

**2019 Annual Groundwater  
Monitoring and Corrective  
Action Report**



Tennessee Valley Authority  
Allen Fossil Plant East Ash Disposal  
Area CCR Unit

Prepared for:  
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January 31, 2020

January 31, 2020

**Reference: 2019 Annual Groundwater Monitoring and Corrective Action Report**  
TVA Allen Fossil Plant East Ash Disposal Area CCR Unit

In accordance with 40 CFR § 257.90(e) of the Disposal of Coal Combustion Residuals from Electric Utilities final rule (CCR Rule), this 2019 Annual Groundwater Monitoring and Corrective Action Report (2019 Annual Report) documents 2019 groundwater monitoring activities at the East Ash Disposal Area CCR Unit at the Tennessee Valley Authority (TVA) Allen Fossil Plant (ALF).

An overview of the current status of the groundwater monitoring and corrective action program for the East Ash Disposal Area is provided below.

- At the start and end of the current 2019 annual reporting period, the East Ash Disposal Area was operating under an assessment monitoring program in accordance with 40 CFR § 257.95. The assessment monitoring program for the East Ash Disposal Area was initiated on August 15, 2018.
- In the 2018 assessment monitoring sampling, statistically significant levels (SSLs) above the groundwater protection standard were observed at monitoring wells: ALF-202, ALF-203 and ALF-204 for arsenic; ALF-203 for fluoride and lead; and ALF-202, ALF-203 and ALF-205 for molybdenum. As a result, an assessment of corrective measures was initiated for the East Ash Disposal Area on April 15, 2019 and was completed on July 15, 2019.
- For the 2019 assessment monitoring events, no new SSLs were identified. There continues to be SSLs above the groundwater protection standards (GWPS) for arsenic in wells AFL-202, ALF-203, and ALF-204, for lead in well ALF-203, and for molybdenum in wells ALF- 202 and ALF-203. However, unlike during 2018, and after inclusion of the three rounds of groundwater monitoring data collected in 2019, based on the 2019 statistical evaluations, there was no longer an SSL over the GWPS for fluoride in well ALF-203 and no SSL over the GWPS for molybdenum in well ALF-205.
- As a final groundwater remedy has not been selected for the East Ash Disposal Area pursuant to 40 CFR § 257.97, a Semiannual Report on the Progress of Remedy Selection was prepared and placed in the operating record on January 15, 2020, in accordance with 40 CFR § 257.97(a) and § 257.105(h)(12), to document the progress made toward selection and design of the remedy.
- Since a remedy has not been selected pursuant to 40 CFR § 257.97, remedial activities have not been initiated for the East Ash Disposal Area pursuant to 40 CFR § 257.98 during the current 2019 annual reporting period discussed herein.

In 2017, TVA established a groundwater monitoring network and program at the ALF East Ash Disposal Area CCR Unit in accordance with 40 CFR § 257.90. The groundwater monitoring network was certified by a qualified Professional Engineer as required by 40 CFR § 257.91(f). During 2019, TVA performed the following groundwater monitoring activities:

- Completed the statistical evaluation of the 2018 assessment monitoring data for Appendix IV constituents in accordance with 40 CFR § 257.95(g) in January 2019 and determined that there were statistically significant levels over the groundwater protection standard for arsenic in wells ALF-202, ALF-203 and ALF-204; fluoride and lead in well ALF-203; and molybdenum in wells ALF-202, ALF-203 and ALF-205.

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- Placed notification of the exceedances of the groundwater protection standard for arsenic in wells ALF-202, ALF-203 and ALF-204; fluoride and lead in well ALF-203; and molybdenum in wells ALF-202, ALF-203 and ALF-205 in the facility operating record in accordance with 40 CFR § 257.95(g) and § 257.105(h)(8); provided notification to the State of Tennessee in accordance with 40 CFR §257.106(h)(6); and placed notification on the CCR Rule Compliance Data and Information website (<https://www.tva.gov/Environment/Environmental-Stewardship/Coal-Combustion-Residuals>) in accordance with 40 CFR § 257.107(h)(6).
- The horizontal and vertical extent of the impacts of Appendix IV constituents of interest (arsenic, fluoride, lead and molybdenum) at the EADA has been largely characterized as a result of the Remedial Investigation conducted between 2017 and 2019 by TVA under the oversight of the Tennessee Department of Environment and Conservation.
- The East Ash Disposal Area is located on property owned by the City of Memphis and Shelby County. While there has been no indication of offsite migration of arsenic-, fluoride-, lead-, or molybdenum-impacted groundwater, TVA provides updates regarding groundwater conditions to the owners of the property upon which the East Ash Disposal Area is located. Thus, notification pursuant to 40 CFR §257.95(g)(2) has occurred, and documentation of the notification has been placed in the facility's operating record and posted to the CCR Rule Compliance Data and Information website (<https://www.tva.gov/Environment/Environmental-Stewardship/Coal-Combustion-Residuals>).
- Initiated Assessment of Corrective Measures in accordance with 40 CFR § 257.95(g)(3)(i) and 40 CFR § 257.96.
- Completed the Assessment of Corrective Measures in accordance with 40 CFR § 257.96(d), which was placed on the CCR Rule Compliance Data and Information website (<https://www.tva.gov/Environment/Environmental-Stewardship/Coal-Combustion-Residuals>) in accordance with 40 CFR § 257.107(h)(8).
- Sampled and analyzed wells in the certified monitoring network for CCR constituents (Appendix III and Appendix IV constituents) for the 2019 semiannual assessment monitoring events in accordance with 40 CFR § 257.95(d)(1). The sampling results were placed in the operating record as required by 40 CFR § 257.95(d)(1) and 257.105(h)(6). Additionally, these results are included in Table 1 of this 2019 Annual Report in accordance with 40 CFR § 257.95(d)(3).
- Placed notification of exceedances of groundwater protection standards in the facility operating record in accordance with 40 CFR § 257.95(g) and 257.105(h)(8); provided notification to the State of Tennessee in accordance with 40 CFR § 257.106(h)(6); and placed the notification on the CCR Rule Compliance Data and Information website (<https://www.tva.gov/Environment/Environmental-Stewardship/Coal-Combustion-Residuals>) in accordance with 40 CFR § 257.107(h)(6)<sup>1</sup>.
- Continued TVA's third-party Quality Assurance Program to evaluate and improve groundwater analytical data using best practices concerning field methods and validation techniques, as well as the application of the most appropriate statistical methods.
- Reviewed new data as it became available to maintain compliance with 40 CFR § 257.90 through 257.98.
- Complied with recordkeeping requirements as 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).

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<sup>1</sup> Table 6 in this 2019 Annual Groundwater Monitoring and Corrective Action Report meets this notification requirement for the second semiannual assessment monitoring sampling event conducted in 2019.

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No problems were encountered during the third year of the Groundwater Quality Monitoring Program; therefore, no further action has been recommended, except for the planned key activities for 2020 that are outlined below.

The projected key activities for 2020 are:

- Continue semiannual assessment monitoring at the certified groundwater monitoring network consistent with 40 CFR § 257.95 and place the sampling results in the operating record as required by 40 CFR § 257.95(d)(1) and 257.105(h)(6).
- Complete an evaluation of whether one or more Appendix IV constituents are detected at SSLs above the established groundwater protection standards in accordance with 40 CFR § 257.95(g).
- Continue to refine the characterization of the nature and extent of the release.
- Perform further site characterization investigations to improve the ALF Conceptual Site Model (CSM).
- Prepare and place in the operating record a Semiannual Progress Report on July 15, 2020 in accordance with 40 CFR § 257.97(a) to document the progress made toward selection and design of the remedy.
- Place notification of exceedances of groundwater protection standards in the facility operating record in accordance with 40 CFR § 257.95(g) and 257.105(h)(8); provide notification to the State of Tennessee in accordance with 40 CFR § 257.106(h)(6); and place the notification on the CCR Rule Compliance Data and Information website (<https://www.tva.gov/Environment/Environmental-Stewardship/Coal-Combustion-Residuals>) in accordance with 40 CFR § 257.107(h)(6).
- Continue TVA's third-party Quality Assurance Program to evaluate groundwater analytical data using best practices concerning field methods and validation techniques, as well as the application of the most appropriate statistical methods.
- Review new data as it becomes available and implement changes to the groundwater monitoring program as necessary to maintain compliance with 40 CFR § 257.90 through 257.98.
- Comply with recordkeeping requirements as 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).

### GROUNDWATER MONITORING WELL NETWORK

The East Ash Disposal Area is located east of the power plant building and formerly received sluiced CCR materials from the fossil plant. The sluiced material entered the disposal area from the west side of the facility and ultimately discharged through an NPDES outfall in the northeast corner of the CCR unit to allow particle settlement to occur. The plant ceased coal firing operations in 2018.

The monitoring well network for the ALF East Ash Disposal Area CCR Unit consists of one background well (ALF-210) and eight downgradient wells (ALF-201, ALF-202, ALF-203, ALF-204, ALF-205, ALF-206, ALF-212 and ALF-213). Figure 1 is an aerial photograph that shows the groundwater monitoring well locations. The downgradient wells are installed at the waste boundary. The monitoring well network was designed for a single CCR Unit (East Ash Disposal Area).

No monitoring wells in the CCR Rule network were installed or decommissioned during the 2019 reporting period. The certification of the groundwater monitoring system required under 40 CFR § 257.91(f) is included in the facility operating record and on the CCR Rule Compliance Data and Information website (<https://www.tva.gov/Environment/Environmental-Stewardship/Coal-Combustion-Residuals>).

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### GROUNDWATER SAMPLING AND LABORATORY ANALYTICAL TESTING

A groundwater sampling and analysis program was developed in 2016-2017 and includes as required by 40 CFR § 257.93(a) procedures and techniques for: sample collection; sample preservation and shipment; analytical procedures; chain-of-custody control; and quality assurance and quality control (QA/QC). The groundwater monitoring program includes sampling and analysis procedures designed to provide monitoring results that are an accurate representation of groundwater quality at background and downgradient wells.

The 2019 assessment monitoring groundwater sampling was conducted between January and October 2019 and the results are summarized in Table 1. Two semiannual assessment monitoring groundwater sampling events were each followed by retesting groundwater sampling events. A summary of groundwater sample locations, well designations, analytes sampled, sampling dates and monitoring program status is provided in Table 2.

Groundwater elevations were measured in each monitoring well immediately prior to purging during each sampling event as required by 40 CFR § 257.93(c). Groundwater elevations and McKellar Lake surface water elevations are summarized in Table 3. Groundwater flow directions were determined for each sampling event, and a generalized depiction of groundwater flow direction is illustrated on Figure 2. The groundwater directional flow at the ALF East Ash Disposal Area is influenced by McKellar Lake to the north of the site. The primary groundwater flow direction is to the north toward McKellar Lake; however, three of the four groundwater level measurement events in 2019 indicated a flow direction to the south.

Testing for hydraulic conductivity at the background or downgradient groundwater monitoring wells, as summarized in Table 4, was determined by a 2018 hydrogeologic evaluation (Terracon, 2019). The uppermost aquifer at the ALF CCR Unit is the Alluvial aquifer. These alluvial deposits are composed of a fine to medium-grained silty sand with intervals of fine-grained silts and clays in the upper portion of the unit and fine- to coarse-grained sand with trace fine- to coarse-grained gravel in the lower portion. The alluvial deposits are underlain by the fine-grained Cook Mountain Formation (hydrogeologically referred to as the upper Claiborne confining unit in this location). The Cook Mountain Formation is underlain by the Memphis Sand, which is characterized by predominantly very fine to very coarse-grained sand with lenses of fine-grained material and is referred to as the Memphis aquifer. Based on deep exploratory drilling in the vicinity of ALF-202, the upper Claiborne confining unit is absent and the Alluvial aquifer directly overlies the Memphis Sand in that area. Testing data indicates the Alluvial Aquifer has a geometric mean hydraulic conductivity of  $5.6 \times 10^{-4}$  centimeters per second (cm/sec). Linear groundwater flow velocity was calculated for the uppermost aquifer using:

- the geometric mean hydraulic conductivity calculated from hydraulic testing ( $5.6 \times 10^{-4}$  cm/sec);
- horizontal hydraulic gradients measured during the implementation of the groundwater sampling and analysis program, ranging from 0.0020 to 0.0091 feet per foot (ft/ft); and,
- an effective porosity of 22% in the native sand (Jazaei et al., 2018).

