



**Semiannual Report on the Status
of Remedy Selection**

**TVA Paradise Fossil Plant,
Peabody Ash Pond, Drakesboro,
Muhlenberg County, Kentucky**

January 15, 2020

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1.0 Introduction

In accordance with 40 CFR § 257.97(a), the Tennessee Valley Authority (TVA) has prepared this semiannual report to document progress toward remedy selection and design at the Peabody Ash Pond (hereinafter referred to as the CCR Unit) at the Paradise Fossil Plant (PAF) in Drakesboro, Muhlenberg County, Kentucky.

1.1 Regulatory Background

On April 17, 2015, the United States Environmental Protection Agency (U.S. EPA) published a rule that sets forth national criteria for the management of coal combustion residuals (CCR) produced by electric utilities. The requirements can be found in Title 40, Code of Federal Regulations (CFR) Part 257, Subpart D. The rule includes requirements for monitoring groundwater and assessing corrective measures if constituents listed in Appendix IV of the rule are detected in groundwater samples collected from downgradient monitoring wells at statistically significant levels (SSLs) greater than established groundwater protection standards (GWPS).

In January 2019, TVA completed an evaluation of whether there were SSLs over established GWPS as defined in 40 CFR § 257.95(h) for one or more Appendix IV constituents in accordance with 40 CFR § 257.95(g). At the CCR Unit, assessment monitoring in 2018 detected an SSL greater than the GWPS for arsenic at monitoring well PAF-119. TVA recalculated the statistical analysis in mid-2019 after incorporating additional groundwater monitoring data from the first assessment monitoring event and retest event in 2019. In late-2019, TVA updated the statistical analysis after incorporating results from the second semiannual groundwater monitoring event. The same SSL was observed at the same monitoring well as previously identified. As of the date of this report, TVA has not completed a demonstration that a source other than the CCR Unit associated with well PAF-119 caused the SSL, as allowed under 40 CFR § 257.95(g)(3)(ii).

In accordance with 40 CFR § 257.96(a), TVA prepared the 2019 Assessment of Corrective Measures (ACM) Report for the CCR Unit at PAF, placed it in the facility operating record on July 15, 2019, and uploaded it to the public website on August 14, 2019. The ACM Report provided an assessment of the effectiveness of potential corrective measures in achieving the criteria provided in 40 CFR § 257.96(c). Three primary strategies were evaluated to address groundwater exhibiting concentrations of arsenic above the GWPS:

- Monitored Natural Attenuation (MNA);
- Hydraulic Containment and Treatment; and,
- Enhanced In-Situ Treatment (EIST).

Following preparation of the ACM Report, TVA began the remedy selection process. Semiannual reports are required pursuant to 40 CFR § 257.97(a) to document progress toward remedy selection and design. The CCR Rule contemplates that more investigation and consideration may be needed to evaluate and design the remedy before making the final selection. TVA will continue to review new data as it becomes available and implement changes to the groundwater monitoring and corrective action program as necessary to maintain compliance with 40 CFR § 257.90 through § 257.98.

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At least 30 days prior to when the final remedy is selected, a public meeting will be held with interested and affected parties to discuss the results of the corrective measures assessment in accordance with 40 CFR § 257.96(e). The selected remedy must meet the requirements of 40 CFR § 257.97(b) and must consider the evaluation factors set forth in 40 CFR § 257.97(c). Once a final remedy is chosen, a final report describing the remedy and how it meets the standards set forth in 40 CFR § 257.97(b) will be prepared. The owner/operator must provide a schedule for implementing the selected remedy that considers the factors set forth in 40 CFR § 257.97(d).

1.2 Report Contents

This first semiannual progress report provides a summary of PAF site characteristics, the groundwater assessment monitoring program, the findings of the ACM process, and the current progress of selecting and designing a remedy for the groundwater.

