Semiannual Report on the Status of Remedy Selection

TVA Paradise Fossil Plant, Slag Ponds Area Multiunit, Drakesboro, Muhlenberg County, Kentucky

January 15, 2020

Prepared for:

Tennessee Valley Authority
Chattanooga, Tennessee

Prepared by:

Stantec Consulting Services Inc.
Indianapolis, Indiana

1.0 Introduction

In accordance with 40 CFR § 257.96(a), the Tennessee Valley Authority (TVA) has prepared this Semiannual report to document progress toward remedy selection and design at Slag Ponds 2A, 2B and Slag Stilling Pond 2C (hereinafter referred to as the Slag Ponds CCR Multiunit) 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 Multiunit, assessment monitoring detected an SSL greater than the GWPS for arsenic at monitoring well PAF-113. 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 Multiunit associated with well PAF-113 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 Multiunit 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.

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 Slag Ponds CCR Multiunit is situated on the western bank of the Green River. **Figure 1** shows an overview map of PAF including the CCR Multiunit. 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 of 2020. The coal combustion process at PAF resulted in the production of fly ash, boiler slag, and gypsum. The plant currently manages these materials in the CCR Multiunit.

The PAF CCR Multiunit Slag Ponds 2A, 2B and Slag Stilling Pond 2C have wetted surface areas of approximately 16.5, 11.5, and, 1.2 acres, respectively. The perimeter dikes of the Slag Ponds Area CCR Multiunit are approximately 30-35 feet in height and were constructed using mine spoil built over alluvial deposits. The mine spoils are described as lean clay, clayey sand, or clayey gravel. The CCR Multiunit has received sluiced fly, bottom ash, boiler slag, plant effluent, water from the Red Water Ponds, the Coal Yard Runoff Ponds and stormwater runoff from the plant and surrounding areas.

The subsurface geology at the Slag Ponds Area CCR Multiunit 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 Formation consists of interbedded layers of sandstone, siltstone, shale, and coal. It should be noted that none of these hydro-stratigraphic units meet the CCR Rule criteria for upper-most aquifer at this location, however, the mine spoils/fill and alluvium/residuum most closely meet the criteria and, for that reason, groundwater from both mine spoils/fill and alluvium/residuum wells is being 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 during implementation of multiple investigations. These investigations provide an understanding of site geology and the presence of water-bearing zones. The groundwater flow direction at the CCR Multiunit is primarily east, towards the Green River. **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 Slag Pond CCR Multiunit 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 two upgradient wells (PAF-108 and PAF-109) were established upgradient, and four monitoring wells (95-47C, PAF-110, PAF-112, and PAF-113) were installed downgradient of the CCR Multiunit. 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 the GWPS. The following summarize the 2018 and 2019 Appendix IV SSLs at the PAF Slag Ponds Area CCR Multiunit:

- Arsenic
    - SSLs for arsenic were identified at monitoring well PAF-113;
    - The arsenic GWPS is 12.7 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-113R) will be installed and its data is anticipated 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 Slag Pond CCR Multiunit 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 Multiunit], 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 convert from wet to dry handling of CCR and to comply with regulatory requirements and timeframes under the CCR Rule, TVA will close the Slag Ponds CCR Multiunit. Complying 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.

Closure of the CCR Multiunit cannot be initiated until provisions are made to re-route water that is currently discharged to the CCR Multiunit, to an alternative treatment facility. Once this water is re-routed the CCR Multiunit 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 Multiunit.

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 Slag Ponds Multiunit. To address data gaps, further characterization of arsenic impacts downgradient or cross-gradient of the CCR Multiunit are needed in addition investigations activities described below.

Current and future activities to further evaluate site conditions:

- Monitoring well PAF-113 will be replaced. The replacement well (PAF-113R) will be developed and sampled to evaluate if replacing the well contributes to lower observed sample turbidity values than those observed at existing monitoring well PAF-113.

