2019 Annual Groundwater Monitoring and Corrective Action Report

Tennessee Valley Authority
Kingston Fossil Plant Peninsula
Disposal Area CCR Unit

Prepared for:
Tennessee Valley Authority
1101 Market Street
Chattanooga, TN 37402

Prepared by:
Stantec Consulting Services Inc.
5778 W 74th Street
Indianapolis IN 46278

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Reference: **2019 Annual Groundwater Monitoring Report**
TVA Kingston Fossil Plant Peninsula 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 Peninsula Disposal Area CCR Unit at the Tennessee Valley Authority (TVA) Kingston Fossil Plant (KIF). In 2017, TVA established a groundwater monitoring network and program at the KIF Peninsula 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).

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

- At the start and end of the current annual reporting period, the Peninsula Disposal Area was operating under the detection monitoring program in 40 CFR § § 257.94.
- In the 2018 detection monitoring sampling, a statistically significant increase (SSI) over background levels for one or more constituents listed in Appendix III to this part pursuant to 40 CFR § 257.94(e) was observed for boron, fluoride and pH in residuum wells G-5A and G-7A and for boron, calcium, chloride, sulfate and total dissolved solids in bedrock wells G-3B and G-5B. An assessment monitoring program was not initiated for the Peninsula Disposal Area because of a successful Appendix III alternate source demonstration performed in April 2018.
- For the 2019 detection monitoring events, similar SSIs were observed, and upon re-evaluation, the alternative source demonstration continues to support that the SSIs are attributable to another source and not the Peninsula Disposal Area.

During 2019, TVA performed the following groundwater monitoring activities:

- Conducted a statistical analysis of the 2018 detection monitoring groundwater sampling data in accordance with 40 CFR § 257.93(h), and it was concluded that there were SSIs over background levels for certain Appendix III constituents. The results were included in Tables 6A and 6B of the 2018 Annual Groundwater Monitoring and Corrective Action Report, which was placed on the CCR Rule Compliance Data and Information website (https://www.tva.gov/Environment/Environmental-Stewardship/Coal-Combustion-Residuals).
- Continued under the detection monitoring program and performed four groundwater sampling events between April and October 2019 of the certified monitoring network in accordance with 40 CFR § 257.94.
- Performed further site characterization to improve the KIF Conceptual Site Model (CSM).
- 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).

No problems were encountered during the third-year phase of the TVA groundwater quality monitoring program, and 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:

- Perform further site characterization to improve the KIF CSM.
- Continue semiannual detection monitoring with retesting of the certified groundwater monitoring network consistent with 40 CFR § 257.94.
- 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

Initial construction of the approximately 52-acre Phase I portion of the Peninsula Disposal Area was completed in 2009. The Phase I area was originally designed as a surface impoundment for gypsum slurry generated from the flue gas desulfurization (FGD) process. However, a failure of the clay liner occurred in December 2010, operation ceased, and mitigation occurred, including over-excavation of the targeted areas. TVA modified the disposal approach by dewatering the FGD gypsum and constructing the CCR unit as a dry landfill with a composite clay/geomembrane liner and leachate collection system. The Phase 1 portion of the Peninsula Disposal Area was subdivided into Phase IA (west) and Phase IB (east) areas and separated by a divider dike. Each of the Phase 1 areas are approximately 25-acres in size. Construction of the Phase 1A area was completed in December of 2011, and the Phase 1B area was completed in September 2014.

The monitoring well network for the KIF Peninsula Disposal Area CCR Unit consists of two background wells (G-1B and KIF-101) and six downgradient wells (G-3A, G-3B, G-5A, G-5B, G-7A, and G-7B)[1]. The downgradient wells are installed at the waste boundary. Figure 1 is an aerial photograph that shows the groundwater monitoring well locations. The monitoring well network was designed for a single CCR Unit (Peninsula Disposal Area). Monitoring wells G-8B, G-9B, and G-10B are currently included as background wells in the system; however, they will be located downgradient from a future landfill expansion. Until that expansion, these wells represent background conditions and are not included in the CCR monitoring well network or in the statistical analysis for KIF.