2.0 Site Background and Characteristics

PAF is located in Drakesboro, Muhlenberg County, Kentucky. The CCR Unit is located along the northern bank of Jacobs Creek. **Figure 1** shows an overview map of PAF including the CCR Unit. Construction of PAF began in 1959, and the facility's three generators were fully operational by 1970. PAF coal-fired generators 1 and 2 were retired in 2017, and the third generator is scheduled to be retired by December 2020 (TVA website). The coal combustion process at PAF resulted in the production of fly ash, boiler slag, and gypsum. The plant currently manages these materials on-site; however, the Peabody Ash Pond CCR Unit no longer receives sluiced fly ash as of July 1, 2019.

The PAF CCR Unit is an active, unlined CCR surface impoundment that is approximately 138 acres in size. Surface mining operations were conducted in the area of the CCR Unit between 1974 and 1991. The strip-mining operations left earth-fill dikes along the southern and eastern sides of the CCR Unit. In 1997, the dikes were raised to their current elevation and are 12 – 20 feet in height (AECOM, Oct 7, 2016a– Initial Static Safety Assessment). The original embankment fill materials generally consist of mine spoils that are characterized as silty clay with variable quantities of silt, sand, coal and rock fragments. The raised dike of the CCR Unit consists of clay with some rock fragments. The CCR Unit primarily has received sluiced fly ash, but also receives decant waters from the Gypsum Disposal Area Stilling Ponds and other non-CCR waste streams (AECOM, 2016b – History of Construction).

The subsurface geology at the CCR Unit consists of three main hydro-stratigraphic units, which from surface to depth, include Coal-Mine Spoils/Fill, Alluvium/Residuum, and the Carbondale Formation. The Carbondale consists of interbedded layers of sandstone, siltstone, shale, and coal. It should be noted that none of these hydro-stratigraphic units strictly meet the CCR Rule criteria for upper-most aquifer at this location; however, the mine spoils most closely aligned with the criteria for water quality, quantity and depth and are therefore monitored in accordance with 40 CFR § 257.91. A typical cross-section view of the subsurface geology is shown on **Figure 2**.

2.1 Conceptual Site Model Summary

The hydrogeologic conceptual site model (CSM) is one of the primary tools that can be used to support decisions on corrective measures. This section of the report provides a summary of the hydrogeologic CSM. The geology and hydrogeology of the PAF site have been characterized through historical investigations since construction of the CCR Unit. These investigations provide an understanding of site geology and the presence of water-bearing zones. The groundwater flow direction at the CCR Unit is primarily east to east-southeast, towards Jacob's Creek. **Figure 3** presents a groundwater flow direction map for PAF.

2.2 Potential Receptor Review

Most of the public water supply in Muhlenberg County is sourced from the Green River. Surface water from the Green River is withdrawn and treated by the Central City Water and Sewer System, which sells its water to the Muhlenberg County Water District for distribution to customers. The City of Drakesboro, which is located approximately 5 miles southwest of the site, provides water that is pumped from the Green River.

3.0 Groundwater Assessment Monitoring Program

Groundwater assessment monitoring for the CCR Unit is conducted at PAF in accordance with 40 CFR § 257.95.

3.1 Groundwater Monitoring Well Network

In compliance with 40 CFR § 257.91, one background well (95-48A) and three upgradient wells (10-5, PAF-105, PAF-106) were established and six monitoring wells (10-4, 10-6, PAF-107, PAF-117, PAF-118, and PAF-119) were installed downgradient of the CCR Unit. The locations of these monitoring wells are presented on **Figure 1**.

3.2 Groundwater Characterization

Groundwater assessment monitoring was conducted during 2018 and 2019. Arsenic, an Appendix IV constituent, was detected at an SSL above a GWPS. The following summarize the 2018 and 2019 Appendix IV SSL at the PAF CCR Unit:

- Arsenic
 - SSL for arsenic were identified at monitoring well PAF-119; and,
 - The arsenic GWPS is 15.4 µg/L.

Data from existing wells have been utilized to characterize the nature and extent of any release from the CCR Unit as required by 40 CFR 257.95(g)(1). An additional monitoring well (PAF-119R) has been installed and its data is helping to further refine this characterization. The potential treatment zone to address the extent of arsenic above GWPS along the unit perimeter is illustrated on **Figure 4**.