- Up to five soil borings will be installed on the northeast side of the Slag Ponds Multiunit as a screening-level investigation to refine the nature and extent of dissolved arsenic in areas east and northeast of well PAF-113.

- Slug testing will be performed at newly installed monitoring well locations surrounding Slag Ponds Multiunit 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-113 at the Slag Ponds Multiunit. Arsenic can be present in multiple valance 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.

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-113 at the Slag Ponds Multiunit. 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-113 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-113 at the Slag Ponds Multiunit. 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.

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).

Attachments:

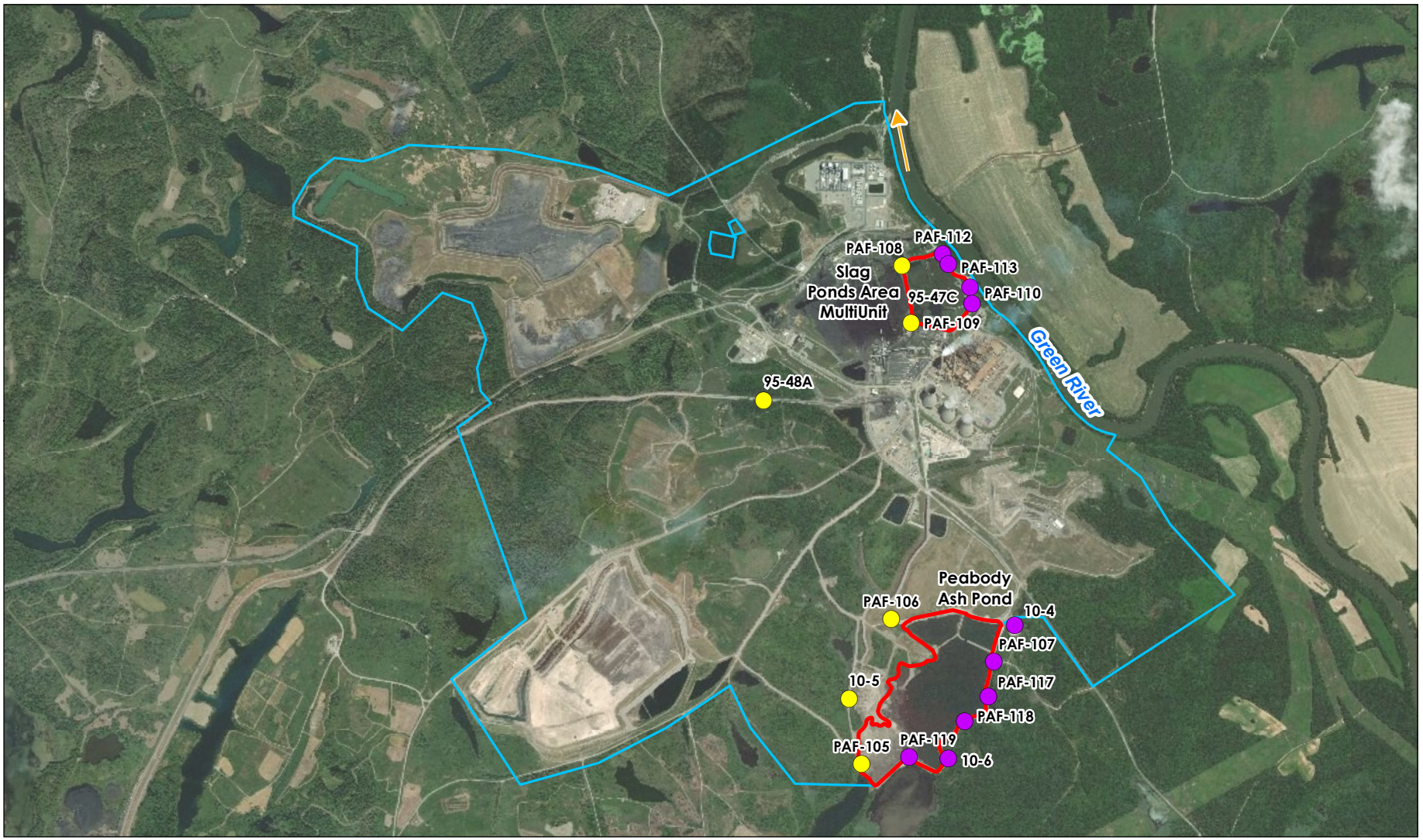
Figures

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

N

0 1,500 3,000 Feet

(At original document size of 8.5x11)
1:36,000

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
Drakesboro
Muhlenberg County, KY

Prepared by LMB on 2019-07-10
Technical Review by EP on 2019-07-10
Independent Review by JB on 2019-07-10

