approximate 42% reduction. Analytical results for uranium metal from the Iron Bridge sampling point reported concentrations approximately 65 times higher for uranium metal as compared to the outlet results during discharge events (32.8 µg/L) as compared to the non-discharge event results (0.5 µg/L). Average concentrations of alpha particles as compared from the outlet (44.1 µg/L) during discharge events to the Iron Bridge (0.6 µg/L) during non-discharge events were roughly 73 times higher. Average concentrations of beta particles as compared from the outlet (106.9 µg/L) during discharge events to the Iron Bridge (9.06 µg/L) during non-discharge events were roughly 12 times higher.

Analysis of the data reported that uranium metal continues to be released during discharge events, which warrants continued oversight and management of on-site storm water. Based on data analysis and field observations, AIP concludes that former Scrap

Yard storm water runoff, building demolition and remedial investigation activities contribute to the off-site migration of metals and radionuclides. Interpretation of this data has determined that the Sediment Basin continues to serve its function by reducing the off-site migration of concentrations of metals, suspended solids and radionuclides. Analytical data collected during 2021 reported percentage reductions from inlet to outlet concentrations of 35% for uranium metal, 34% for alpha particles and 35% for beta particles. These percentage reductions in radionuclide concentrations are historically low, as past reductions have been approximately one-half to two-thirds. Based on the observed lower percentage reduction in concentrations, AIP has concerns as to the amount of sediment that has precipitated into the Sed Basin during its over eighteen years of operation. High concentrations of radionuclides in the precipitated sediment may be impeding additional sediments from precipitating. AIP recommends that DOE collects a rough measurement of the accumulated sediment thickness that could be used to calculate the approximate volume of sediment in the C-613 Sediment Basin. Even with reduced precipitation, the AIP continues to believe that the C-613 Sediment Basin is performing as designed and should continue operation.

Radiation Health Branch AIP Sampling

The RHB has a robust environmental monitoring program, funded by the AIP, designed to ensure that there is no danger to public health from PGDP's radionuclide releases to groundwater, surface water, or air. In 2021, RHB collected 1,537 samples and performed 929 analyses on those samples, plus 342 analyses on an additional 161 samples collected by EEC.

Groundwater

RHB monitors groundwater by routinely collecting quarterly samples at 10 residential wells surrounding the site (Figure 9). Each sample is analyzed for gross alpha/beta counting and gamma spectroscopy. If gross alpha equals or exceeds 5 pCi/L and/or gross beta equals or exceeds 9 pCi/L, then technetium-99 is also analyzed.

The majority of the locations are private drinking water wells that are potentially impacted by the TCE and Tc-99 plumes travelling off the site. These wells are no longer used for drinking water. RHB continually evaluates the results from this activity, along with results from third party activities and activities at the site, to determine the need for additional monitoring locations or modification of current locations.

In 2021, there were no abnormal measurements from RHB groundwater monitoring efforts.

Surface Water

RHB AIP monitors surface water by taking quarterly samples at 28 locations surrounding the site (Figure 10) and through continuous sampling at an additional 4 locations (Figure 11). Note: Sampling locations are labeled “ISCO” due to the brand name of the samplers that are used. Gross alpha/beta analysis and isotope specific analyses are performed on the samples, with the ISCO samples being collected and composited over 21-day periods.

The locations for surface water monitoring were selected based on outfalls from the site, locations of known runoff from contaminated areas, and historical sampling locations. The background locations are located upstream in Bayou Creek (ISCO B and BBCUG), upstream in Little Bayou Creek (LBCUG), upstream of the C-746-K Landfill (UPC746K), and approximately 5 miles to the southeast on Massac Creek (a known unimpacted local waterway, not shown on map).

In 2013, elevated levels of uranium were found leaving the C-746-U solid waste landfill in surface water. This contamination was determined to be sourced from recently removed C-340 paneling that had high levels of surface contamination by a mobile uranium compound (likely UO_2F_2, uranyl fluoride). In response, RHB AIP began monitoring points in the discharge path from C-746-U, beginning in August 2013, to ensure that effluent release limits were not exceeded. These levels have naturally decreased with time and have been well below the effluent release limits. During the fourth quarter of 2015, DOE implemented treatment on C-746-U discharges, significantly lowering the levels of contamination. Future results are expected to be comparable to background at current landfill inventory, but monitoring will continue.

In 2021, there were no abnormal measurements from samples collected at RHB AIP surface water monitoring locations.

Air

RHB AIP monitors air by taking continuous samples at 10 locations surrounding the site (Figure 12), collected at 21-day periods. A gross alpha/beta analysis is performed on each filter, and the filters are composited quarterly for isotope specific analyses.

The locations for air monitoring were selected based on prevailing winds at the plant and expected release points/types from the plant. The background location is approximately three miles southeast of the plant at the Barkley Regional Airport (not shown on map) and is > 90 degrees offset from prevailing winds. RHB continually evaluates the results from this activity, along with results from third party activities and other activities at the site, to determine the need for additional monitoring locations or modification of current locations.

In 2021, there were no observed abnormal measurements from RHB AIP air monitoring efforts.