4.0 Assessment of Corrective Measures

TVA prepared the 2019 ACM Report for the CCR Unit and added it to the operating record on July 15, 2019. The report was posted to the TVA CCR Rule Compliance Data and Information website on August 14, 2019. The ACM Report provided an assessment of the effectiveness of potential corrective measures in achieving the criteria provided in 40 CFR § 257.96(c).

4.1 Planned Source Control Measures

The objectives of corrective measures under 40 CFR § 257.96(a) are to “prevent further releases [from the CCR Units], to remediate any releases, and to restore affected areas to original conditions.” Ultimately, in accordance with 40 CFR § 257.97(b)(3), the selected corrective measure must at a minimum “[c]ontrol the source(s) of releases so as to reduce or eliminate, to the maximum extent feasible, further releases of constituents of appendix IV to this part into the environment.”

The Preamble (80 Fed. Reg. 21302, 21406) to the CCR Rule discusses that source control measures may include modifying operational procedures. To achieve TVA’s commitment to comply with regulatory requirements and timeframes under the CCR Rule, TVA will close the CCR Unit in accordance with 40 CFR § 257.102.

Groundwater assessment monitoring as required by 40 CFR § 257.96(b) will continue until a remedy is selected. The monitoring will be conducted to track changes in groundwater conditions as a result of these closures and operational changes. These data will also be considered in the selection and design of a remedy in accordance with 40 CFR § 257.97.

The CCR Unit cannot be closed until provisions are made to re-route water that is currently discharged to the CCR Unit, to an alternative treatment facility or to the Slag Ponds Area Multiunit. Once this water is re-routed, the CCR Unit can be completely removed from service and dewatering operations can commence. A process water basin is currently under construction with an anticipated completion in April 2020.

4.2 Potential Remedial Technologies

In addition to source control measures, three primary strategies were evaluated to address groundwater exhibiting concentrations of arsenic above the GWPS including:

- Monitored Natural Attenuation (MNA);
- Hydraulic Containment and Treatment; and,
- Enhanced In-Situ Treatment (EIST).

The ACM Report provides a more detailed description of these corrective measures. The effectiveness of each potential corrective measure was assessed in accordance with 40 CFR § 257.96(c) and all are currently considered feasible for remediating the groundwater at the CCR Unit.

5.0 Selection of Remedy: Current Progress

A remedy to address the arsenic SSL in groundwater will be selected in accordance with 40 CFR § 257.97. In support of the remedy selection process, additional investigation is needed and is described below.

5.1 Data Requirements for Design of Groundwater Corrective Action

Additional data requirements are needed to refine the targeted area for corrective measures, develop remedial cost estimates, and finalize the alternative for the Peabody Ash Pond. To address data gaps, further characterization of arsenic impacts downgradient or cross-gradient of the CCR Unit are needed in addition investigations activities described below.

Current and future activities to further evaluate site conditions:

- Monitoring well PAF-119 has been replaced. The replacement well (PAF-119R) is being developed and sampled to evaluate if screening the well at a shallower depth that does not straddle a zone of weathered bedrock¹ contributes to lower dissolved arsenic concentrations than those observed at existing monitoring well PAF-119.
- Up to five soil borings will be installed on the southeast side of the Peabody Ash Pond as a screening-level investigation to refine the nature and extent of dissolved arsenic in areas east and west of wells PAF-119 and PAF-119R.
- Slug testing will be performed at newly installed monitoring well locations surrounding Peabody Ash Pond to further evaluate hydraulic conductivity.

Potential future activities to further evaluate MNA:

- A geochemical investigation will be conducted to evaluate groundwater and aquifer solids in areas proximal to PAF-119 and PAF-119R at Peabody Ash Pond. Arsenic can be present in multiple valence states and their chemical reactivity is affected by groundwater pH, redox potential, the presence of iron and sulfur, and other subsurface variations. The effectiveness of geochemical processes can be evaluated by collecting native soil and groundwater samples and conducting bench-scale testing to evaluate the effectiveness of MNA.
- Groundwater Flow Modeling – A groundwater flow model will be developed based on groundwater elevation and hydraulic conductivity data gained from additional hydrogeologic characterization efforts.
- Groundwater Fate and Transport Modeling Simulations – The groundwater flow model being developed will be calibrated to more recent existing conditions before groundwater fate and transport modeling can be performed. The fate and transport model will be used to further evaluate the estimated time for natural attenuation mechanisms to reduce the arsenic concentrations to below GWPS.