[1] Monitoring wells with A in the suffix, or no suffix are screened in the residuum unit consisting of clay and silt. Monitoring wells with a B in the suffix are screened in the Knox Group bedrock aquifer.

No monitoring wells 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).

GROUNDWATER SAMPLING AND LABORATORY ANALYTICAL TESTING

A groundwater sampling and analysis program was developed 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 semiannual detection monitoring was completed in compliance with 40 CFR § 257.94. Groundwater sampling was conducted between April and October 2019 and the results are summarized in Tables 1A and 1B for the residuum and bedrock saturated zones, respectively. 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 Emory River 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 Figures 2A and 2B for the residuum and bedrock saturated zones, respectively. In general, groundwater flow at the KIF Peninsula Disposal Area CCR Unit is influenced by the confluence of the Emory River and the Clinch River to the southeast of the site. The primary groundwater flow direction from the CCR unit is to the south towards the Clinch River in both the residuum and bedrock saturated zones.

Hydraulic conductivity values in the uppermost aquifer (residuum) at the background or downgradient monitoring wells, as summarized in Table 4, are documented in a hydrogeological evaluation report (Terracon, 2019). Testing data indicates the uppermost saturated zone has a geometric mean hydraulic conductivity of 1.17×10^{-3} 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;
- horizontal hydraulic gradients measured during the implementation of the groundwater sampling and analysis program, ranging from 0.0398 to 0.0414 feet per foot (ft/ft); and,
- an effective porosity of 27% (TVA, 2005).

The average linear flow velocity in the uppermost aquifer (residuum) ranges from approximately 178 to 185 feet per year. The rate and direction of groundwater flow in the residuum for each groundwater sampling event is summarized in Table 5A in accordance with 40 CFR § 257.93(c).

Hydraulic conductivity values in the bedrock aquifer (Knox Group Dolomite) at the background or downgradient monitoring wells, as summarized in Table 4, are documented in a hydrogeological evaluation report (Terracon, 2019). Testing data indicates the bedrock aquifer has a geometric mean hydraulic conductivity of 7.05×10^{-5} centimeters per second (cm/sec). Linear groundwater flow velocity was calculated for the bedrock aquifer using:

- the geometric mean hydraulic conductivity calculated from hydraulic testing;
- horizontal hydraulic gradients measured during the implementation of the groundwater sampling and analysis program, ranging from 0.0026 to 0.0063 feet per foot (ft/ft); and,
- an effective porosity of 17% (TVA, 2005).

The average linear flow velocity in the bedrock aquifer ranges from approximately 1.1 to 2.7 feet per year. The rate and direction of groundwater flow in the bedrock for each groundwater sampling event is summarized in Table 5B in accordance with 40 CFR § 257.93(c).

STATISTICAL ANALYSIS OF GROUNDWATER DATA

The groundwater monitoring data was evaluated using statistical procedures as required by 40 CFR § 257.93(f) through 257.93(h). The statistical method certification is included in the facility operating record and the CCR Rule Compliance Data and Information website. Background groundwater quality was established for the background monitoring wells.

Baseline and detection monitoring data sets for Year-One (2017) and Year-Two (2018) and those results obtained during Year-Three (2019) of the CCR Rule Groundwater Quality Monitoring Program were evaluated in order to establish upper prediction limits (UPLs) on background data, and then to compare Year-Three (2019) compliance measurements against these statistical limits to assess any SSIs above background. To assess whether any SSIs occurred during the 2019 Detection Monitoring, the routine sampling events from sampling rounds 1 and 3 at each well-constituent pair were compared against their respective UPL. Under a 1-of-2 retesting strategy, sampling rounds 2 and 4 were included as resamples. A summary of the detection monitoring statistical evaluation is provided in Tables 6A and 6B for the residuum and bedrock saturated zones, respectively. The Statistical Analysis Report is provided as Appendix A.