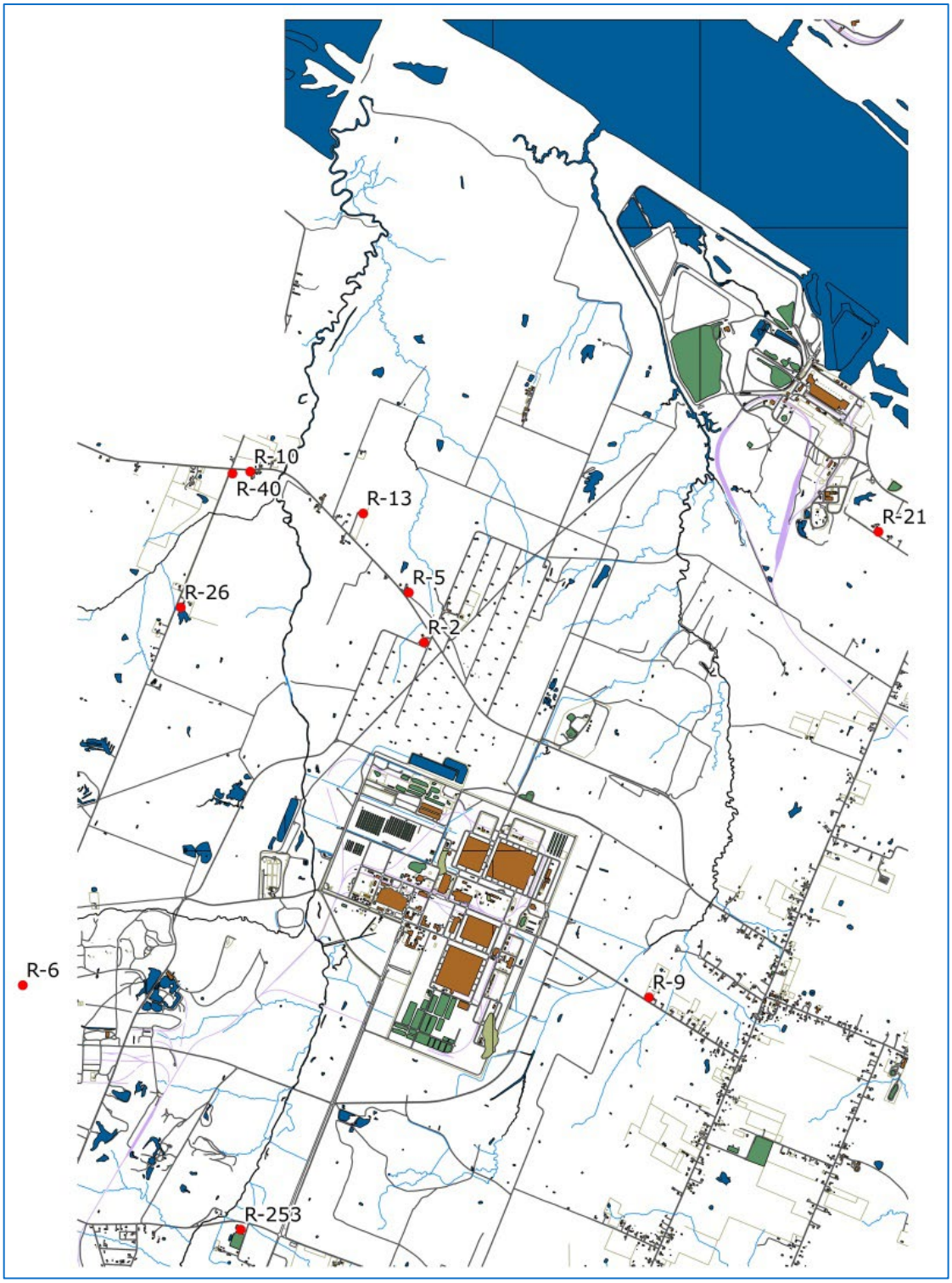

Figure 9. RHB AIP 2021 Groundwater Monitoring Locations

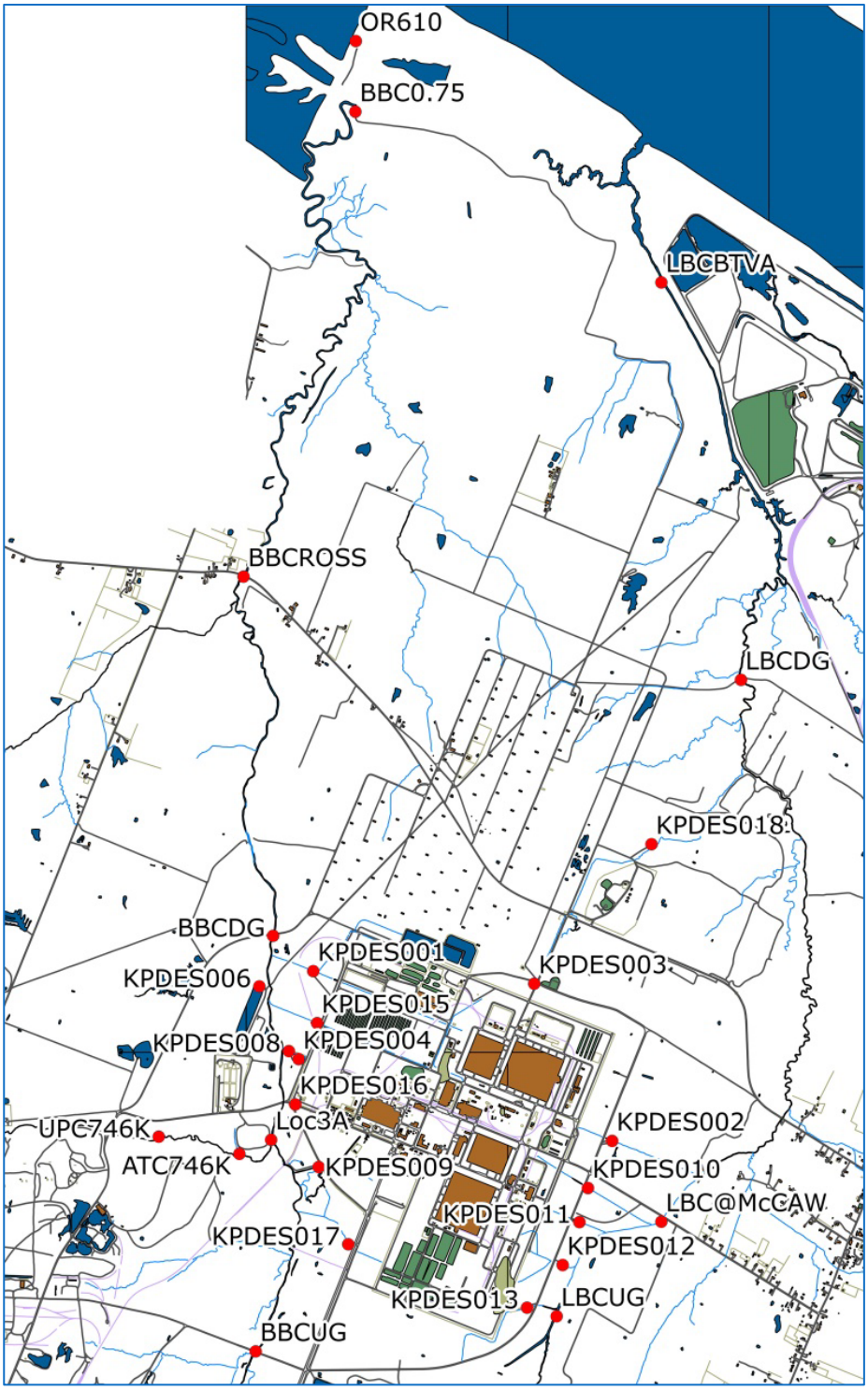

Figure 10. RHB AIP 2021 Quarterly Surface Water Sampling Locations

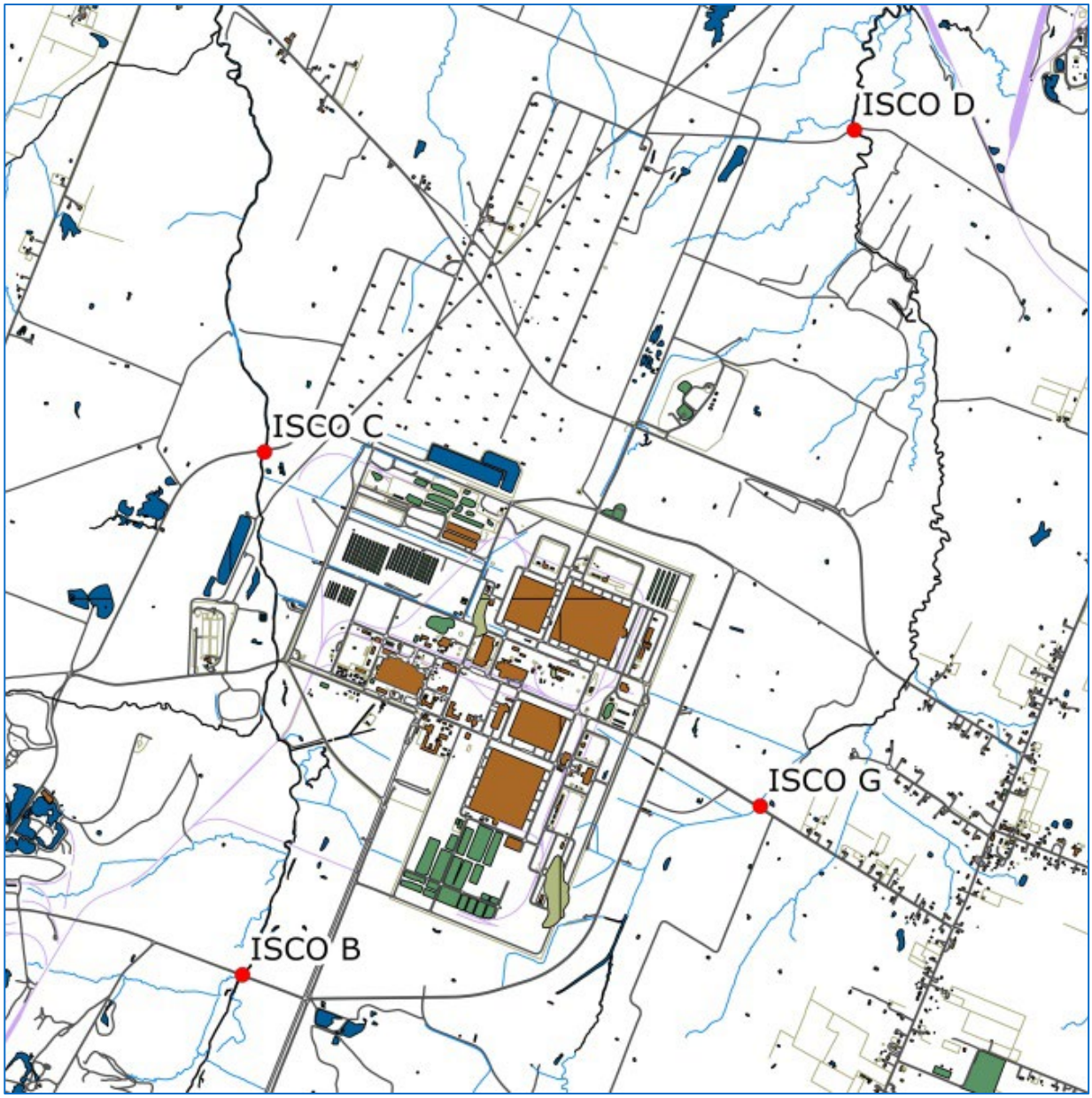

Figure 11. RHB AIP 2021 ISCO Sampling Locations

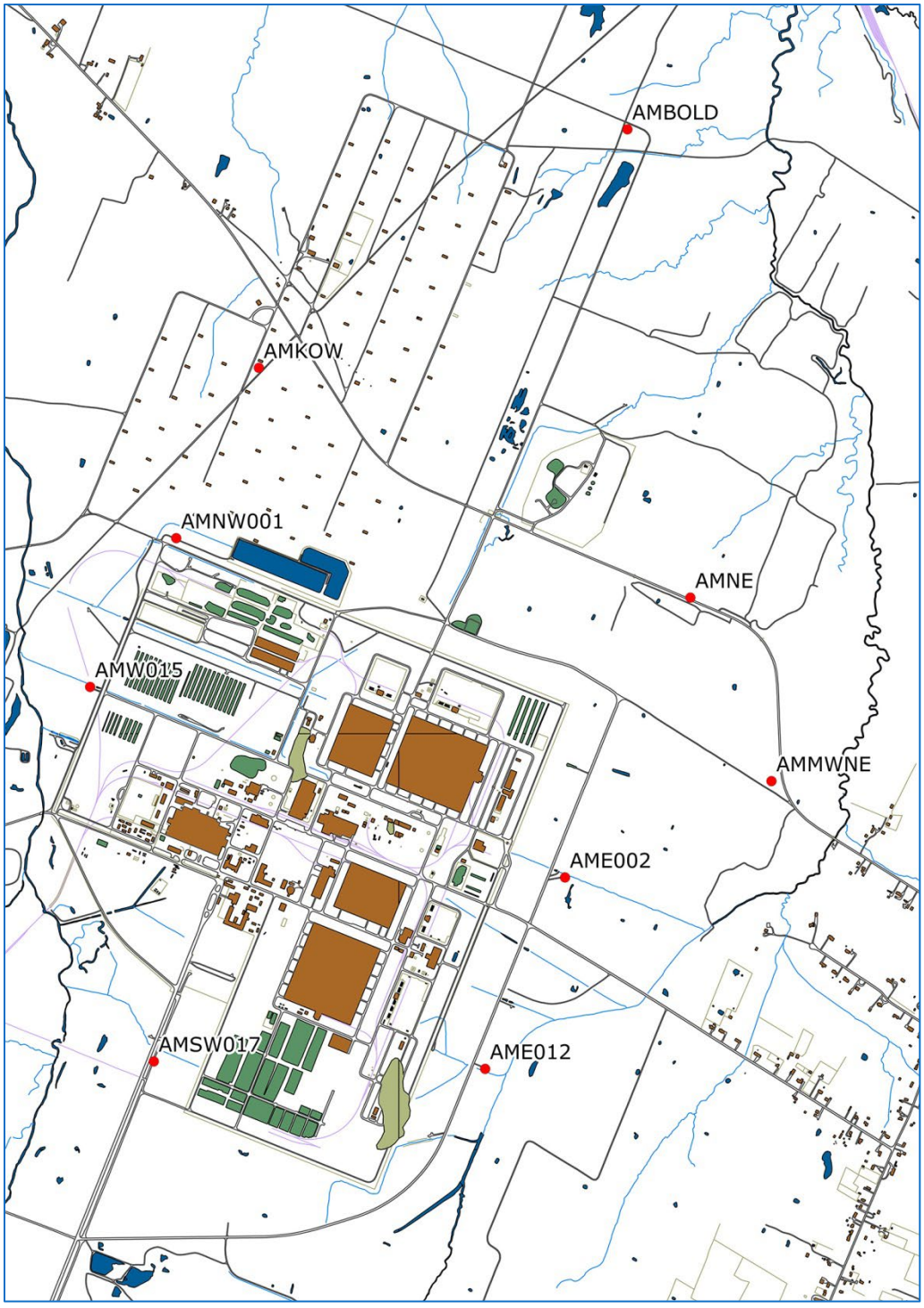

Figure 12. RHB AIP 2021 Air Monitoring Locations

Additional Oversight Activities

During 2021, DWM AIP staff routinely observed portions of the PGDP reservation on a weekly basis. Locations within the Limited Area that were routinely observed included areas adjacent to the process buildings (C-310, C-331, C-333, C-335, C-337), the C-400 Maintenance Facility and groundwater treatment unit, the C-600 Steam Plant and natural gas boilers, former scrap metal yards, cylinder yards, process and sanitary wastewater treatment facilities, the C-404 Landfill, and burial grounds. Areas outside of the Limited Area observed weekly included wastewater lagoons, the Northeast and Northwest Plume Pump-and-Treat Units, the C-613 Sedimentation Basin, the K-Landfill, the water treatment plant and sedimentation ponds, and plant outfalls (001, 002, 006, 008, 