The average linear flow velocity in the uppermost aquifer ranges from approximately 5.3 to 24 feet per year. The rate and direction of groundwater flow for each groundwater sampling event is summarized in Table 5 in accordance with 40 CFR § 257.93(c).

### STATISTICAL ANALYSIS OF GROUNDWATER DATA

The groundwater monitoring data for the 2019 assessment monitoring events were evaluated using statistical procedures as required by 40 CFR § 257.93(f)-(h). The statistical method certification is included in the facility operating record and the CCR Rule Compliance Data and Information website. Groundwater protection standards were established in accordance with 40 CFR § 257.95(h), as the larger of published regulatory limits or screening criteria (e.g., maximum contaminant levels (MCLs) and upper tolerance limits

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(UTLs) derived from background). Maximum contaminant levels may or may not be considered the appropriate groundwater protection standard depending on background well concentrations for each Appendix IV<sup>2</sup> constituent<sup>3</sup>. The 2019 Statistical Analysis Report is included in Appendix A.

The sampling results used to identify potential groundwater protection standards exceedances were obtained during four monitoring events that were performed between January and October of 2019.<sup>4</sup> Comparisons were made against a fixed groundwater protection standard via a confidence interval band. Retesting was conducted after each semiannual sampling event, and none of the individual compliance point measurements were directly compared against the groundwater protection standard. The Appendix IV monitoring data collected in Year-One (2017), Year-Two (2018), and Year-Three (2019)<sup>5</sup> were used to construct the confidence interval bands. Cross-sections of each confidence interval band were then compared to the groundwater protection standard for the most recent assessment monitoring event in each case for the purpose of identifying any SSLs. A well-constituent pair is considered out of compliance only if its average constituent levels, as estimated via the confidence interval cross-section, currently exceed the groundwater protection standard.

### NARRATIVE DISCUSSION OF ANY TRANSITION BETWEEN MONITORING PROGRAMS

An Assessment Monitoring Program was established on August 15, 2018 and implemented as specified in 40 CFR § 257.95. Notification of the assessment monitoring program was provided to the State of Tennessee and placed on the CCR Rule Compliance Data and Information website (<https://www.tva.gov/Environment/Environmental-Stewardship/Coal-Combustion-Residuals>) on September 14, 2018 in accordance with 40 CFR § 257.106(h)(4) and 40 CFR § 257.107(h)(4), respectively.

In accordance with assessment monitoring program requirements, subsequent sampling and analysis of all wells in the certified monitoring network for Appendix III and IV constituents occurred in accordance with 40 CFR § 257.95(d)(1). Appendix III and IV constituent concentrations from 2019 assessment monitoring sampling events are summarized in Table 1. Groundwater protection standards were established in accordance with 40 CFR § 257.95(d)(2) and are summarized along with Appendix IV SSLs in Table 6. Based on the statistical analysis, there continues to be SSLs above the groundwater protection standards for arsenic in wells AFL-202, ALF-203, and ALF-204, for lead in well ALF-203, and for molybdenum in wells ALF-202 and ALF-203. However, based on the 2019 statistical evaluations, there was no longer an SSL over the GWPS for fluoride in well ALF-203 or for molybdenum in well ALF-205. TVA will continue to review new data as it becomes available and implement changes to the groundwater monitoring program as necessary to maintain compliance with 40 CFR § 257.90 through 257.98.

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<sup>2</sup> Appendix IV CCR Constituents: antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, fluoride, lead, lithium, mercury, molybdenum, selenium, thallium, radium 226 and radium 228 combined

<sup>3</sup> USEPA has published Maximum Contaminant Limits (MCL) or alternate regulatory limits for each of the Appendix IV constituents. Consequently, in most cases the groundwater protection standard is equal to the MCL. However, there may be cases where background levels of a constituent exceed the MCL. In these instances, an alternate groundwater protection standard must be derived from on-site background levels. On July 30, 2018, EPA provided alternate regulatory limits (i.e., that could be used as potential groundwater protection standards) for four of the Appendix IV chemical Constituents of Interest (COIs) for which the agency has not assigned MCLs to date. If site-specific background levels are lower, then these may be used in place of background levels under 40 CFR § 257.95(h)(2). Specifically, those alternate COIs include threshold values at the following levels: 1.) Cobalt - 6 µg/L; 2.) Lithium - 40 µg/L; 3.) Molybdenum – 100 µg/L; and, 4.) Lead - 15 µg/L.

<sup>4</sup> The CCR rule requires a minimum of two semiannual sampling events per well once the required background data has been obtained. In 2019, two semiannual assessment monitoring groundwater sampling events were each followed by retesting groundwater sampling events.

<sup>5</sup> The October 2019 retest groundwater sampling event that followed the second semiannual sampling event was not included in the statistical evaluation. This information will be included in the statistical evaluation of 2020 assessment monitoring sampling events.

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## LIMITATIONS

This document entitled 2019 Annual Groundwater Monitoring and Corrective Action Report was prepared by Stantec Consulting Services Inc. ("Stantec") for the Tennessee Valley Authority (the "Client"). The material in it reflects Stantec's professional judgment in light of the scope, schedule and other limitations stated in the document. The opinions in the document are based on conditions and information existing at the time the document was published and do not take into account any subsequent changes. In preparing the document, Stantec relied upon data and information supplied to it by the client.

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January 31, 2020

## References:

Jazaei, F., Waldron, B., Schoefernacker, S. and Larsen, D. 2018. *Application of Numerical Tools to Investigate a Leaky Aquitard beneath Urban Well Fields* Center for Applied Earth Science and Engineering Research (CAESER), University of Memphis, Memphis, TN 38152, USA - *Water* 2019, 11(1), 5; <https://doi.org/10.3390/w11010005>

Terracon, 2019. Aquifer Testing and Equipment Blank Results. TVA CCR Rule – Allen Fossil Plant (ALF). Terracon Consultants, Inc. January 15, 2019.

## Attachments:

Figure 1 – Map with CCR Unit Background and Downgradient Wells

Figure 2 – Generalized Groundwater Flow Direction Map

Table 1 – Assessment Monitoring Groundwater Sampling Results

Table 2 – Groundwater Sampling Summary

Table 3 – Groundwater and Surface Water Elevation Summary

Table 4 – Hydraulic Conductivity Data Summary

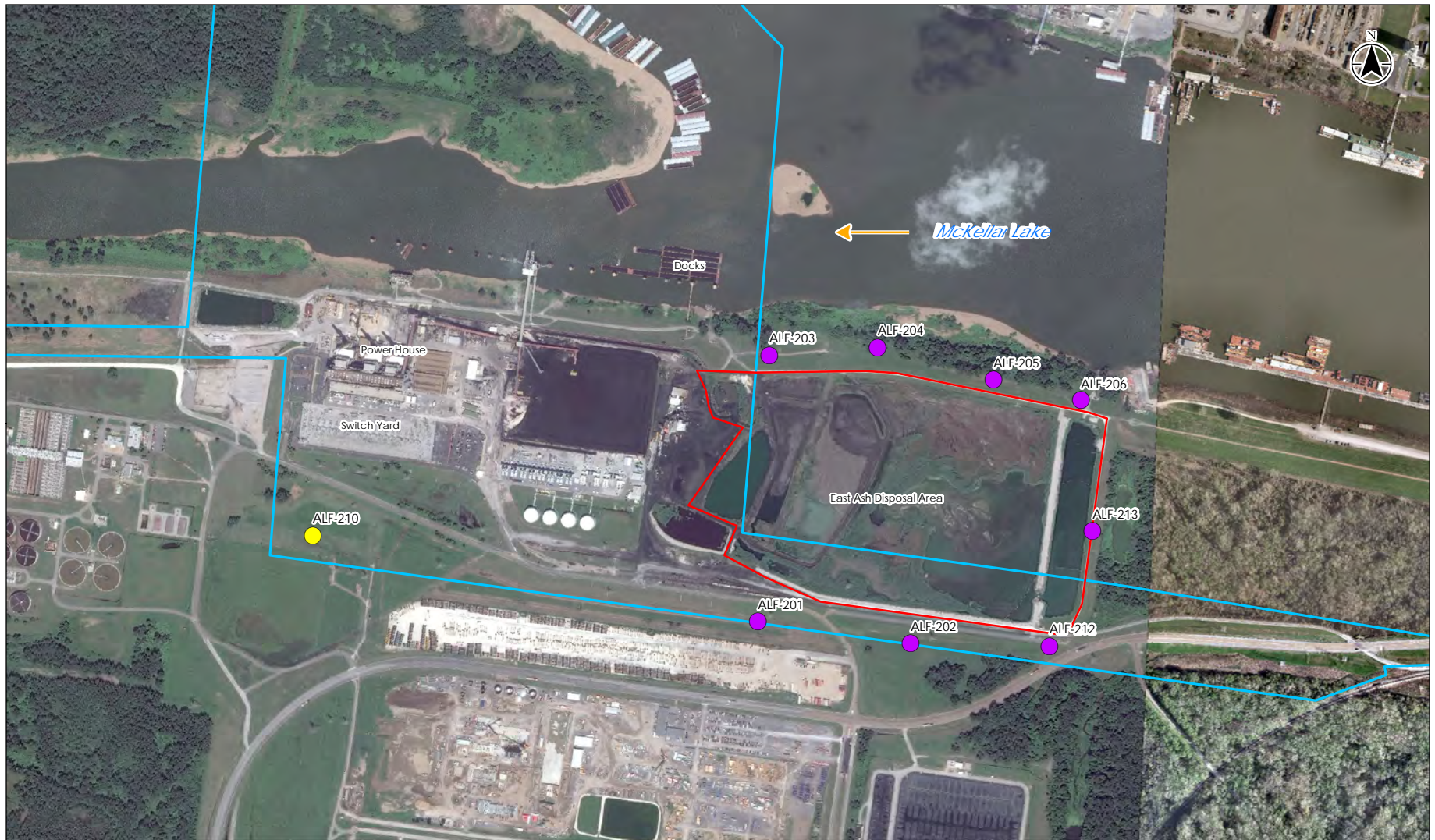
Table 5 – Rate and Direction of Groundwater Flow Summary

Table 6 – Statistically Significant Levels (SSLs) Above GWPSs

Appendix A – 2019 Statistical Analysis Report



## **FIGURES**



- Background Well
- Downgradient Well
- Surface Water Flow Direction
- CCR Unit Subject to CCR Rule
- TVA Property Boundary



Notes  
 1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet  
 2. Imagery Provided by Client (dated 2016)