NARRATIVE DISCUSSION OF ANY TRANSITION BETWEEN MONITORING PROGRAMS

TVA evaluated the groundwater monitoring data for SSIs over background levels for the constituents listed in Appendix III[2] as required by 40 CFR § 257.93(h). The groundwater analytical results from the 2019 rounds of detection monitoring indicated similar SSIs of Appendix III CCR constituents at the downgradient monitoring wells screened in residuum with the following exception: 1.) monitoring well G-5A no longer has an SSI for pH. The groundwater analytical results from the 2019 rounds of detection monitoring indicated similar SSIs of Appendix III CCR constituents at the downgradient monitoring wells screened in bedrock with the following exception: 1.) monitoring well G-3B had an SSI for chloride that was not observed in 2017 or in the second half of 2018. TVA performed confirmation of the SSIs via retesting procedures and error checking and investigated whether the SSIs over background resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality as specified in 40 CFR § 257.94(e)(2).

Following the 2017 groundwater data collection, TVA performed investigations to determine whether a source other than the CCR materials contained in the KIF Peninsula Disposal Area were the cause of any verified SSIs over background as specified in 40 CFR § 257.94(e)(2). The investigations evaluated whether the SSIs over background resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality. The Appendix III alternate source demonstration study was successfully

[2] Appendix III CCR Constituents: boron, calcium, chloride, fluoride, pH, sulfate, and total dissolved solids (TDS).

completed, certified by a qualified professional engineer, and determined that the SSIs were a result of another source and not attributable to the Peninsula Disposal Area. Alternate source demonstration documentation is provided in Appendix B. The alternate source demonstration was re-evaluated and supports that the SSI for chloride at monitoring well G-3B was also attributable to another source and not the Peninsula Disposal Area. 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.

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.

Prepared by Benjamin D. Schutt
(signature)

Benjamin D. Schutt
Environmental Engineer

Reviewed by _____
(signature)

Bob Reynolds
Senior Geologist

Reviewed by _____
(signature)

Matthew J. Dagon, LPG #5962
Senior Geologist

References:

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

TVA, Kingston Fossil Plant, 2005. Peninsular Site, Hydrogeological Evaluation of Coal-Combustion Byproduct Disposal Facility WR2005-1-36-133. October 2005.