009, 010, 011, 012, 013, 015, 016, 017). No significant issues requiring DOE's attention were noted during any oversight activity in 2021. The following is an abbreviated list of oversight activities completed in 2021:

- Approximately 6,875 nickel ingots are stored on-site near the C-746-A Warehouse. About 50 of the ingots contain trace amounts of asbestos. The nickel ingots were observed twice in 2021 to ensure that they are completely covered with the required tarps.
- The C-746-U Landfill was visited on a weekly basis during the year. The specific areas of the landfill that were observed included the landfill working face, the leachate collection building, the sedimentation basin, Outfalls 019 and 020, and the closed S & T Landfill.
- A total of 7,705 monitoring well evaluations were completed. The components assessed during an evaluation include the well padlock, outer casing condition, protective bollards, the concrete pad and overall accessibility.
- 26 Regulatory Notifications were submitted to the Division and were acknowledged by the KDWM in 2021. Surveillances of activities in the SWMUs designated in the submitted Regulatory Notifications were routinely conducted on a weekly basis for proper management of SWMU material and spoils.

- Construction activities of a new TVA switchyard at C-755-N and associated transmission lines into the limited area were observed to ensure proper storm water runoff controls were installed and maintained throughout the project to minimize offsite mobilization of sediments.
- Monitoring of equipment removal from C-331, C-333, C-335, and C-337 associated with the deactivation of the process buildings was conducted as part of the weekly observation activities.

Kentucky FFA Program Elements for 2021

Surface Water Operable Unit

Surface Water Operable Unit (SWOU)

DOE reprioritized the Surface Water Operable Unit to an out-year activity after DOE's near-term priority became the C-400 Complex OU. The SWOU is comprised of thirty (30) Solid Waste Management Units (SWMUs) and Others (Outfalls 017, 018, 019/020 and SWMU 526 and associated ditches). These SWMUs have likely contributed significant contamination to the creeks and outfalls that receive surface water runoff from the PGDP. This potential to affect off-site waterways is one of the main reasons for the prioritization of investigative and removal actions.