Client/Project
Tennessee Valley Authority
Paradise Fossil Plant
CCR Rule

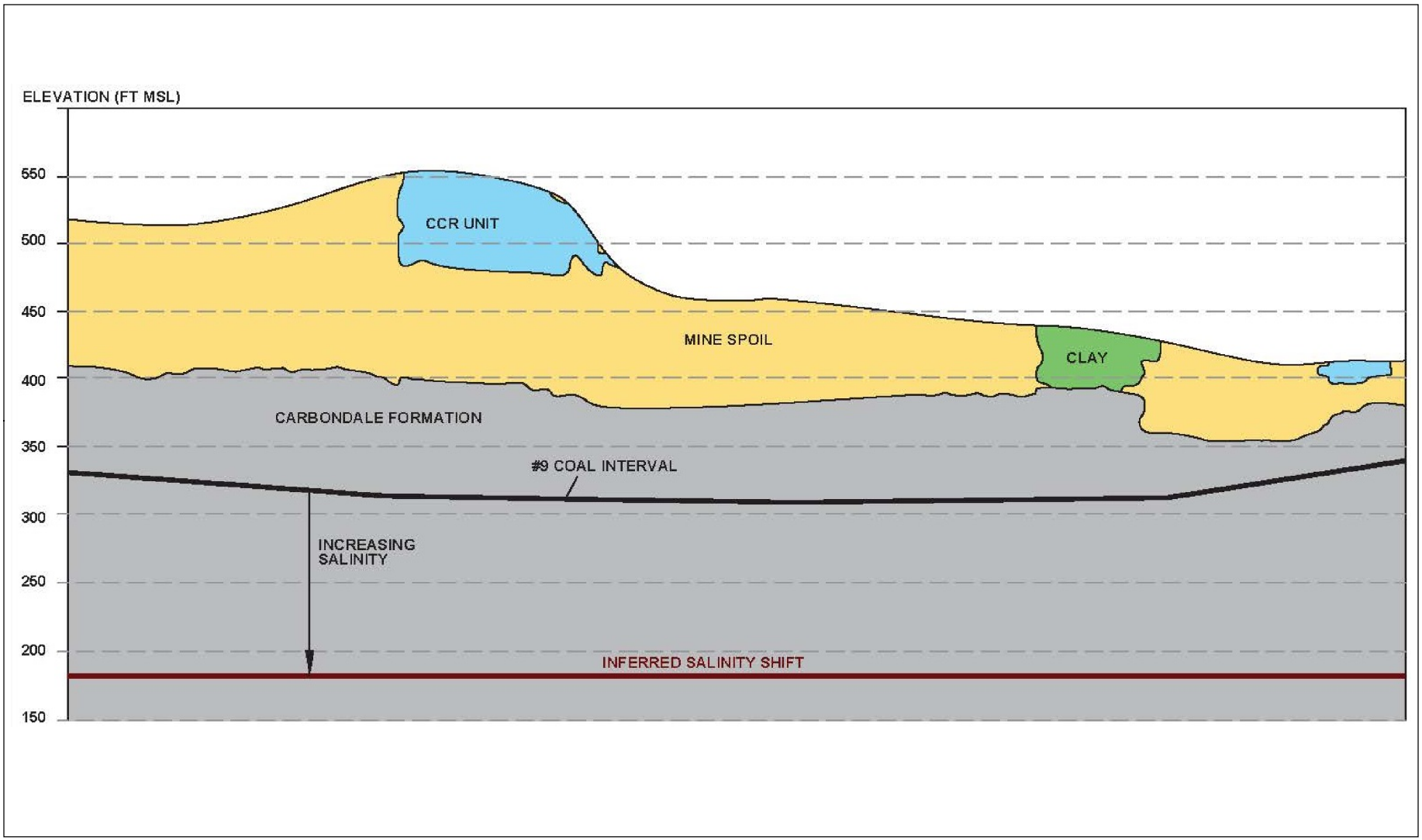
182603473

Figure No.
Figure 1

Title
CCR Units with Background and Downgradient Wells

U:\TVA-ACM\PAF\gis\mxd\TVA_ACM_PAF_Figure2-1.mxd Revised: 2019-07-11 By: LBlackman

Disclaimer: This document has been prepared based on information provided by others as cited in the Notes section. Stantec has not verified the accuracy and/or completeness of this information and shall not be responsible for any errors or omissions which may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format, and the recipient accepts full responsibility for verifying the accuracy and completeness of the data.



Project Location
Drakesboro
Muhlenberg County, KY

Prepared by LMB on 2019-07-11
Technical Review by EP on 2019-07-11
Independent Review by JB on 2019-07-11