¹ The weathered bedrock unit at PAF-119 consists of shale and coal that have the potential to have elevated naturally occurring levels of arsenic.

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Potential future activities to further evaluate hydraulic containment and treatment:

- A geochemical investigation will be conducted to evaluate groundwater and aquifer solids in areas proximal to PAF-119 at the Peabody Ash Pond CCR Unit. The applicability and orientation of a hydraulic containment system is largely based on site-specific conditions including aquifer dimensions and conductivity, presence of confining layers, depth, gradient, characteristics of the arsenic, and presence of receiving water bodies or wells.
- Groundwater Flow Modeling Simulations – The groundwater flow model being developed will be refined based on expanded groundwater elevation data gained from additional hydrogeologic characterization efforts. These flow model refinements will incorporate several groundwater extraction scenarios to optimize hydraulic containment of arsenic-impacted groundwater while balancing extracted groundwater treatment requirements.
- Groundwater Treatability Study - For ex-situ treatment of extracted groundwater, treatability studies would be needed to evaluate technologies for the treatment of arsenic.
- Supplemental Hydraulic Properties Evaluation – A groundwater extraction well and three piezometers will potentially be installed proximal to monitoring well PAF-119 and PAF-119R to conduct a 72-hour pump test to evaluate hydraulic capture geometry and potential groundwater recovery rates. This data would feed back into the groundwater flow modeling simulations for groundwater extraction to inform the feasibility, design, and implementation of any groundwater recovery systems.

Potential future activities to evaluate Enhanced In-situ Treatment:

- A geochemical investigation will be conducted to evaluate groundwater and aquifer solids in areas proximal to PAF-119 at the Peabody Ash Pond CCR Unit. Removal of arsenic with multiple treatment technologies have been demonstrated in industrial wastewater applications. Potential treatment alternatives include advanced filtration, co-precipitation, redox manipulation, adsorption, and ion exchange. The most effective alternative(s) would be selected based on the geochemistry of the groundwater.
- Groundwater Treatability Study – For in-situ treatment of groundwater, bench-scale treatability studies might be conducted on representative groundwater samples prior to selecting a groundwater corrective measure for implementation to address arsenic concentrations.

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5.2 Semiannual Reporting, Public Meeting, Remedy Selection and Final Report

Progress toward the selection and design of the remedy will be documented in semiannual reports in accordance with 40 CFR § 257.97(a). At least 30-days prior to selecting a remedy, a public meeting to discuss the results of the corrective measures assessment will be conducted as required by 40 CFR § 257.96(e). A final report will be prepared after the remedy is selected. This final report will describe the remedy and how it meets the standards specified in 40 CFR § 257.97(b) and 257.97(c). Recordkeeping requirements specified in 40 CFR § 257.105(h), notification requirements specified in 40 CFR § 257.106(h), and internet requirements specified in 40 CFR § 257.107(h) will be complied with as required by 40 CFR § 257.96(f).

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Attachments:

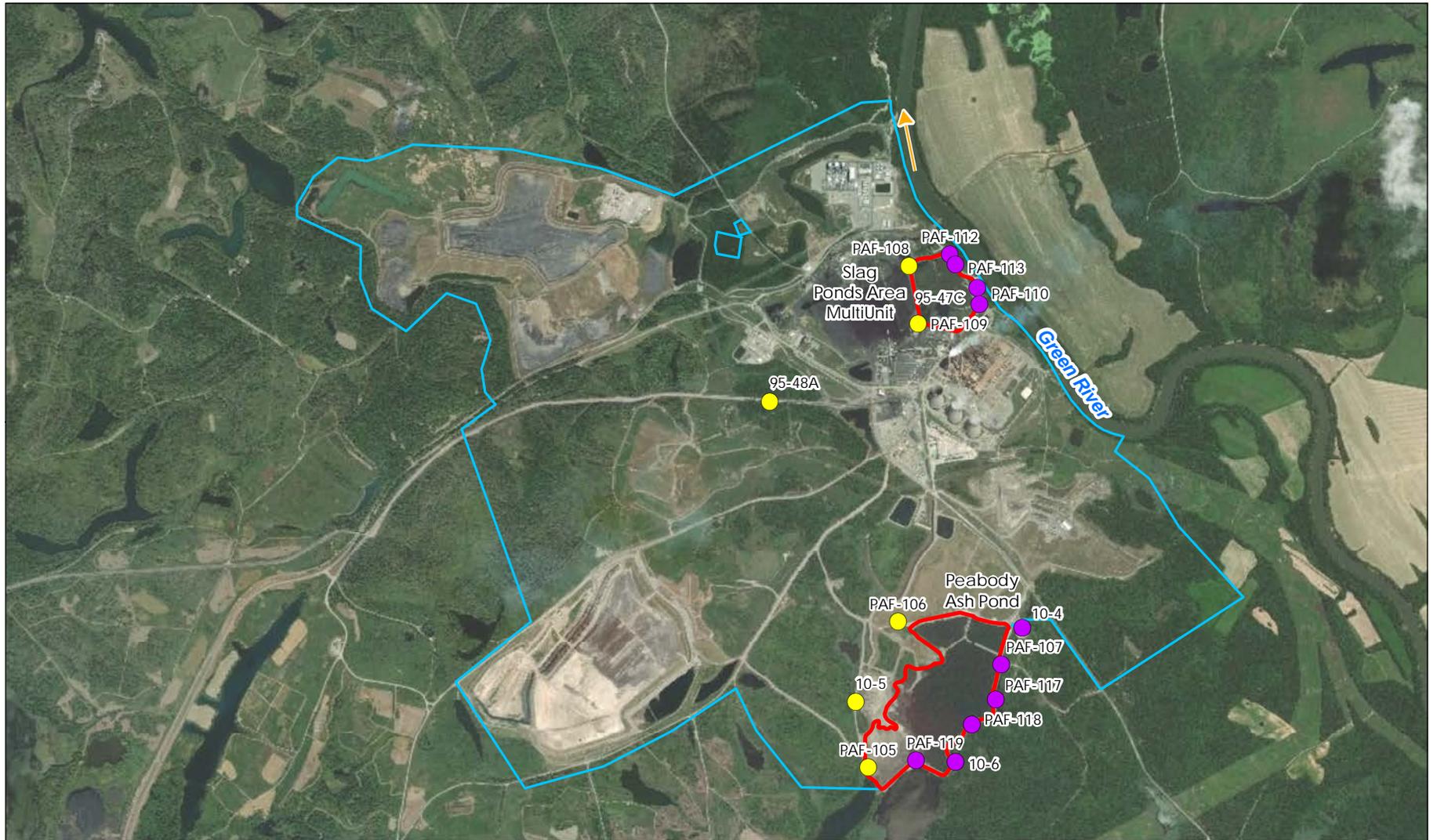
Figures

Figure 1 – CCR Unit with Background and Downgradient Wells

Figure 2 – Geological Cross-Section

Figure 3 – Groundwater Flow Direction

Figure 4 – Monitoring Wells and Limits of COI Impacts



- Downgradient Well
- Background or Upgradient Well
- CCR Unit Subject to CCR Rule Under § 257.96
- TVA Property Boundary



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Notes

1. Coordinate System: NAD 1983 StatePlane Kentucky South FIPS 1602 Feet
2. Background: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Project Location Prepared by LMB on 2019-07-10
 Drakesboro Technical Review by EP on 2019-07-10
 Muhlenberg County, KY Independent Review by JB on 2019-07-10
Client/Project 182603473
 Tennessee Valley Authority
 Paradise Fossil Plant
 CCR Rule