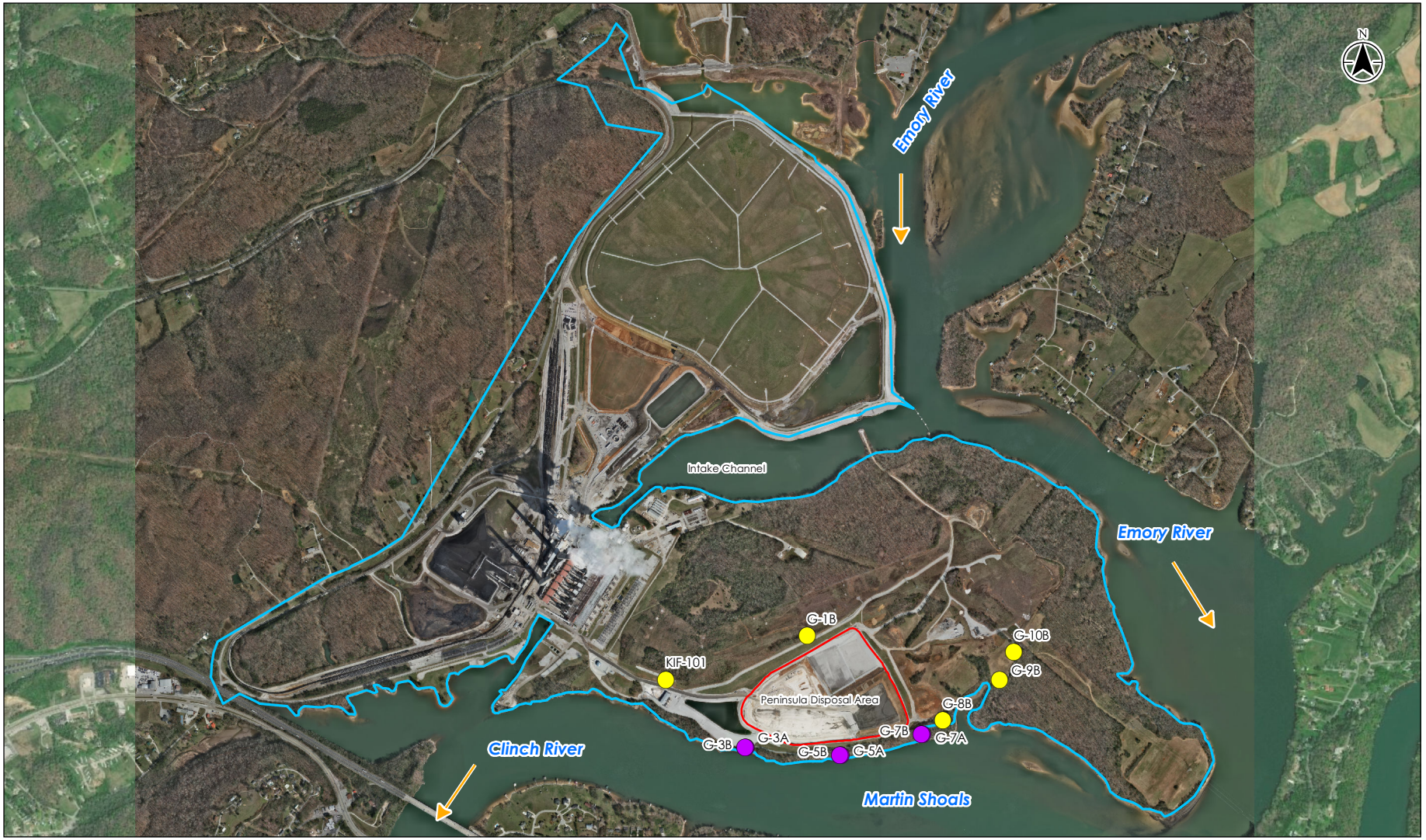
Attachments:

Figure 1 – Map with CCR Unit Background and Downgradient Wells
Figure 2A – Generalized Groundwater Flow Direction Map – Residuum
Figure 2B – Generalized Groundwater Flow Direction Map - Bedrock

Table 1A – Detection Monitoring Groundwater Sampling Results – Residuum
Table 1B – Detection Monitoring Groundwater Sampling Results - Bedrock
Table 2 – Groundwater Sampling Summary
Table 3 – Groundwater and Surface Water Elevation Summary
Table 4 – Hydraulic Conductivity Data Summary
Table 5A – Rate and Direction of Groundwater Flow Summary – Residuum
Table 5B – Rate and Direction of Groundwater Flow Summary - Bedrock
Table 6A – Detection Monitoring Statistical Evaluation – Residuum
Table 6B – Detection Monitoring Statistical Evaluation - Bedrock

Appendix A – Statistical Analysis Report
Appendix B – Alternate Source Demonstration Documentation