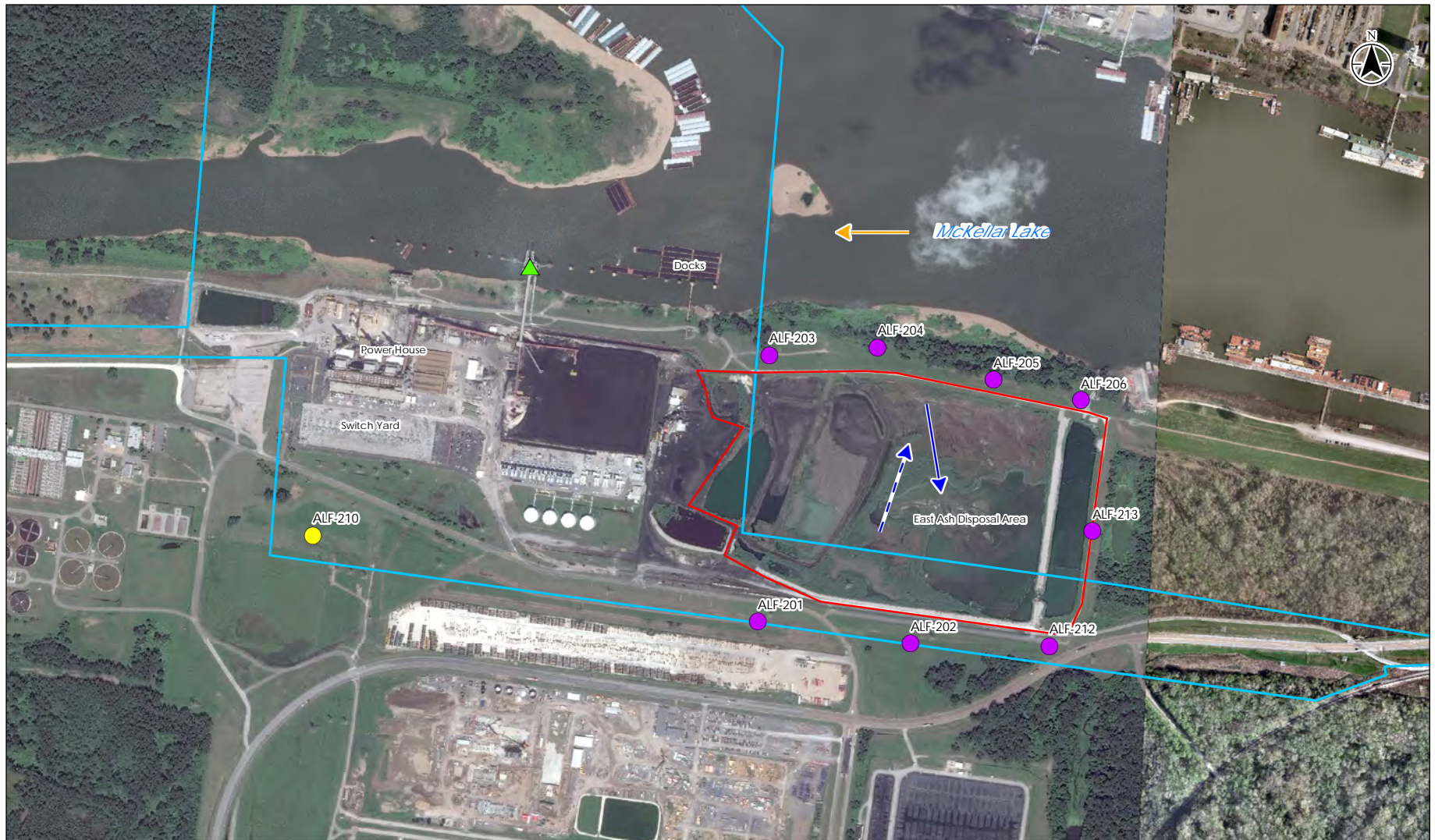
Project Location 182603174  
 City of Memphis Prepared by WSW on 2020-01-27  
 Shelby County, Tennessee Technical Review by SB on 2020-01-27  
 Tennessee Independent Review by JK on 2020-01-27

Client/Project  
 Tennessee Valley Authority  
 Allen Fossil Plant  
 CCR Rule

Figure No.  
 1



Title  
 Map with CCR Unit Background and Downgradient Wells



U:\182603174\GIS\mxd\182603174\_002\_GeneralizedGroundwaterFlowDir.mxd Revised: 2020-01-27 By: pchowdh



- ▲ Staff Gauge
- Background Well
- Downgradient Well
- Surface Water Flow Direction
- Groundwater Flow Direction - January, April and October 2019
- Groundwater Flow Direction - August 2019
- CCR Unit Subject to CCR Rule
- TVA Property Boundary

Groundwater flow directions are based on TVA Property Boundary, Mckellar Lake elevations and groundwater elevations from CCR and Non-CCR monitoring wells.



Notes  
 1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet  
 2. Imagery Provided by Client (dated 2016)



Project Location: 182603174  
 City of Memphis  
 Shelby County,  
 Tennessee  
 Prepared by CMB on 2020-01-27  
 Technical Review by WSW on 2020-01-27  
 Independent Review by MD on 2020-01-27

Client/Project:  
 Tennessee Valley Authority  
 Allen Fossil Plant  
 CCR Rule

Figure No.  
 2

Title  
 Generalized Groundwater  
 Flow Direction Map

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## **TABLES**

**Table 1  
Assessment Monitoring  
Groundwater Sampling  
Results**

**CCR Annual Groundwater Monitoring  
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| Monitoring Well          |       | ALF-201      |    |              |    |              |    |              |    |
|--------------------------|-------|--------------|----|--------------|----|--------------|----|--------------|----|
| Sample Date              |       | 08-Jan-19    |    | 23-Apr-19    |    | 20-Aug-19    |    | 15-Oct-19    |    |
| Sample Round             |       | 1            |    | 1 - Retest   |    | 2            |    | 2 - Retest   |    |
| Well Designation         |       | Downgradient |    | Downgradient |    | Downgradient |    | Downgradient |    |
| Analyte                  | Units | Result       | Q  | Result       | Q  | Result       | Q  | Result       | Q  |
| <b>Total Metals</b>      |       |              |    |              |    |              |    |              |    |
| Antimony                 | ug/L  | < 1.12       | U  | < 0.378      | U  | < 0.378      | U  | < 0.378      | U  |
| Arsenic                  | ug/L  | < 1.06       | U* | < 0.961      | U* | 0.654        | J  | 0.546        | J  |
| Barium                   | ug/L  | 242          |    | 232          |    | 228          |    | 227          |    |
| Beryllium                | ug/L  | < 0.057      | U  | < 0.155      | U  | < 0.182      | U  | < 0.182      | U  |
| Boron                    | ug/L  | 2120         |    | 1410         |    | 1250         |    | 1140         |    |
| Cadmium                  | ug/L  | < 0.125      | U  | < 0.125      | U  | < 0.125      | U  | < 0.125      | U  |
| Calcium                  | ug/L  | 115000       |    | 112000       |    | 105000       |    | 105000       |    |
| Chromium                 | ug/L  | < 1.48       | U* | < 1.53       | U  | < 2.39       | U* | < 1.53       | U  |
| Cobalt                   | ug/L  | 0.468        | J  | 0.341        | J  | 0.351        | J  | 0.232        | J  |
| Lead                     | ug/L  | < 0.094      | U  | < 0.128      | U  | < 0.128      | U  | < 0.128      | U  |
| Lithium                  | ug/L  | 16           |    | 19.2         |    | 16.1         |    | < 18.5       | U* |
| Molybdenum               | ug/L  | 137          |    | 85.6         |    | 69           |    | 84           |    |
| Selenium                 | ug/L  | 1.67         | J  | < 2.62       | U  | 3.26         | J  | < 1.82       | U* |
| Thallium                 | ug/L  | < 0.063      | U  | < 0.128      | U  | < 0.148      | U  | < 0.148      | U  |
| Radium 226 + Radium 228  | pCi/L | 0.529        | J  | 0.463        | J  | 1.13         | J  | 0.969        | J  |
| <b>Anions</b>            |       |              |    |              |    |              |    |              |    |
| Chloride                 | mg/L  | 8.51         |    | 7.09         |    | 9.9          |    | 10.6         |    |
| Fluoride                 | mg/L  | 1.04         |    | 0.651        |    | < 0.87       | U* | 0.645        |    |
| Sulfate                  | mg/L  | 60.9         |    | 55.4         |    | 51.6         |    | 63           |    |
| <b>General Chemistry</b> |       |              |    |              |    |              |    |              |    |
| Total Dissolved Solids   | mg/L  | 523          |    | 452          |    | 462          |    | 165          |    |
| <b>Field Parameters</b>  |       |              |    |              |    |              |    |              |    |
| Temperature, Water (C)   | DEG_C | 20           |    | 19.1         |    | 24.8         |    | 21.1         |    |
| Turbidity, field         | NTU   | 2.13         |    | 2.45         |    | 2.87         |    | 0.59         |    |
| ORP                      | mV    | 54.4         |    | 131.6        |    | -103.9       |    | 50.9         |    |
| Specific Cond. (Field)   | mS/cm | 0.81         |    | 0.54         |    | 0.75         |    | 0.68         |    |
| Dissolved Oxygen         | mg/L  | 0.53         |    | 0.41         |    | 0.66         |    | 0.4          |    |
| pH (field)               | SU    | 6.72         |    | 6.85         |    | 6.81         |    | 6.93         |    |

Notes:

Q - Data Qualifier

U\* - Result should be considered "not-detected" because it was detected in a rinsate blank or laboratory blank at similar level

J - Quantitation is approximate due to limitations identified during data validation

UJ - Analyte not detected, but the reporting limit may or may not be higher due to a bias identified during data validation

U - Analyte not detected

ug/L - micrograms per liter

NTU - Nephelometric Turbidity Units

mg/L - milligrams per liter

mV - millivolts

pCi/L - picoCurie per liter

mS/cm - milliseimens per centimeter

DEG\_C - degrees Celsius

SU - Standard Unit

**ASSESSMENT  
MONITORING**

**Table 1  
Assessment Monitoring  
Groundwater Sampling  
Results**

**CCR Annual Groundwater Monitoring  
and Corrective Action Report - TVA  
Allen Fossil Plant**

| Monitoring Well          |       | ALF-202      |    |              |    |              |    |              |    |
|--------------------------|-------|--------------|----|--------------|----|--------------|----|--------------|----|
| Sample Date              |       | 08-Jan-19    |    | 23-Apr-19    |    | 20-Aug-19    |    | 16-Oct-19    |    |
| Sample Round             |       | 1            |    | 1 - Retest   |    | 2            |    | 2 - Retest   |    |
| Well Designation         |       | Downgradient |    | Downgradient |    | Downgradient |    | Downgradient |    |
| Analyte                  | Units | Result       | Q  | Result       | Q  | Result       | Q  | Result       | Q  |
| <b>Total Metals</b>      |       |              |    |              |    |              |    |              |    |
| Antimony                 | ug/L  | < 1.12       | U  | < 0.378      | U  | < 0.378      | U  | < 0.378      | U  |
| Arsenic                  | ug/L  | 334          |    | 306          |    | 325          |    | 337          |    |
| Barium                   | ug/L  | 58.9         |    | 57.3         |    | 79.4         |    | 64.6         |    |
| Beryllium                | ug/L  | < 0.057      | U  | < 0.155      | U  | < 0.182      | U  | < 0.182      | U  |
| Boron                    | ug/L  | 5480         |    | 5030         |    | 5660         |    | 5100         |    |
| Cadmium                  | ug/L  | 0.155        | J  | 0.134        | J  | 0.187        | J  | < 0.125      | U  |
| Calcium                  | ug/L  | 19800        |    | 22800        |    | 21500        |    | 19400        |    |
| Chromium                 | ug/L  | < 2.06       | U* | 2.71         |    | < 2.3        | U* | < 1.53       | U  |
| Cobalt                   | ug/L  | 0.185        | J  | 0.103        | J  | 0.118        | J  | 0.09         | J  |
| Lead                     | ug/L  | 0.868        | J  | < 0.4        | U* | 0.639        | J  | 0.73         | J  |
| Lithium                  | ug/L  | < 5.73       | U* | < 7.67       | U* | 8.18         |    | 8.86         |    |
| Molybdenum               | ug/L  | 273          |    | 405          |    | 386          |    | 325          |    |
| Selenium                 | ug/L  | < 0.813      | U  | < 2.62       | U  | < 1.51       | U  | < 1.92       | U* |
| Thallium                 | ug/L  | < 0.063      | U  | < 0.128      | U  | < 0.148      | U  | < 0.148      | U  |
| Radium 226 + Radium 228  | pCi/L | < 0.343      | U  | 0.339        | J  | < 0.526      | U  | < 0.00       | U  |
| <b>Anions</b>            |       |              |    |              |    |              |    |              |    |
| Chloride                 | mg/L  | 15.2         |    | 14.3         |    | 13.9         |    | 13.9         |    |
| Fluoride                 | mg/L  | 3.57         |    | 3.94         |    | 3.61         |    | 3.6          |    |
| Sulfate                  | mg/L  | 154          |    | 112          |    | 124          |    | 136          |    |
| <b>General Chemistry</b> |       |              |    |              |    |              |    |              |    |
| Total Dissolved Solids   | mg/L  | 364          |    | 356          |    | 371          |    | 367          |    |
| <b>Field Parameters</b>  |       |              |    |              |    |              |    |              |    |
| Temperature, Water (C)   | DEG_C | 18.9         |    | 18.6         |    | 19.9         |    | 19           |    |
| Turbidity, field         | NTU   | 0.84         |    | 4.45         |    | 3.03         |    | 0.67         |    |
| ORP                      | mV    | 16.4         |    | -133.7       |    | -166.9       |    | -123         |    |
| Specific Cond. (Field)   | mS/cm | 0.52         |    | 0.377        |    | 0.56         |    | 0.487        |    |
| Dissolved Oxygen         | mg/L  | 0.24         |    | 0.11         |    | 0.13         |    | 0.14         |    |
| pH (field)               | SU    | 7.32         |    | 7.5          |    | 6.89         |    | 7.69         |    |