Client/Project
Tennessee Valley Authority
Paradise Fossil Plant
CCR Rule

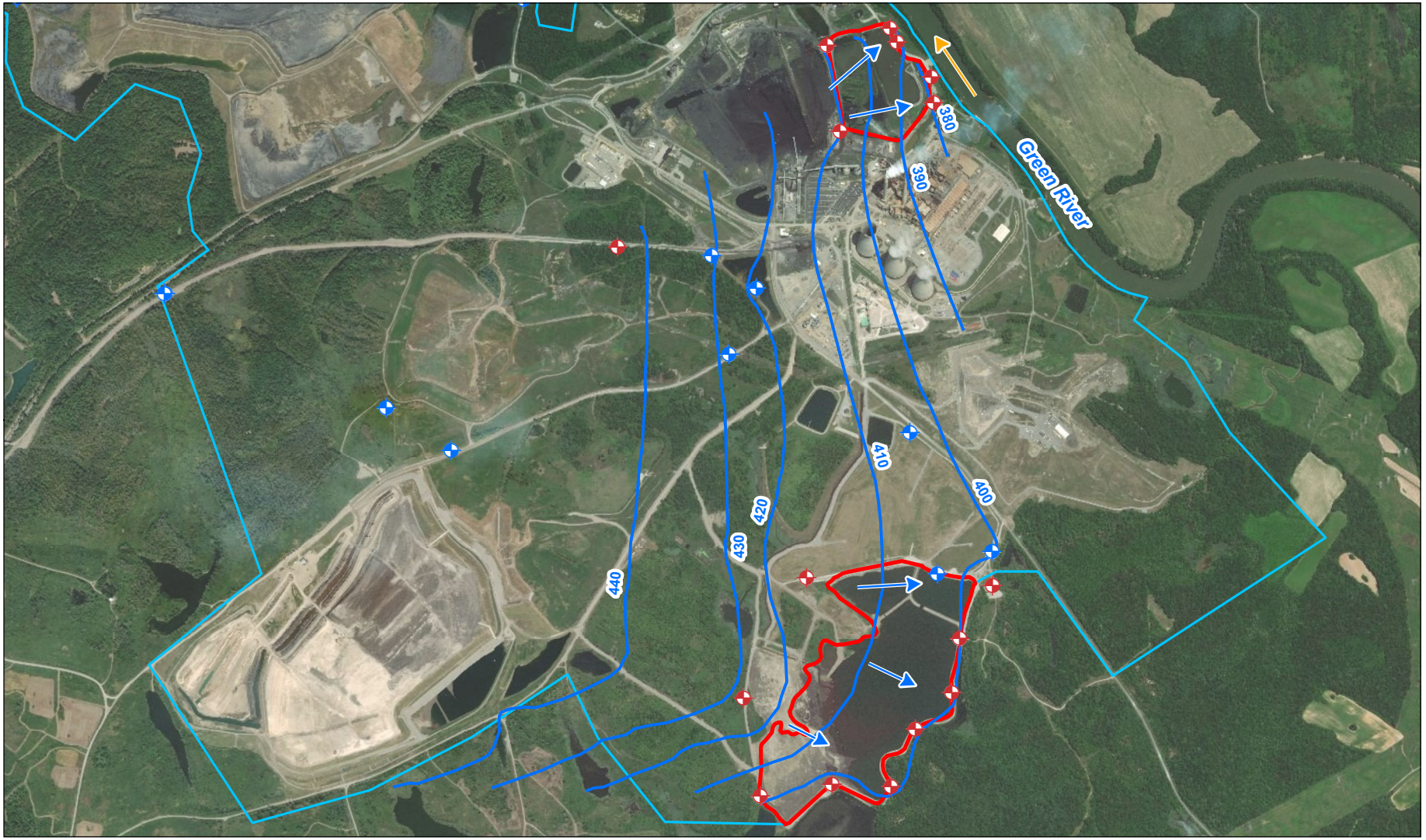
182603473

Figure No.
Figure 2

Title
Geologic Cross-Section

U:\TVA-ACM\PAF\gis\mxd\TVA_ACM_PAF_Figure2-2.mxd Revised: 2019-07-11 By: LBlackman

Disclaimer: This document has been prepared based on information provided by others as cited in the Notes section. Stantec has not verified the accuracy and/or completeness of this information and shall not be responsible for any errors or omissions which may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format, and the recipient accepts full responsibility for verifying the accuracy and completeness of the data.



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

N

0 1,000 2,000 Feet
(At original document size of 8.5x11)
1:24,000

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
Drakesboro
Muhlenberg County, KY

Prepared by LMB on 2019-07-11
Technical Review by EP on 2019-07-11
Independent Review by JB on 2019-07-11