FIGURES



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

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Notes

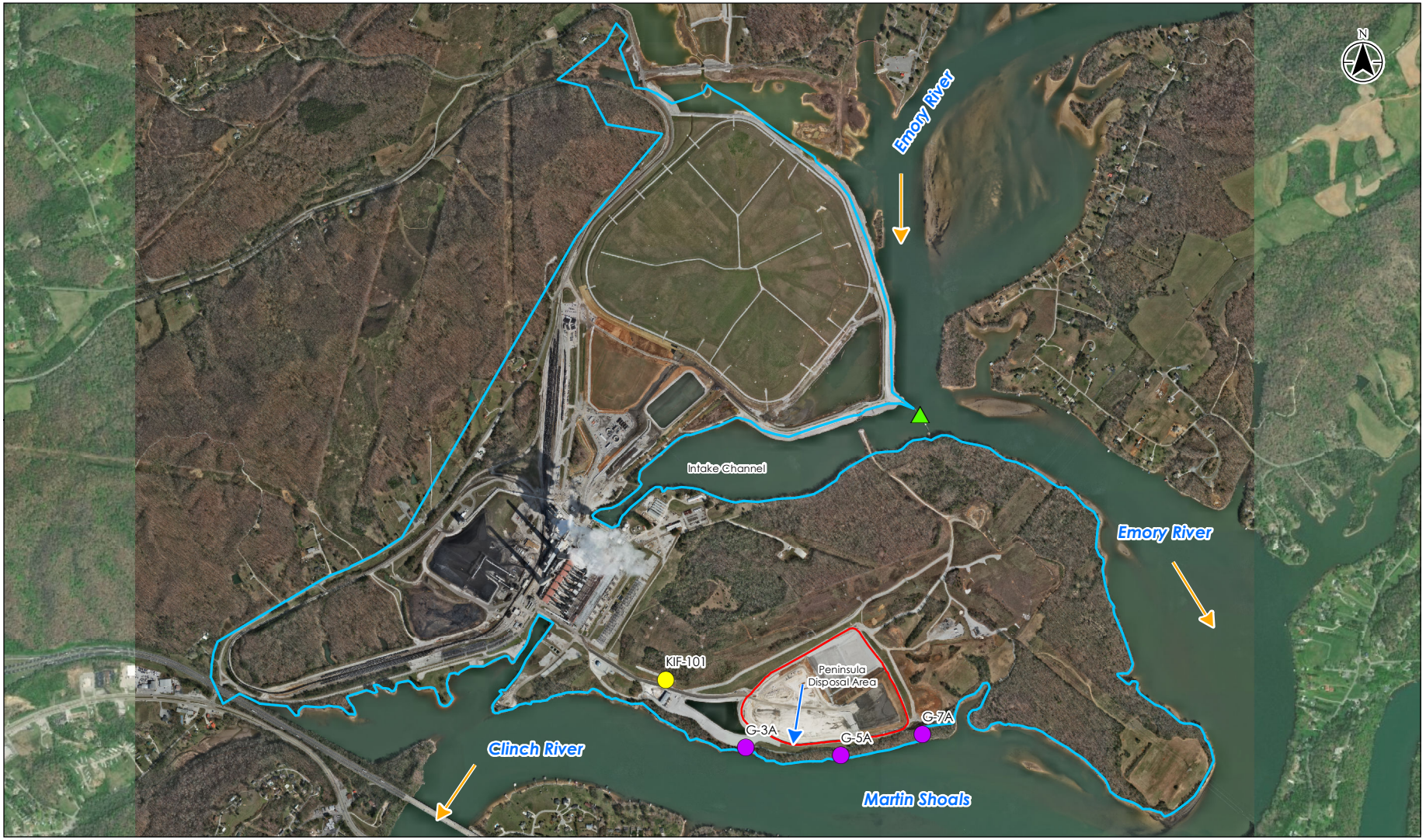
1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Source: Tucker Mapping Solutions, INC (2017-03-16) and Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Project Location	182603521
City of Kingston Roane County, Tennessee	Prepared by LMB on 2020-01-27 Technical Review by MD on 2020-01-27 Independent Review by TR on 2020-01-27

Client/Project
Tennessee Valley Authority
Kingston Fossil Plant
CCR Rule

Figure No.
1

Title
Map with CCR Unit Background and Downgradient Wells



Staff Gauge
Background Well
Downgradient Well
Groundwater Flow Direction
Surface Water Flow Direction
CCR Unit Subject to CCR Rule
TVA Property Boundary

Groundwater flow directions are based on Emory River elevations and groundwater elevations from CCR and Non-CCR monitoring wells.