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DEG\_C - degrees Celsius

SU - Standard Unit

**ASSESSMENT  
MONITORING**

**Table 1  
Assessment Monitoring  
Groundwater Sampling  
Results**

**CCR Annual Groundwater Monitoring  
and Corrective Action Report - TVA  
Allen Fossil Plant**

| Monitoring Well          |       | ALF-203      |    |              |    |              |   |              |    |
|--------------------------|-------|--------------|----|--------------|----|--------------|---|--------------|----|
| Sample Date              |       | 10-Jan-19    |    | 24-Apr-19    |    | 22-Aug-19    |   | 17-Oct-19    |    |
| Sample Round             |       | 1            |    | 1 - Retest   |    | 2            |   | 2 - Retest   |    |
| Well Designation         |       | Downgradient |    | Downgradient |    | Downgradient |   | Downgradient |    |
| Analyte                  | Units | Result       | Q  | Result       | Q  | Result       | Q | Result       | Q  |
| <b>Total Metals</b>      |       |              |    |              |    |              |   |              |    |
| Antimony                 | ug/L  | 1.67         | J  | 1.13         | J  | 1.36         | J | 1.41         | J  |
| Arsenic                  | ug/L  | 1910         |    | 1180         |    | 2060         |   | 2080         |    |
| Barium                   | ug/L  | 19.4         |    | 116          |    | 24.1         |   | 22.7         |    |
| Beryllium                | ug/L  | 0.086        | J  | 0.231        | J  | < 0.182      | U | < 0.182      | U  |
| Boron                    | ug/L  | 6960         |    | 5240         |    | 9020         |   | 7680         |    |
| Cadmium                  | ug/L  | 1.16         |    | 1.23         |    | 1.28         |   | 0.978        | J  |
| Calcium                  | ug/L  | 6240         |    | 57800        |    | 9310         |   | 8440         |    |
| Chromium                 | ug/L  | < 3.67       | U* | < 2.47       | U* | < 1.53       | U | < 1.53       | U  |
| Cobalt                   | ug/L  | 0.413        | J  | 0.555        |    | 0.37         | J | 0.292        | J  |
| Lead                     | ug/L  | 36.2         |    | 24.7         |    | 37.9         |   | 30.3         |    |
| Lithium                  | ug/L  | < 4.4        | U* | < 13         | U* | < 3.39       | U | 4            | J  |
| Molybdenum               | ug/L  | 463          |    | 373          |    | 536          |   | 400          |    |
| Selenium                 | ug/L  | 5.98         |    | 7.3          |    | 4.8          | J | < 6.6        | U* |
| Thallium                 | ug/L  | < 0.063      | U  | < 0.128      | U  | < 0.148      | U | < 0.148      | U  |
| Radium 226 + Radium 228  | pCi/L | 0.952        | J  | 0.306        | J  | < 0.609      | U | < 0.880      | U  |
| <b>Anions</b>            |       |              |    |              |    |              |   |              |    |
| Chloride                 | mg/L  | 18.3         |    | 12.2         |    | 16.9         |   | 15.9         |    |
| Fluoride                 | mg/L  | 5.02         |    | 3.12         |    | 4.93         |   | 4.21         |    |
| Sulfate                  | mg/L  | 298          |    | 173          |    | 293          |   | 232          |    |
| <b>General Chemistry</b> |       |              |    |              |    |              |   |              |    |
| Total Dissolved Solids   | mg/L  | 782          |    | 631          |    | 787          |   | 683          |    |
| <b>Field Parameters</b>  |       |              |    |              |    |              |   |              |    |
| Temperature, Water (C)   | DEG_C | 16.8         |    | 19.4         |    | 21.9         |   | 21           |    |
| Turbidity, field         | NTU   | 1.26         |    | 3.05         |    | 3.89         |   | 1.06         |    |
| ORP                      | mV    | 33.7         |    | 115.1        |    | -176.2       |   | -63.7        |    |
| Specific Cond. (Field)   | mS/cm | 0.97         |    | 0.65         |    | 1.09         |   | 0.87         |    |
| Dissolved Oxygen         | mg/L  | 0.36         |    | 0.3          |    | 0.12         |   | 0.23         |    |
| pH (field)               | SU    | 10.56        |    | 8.68         |    | 9.83         |   | 10.22        |    |

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**ASSESSMENT  
MONITORING**

**Table 1  
Assessment Monitoring  
Groundwater Sampling  
Results**

**CCR Annual Groundwater Monitoring  
and Corrective Action Report - TVA  
Allen Fossil Plant**

| Monitoring Well          |       | ALF-204      |    |              |    |              |    |              |    |
|--------------------------|-------|--------------|----|--------------|----|--------------|----|--------------|----|
| Sample Date              |       | 10-Jan-19    |    | 24-Apr-19    |    | 21-Aug-19    |    | 17-Oct-19    |    |
| Sample Round             |       | 1            |    | 1 - Retest   |    | 2            |    | 2 - Retest   |    |
| Well Designation         |       | Downgradient |    | Downgradient |    | Downgradient |    | Downgradient |    |
| Analyte                  | Units | Result       | Q  | Result       | Q  | Result       | Q  | Result       | Q  |
| <b>Total Metals</b>      |       |              |    |              |    |              |    |              |    |
| Antimony                 | ug/L  | < 1.12       | U  | < 0.378      | U  | < 0.378      | U  | < 0.378      | U  |
| Arsenic                  | ug/L  | 40.3         |    | 39.5         |    | 62.9         |    | 45.8         |    |
| Barium                   | ug/L  | 317          |    | 336          |    | 327          | J  | 283          |    |
| Beryllium                | ug/L  | < 0.057      | U  | < 0.155      | U  | 0.182        | J  | < 0.182      | U  |
| Boron                    | ug/L  | 527          |    | 604          |    | < 446        | U* | < 461        | U* |
| Cadmium                  | ug/L  | < 0.125      | U  | < 0.125      | U  | 0.171        | J  | < 0.125      | U  |
| Calcium                  | ug/L  | 64500        |    | 67800        |    | 59000        |    | 56900        |    |
| Chromium                 | ug/L  | < 1.87       | U* | < 1.53       | U  | < 3.92       | U* | < 1.53       | U  |
| Cobalt                   | ug/L  | < 0.075      | U  | 0.352        | J  | < 0.22       | U* | 0.106        | J  |
| Lead                     | ug/L  | < 0.094      | U  | < 0.221      | U* | 0.156        | J  | 0.162        | J  |
| Lithium                  | ug/L  | < 8.15       | U* | < 8.24       | U* | 7.69         | J  | 7.29         |    |
| Molybdenum               | ug/L  | 16.7         |    | 12.1         |    | 5.73         |    | 12.5         |    |
| Selenium                 | ug/L  | < 0.813      | U  | < 2.62       | U  | < 1.51       | U  | < 1.82       | U* |
| Thallium                 | ug/L  | < 0.063      | U  | < 0.128      | U  | 0.266        | J  | < 0.148      | U  |
| Radium 226 + Radium 228  | pCi/L | < 0.293      | U  | 0.143        | J  | < 0.628      | U  | < 0.887      | U* |
| <b>Anions</b>            |       |              |    |              |    |              |    |              |    |
| Chloride                 | mg/L  | 14.4         |    | 11           |    | 12.5         |    | 12.6         |    |
| Fluoride                 | mg/L  | 0.178        |    | 0.13         |    | < 0.127      | U* | < 0.13       | U* |
| Sulfate                  | mg/L  | 30.7         |    | 23.8         |    | 20.2         |    | 20.4         |    |
| <b>General Chemistry</b> |       |              |    |              |    |              |    |              |    |
| Total Dissolved Solids   | mg/L  | 311          |    | 285          |    | 296          |    | 274          |    |
| <b>Field Parameters</b>  |       |              |    |              |    |              |    |              |    |
| Temperature, Water (C)   | DEG_C | 14.3         |    | 18.7         |    | 21.1         |    | 18.1         |    |
| Turbidity, field         | NTU   | 4.27         |    | 2.93         |    | 3.47         |    | 1.65         |    |
| ORP                      | mV    | 20.3         |    | -83.8        |    | -174.5       |    | -135.3       |    |
| Specific Cond. (Field)   | mS/cm | 0.501        |    | 0.382        |    | 0.53         |    | 0.439        |    |
| Dissolved Oxygen         | mg/L  | 0.44         |    | 0.27         |    | 0.31         |    | 0.32         |    |
| pH (field)               | SU    | 6.93         |    | 6.86         |    | 7.1          |    | 7.11         |    |

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**ASSESSMENT  
MONITORING**



**Table 1  
Assessment Monitoring  
Groundwater Sampling  
Results**

**CCR Annual Groundwater Monitoring  
and Corrective Action Report - TVA  
Allen Fossil Plant**

| Monitoring Well          |       | ALF-205      |    |              |    |              |    |              |   |
|--------------------------|-------|--------------|----|--------------|----|--------------|----|--------------|---|
| Sample Date              |       | 09-Jan-19    |    | 24-Apr-19    |    | 21-Aug-19    |    | 16-Oct-19    |   |
| Sample Round             |       | 1            |    | 1 - Retest   |    | 2            |    | 2 - Retest   |   |
| Well Designation         |       | Downgradient |    | Downgradient |    | Downgradient |    | Downgradient |   |
| Analyte                  | Units | Result       | Q  | Result       | Q  | Result       | Q  | Result       | Q |
| <b>Total Metals</b>      |       |              |    |              |    |              |    |              |   |
| Antimony                 | ug/L  | < 1.12       | U  | < 0.378      | U  | < 0.378      | U  | < 0.378      | U |
| Arsenic                  | ug/L  | < 1.31       | U* | < 1.24       | U* | < 1.57       | U* | 1.06         |   |
| Barium                   | ug/L  | 141          |    | 192          |    | 218          | J  | 179          |   |
| Beryllium                | ug/L  | < 0.057      | U  | < 0.155      | U  | < 0.182      | U  | < 0.182      | U |
| Boron                    | ug/L  | 6850         |    | 6740         |    | 6990         |    | 6140         |   |
| Cadmium                  | ug/L  | < 0.125      | U  | < 0.125      | U  | 0.231        | J  | 0.133        | J |
| Calcium                  | ug/L  | 78300        |    | 105000       |    | 121000       |    | 99100        |   |
| Chromium                 | ug/L  | < 2          | U* | < 1.83       | U* | < 3.68       | U* | < 1.53       | U |
| Cobalt                   | ug/L  | 0.756        |    | 1.28         |    | 1.79         |    | 1.27         |   |
| Lead                     | ug/L  | < 0.094      | U  | < 0.128      | U  | 0.165        | J  | < 0.128      | U |
| Lithium                  | ug/L  | < 18.6       | U* | < 21.6       | U* | 20.2         | J  | 20.2         |   |
| Molybdenum               | ug/L  | 180          |    | 145          |    | 116          |    | 125          |   |
| Selenium                 | ug/L  | < 0.813      | U  | < 2.62       | U  | < 1.51       | U  | < 1.51       | U |
| Thallium                 | ug/L  | < 0.063      | U  | < 0.128      | U  | 0.269        | J  | < 0.148      | U |
| Radium 226 + Radium 228  | pCi/L | 0.359        | J  | 0.229        | J  | < 0.353      | U  | 1.07         | J |
| <b>Anions</b>            |       |              |    |              |    |              |    |              |   |
| Chloride                 | mg/L  | 19.1         |    | 11.3         |    | 13.1         |    | 14.5         |   |
| Fluoride                 | mg/L  | 1.87         |    | 1.22         |    | < 1.1        | U* | 1.2          |   |
| Sulfate                  | mg/L  | 116          |    | 91           |    | 71.8         |    | 101          |   |
| <b>General Chemistry</b> |       |              |    |              |    |              |    |              |   |
| Total Dissolved Solids   | mg/L  | 519          |    | 546          |    | 591          |    | 593          |   |
| <b>Field Parameters</b>  |       |              |    |              |    |              |    |              |   |
| Temperature, Water (C)   | DEG_C | 16.1         |    | 18.1         |    | 21.5         |    | 19           |   |
| Turbidity, field         | NTU   | 0.42         |    | 1.56         |    | 2.41         |    | 0.5          |   |
| ORP                      | mV    | 36.7         |    | 32.3         |    | -145.3       |    | -12.9        |   |
| Specific Cond. (Field)   | mS/cm | 0.73         |    | 0.64         |    | 0.96         |    | 0.79         |   |
| Dissolved Oxygen         | mg/L  | 0.47         |    | 0.45         |    | 0.46         |    | 0.39         |   |
| pH (field)               | SU    | 7.01         |    | 6.99         |    | 6.85         |    | 6.9          |   |