Client/Project
Tennessee Valley Authority
Paradise Fossil Plant
CCR Rule

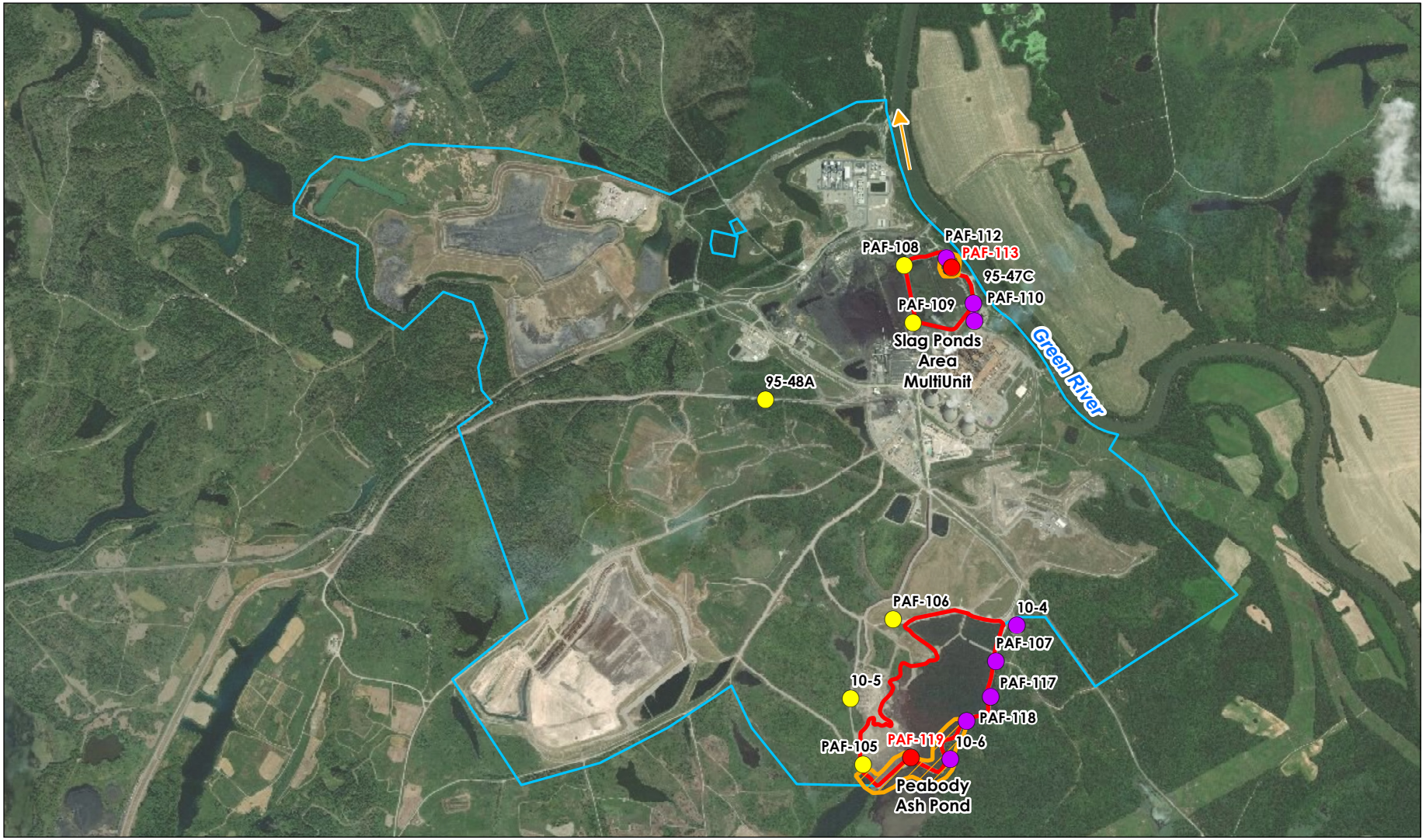
182603473

Figure No.
Figure 3

Title
Groundwater Flow Direction

U:\TVA-ACMPAP\gis\mxd\TVA_ACM_PAP_Figure2-4.mxd Revised: 2019-07-11 By: LBlackman

Disclaimer: This document has been prepared based on information provided by others as cited in the Notes section. Stantec has not verified the accuracy and/or completeness of this information and shall not be responsible for any errors or omissions which may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format, and the recipient accepts full responsibility for verifying the accuracy and completeness of the data.



- 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)

N

0 1,500 3,000 Feet

(At original document size of 8.5x11)
1:36,000

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

TVA

Project Location
Drakesboro
Muhlenberg County, KY

Prepared by LMB on 2019-07-15
Technical Review by EP on 2019-07-15
Independent Review by JB on 2019-07-15

Client/Project
Tennessee Valley Authority
Paradise Fossil Plant
CCR Rule

182603473

Figure No.
Figure 4

Title
Monitoring Wells and Limits of COI Impacts

U:\TVA-ACM\PAF\gis\mxd\TVA_ACM_PAF_Figure3-1_new.mxd Revised: 2019-07-15 By: cwooten

Disclaimer: This document has been prepared based on information provided by others as cited in the Notes section. Stantec has not verified the accuracy and/or completeness of this information and shall not be responsible for any errors or omissions which may be incorporated herein as a result. Stantec assumes no responsibility for data supplied in electronic format, and the recipient accepts full responsibility for verifying the accuracy and completeness of the data.