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Notes

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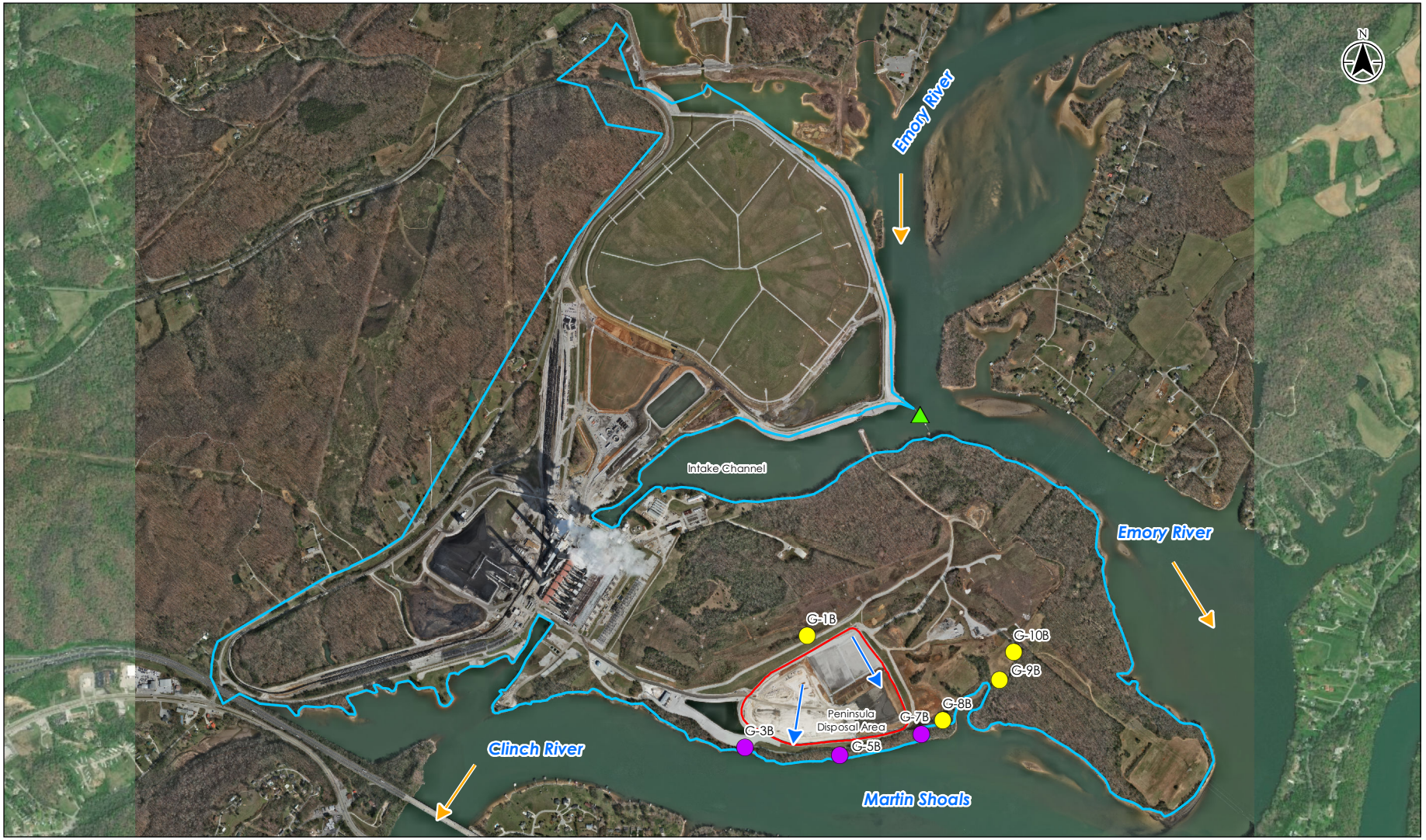
Project Location	182603521
City of Kingston Roane County, Tennessee	Prepared by CMB on 2020-01-27 Technical Review by WSW on 2020-01-27 Independent Review by MD on 2020-01-27