During uranium enrichment operations, the Paducah Site used approximately 20 million gallons of water daily which was pumped from the Ohio River. After active enrichment operations ceased on July 25, 2013, the PGDP began using significantly less water. After use, water is discharged via unlined ditches through outfalls and into Little Bayou and Bayou Creeks. These two creeks converge and ultimately discharge back into the Ohio River. The Kentucky Division of Water regulates these outfall discharges under one Kentucky Pollutant Discharge Elimination System (KPDES) permit. Waters discharged through these Outfalls include storm water runoff, treated groundwater from pump-n-treat systems, process wastewater, cooling wastewater, sediment basin discharge water and sanitary wastewater.

DOCUMENTS REVIEWED IN 2021

No Surface Water Operable Unit documents were received or reviewed in 2021.

C-400 Complex Operable Unit (C-400 OU)

The C-400 Complex (C-400 OU) is a new OU established in a *Memorandum of Agreement on the C-400 Complex under the Federal Facility Agreement for the PGDP*, which was signed on August 8, 2017. This agreement was incorporated into the 2020/2021 Site Management Plan (SMP). The C-400 OU is comprised of seven SWMUs, of which more may be added if new SWMUs are discovered during investigation, deactivation or demolition activities.

Field work commenced with drilling activities which began on March 2, 2020, but were ceased on March 25, 2020, due to the COVID-19 pandemic. Field work was resumed on August 3, 2020, and boring and sampling activities were completed on December 2, 2021.

C-400 Investigatory work was shared and discussed during weekly groundwater update calls. Work performed during the previous week was shared via virtual meetings. Analytical results, along with Membrane Interface Probe (MIP) and DyeLIF (Light Induced Fluorescence) graphs, were routinely posted to a shared website as soon as data was received by DOE. This information was used to update shared maps and figures which could be shared with the group. Typically, DOE would propose the location and sampling intervals of contingency borings for the next week's allotment of work, and the proposals would be approved or discussed and revised as agreed upon by all three FFA parties. A set number of contingency borings had been included within the RI/FS Work Plan for utilization once the primary phase of investigation was completed.

DOCUMENTS REVIEWED IN 2021

No C-400 Complex Operable Unit documents were received or reviewed in 2021.

Groundwater Operable Unit

Northeast Plume Containment System (Pump-and-Treat)

The Northeast Plume Containment System was installed to remove and treat groundwater from the higher concentration portions of the Northeast Plume. The system consists of extraction wells EW234 and EW235 and their respective water treatment units C-765 and C-765A. The treatment units each contain an air stripper, which treats the water to less than the effluent concentration goal of 30 ppb TCE. Once treated, the water from each unit is piped to a reservoir and discharged to KPDES Outfall 001, which flows to Little Bayou Creek.

In 2021, the Northeast Plume extraction wells EW234 and EW235 pumped 82,053,413 gallons of water, which resulted in the removal of 13.1 gallons of TCE. Northeast Plume pumping operations began on February 28, 1997. As of December 31, 2021, the system had extracted approximately 2,096,226,038 gallons of groundwater, and 360 gallons of TCE has been cumulatively removed. An operational chart of the Northeast Plume Containment System reports both the operational efficiency and gallons of water treated during each month in 2021 is presented below.

Table 6. 2021 Northeast Plume Containment System Operation Data

Month	Percent Operational		Gallons	Month	Percent Operational		Gallons
	C-765	C-765-A			C-765	C-765-A	
January	100.0	100.0	7,823,874	July	100.0	100.0	7,816,596
February	100.0	100.0	7,047,540	August	99.9	99.9	7,812,395
March	99.9	99.9	7,787,066	September	43.6	98.5	5,173,268
April	100.0	100.0	7,564,901	October	0.0	100.0	3,353,174
May	100.0	99.3	7,805,377	November	91.1	100.0	7,099,103
June	97.6	99.1	7,424.048	December	42.9	100.0	5,346,071

During 2021, the Northeast Plume Interim Remedial Action Optimization Project continued, with the adjustment of extraction well pumping rates and quarterly monitoring of seven (C-400) transect wells. Each sentinel transect well is spaced ~200 feet apart and located approximately 800 feet east of the C-400 building. Transect wells are monitored quarterly for volatile organic compounds (VOCs) and Tc-99 and results are compared to background (pre-pumping) concentrations to provide an early warning if TCE or Tc-99 is pulled east (away) from the C-400 area by the two optimized extraction wells. If concentration trends significantly increase over time, the FFA parties will meet to develop a solution before TCE or Tc-99 can spread by migrating eastward toward the two new extraction wells.

The FFA senior parties signed an MOA in 2015 which outlined actions that would be taken to prevent the extraction wells from causing or contributing to the undesirable expansion of TCE and Tc-99 from C-400 within the NE Plume. The quarterly 2021 sampling results for TCE concentrations continued to increase in some transect wells. Quarterly sampling of the transect wells will continue to monitor if optimization efforts are mobilizing contaminants away from the C-400 area.

Northeast Plume Optimization Documents Reviewed In 2021:

Operation and Maintenance Plan for the Northeast Plume Containment System Interim Remedial Action (DOE/LX/07-2470&D1), dated December 16, 2021.