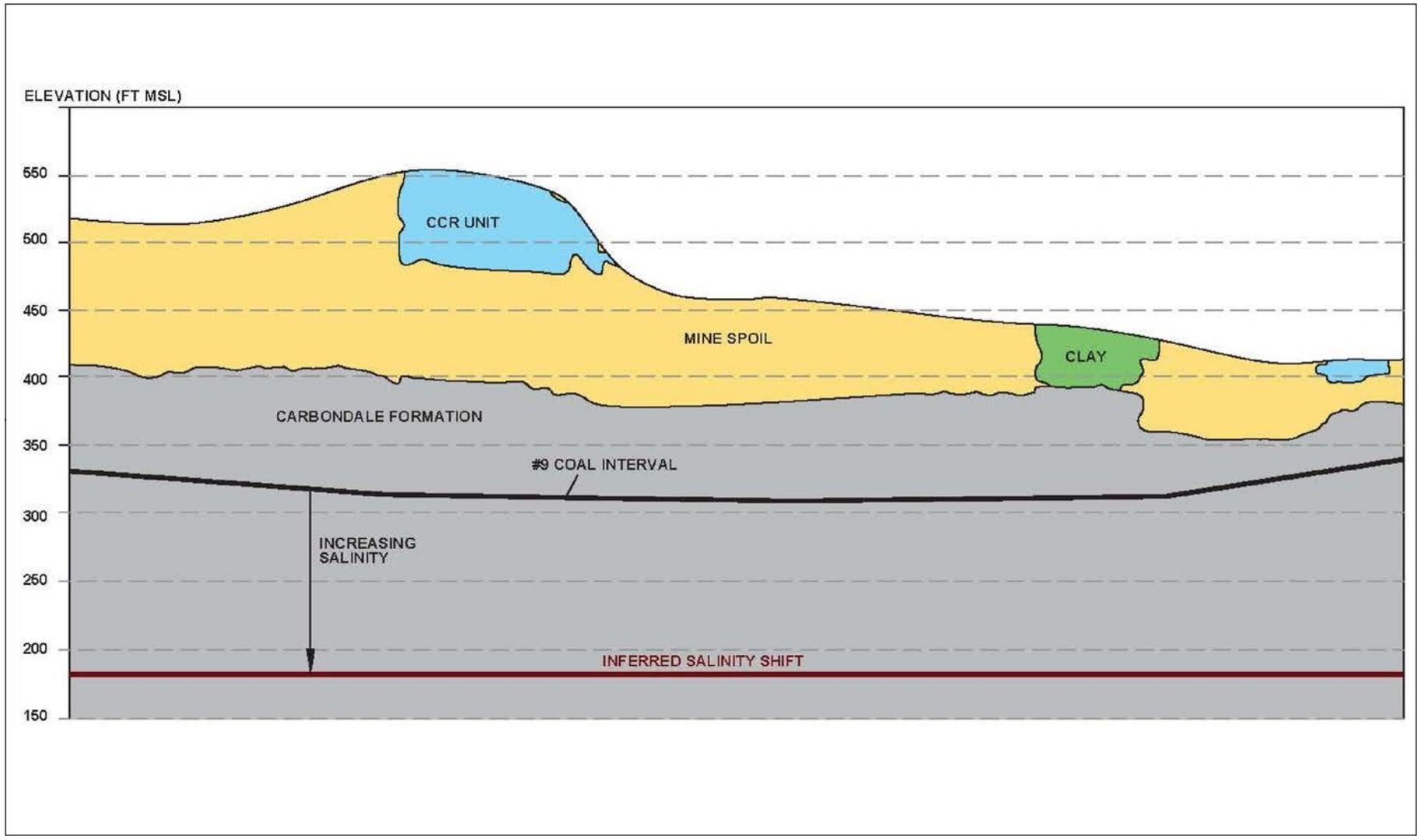
Figure No.