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**ASSESSMENT  
MONITORING**

**Table 1  
Assessment Monitoring  
Groundwater Sampling  
Results**

**CCR Annual Groundwater Monitoring  
and Corrective Action Report - TVA  
Allen Fossil Plant**

| Monitoring Well          |       | ALF-206      |    |              |    |              |    |              |    |
|--------------------------|-------|--------------|----|--------------|----|--------------|----|--------------|----|
| Sample Date              |       | 09-Jan-19    |    | 24-Apr-19    |    | 21-Aug-19    |    | 17-Oct-19    |    |
| Sample Round             |       | 1            |    | 1 - Retest   |    | 2            |    | 2 - Retest   |    |
| Well Designation         |       | Downgradient |    | Downgradient |    | Downgradient |    | Downgradient |    |
| Analyte                  | Units | Result       | Q  | Result       | Q  | Result       | Q  | Result       | Q  |
| <b>Total Metals</b>      |       |              |    |              |    |              |    |              |    |
| Antimony                 | ug/L  | < 1.12       | U  | < 0.378      | U  | < 0.378      | U  | < 0.378      | U  |
| Arsenic                  | ug/L  | 5.76         |    | 6.27         |    | 7.17         |    | 5.84         |    |
| Barium                   | ug/L  | 238          |    | 277          |    | 243          | J  | 250          |    |
| Beryllium                | ug/L  | < 0.057      | U  | 0.42         | J  | < 0.182      | U  | < 0.182      | U  |
| Boron                    | ug/L  | < 90.4       | U* | < 109        | U* | < 140        | U* | < 131        | U* |
| Cadmium                  | ug/L  | < 0.125      | U  | 0.193        | J  | < 0.125      | U  | < 0.125      | U  |
| Calcium                  | ug/L  | 38400        |    | 41400        |    | 38700        |    | 37400        |    |
| Chromium                 | ug/L  | < 2.2        | U* | < 1.81       | U* | < 3.81       | U* | < 1.53       | U  |
| Cobalt                   | ug/L  | < 0.075      | U  | 0.113        | J  | 0.079        | J  | < 0.075      | U  |
| Lead                     | ug/L  | < 0.094      | U  | < 0.149      | U* | < 0.128      | U  | < 0.128      | U  |
| Lithium                  | ug/L  | < 8.97       | U* | < 12         | U* | 6.28         | J  | 6.97         |    |
| Molybdenum               | ug/L  | 2.62         | J  | 2.45         | J  | 2.15         | J  | 2.42         | J  |
| Selenium                 | ug/L  | < 0.813      | U  | < 2.62       | U  | < 1.51       | U  | < 1.84       | U* |
| Thallium                 | ug/L  | < 0.063      | U  | 0.316        | J  | < 0.148      | U  | < 0.148      | U  |
| Radium 226 + Radium 228  | pCi/L | 0.967        |    | 0.664        | J  | < 0.926      | U  | < 1.11       | U* |
| <b>Anions</b>            |       |              |    |              |    |              |    |              |    |
| Chloride                 | mg/L  | 14.9         |    | 12           |    | 10.8         |    | 11.3         |    |
| Fluoride                 | mg/L  | 0.394        |    | 0.302        |    | < 0.318      | U* | 0.223        |    |
| Sulfate                  | mg/L  | 26           |    | 26.6         |    | 22.2         |    | 25.8         |    |
| <b>General Chemistry</b> |       |              |    |              |    |              |    |              |    |
| Total Dissolved Solids   | mg/L  | 185          |    | 229          |    | 199          |    | 205          |    |
| <b>Field Parameters</b>  |       |              |    |              |    |              |    |              |    |
| Temperature, Water (C)   | DEG_C | 15.8         |    | 15.9         |    | 16.9         |    | 15.9         |    |
| Turbidity, field         | NTU   | 0.8          |    | 0.76         |    | 1.95         |    | 0.99         |    |
| ORP                      | mV    | 11.3         |    | -162         |    | -180.8       |    | -120.6       |    |
| Specific Cond. (Field)   | mS/cm | 0.32         |    | 0.255        |    | 0.345        |    | 0.32         |    |
| Dissolved Oxygen         | mg/L  | 0.26         |    | 0.17         |    | 0.2          |    | 0.15         |    |
| pH (field)               | SU    | 7.04         |    | 7.04         |    | 6.98         |    | 7.22         |    |

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**ASSESSMENT  
MONITORING**

**Table 1  
Assessment Monitoring  
Groundwater Sampling  
Results**

**CCR Annual Groundwater Monitoring  
and Corrective Action Report - TVA  
Allen Fossil Plant**

| Monitoring Well          |       | ALF-210    |    |            |    |            |    |            |    |
|--------------------------|-------|------------|----|------------|----|------------|----|------------|----|
| Sample Date              |       | 07-Jan-19  |    | 22-Apr-19  |    | 19-Aug-19  |    | 15-Oct-19  |    |
| Sample Round             |       | 1          |    | 1 - Retest |    | 2          |    | 2 - Retest |    |
| Well Designation         |       | Background |    | Background |    | Background |    | Background |    |
| Analyte                  | Units | Result     | Q  | Result     | Q  | Result     | Q  | Result     | Q  |
| <b>Total Metals</b>      |       |            |    |            |    |            |    |            |    |
| Antimony                 | ug/L  | < 1.12     | U  | < 0.378    | U  | < 0.378    | U  | < 0.378    | U  |
| Arsenic                  | ug/L  | < 1.43     | U* | < 1.39     | U* | 1.56       |    | 1.62       |    |
| Barium                   | ug/L  | 314        |    | 331        |    | 349        |    | 366        |    |
| Beryllium                | ug/L  | < 0.057    | U  | < 0.155    | U  | < 0.182    | U  | < 0.182    | U  |
| Boron                    | ug/L  | < 84       | U* | < 63.2     | U* | 96.5       |    | < 66.8     | U* |
| Cadmium                  | ug/L  | < 0.125    | U  | < 0.125    | U  | < 0.125    | U  | < 0.125    | U  |
| Calcium                  | ug/L  | 123000     |    | 130000     |    | 133000     |    | 128000     |    |
| Chromium                 | ug/L  | < 2        | U* | 2.52       |    | < 2.38     | U* | < 1.53     | U  |
| Cobalt                   | ug/L  | 1.2        |    | 1.99       |    | 2.09       |    | 2.09       |    |
| Lead                     | ug/L  | < 0.094    | U  | < 0.128    | U  | < 0.128    | U  | < 0.128    | U  |
| Lithium                  | ug/L  | 19.4       |    | 23.3       |    | 22.7       |    | 23.7       |    |
| Molybdenum               | ug/L  | 1.67       | J  | 1.69       | J  | 1.73       | J  | 1.71       | J  |
| Selenium                 | ug/L  | < 0.813    | U  | < 2.62     | U  | < 1.51     | U  | < 1.67     | U* |
| Thallium                 | ug/L  | < 0.063    | U  | < 0.128    | U  | 0.158      | J  | < 0.148    | U  |
| Radium 226 + Radium 228  | pCi/L | < 0.470    | U* | 0.195      | J  | 1.46       |    | < 1.15     | U  |
| <b>Anions</b>            |       |            |    |            |    |            |    |            |    |
| Chloride                 | mg/L  | 0.827      | J  | < 0.715    | U  | 1.41       |    | 1.33       |    |
| Fluoride                 | mg/L  | 0.238      |    | 0.198      |    | < 0.562    | U* | 0.167      |    |
| Sulfate                  | mg/L  | 11         |    | 9.78       |    | 11.5       |    | 11.7       |    |
| <b>General Chemistry</b> |       |            |    |            |    |            |    |            |    |
| Total Dissolved Solids   | mg/L  | 445        |    | 469        |    | 478        |    | 479        |    |
| <b>Field Parameters</b>  |       |            |    |            |    |            |    |            |    |
| Temperature, Water (C)   | DEG_C | 18         |    | 19.7       |    | 21.1       |    | 19.6       |    |
| Turbidity, field         | NTU   | 10.3       |    | 30.6       |    | 13.5       |    | 9.43       |    |
| ORP                      | mV    | 31.5       |    | 151.7      |    | -69.8      |    | -30.1      |    |
| Specific Cond. (Field)   | mS/cm | 0.73       |    | 0.55       |    | 0.8        |    | 0.71       |    |
| Dissolved Oxygen         | mg/L  | 0.44       |    | 0.37       |    | 0.53       |    | 0.27       |    |
| pH (field)               | SU    | 6.96       |    | 6.65       |    | 6.59       |    | 6.7        |    |

Notes:

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ug/L - micrograms per liter

NTU - Nephelometric Turbidity Units

mg/L - milligrams per liter

mV - millivolts

pCi/L - picoCurie per liter

mS/cm - milliseimens per centimeter

DEG\_C - degrees Celsius

SU - Standard Unit

**ASSESSMENT  
MONITORING**

**Table 1  
Assessment Monitoring  
Groundwater Sampling  
Results**

**CCR Annual Groundwater Monitoring  
and Corrective Action Report - TVA  
Allen Fossil Plant**

| Monitoring Well          |       | ALF-212      |    |              |    |              |    |              |    |
|--------------------------|-------|--------------|----|--------------|----|--------------|----|--------------|----|
| Sample Date              |       | 08-Jan-19    |    | 23-Apr-19    |    | 20-Aug-19    |    | 16-Oct-19    |    |
| Sample Round             |       | 1            |    | 1 - Retest   |    | 2            |    | 2 - Retest   |    |
| Well Designation         |       | Downgradient |    | Downgradient |    | Downgradient |    | Downgradient |    |
| Analyte                  | Units | Result       | Q  | Result       | Q  | Result       | Q  | Result       | Q  |
| <b>Total Metals</b>      |       |              |    |              |    |              |    |              |    |
| Antimony                 | ug/L  | < 1.12       | U  | < 0.378      | U  | < 0.378      | U  | < 0.378      | U  |
| Arsenic                  | ug/L  | 12.3         |    | 15.1         |    | 10           |    | 10.9         |    |
| Barium                   | ug/L  | 234          |    | 235          |    | 252          |    | 252          |    |
| Beryllium                | ug/L  | < 0.057      | U  | < 0.155      | U  | < 0.182      | U  | 0.254        | J  |
| Boron                    | ug/L  | 1980         |    | 1680         |    | 1770         |    | 1750         |    |
| Cadmium                  | ug/L  | < 0.125      | U  | < 0.125      | U  | < 0.125      | U  | 0.128        | J  |
| Calcium                  | ug/L  | 69400        |    | 72000        |    | 76500        |    | 72900        |    |
| Chromium                 | ug/L  | < 2.3        | U* | 3.09         |    | < 2.66       | U* | < 1.53       | U  |
| Cobalt                   | ug/L  | 0.415        | J  | 0.29         | J  | 0.213        | J  | 0.197        | J  |
| Lead                     | ug/L  | 0.136        | J  | < 0.128      | U  | < 0.128      | U  | < 0.128      | U  |
| Lithium                  | ug/L  | < 10.9       | U* | < 12.9       | U* | 13.8         |    | 14.7         |    |
| Molybdenum               | ug/L  | 48.9         |    | 43.7         |    | 40.3         |    | 40.1         |    |
| Selenium                 | ug/L  | < 0.813      | U  | < 2.62       | U  | < 1.51       | U  | < 1.78       | U* |
| Thallium                 | ug/L  | < 0.063      | U  | < 0.128      | U  | < 0.148      | U  | < 0.148      | U  |
| Radium 226 + Radium 228  | pCi/L | 0.486        | J  | 0.630        |    | < 0.264      | U  | < 0.398      | U  |
| <b>Anions</b>            |       |              |    |              |    |              |    |              |    |
| Chloride                 | mg/L  | 16.5         |    | 12.7         |    | 17.1         |    | 15.9         |    |
| Fluoride                 | mg/L  | 1.34         |    | 1.34         |    | < 1.47       | U* | 1.2          |    |
| Sulfate                  | mg/L  | 8.95         |    | 5.77         |    | 4.6          |    | 3.64         |    |
| <b>General Chemistry</b> |       |              |    |              |    |              |    |              |    |
| Total Dissolved Solids   | mg/L  | 360          |    | 340          |    | 376          |    | 387          |    |
| <b>Field Parameters</b>  |       |              |    |              |    |              |    |              |    |
| Temperature, Water (C)   | DEG_C | 18.8         |    | 19.3         |    | 20.4         |    | 18.7         |    |
| Turbidity, field         | NTU   | 1.69         |    | 1.12         |    | 1.42         |    | 0.99         |    |
| ORP                      | mV    | 5.1          |    | -128.1       |    | -188.1       |    | -119.7       |    |
| Specific Cond. (Field)   | mS/cm | 0.6          |    | 0.441        |    | 0.66         |    | 0.58         |    |
| Dissolved Oxygen         | mg/L  | 0.24         |    | 0.27         |    | 0.25         |    | 0.15         |    |
| pH (field)               | SU    | 6.96         |    | 6.97         |    | 7.02         |    | 6.98         |    |