Northwest Plume Containment System (Pump-and-Treat)

The Northwest Plume Containment System was installed to remove and treat groundwater from higher-concentration portions of the Northwest Plume. The system is located at the plant's northwest corner and consists of two extraction wells and the C-612 water treatment facility. The Northwest pump-and-treat system was optimized in 2010 and a major refurbishment and upgrade of the C-612 water treatment system was completed in early 2016. In 2021, the Northwest Plume System pumped 102,240,547 gallons of water from extraction wells EW232 and EW233, which resulted in the removal of 71.2 gallons of TCE. Northwest Plume pumping operations began on August 28, 1995. During that time, the system has extracted 2,636,117,984 gallons of groundwater, and

approximately 3,932.3 gallons of TCE has been cumulatively removed. An operational chart of the Northwest Plume Containment System reports both the operational efficiency and gallons of water treated during each month in 2021 is presented below

Table 7: 2021 Northwest Plume Groundwater System Operation Data

Month	Percent Operational	Gallons	Month	Percent Operational	Gallons
January	99.1	8,747,972	July	98.9	8,826,432
February	100.0	7,957,820	August	92.6	8,221,578
March	99.8	8,775,601	September	99.6	8,565,440
April	100.0	8,637,518	October	100.0	8,841,929
May	97.8	8,743,802	November	100.0	8,540,481
June	99.0	8,602,450	December	88.4	7,779,524

Northwest Plume Groundwater System Documents Reviewed In 2021:

Operation and Maintenance Plan for the Northwest Plume Groundwater System Interim Remedial Action (DOE/LX/07-2469&D1), dated July 6, 2021. The EPA approved the D1 version on July 5, 2021, and the KDWM submitted comments on August 16, 2021.

Operation and Maintenance Plan for the Northwest Plume Groundwater System Interim Remedial Action (DOE/LX/07-2469&D2), dated October 20, 2021. Both the EPA and KDWM approved the D2 version on December 10, 2021.

Southwest Plume Sources

SWMU 1 C-747-C Oil Landfarm

A deep soil mixing remedial action using a large (8-ft) diameter auger, followed by steam with vapor extraction/treatment and zero-valent iron injection was completed in 2015 at the SWMU 1 Oil Landfarm. The purpose of the project was to remove organic solvents (primarily TCE) from 258 soil columns to a depth of approximately 60 feet bgs. The remedial action recovered 24 +/-12 gallons of VOCs during operation. Passive treatment using zero-valent iron (ZVI) may still be occurring. Semi-annual sampling of SWMU 1 monitoring wells was performed to monitor the continuing effects of the ZVI. Table 8

displays trend analysis of several VOCs. Trend determinations were made by evaluating data from samples collected during 2020 (not shown on Table) and 2021. Determinations are somewhat subjective, especially when considering the limited time span and data set. Concentrations of TCE in samples collected from MW161 during 2020 were higher than all samples collected during 2021, but the difference in data between the years was not huge, and concentrations fluctuated during 2021. Concentrations of 1,1-DCE may have gone down from 2020 to 2021, but it is difficult to confirm this since 1,1-DCE was only detected in one sample, but the other two samples had a detection limit of 5 µg/L, which is higher than the concentrations detected in 2020. Concentrations of VC in MW161 were considered stable since all samples during the 2020-21 timeframe were below detection limits.

Concentrations of TCE in MW542 continued to decline during 2021, and all samples collected during 2020 and 2021 were below 2 µg/L. Concentrations of 1,1-DCE have all been non-detect (ND) during the two-year period. Vinyl Chloride concentrations are labeled as "Stable." The case could be made that concentrations are decreasing, since all samples collected during 2021 were ND, however, the only detections in 2020 were from a split sample with results that were both less than 1 µg/L over the detection limit of 1 µg/L. Concentrations of TCE continued to decline in MW543 in 2021, concentrations of 1,1-DCE were stable (both ND at 1 µg/L), while concentrations of Vinyl Chloride declined from 2020.

TCE concentrations in MW544 fluctuated during the two-year period. Concentrations began at 105 µg/L, more than doubled to 236 µg/L, then ranged between 129-116 µg/L for three events before falling to a low of 23.5 µg/L. Concentrations of 1,1-DCE remained stable, as 5 of 6 samples collected during the two-year period were between 2 and 3 µg/L. Concentrations of Vinyl Chloride generally showed a downward trend, as a detection of 88.5 µg/L was reported in December of 2020, while all four samples collected during 2021 ranged between a high of 13 µg/L to a low of ND at 1 µg/L.

All three VOCs shown in Table 8 were stable in MW545. Of five samples collected during the two-year period, four of the samples contained Vinyl Chloride at concentrations between 1 and 2 µg/L, while the last sample was a slight outlier at 4.21 µg/L.

Concentrations of TCE in MW546 ranged between 194 µg/L and 61.5 µg/L in 2020, and samples collected in 2021 yielded concentrations of 184 µg/L and 108 µg/L, swings significant enough to be best describe concentrations through the time period as fluctuating. Concentrations of 1,1-DCE displayed a similar pattern, with concentrations in 2021 being between the highs and lows of 2020. However, given that the range was only 2.6 µg/L, "stable" would best describe the trend during this time frame. During 2020, concentrations of Vinyl Chloride ranged between 240 µg/L and 3.32 µg/L in MW546. Concentrations from samples collected during 2021 were 114 and 153 µg/L, so the trend is considered fluctuating.

TCE concentrations from samples collected from MW547 during 2020 hovered around 1,000 µg/L, which had been a rise from the previous year. Concentrations in 2021 were 888 and 839 µg/L, both a reduction from the three samples collected in 2020. Concentrations of 1,1-DCE in 2021 were stable (within slightly over 1 ppb of samples collected the previous year). Vinyl Chloride concentrations remained below detection limits.