Client/Project
Tennessee Valley Authority
Kingston Fossil Plant
CCR Rule

Figure No.
2A

Title
Generalized Groundwater Flow Direction Map - Residuum



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

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Notes

1. Coordinate System: NAD 1983 StatePlane Tennessee FIPS 4100 Feet
2. Imagery Source: Tucker Mapping Solutions, INC (2017-03-16) and Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Groundwater flow directions are based on Emory River elevations and groundwater elevations from CCR and Non-CCR monitoring wells.

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Client/Project
Tennessee Valley Authority
Kingston Fossil Plant
CCR Rule

Figure No.
2B

Title
Generalized Groundwater Flow Direction Map - Bedrock

TABLES

Table 1A
Detection Monitoring
Groundwater Sampling
Results

Monitoring Well		G-3A							
Sample Date		09-Apr-19		20-Jun-19		10-Sep-19		09-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
Total Metals									
Boron	ug/L	< 30.3	U	< 43.8	U*	< 38.6	U	< 38.6	U
Calcium	ug/L	20600		18100		38700		41900	
Anions									
Chloride	mg/L	1.34		1.14		1.61		2.9	
Fluoride	mg/L	< 0.0263	U	< 0.0263	U	0.0466	J	0.0495	J
Sulfate	mg/L	23.4	J	24		22		19.4	
General Chemistry									
Total Dissolved Solids	mg/L	112		92		137		182	
Field Parameters									
Temperature, Water	DEG_C	15		15.8		17.6		17.2	
Turbidity (field)	NTU	3.63		4.17		4.32		3.48	
ORP	mV	228.4		134.5		65.4		68.2	
Specific Conductivity (field)	mS/cm	0.19		0.15		0.339		0.373	
Dissolved Oxygen	mg/L	4.68		2.41		0.86		0.92	
pH (field)	SU	6.06		6.08		6.5		6.82	

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

U - Analyte not detected

ug/L - micrograms per liter

mg/L - milligrams per liter

DEG_C - degrees Celsius

NTU - Nephelometric Turbidity Units

mV - millivolts

mS/cm - milliseimens per centimeter

SU - Standard Unit

Table 1A
Detection Monitoring
Groundwater Sampling
Results

Monitoring Well		G-5A							
Sample Date		09-Apr-19		20-Jun-19		11-Sep-19		09-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
Total Metals									
Boron	ug/L	123		< 182	U*	128		110	
Calcium	ug/L	63400		60200		62000		62100	
Anions									
Chloride	mg/L	10.4		7.6		7.83		8.82	
Fluoride	mg/L	0.148		0.143		0.166		0.123	
Sulfate	mg/L	18.4	J	16.5		20.4		20	
General Chemistry									
Total Dissolved Solids	mg/L	264		280		283		256	
Field Parameters									
Temperature, Water	DEG_C	15.5		15.4		16		15.8	
Turbidity (field)	NTU	0.41		0.94		3.65		1.03	
ORP	mV	102.9		203.2		151.7		213.4	
Specific Conductivity (field)	mS/cm	0.499		0.453		0.516		0.488	
Dissolved Oxygen	mg/L	4.4		3.12		1.75		1.54	
pH (field)	SU	6.85		6.81		6.62		6.91	

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mS/cm - milliseimens per centimeter