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NTU - Nephelometric Turbidity Units

mg/L - milligrams per liter

mV - millivolts

pCi/L - picoCurie per liter

mS/cm - milliseimens per centimeter

DEG\_C - degrees Celsius

SU - Standard Unit

**ASSESSMENT  
MONITORING**

**Table 1  
Assessment Monitoring  
Groundwater Sampling  
Results**

**CCR Annual Groundwater Monitoring  
and Corrective Action Report - TVA  
Allen Fossil Plant**

| Monitoring Well          |       | ALF-213      |    |              |    |              |    |              |    |
|--------------------------|-------|--------------|----|--------------|----|--------------|----|--------------|----|
| Sample Date              |       | 09-Jan-19    |    | 23-Apr-19    |    | 20-Aug-19    |    | 17-Oct-19    |    |
| Sample Round             |       | 1            |    | 1 - Retest   |    | 2            |    | 2 - Retest   |    |
| Well Designation         |       | Downgradient |    | Downgradient |    | Downgradient |    | Downgradient |    |
| Analyte                  | Units | Result       | Q  | Result       | Q  | Result       | Q  | Result       | Q  |
| <b>Total Metals</b>      |       |              |    |              |    |              |    |              |    |
| Antimony                 | ug/L  | < 1.12       | U  | < 0.378      | U  | < 0.378      | U  | < 0.378      | U  |
| Arsenic                  | ug/L  | 6.72         |    | 7.03         |    | 15.3         |    | 18.5         |    |
| Barium                   | ug/L  | 287          |    | 304          |    | 395          |    | 353          |    |
| Beryllium                | ug/L  | < 0.057      | U  | < 0.155      | U  | < 0.182      | U  | < 0.182      | U  |
| Boron                    | ug/L  | < 178        | U* | < 178        | U* | < 260        | U* | < 221        | U* |
| Cadmium                  | ug/L  | < 0.125      | U  | < 0.125      | U  | < 0.125      | U  | < 0.125      | U  |
| Calcium                  | ug/L  | 36200        |    | 37700        |    | 49200        |    | 45800        |    |
| Chromium                 | ug/L  | < 1.8        | U* | 2.95         |    | < 2.25       | U* | < 1.53       | U  |
| Cobalt                   | ug/L  | 0.101        | J  | 0.076        | J  | 0.097        | J  | < 0.075      | U  |
| Lead                     | ug/L  | < 0.094      | U  | < 0.128      | U  | < 0.128      | U  | < 0.128      | U  |
| Lithium                  | ug/L  | < 10.7       | U* | < 8.05       | U* | 8.87         |    | 8.88         |    |
| Molybdenum               | ug/L  | 4.13         | J  | 3.87         | J  | 3.11         | J  | 3.18         | J  |
| Selenium                 | ug/L  | < 0.813      | U  | < 2.62       | U  | < 1.51       | U  | < 1.68       | U* |
| Thallium                 | ug/L  | < 0.063      | U  | < 0.128      | U  | < 0.148      | U  | < 0.148      | U  |
| Radium 226 + Radium 228  | pCi/L | 0.701        |    | 0.563        | J  | < 0.531      | U  | 1.25         | J  |
| <b>Anions</b>            |       |              |    |              |    |              |    |              |    |
| Chloride                 | mg/L  | 16.8         |    | 13.9         |    | 14.6         |    | 14.4         |    |
| Fluoride                 | mg/L  | 0.503        |    | 0.442        |    | < 0.718      | U* | 0.287        |    |
| Sulfate                  | mg/L  | 20.9         |    | 11.7         |    | 7.83         |    | 5.63         |    |
| <b>General Chemistry</b> |       |              |    |              |    |              |    |              |    |
| Total Dissolved Solids   | mg/L  | 204          |    | 173          |    | 245          |    | 222          |    |
| <b>Field Parameters</b>  |       |              |    |              |    |              |    |              |    |
| Temperature, Water (C)   | DEG_C | 16.6         |    | 17.6         |    | 18.2         |    | 17.3         |    |
| Turbidity, field         | NTU   | 0.43         |    | 0.69         |    | 1.89         |    | 1.49         |    |
| ORP                      | mV    | 12.9         |    | -166.1       |    | -187.7       |    | -145.7       |    |
| Specific Cond. (Field)   | mS/cm | 0.36         |    | 0.26         |    | 0.467        |    | 0.414        |    |
| Dissolved Oxygen         | mg/L  | 0.28         |    | 0.23         |    | 0.19         |    | 0.16         |    |
| pH (field)               | SU    | 6.82         |    | 7.09         |    | 7.45         |    | 7.18         |    |

Notes:

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mg/L - milligrams per liter

mV - millivolts

pCi/L - picoCurie per liter

mS/cm - milliseimens per centimeter

DEG\_C - degrees Celsius

SU - Standard Unit

**ASSESSMENT  
MONITORING**

**Table 2  
Groundwater Sampling Summary**

**CCR Annual Groundwater Monitoring and Corrective Action Report -  
TVA Allen Fossil Plant**

| Well ID | Well Designation | Number of Sampling Events Conducted | January 7-10, 2019 | April 22-24, 2019 | August 19-22, 2019 | October 15-17, 2019 | Groundwater Monitoring Program                                                                         |
|---------|------------------|-------------------------------------|--------------------|-------------------|--------------------|---------------------|--------------------------------------------------------------------------------------------------------|
|         |                  |                                     | Sample Round 1     | 1 - Retest        | 2                  | 2 - Retest          |                                                                                                        |
| ALF-201 | Downgradient     | 4                                   | X                  | X                 | X                  | X                   | Assessment Monitoring - 257.95(a); 257.95(b); 257.95(d)(1) - Appendix III and Appendix IV Constituents |
| ALF-202 | Downgradient     | 4                                   | X                  | X                 | X                  | X                   | Assessment Monitoring - 257.95(a); 257.95(b); 257.95(d)(1) - Appendix III and Appendix IV Constituents |
| ALF-203 | Downgradient     | 4                                   | X                  | X                 | X                  | X                   | Assessment Monitoring - 257.95(a); 257.95(b); 257.95(d)(1) - Appendix III and Appendix IV Constituents |
| ALF-204 | Downgradient     | 4                                   | X                  | X                 | X                  | X                   | Assessment Monitoring - 257.95(a); 257.95(b); 257.95(d)(1) - Appendix III and Appendix IV Constituents |
| ALF-205 | Downgradient     | 4                                   | X                  | X                 | X                  | X                   | Assessment Monitoring - 257.95(a); 257.95(b); 257.95(d)(1) - Appendix III and Appendix IV Constituents |
| ALF-206 | Downgradient     | 4                                   | X                  | X                 | X                  | X                   | Assessment Monitoring - 257.95(a); 257.95(b); 257.95(d)(1) - Appendix III and Appendix IV Constituents |
| ALF-210 | Background       | 4                                   | X                  | X                 | X                  | X                   | Assessment Monitoring - 257.95(a); 257.95(b); 257.95(d)(1) - Appendix III and Appendix IV Constituents |
| ALF-212 | Downgradient     | 4                                   | X                  | X                 | X                  | X                   | Assessment Monitoring - 257.95(a); 257.95(b); 257.95(d)(1) - Appendix III and Appendix IV Constituents |
| ALF-213 | Downgradient     | 4                                   | X                  | X                 | X                  | X                   | Assessment Monitoring - 257.95(a); 257.95(b); 257.95(d)(1) - Appendix III and Appendix IV Constituents |

Notes:

Assessment Monitoring groundwater samples analyzed for Appendix III and Appendix IV constituents

Appendix III Constituents - boron, calcium, chloride, fluoride, pH, sulfate, total dissolved solids (TDS)

Appendix IV Constituents - antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, fluoride, lead, lithium, mercury, molybdenum, selenium, thallium, radium 226 and radium 228 combined

**Table 3  
Groundwater and Surface Water  
Elevation Summary**

**CCR Annual Groundwater  
Monitoring and Corrective Action  
Report - TVA Allen Fossil Plant**

| Groundwater Elevation Collection Date |        | 07-Jan-19     | 22-Apr-19 | 19-Aug-19 | 15-Oct-19 |
|---------------------------------------|--------|---------------|-----------|-----------|-----------|
| Monitoring Well                       | Units  |               |           |           |           |
| ALF-201                               | ft-MSL | 201.92        | 206.07    | 195.92    | 193.90    |
| ALF-202                               | ft-MSL | 210.06        | 211.07    | 205.73    | 202.88    |
| ALF-203                               | ft-MSL | 208.04        | 210.50    | 195.39    | 195.69    |
| ALF-204                               | ft-MSL | 207.95        | 209.38    | 192.26    | 195.60    |
| ALF-205                               | ft-MSL | 206.50        | 208.32    | 191.60    | 194.66    |
| ALF-206                               | ft-MSL | 206.95        | 208.79    | 192.45    | 195.33    |
| ALF-210                               | ft-MSL | 204.54        | 208.97    | 196.23    | 194.75    |
| ALF-212                               | ft-MSL | 208.83        | 209.86    | 205.21    | 202.81    |
| ALF-213                               | ft-MSL | 203.94        | 207.02    | 193.48    | NM        |
|                                       |        | Surface Water |           |           |           |
| <b>McKellar Lake</b>                  | ft-MSL | 209.89        | 210.74    | 191.92    | 196.67    |

Notes:

ft-MSL - Feet above mean sea level

NM - Static water level was not measured at ALF-213 until 10/17/19 due to equipment operating in the area

**Table 4  
Hydraulic Conductivity Data  
Summary**

**CCR Annual Groundwater Monitoring and  
Corrective Action Report - TVA Allen  
Fossil Plant**

| <b>Well ID</b>                                           | <b>Well Designation</b> | <b>Slug Test Hydraulic Conductivity (cm/sec)</b> |
|----------------------------------------------------------|-------------------------|--------------------------------------------------|
| <b>ALF-201</b>                                           | Downgradient            | 7.6E-05                                          |
| <b>ALF-202</b>                                           | Downgradient            | 3.16E-03                                         |
| <b>ALF-203</b>                                           | Downgradient            | 1.91E-04                                         |
| <b>ALF-204</b>                                           | Downgradient            | 2.62E-04                                         |
| <b>ALF-205</b>                                           | Downgradient            | 2.62E-04                                         |
| <b>ALF-206</b>                                           | Downgradient            | 1.31E-02                                         |
| <b>ALF-210</b>                                           | Background              | 7.15E-05                                         |
| <b>ALF-212</b>                                           | Downgradient            | 3.82E-04                                         |
| <b>ALF-213</b>                                           | Downgradient            | 5.02E-03                                         |
| <b>Geometric Mean of Hydraulic Conductivity (cm/sec)</b> |                         | <b>5.6E-04</b>                                   |