Figure 1

Title
CCR Units with Background and Downgradient Wells



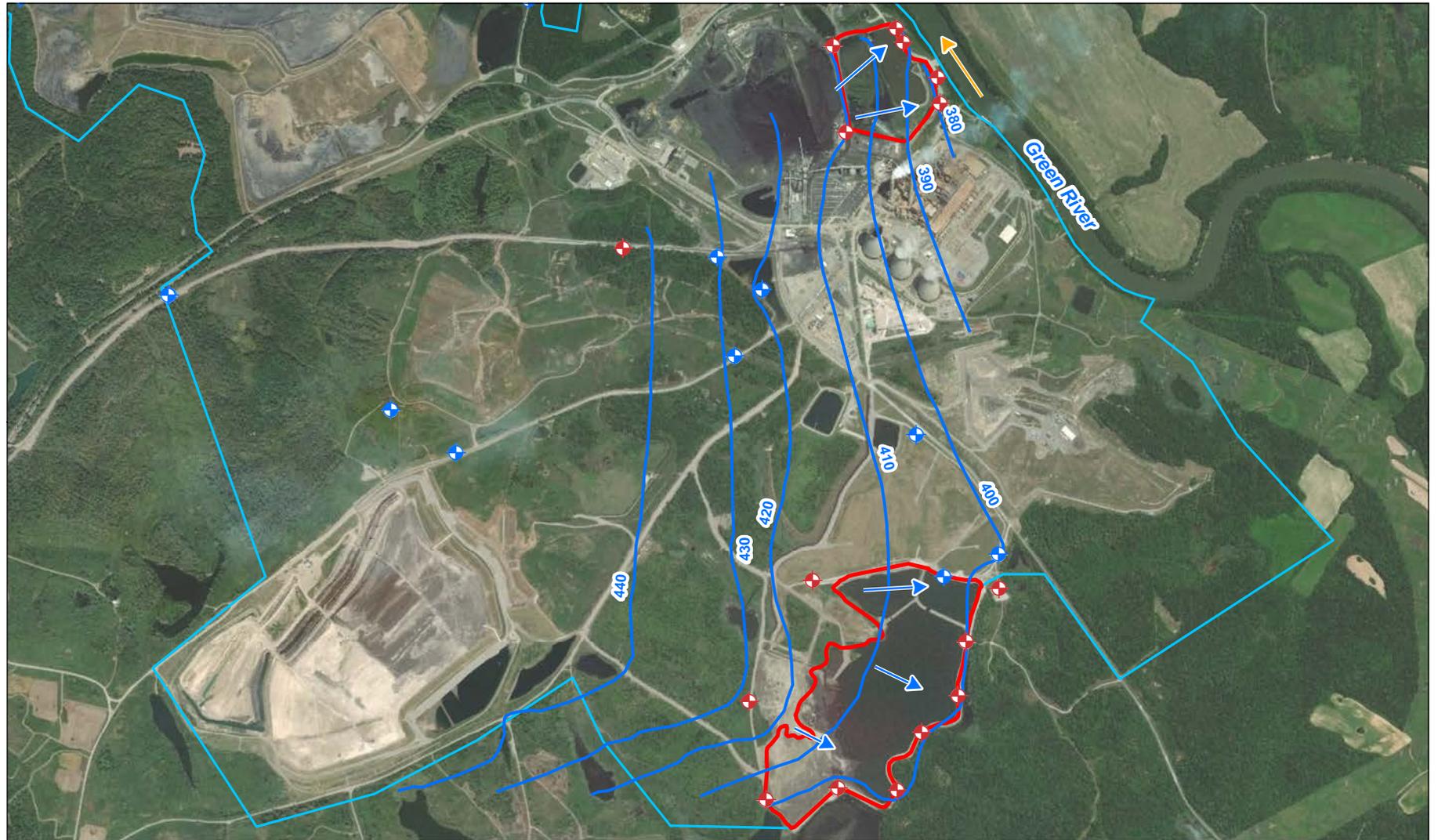
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Project Location Prepared by LMB on 2019-07-11
 Drakesboro Technical Review by EP on 2019-07-11
 Muhlenberg County, KY Independent Review by JB on 2019-07-11
 Client/Project 182603473
 Paradise Valley Authority
 Paradise Fossil Plant
 CCR Rule

Figure No. **Figure 2**
 Title **Geologic Cross-Section**





- ◆ CCR Compliance Well
- ◆ CCR Observation Well
- ➔ Groundwater Flow Direction
- Groundwater Contour
- November 28, 2016 sampling event
- CCR Unit Subject to CCR Rule Under § 257.96
- TVA Property Boundary