Table 8. SWMU 1 C-747-C Oil Landfarm TCE, 1,1-DCE and VC Concentrations

Well #	Sample Date	TCE µg/L	TCE[1] Conc. Trend	1,1-DCE µg/L	1,1-DCE[1] Conc. Trend	VC µg/L	VC[1] Conc. Trend
MW161 (DG)	5/11/21	248	Fluctu-ating	.88 J	↓	1 U	Stable
	6/15/21	197		5 U		5 U	
	12/7/21	208		5 U	Stable	5 U	
	12/28/21	259		NS		5 U	
	12/28/21	250		NS		1.5 U	
MW 542 (DG)	6/15/21	1.52	↓	1 U	Stable	1 U	Stable
	12/7/21	.55 J		1 U		1 U	
	12/7/21	.54 J		1 U		1 U	

MW 543 (UG)	6/15/21	1.36	Stable	1 U	Stable	**4.18**	Stable
	12/7/21	1.19		1 U		**3.93**	
MW544 (UG)	3/24/21	**129** (KDEP)	Fluctu-ating	2.99 J (KDEP)	Stable	**13** (KDEP)	Stable
	6/15/21	**128**		2.65		**8.77**	
	6/22/21	**116** (KDEP)		2.72 J (KDEP)		**9.61** (KDEP)	
	12/7/21	**23.5**		1 U		1 U	
MW545 (DG)	6/15/21	1.32	Stable	1 U	Stable	1.55	Stable
	6/22/21	.5 U (KDEP)		.5 U (KDEP)		1.88 (KDEP)	
	12/7/21	1.51		1 U		**4.21**	
MW546 (SG)	6/15/21	**184**	Fluctu-ating	2.59	Stable	**114**	Fluctu-ating
	12/7/21	**108**		2.44		**153**	
MW 547 (DG)	6/15/21	**888**	↓	**11.88**	Stable	1 U	Stable
	12/7/21	**839.0**		**11.4** J		**20.0** U	

[1]Trend determinations were made by evaluating all sampling data collected from January 2020 through December 2021

Bold red numbers = result above MCL of 5 ppb for TCE, 7 ppb for 1,1-DCE and 2 ppb for VC

Bold blue numbers = laboratory detection limit above MCLJ = Estimated

U = Not detected above listed detection limit
D = Analyzed at higher dilution
DG = Downgradient
UG = Upgradient
SG = Sidegradient

SWMU 211-A and 211-B (C-720 sites)

An investigation of RGA groundwater conducted in 2015 found TCE concentrations at SWMU 211-A in the upper RGA, indicating an upgradient UCRS source that possibly originating under the C-720 building or from SWMU 211-B. The investigation concluded that the conceptual site model (CSM) for SWMU 211-A is valid, and the DOE recommended implementing bioremediation and long-term monitoring. The CSM for SWMU 211-B was found to be invalid because of analytical results indicating that DNAPL is likely nearby. The Southwest Plumes Sources ROD only addresses VOCs in UCRS soils and corresponding shallow groundwater. The three parties agreed that enhanced bioremediation would be effective even against higher VOC concentrations associated with DNAPL-like concentrations known to exist in the upper RGA.

Southwest Plume Sources Documents Reviewed in 2021:

Remedial Action Work Plan for SWMU 211-A Enhanced In Situ *Bioremediation for Volatile Organic Compound Sources to the Southwest Groundwater Plume* (DOE/LX/07-2443&D2), DOE invocation of Informal Dispute, dated June 26, 2020. Informal Dispute negotiations continued until October 4, 2021, when a Memorandum of Agreement was signed by the three parties.

Remedial Action Work Plan for SWMU 211-A Enhanced In Situ *Bioremediation for Volatile Organic Compound Sources to the Southwest Groundwater Plume* (DOE/LX/07-2443&D2/R1), dated November 3, 2021. On November 18, 2021, the EPA granted conditional concurrence and the KDWM concurred with the document.

Remedial Action Work Plan for SWMU 211-A Enhanced In Situ *Bioremediation for Volatile Organic Compound Sources to the Southwest Groundwater Plume* (DOE/LX/07-2443&D2/R2), dated December 16, 2021. The KDWM concurred with the document on December 20, 2021, and the EPA on December 21, 2021.

Burial Grounds Operable Unit

The historic generation of various types of waste materials at the PGDP led to on-site subsurface disposal in areas referred to as Burial Grounds. The Burial Grounds Operable Unit is comprised of 10 such areas that are designated by their respective SWMU

numbers: the C-749 Uranium Burial Ground (SWMU 2); the C-404 Low-Level Radioactive Waste Burial Grounds (SWMU 3); the C-747 Contaminated Burial Yard and C-748-B Burial Area (SWMU 4); the C-746-F Burial Yard (SWMU 5); the C-747-B Burial Grounds (SWMU 6); the C-747-A Burial Grounds and Burn Area (SWMU 7); the C-746-S Landfill (SWMU 9); the C-746-T Landfill (SWMU 10); the C-747-A Burial Grounds and Burn Area (SWMU 30) and the Residential/Inert Landfill Borrow Area (P-Landfill) (SWMU 145).

BGOU Documents Reviewed in 2021:

No Burial Ground Operable Unit documents were reviewed in 2021.