Notes:

cm/sec - centimeters per second



**Table 5**  
**Rate and Direction of Groundwater**  
**Flow Summary**

**CCR Initial Annual Groundwater Monitoring and**  
**Corrective Action Report**  
**TVA - Allen Fossil Plant**

| Groundwater Elevation Collection Date | 7-Jan-19 | 22-Apr-19  | 19-Aug-19 | 15-Oct-19  |
|---------------------------------------|----------|------------|-----------|------------|
| Sample Round                          | 1        | 1 - Retest | 2         | 2 - Retest |
| Horizontal Gradient                   | 0.0037   | 0.0020     | 0.0081    | 0.0058     |
| Hydraulic Conductivity (cm/sec)       | 5.6E-04  | 5.6E-04    | 5.6E-04   | 5.6E-04    |
| Effective Porosity                    | 22%      | 22%        | 22%       | 22%        |
| Flow Direction (cardinal)             | South    | South      | North     | South      |
| Linear Velocity (ft/yr)               | 9.8      | 5.4        | 21.3      | 15.3       |

Notes:

cm/sec - centimeters per second

ft/yr - feet per year

**TABLE 6: Statistically Significant Levels (SSLs) Above GWPSs**

| Appendix IV Parameter* | GWPS (a) | Updated GWPS (b) | Downgradient wells with analytical results above GWPS (c) | Updated LCBs (d) | SSL LCB > GWPS (e) |
|------------------------|----------|------------------|-----------------------------------------------------------|------------------|--------------------|
| Antimony (mg/l)        | 0.006    | 0.006            | None                                                      | NA               | NA                 |
| Arsenic (mg/l)         | 0.0176   | 0.014            | ALF-202                                                   | 0.321            | YES                |
|                        |          |                  | ALF-203                                                   | 0.996            | YES                |
|                        |          |                  | ALF-204                                                   | 0.041            | YES                |
|                        |          |                  | ALF-212                                                   | 0.004            | NO                 |
|                        |          |                  | ALF-213                                                   | -0.003           | NO                 |
| Barium (mg/l)          | 2        | 2                | None                                                      | NA               | NA                 |
| Beryllium (mg/l)       | 0.004    | 0.004            | None                                                      | NA               | NA                 |
| Cadmium (mg/l)         | 0.005    | 0.005            | None                                                      | NA               | NA                 |
| Chromium (mg/l)        | 0.1      | 0.1              | None                                                      | NA               | NA                 |
| Cobalt (mg/l)          | 0.006    | 0.006            | None                                                      | NA               | NA                 |
| Fluoride (mg/l)        | 4        | 4                | ALF-202                                                   | 2.874            | NO                 |
|                        |          |                  | ALF-203                                                   | 3.465            | NO                 |
| Lead (mg/l)            | 0.015    | 0.015            | ALF-203                                                   | 0.022            | YES                |
| Lithium (mg/l)         | 0.04     | 0.04             | None                                                      | NA               | NA                 |
| Mercury (mg/l)         | 0.002    | 0.002            | None                                                      | NA               | NA                 |
| Molybdenum (mg/l)      | 0.1      | 0.1              | ALF-201                                                   | -0.035           | NO                 |
|                        |          |                  | ALF-202                                                   | 0.253            | YES                |
|                        |          |                  | ALF-203                                                   | 0.435            | YES                |
|                        |          |                  | ALF-205                                                   | 0.082            | NO                 |
| Radium-226+228 (pCi/l) | 5        | 5                | None                                                      | NA               | NA                 |
| Selenium (mg/l)        | 0.05     | 0.05             | None                                                      | NA               | NA                 |
| Thallium (mg/l)        | 0.002    | 0.002            | None                                                      | NA               | NA                 |

Notes:

\* - Total Metals concentrations presented in Table 1 are reported in micrograms per liter (µg/L)

NA – Not applicable

- (a) GWPSs documented in notice dated 10/15/2018 [reported in milligrams per liter (mg/L)]
- (b) GWPSs updated as of 11/25/2019 with 3 additional sample results collected on January 7-11, 2019, March 4-7, 2019 and August 19-22, 2019 [reported in mg/L]
- (c) Downgradient wells with analytical results above GWPS November 2016 through August 19-22, 2019 (per 40 CFR 257.95(b) and (d))
- (d) Most recent value of 99% lower confidence band (LCB) on the mean of Appendix IV groundwater sampling events between November 2016 and August 19-22, 2019. Upper confidence band (UCB) not shown as it is greater than LCB [reported in mg/L]
- (e) SSL: "statistically significant level over GWPS" occurs when the updated LCB value at the last sampling event exceeds the updated GWPS

**APPENDIX A**  
**STATISTICAL ANALYSIS REPORT**

**STATISTICAL ANALYSIS REPORT FOR  
ALLEN FOSSIL PLANT**

**2019**

1/14/2020

## Contents

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# 1 Introduction

This report summarizes the statistical analysis performed on groundwater quality constituents monitored during Year-Three of the Coal Combustion Residuals (CCR) Rule’s 2019 Annual Groundwater Monitoring (GWM) Program for the East Ash Disposal Area at the Tennessee Valley Authority (TVA) Allen Fossil Plant (ALF). The 2019 Annual GWM Program is the third year of the program. Statistically significant increases (SSIs) were identified for one or more parameters based on the 2017 annual groundwater monitoring sampling results; therefore, the East Ash Disposal Area continued in the Assessment Monitoring phase of the monitoring program, after transitioning in 2018.

Baseline datasets collected during the first two years of monitoring were combined with data collected in 2019 and were used to establish statistically-derived Groundwater Protection Standards (GWPS) for the East Ash Disposal Area located at ALF. Consistent with methods presented in USEPA’s Unified Guidance document on the statistical analysis of groundwater monitoring data (2009), confidence-interval (CI) bands were compared against relevant GWPS. A statistically significant level (SSL) is found if and only if the lower limit of the CI band exceeds the GWPS for the most recent Assessment Monitoring sampling event.

At the ALF plant’s CCR Unit, the sampling results used to identify potential GWPS exceedances were obtained during three distinct monitoring events that were performed between January of 2019 and August of 2019 by the firm of Terracon, with laboratory analysis performed by Test America Laboratories (located at Pittsburg, PA, and St Louis, MO), and Quality Assurance Controls by Environmental Standards, Inc., all under direct contracts to TVA.

The current CCR Rule groundwater monitoring network, as Certified by a Professional Engineer at the firm of AECOM or other, is presented in **Table 1**.

**Table 1. CCR Rule Monitoring Well Network**

| Background | Downgradient |         |
|------------|--------------|---------|
| ALF-210    | ALF-201      | ALF-205 |
|            | ALF-202      | ALF-206 |
|            | ALF-203      | ALF-212 |
|            | ALF-204      | ALF-213 |

The ‘R’ Statistical Analysis package ([www.r-project.org](http://www.r-project.org)) in conjunction with R-Studio ([www.rstudio.com](http://www.rstudio.com)) (both popular public domain software products) and other analytical tools were used in the production of the statistical values and graphs. ProUCL data dumps from TVA’s EQUIS Professional and Enterprise Database were used to populate the R-based statistical analyses.

Groundwater samples collected as part of the CCR Rule monitoring program were analyzed for constituents listed in Appendix IV of the CCR Rule. Only non-filtered sample results were utilized for the statistical analysis of Appendix IV constituents. As high turbidity measurements during the purging of wells (e.g., values above 5 NTUs) have the propensity to increase the

concentrations of Appendix IV constituents, filtered samples were also collected to better understand and/or dispel the potential source(s) of falsely-named GWPS exceedances. Appendix A summary of constituents included in the data analysis is provided in the second column of **Table 2**.

**Table 2. CCR Rule Monitored Constituents**

| Appendix III Constituents<br>(Detection Monitoring)                                               | Appendix IV Constituents<br>(Assessment Monitoring)                                                                                                                             |
|---------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Boron<br>Calcium<br>Chloride<br>Fluoride<br>pH (field)<br>Sulfate<br>Total Dissolved Solids (TDS) | Antimony<br>Arsenic<br>Barium<br>Beryllium<br>Cadmium<br>Chromium<br>Cobalt<br>Fluoride<br>Lead<br>Lithium<br>Mercury<br>Molybdenum<br>Radium 226 + 228<br>Selenium<br>Thallium |

## 2 Statistical Analysis

The Assessment Monitoring analysis includes the following steps:

- 1) Developing GWPSs for each Appendix IV constituent. The GWPS is the published MCL/water quality limit or the background concentration (95% UTL with 95% coverage), whichever is larger;
- 2) Computing trends and associated CI bands for each downgradient well location and Appendix IV constituent (i.e., each well-constituent pair); and
- 3) Comparing each CI band against its respective GWPS to assess whether an exceedance occurred.

### 2.1 Developing Groundwater Protection Standards (GWPSs)

According to the promulgated CCR Rule (80 Federal Register 21302, 21405, April 17, 2015): “For each appendix IV constituent that is detected, a groundwater protection standard must be set. The groundwater protection standards must be the MCL or the background concentration level for the detected constituent, whichever is higher. If there is no MCL promulgated for a detected constituent, then the groundwater protection standard must be set at background.”

On July 17, 2018, EPA unofficially promulgated alternate regulatory limits (i.e., potential GWPSs) for the four of the Appendix IV chemical Constituents of Interest (COIs) for which the agency has not assigned MCLs to date. In the absence of MCLs or site-specific GWPS, those may be used in place of background levels under 257.95(h)(2).

Specifically, those alternate COIs include threshold values at the following health-based levels:

1. Cobalt - 6 µg/L
2. Lithium - 40 µg/L
3. Molybdenum – 100 µg/L
4. Lead - 15 µg/L.

An Upper Tolerance Limit (UTL) with 95% confidence and 95% coverage was calculated using pooled site-specific background data for each Appendix IV parameter. Then these UTLs were compared against promulgated regulatory limits to determine the site-specific GWPS.

To handle any non-detects in these calculations, non-detect values were treated as statistically ‘left-censored,’ with the censoring limit equal to the reporting limit (RL). Then the Kaplan-Meier adjustment method (USEPA, 2009) was employed to derive estimated summary statistics that account for the presence of non-detects.

For the Allen Fossil Plant, **Table 3**, lists the calculated UTLs and final GWPS established for the East Ash Disposal Area CCR Unit.



**Table 3: ALF Groundwater Protection Standards (GWPS)**

| COI        | N  | ND.PCT | MODEL       | COV  | CONF | UTL    | UNITS | MCL   | GWPS  |
|------------|----|--------|-------------|------|------|--------|-------|-------|-------|
| Antimony   | 17 | 100    | NP          | 0.95 | 0.58 | 0.0020 | mg/L  | 0.006 | 0.006 |
| Arsenic    | 17 | 23.5   | NORMAL      | 0.95 | 0.95 | 0.0140 | mg/L  | 0.01  | 0.014 |
| Barium     | 17 | 0      | Log         | 0.95 | 0.95 | 0.4077 | mg/L  | 2     | 2     |
| Beryllium  | 17 | 100    | NP          | 0.95 | 0.58 | 0.0010 | mg/L  | 0.004 | 0.004 |
| Cadmium    | 17 | 100    | NP          | 0.95 | 0.58 | 0.0010 | mg/L  | 0.005 | 0.005 |
| Chromium   | 17 | 94.1   | NP          | 0.95 | 0.58 | 0.0025 | mg/L  | 0.1   | 0.1   |
| Cobalt     | 17 | 5.9    | NORMAL      | 0.95 | 0.95 | 0.0037 | mg/L  | 0.006 | 0.006 |
| Fluoride   | 17 | 5.9    | Sixth Root  | 0.95 | 0.95 | 0.3167 | mg/L  | 4     | 4     |
| Lead       | 17 | 100    | NP          | 0.95 | 0.58 | 0.0010 | mg/L  | 0.015 | 0.015 |
| Lithium    | 17 | 0      | Log         | 0.95 | 0.95 | 0.0270 | mg/L  | 0.04  | 0.04  |
| Mercury    | 17 | 100    | NP          | 0.95 | 0.58 | 0.0002 | mg/L  | 0.002 | 0.002 |
| Molybdenum | 17 | 17.6   | Log         | 0.95 | 0.95 | 0.0027 | mg/L  | 0.1   | 0.1   |
| Rad226+228 | 16 | 0      | Square Root | 0.95 | 0.95 | 1.7194 | pCi/L | 5     | 5     |
| Selenium   | 17 | 76.5   | Log         | 0.95 | 0.95 | 0.0175 | mg/L  | 0.05  | 0.05  |
| Thallium   | 17 | 88.2   | NP          | 0.95 | 0.58 | 0.0010 | mg/L  | 0.002 | 0.002 |

\* No potential Health Effects provided for these Constituents of Interests (COI) - See Appendix "C"

To compute each UTL, the following steps were taken:

- 1) All baseline data - those from designated up-gradient or background wells collected from the Program's first sampling event through August of 2019 were grouped and checked for possible outliers.