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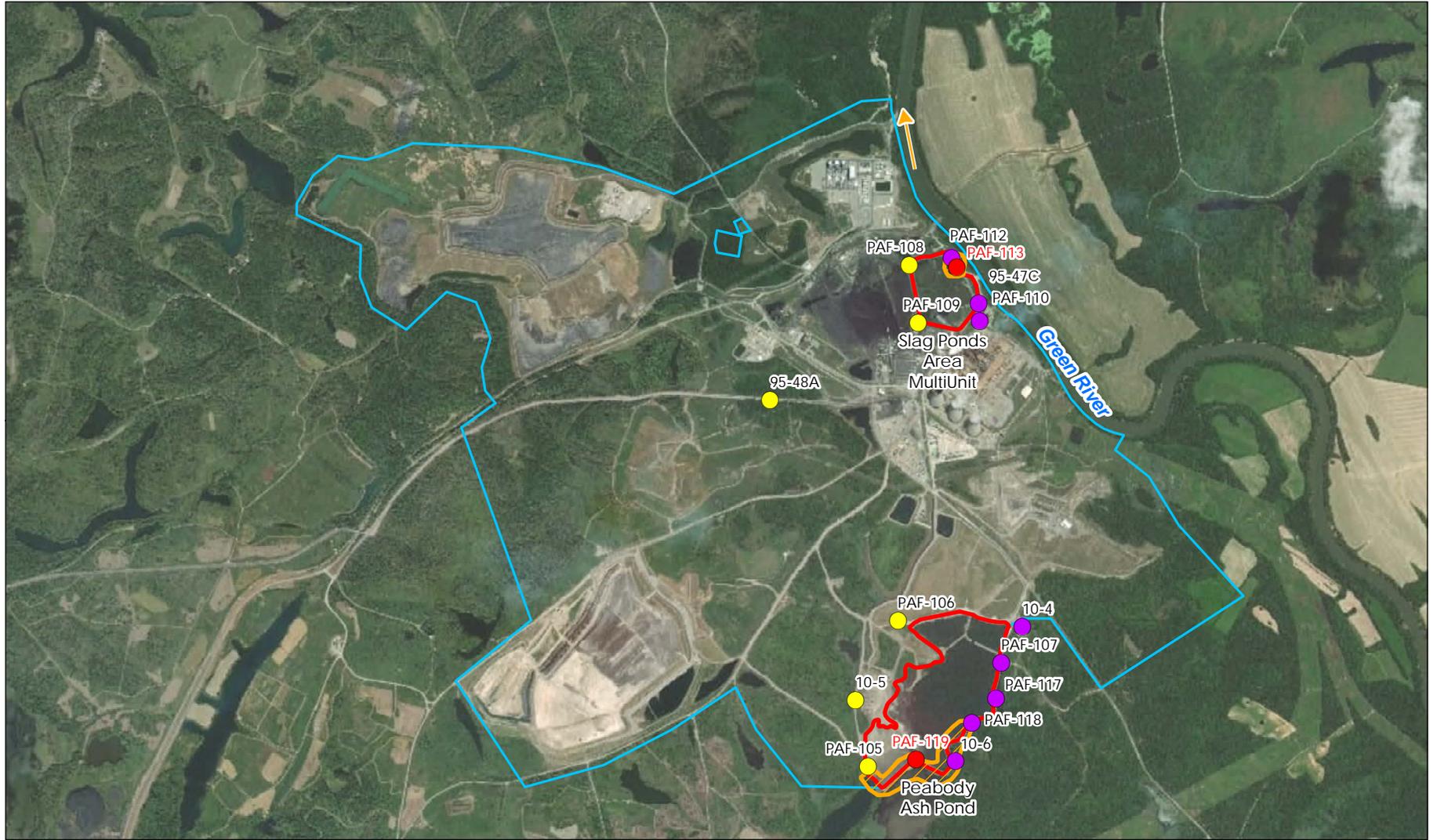
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Figure No.
Figure 3
Title
Groundwater Flow Direction





- Downgradient Well
- Background or Upgradient Well
- GWPS Exceedance Well
- CCR Unit Subject to CCR Rule Under § 257.96
- TVA Property Boundary
- Potential Treatment Zones (Arsenic)



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Figure No.

Figure 4

Title
**Monitoring Wells and
 Limits of COI Impacts**