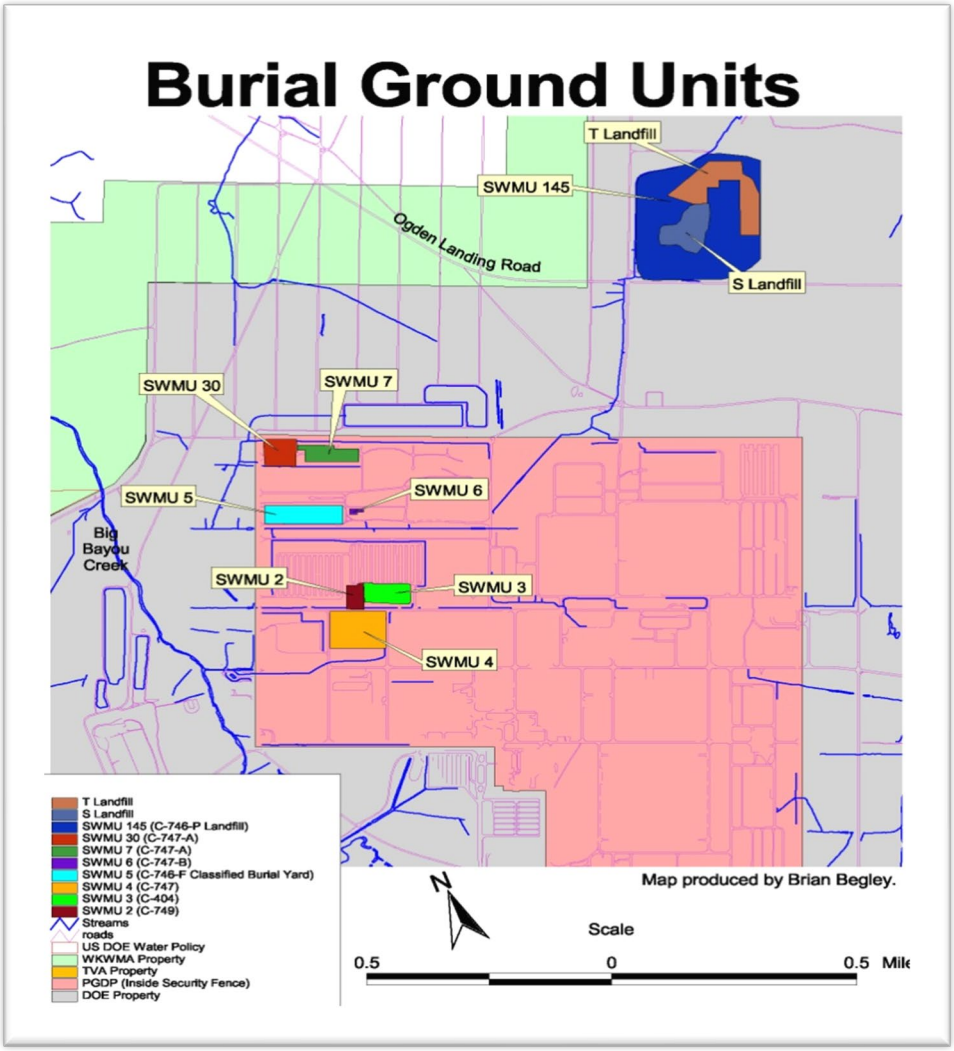

Figure 13. Burial Ground SWMUs

Soils Operable Unit

There are currently 72 SWMUs in the Soils Operable Unit. A major objective of the Soils OU investigations is to determine the nature and extent of contamination in the soils to a depth of 10 feet below grade surface.

Soils Operable Unit Documents Reviewed in 2021:

No Soils Operable Unit documents were reviewed in 2021.

Decontamination and Decommissioning Operable Unit

The pre-GDP D&D OU has addressed 17 inactive facilities at the Paducah site, some of which have been out of service for decades. The C-410/420 Complex was the last of the inactive facilities to be addressed under this OU. The scope of the pre-GDP shutdown D&D OU has been completed.

No D&D Operable Unit documents were reviewed in 2021.

Waste Management

Waste Disposition Alternatives (WDA) Project

Over the next several decades, large quantities of waste will be generated at the Paducah Site. Much of this waste will be in the form of concrete, structural steel and decommissioned equipment that will require disposal following decontamination and decommissioning of large process buildings. Lesser volumes of waste will be created as contaminated soils and burial grounds are remediated. As much as 4.6 million cubic yards of waste are projected to be generated at the Paducah site during the remaining course of site cleanup. Where this waste will eventually be disposed of is the subject of a CERCLA waste disposal alternatives feasibility study.

The WDA Feasibility Study evaluates two general disposal options, on-site versus off-site disposal. Since it is somewhat uncertain how much waste will actually require disposal, both the on-site and off-site alternatives are further broken down into subcategories based upon certain assumptions. The base case sub-category assumes that some of the waste generated will go to an existing on-site solid waste landfill. The high-volume sub-category

assumes that this landfill will not be available for use and that all waste will require disposal in a new on-site cell or disposition in an off-site landfill. An on-site repository would allow for safe disposal of non-hazardous, hazardous, TSCA, low-level radioactive and low-level radioactive mixed wastes on-site, thereby avoiding more expensive off-site disposal options. However, the option to ship a portion or all the waste off-site to a DOE owned or commercial waste facility still exists.

Waste Disposition Alternatives Documents Reviewed in 2021:

No CERCLA Waste Disposal Alternatives Evaluation documents were reviewed in 2021.

Solid Waste Management Units (SWMUs)

During the reporting period from January 1 to December 31, 2021, Kentucky received three newly discovered SWMUs and one revised Solid Waste Management Unit Assessment Report (SAR). The three newly discovered SWMUs were assigned Requires Further Investigation (RFI) status.

Table 9. Revised and Newly Discovered SWMU Assessment Reports Submitted to Kentucky Between January 1 and December 31, 2021

SWMU Number	Description	OU Location	Sub-project	Status	SAR Report Date	Date(s) SAR Amended	Date of RFI
20	C-410-B HF Neutralization Lagoon	Soils and Slabs	N/A	Requires RFI	N/A	11/16/21	3/17/93
571	C-602 Coal Storage Yard	Soils and Slabs	N/A	Requires RFI	6/24/21	N/A	7/16/21
572	C-360 Toll Transfer and Sampling Building	Soils and Slabs	Remaining D&D	Requires RFI	7/20/21	N/A	7/27/21
573	C-750 Garage Slab and Underlying Soils and Associated Outside Areas	Soils and Slabs	N/A	Requires RFI	8/16/21	N/A	8/18/21

Table 10. Solid Waste Management Units that Kentucky Granted No Further Action Status Between January 1 and December 31, 2021

SWMU Number	Description	(Former) OU Location	(Former) Sub-project	Status	SAR Report Date	Date(s) SAR Amended	Date of NFA
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

SWMU DOCUMENTS REVIEWED IN 2021

In 2021, one SAR Revision and three newly-discovered SWMUs were submitted. The three newly discovered SWMUs were assigned to the Soils and Slabs OU. At the end of the reporting period, no SARs were under review by the Division.