At ALF, three possible outliers at the lone background well ALF-210 were flagged and confirmed as statistical outliers by Rosner's test, one each for chloride, fluoride, and sulfate. These values were excluded from the UTL calculations.

- 2) The grouped baseline data — those data excluding any confirmed outliers — were also analyzed to determine whether they could be fit to a known statistical model. If so, a parametric UTL was computed; if not, a nonparametric UTL was constructed.

To fit potential statistical models, a series of normalizing mathematical transformations was applied to each baseline dataset. These transformations are known as power transformations, since they raise each observation to a mathematical power. The goal is to find, if possible, a transformation that normalizes the data on the transformed scale.

Datasets which could not be sufficiently normalized were analyzed using nonparametric methods. Nonparametric UTLs do not assume a known statistical model and require larger sample sizes to achieve the target confidence level of 95%.

- 3) The final statistical model for each COI was used to compute an UTL with 95% coverage and 95% confidence.

When a parametric model is appropriate, on the normalized scale, a UTL is computed using the standard normal theory equation:

$$UTL = \bar{x} + \kappa s$$

where  $\bar{x}$  and  $s$  represent the mean and standard deviation of the (transformed) observations, and  $\kappa$  is a multiplier which depends on the number of baseline measurements, as well as the desired coverage and confidence levels. If the data have been transformed, the final UTL is derived by back-transforming the scaled UTL.

For nonparametric models, the normal theory equation does not apply. Instead, the UTL is selected as one of the largest of the sample values, typically the maximum. Because there is no multiplier as in the parametric case, the confidence level associated with a nonparametric UTL is computed 'after the fact,' based on the sample size and desired coverage level: the smaller the sample size, the lower the confidence; the bigger the sample size, the higher the confidence level.

**Table 4. Summary of Background Data Set Descriptive Statistics**

| Constituent      | Unit  | Sample Size | No. of NDs | With NDs Included as Left-Censored Values |         |        |        |
|------------------|-------|-------------|------------|-------------------------------------------|---------|--------|--------|
|                  |       |             |            | Minimum                                   | Maximum | Mean   | Median |
| Antimony         | mg/L  | 17          | 17         | 0.0020                                    | 0.0020  | 0.0010 | 0.0020 |
| Arsenic          | mg/L  | 17          | 4          | 0.0011                                    | 0.0106  | 0.0043 | 0.0035 |
| Barium           | mg/L  | 17          | 0          | 0.2980                                    | 0.4240  | 0.3345 | 0.3310 |
| Beryllium        | mg/L  | 17          | 17         | 0.0010                                    | 0.0010  | 0.0005 | 0.0010 |
| Cadmium          | mg/L  | 17          | 17         | 0.0010                                    | 0.0010  | 0.0005 | 0.0010 |
| Chromium         | mg/L  | 17          | 16         | 0.0020                                    | 0.0025  | 0.0020 | 0.0022 |
| Cobalt           | mg/L  | 17          | 1          | 0.0002                                    | 0.0027  | 0.0015 | 0.0018 |
| Fluoride         | mg/L  | 18          | 1          | 0.1690                                    | 1.7100  | 0.3080 | 0.2270 |
| Lead             | mg/L  | 17          | 17         | 0.0010                                    | 0.0010  | 0.0005 | 0.0010 |
| Lithium          | mg/L  | 17          | 0          | 0.0194                                    | 0.0259  | 0.0223 | 0.0227 |
| Mercury          | mg/L  | 17          | 17         | 0.0002                                    | 0.0002  | 0.0001 | 0.0002 |
| Molybdenum       | mg/L  | 17          | 3          | 0.0012                                    | 0.0050  | 0.0017 | 0.0017 |
| Radium 226 + 228 | pCi/L | 16          | 0          | 0.1950                                    | 1.4600  | 0.7050 | 0.6970 |
| Selenium         | mg/L  | 17          | 13         | 0.0007                                    | 0.0138  | 0.0023 | 0.0019 |
| Thallium         | mg/L  | 17          | 15         | 0.0001                                    | 0.0010  | 0.0001 | 0.0001 |

Notes:

1. ND = not detected above the laboratory reporting limit.

## 2.2 Computing Trend Lines and Confidence Interval Bands

The USEPA's Unified Guidance recommends comparing some type of CI against a GWPS in order to assess whether or not the limit has been exceeded with statistical significance. If the entire interval exceeds the GWPS, a SSL is identified. If none of the interval, or only part, exceeds the GWPS, no SSL is recorded.

Since groundwater data are collected over time, and not all at once, some or most of the variation in the measurements may be due to a trend. To better account for this possibility, USEPA also recommends a variation on the confidence interval method known as a confidence interval band around a trend line. In this case, a (linear) trend line is first fit to the data, then a confidence band is constructed around the trend line. The confidence interval band can be compared against a GWPS in much the same fashion as a confidence interval, only now a comparison can be made at different points in time by comparing the 'cross-section' of the band for a given sampling date. If the interval represented by the confidence band cross-section fully exceeds the GWPS, an SSL is identified for that sampling event.

At TVA's ALF East Ash Disposal Area, CI bands were constructed using equations [2.24] and [21.25] of Section 21.3 in the Unified Guidance for each well-constituent pair using all data collected through August of 2018. Cross-sections of each band were then compared to the GWPS for the most recent Assessment Monitoring event in each case for the purpose of identifying any SSLs.

### 2.2.1 Trend Lines Using Linear Regression

For well-constituent pairs with no non-detects, linear regression and the formula above were used to construct each confidence band with 98% overall confidence, corresponding to a lower confidence limit with 99% confidence. When non-detects are present, the same formulas apply but an adjustment must be made for the censored measurements. The strategy adopted for TVA's CCR sites involves the following steps:

- 1) Each non-detect is assumed to follow a triangle distribution centered at half the (sample-specific) reporting limit, and with limits extending from zero to the reporting limit. Then an imputation for each non-detect is randomly drawn from this distribution;
- 2) The combined set of detected values and imputed non-detects are used to estimate a linear regression trend line and associated confidence band with 98% statistical confidence;
- 3) Steps (1) and (2) are repeated 500 times, each time with a different set of random imputations, leading to 500 potentially different trend lines and confidence bands;
- 4) The 500 sets of trends lines and bands are averaged point-wise (i.e., at each time along a sequence of dates spanning the time range of the data) to compute the final trend and confidence band estimates.

By repeating this sequence of steps a large number of times (500), the uncertainty associated with the non-detects can be reasonably captured within the final CI band estimate.

## 2.3 Comparing Confidence Interval Bands Against GWPSs

To assess whether any SSLs occurred during the 2018 Assessment Monitoring at the ALF East Ash Disposal Area, the CI bands were compared against the constituent-specific GWPS. An SSL was identified if and only if the CI band fully exceeded the GWPS at the *most recent* sampling event.

### 3 Summary of Statistical Analysis

To facilitate an ‘at-a-glance’ summary of the statistical comparison results, **Table 5** is a ‘traffic light’ matrix, showing a compact representation of each well location matched against each constituent in Appendix IV. This summary is useful in planning for mitigation actions. Green cells indicate that no SSL was observed in 2019. Red cells indicate that an SSL was flagged during the most recent sampling events. Yellow cells are warnings which indicate that a well-constituent pair should be closely watched. These cases have increasing trends and a CI band whose lower limit is at least 65% of the GWPS. Often, the CI band cross-section straddles the GWPS in yellow cells.

At the ALF site, arsenic related SSLs during year-three of the Program were recorded at wells ALF-202, ALF-203, and ALF-204. Similarly, molybdenum related SSLs were recorded at wells ALF-202 and ALF-203. An SSL for lead was also recorded at well ALF-203. Additionally, warning flags (yellow) were raised for arsenic at ALF-212 and ALF-213, for fluoride at ALF-203, and for molybdenum at wells ALF-201 and ALF-205. In summary, a total of six SSLs and five warnings were identified at Program network wells that are located near to the ALF plant’s East CCR Unit during the year-three monitoring phase.

**Table 5: Traffic Light Matrix Based on Comparative Analysis of Statistical Analysis Results versus Groundwater Protection Standards (GWPS)**

| ITEM No.                 | Constituent of Interest | TRAFFIC LIGHT MATRIX                                                                                                                               |         |         |         |         |         |         |         |         |
|--------------------------|-------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|---------|---------|---------|---------|---------|---------|---------|---------|
|                          |                         | GROUNDWATER QUALITY MONITORING WELL LOCATIONS                                                                                                      |         |         |         |         |         |         |         |         |
|                          |                         | ALF-210                                                                                                                                            | ALF-201 | ALF-202 | ALF-212 | ALF-213 | ALF-206 | ALF-205 | ALF-204 | ALF-203 |
| 1.                       | Antimony                | GREEN                                                                                                                                              | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   |
| 2.                       | Arsenic                 | GREEN                                                                                                                                              | GREEN   | RED     | YELLOW  | YELLOW  | GREEN   | GREEN   | RED     | RED     |
| 3.                       | Barium                  | GREEN                                                                                                                                              | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   |
| 4.                       | Beryllium               | GREEN                                                                                                                                              | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   |
| 5.                       | Cadmium                 | GREEN                                                                                                                                              | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   |
| 6.                       | Chromium                | GREEN                                                                                                                                              | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   |
| 7.                       | Cobalt                  | GREEN                                                                                                                                              | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   |
| 8.                       | Fluoride                | GREEN                                                                                                                                              | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   | YELLOW  |
| 9.                       | Lead                    | GREEN                                                                                                                                              | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   | RED     |
| 10.                      | Lithium                 | GREEN                                                                                                                                              | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   |
| 11.                      | Mercury                 | GREEN                                                                                                                                              | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   |
| 12.                      | Molybdenum              | GREEN                                                                                                                                              | YELLOW  | RED     | GREEN   | GREEN   | GREEN   | YELLOW  | GREEN   | RED     |
| 13.                      | Rad226+228              | GREEN                                                                                                                                              | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   |
| 14.                      | Selenium                | GREEN                                                                                                                                              | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   |
| 15.                      | Thallium                | GREEN                                                                                                                                              | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   | GREEN   |
| <b>COLOR-CODING KEY:</b> |                         |                                                                                                                                                    |         |         |         |         |         |         |         |         |
|                          |                         | Monitored data for the specific COI are deemed to fall below GWPS                                                                                  |         |         |         |         |         |         |         |         |
|                          |                         | Monitored data are deemed to fall below GWPS, but an internal warning is issued to TVA staff that CI band lower limit is at least 65% of the GWPS. |         |         |         |         |         |         |         |         |
|                          |                         | Monitored data for the specific COI are deemed to exceed GWPS                                                                                      |         |         |         |         |         |         |         |         |

## 4 References

1) US Environmental Protection Agency (2009) *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance* - Office of Resource Conservation and Recovery EPA 530/R-09-007

2) US Environmental Protection Agency (2007) *Framework for Metals Risk Assessment* EPA 120/R-07/001 Office of the Science Advisor Risk Assessment Forum, Washington, DC 20460