SU - Standard Unit

Table 1A
Detection Monitoring
Groundwater Sampling
Results

Monitoring Well		KIF-101							
Sample Date		08-Apr-19		18-Jun-19		10-Sep-19		07-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
Total Metals									
Boron	ug/L	< 30.3	U	< 42.3	U*	< 38.6	U	< 38.6	U
Calcium	ug/L	89600		96600		106000		104000	
Anions									
Chloride	mg/L	5.15		4.09		5.27		4.73	
Fluoride	mg/L	0.0435	J	0.0524	J	0.0683	J	0.0657	J
Sulfate	mg/L	75.7		91.7		121		122	J
General Chemistry									
Total Dissolved Solids	mg/L	362		378		417		438	
Field Parameters									
Temperature, Water	DEG_C	15.5		16.8		18.2		17.9	
Turbidity (field)	NTU	0.45		1.57		2.51		0.69	
ORP	mV	184.7		211		140.4		50.3	
Specific Conductivity (field)	mS/cm	0.597		0.571		0.69		0.65	
Dissolved Oxygen	mg/L	4.68		5.09		3.07		0.01	
pH (field)	SU	6.59		6.58		6.59		6.55	

Notes:

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mg/L - milligrams per liter

DEG_C - degrees Celsius

NTU - Nephelometric Turbidity Units

mV - millivolts

mS/cm - milliseimens per centimeter

SU - Standard Unit

Table 1B
Detection Monitoring
Groundwater Sampling
Results

Monitoring Well		G-1B							
Sample Date		08-Apr-19		18-Jun-19		10-Sep-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
Total Metals									
Boron	ug/L	< 30.3	U	< 30.3	U	< 38.6	U		
Calcium	ug/L	48800		48100		45300			
Anions									
Chloride	mg/L	1.65		1.47		1.55			
Fluoride	mg/L	< 0.0263	U	< 0.0263	U	0.0315	J		
Sulfate	mg/L	< 0.958	U*	0.673	J	1.05			
General Chemistry									
Total Dissolved Solids	mg/L	208		187		175			
Field Parameters									
Temperature, Water	DEG_C	14.8		15.3		16.5			
Turbidity (field)	NTU	0.32		2		2.66			
ORP	mV	150.8		175.8		105.6			
Specific Conductivity (field)	mS/cm	0.413		0.382		0.402			
Dissolved Oxygen	mg/L	7.28		7.83		6.87			
pH (field)	SU	7.29		7.3		7.29			

Notes:

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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

U - Analyte not detected

NTU - Nephelometric Turbidity Units

ug/L - micrograms per liter

mV - millivolts

mg/L - milligrams per liter

mS/cm - milliseimens per centimeter

DEG_C - degrees Celsius

SU - Standard Unit

* - Monitoring well G-1B had insufficient water for sampling during the October 2019 sampling event

Table 1B
Detection Monitoring
Groundwater Sampling
Results

Monitoring Well		G-3B							
Sample Date		09-Apr-19		20-Jun-19		10-Sep-19		09-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
Total Metals									
Boron	ug/L	< 30.3	U	< 33	U*	< 38.6	U	< 38.6	U
Calcium	ug/L	43300		41600		41000		40200	
Anions									
Chloride	mg/L	2.57		1.99		2.54		2.51	
Fluoride	mg/L	0.048	J	0.0541	J	0.0584	J	0.0563	J
Sulfate	mg/L	27.6	J	24.6		28.8		25.6	
General Chemistry									
Total Dissolved Solids	mg/L	226		213		202		207	
Field Parameters									
Temperature, Water	DEG_C	16.7		18.2		20.9		19.2	
Turbidity (field)	NTU	2.93		4.07		4.79		1.62	
ORP	mV	120.9		98.4		7.8		-40.4	
Specific Conductivity (field)	mS/cm	0.426		0.388		0.431		0.421	
Dissolved Oxygen	mg/L	1.72		1.25		1.9		0.34	
pH (field)	SU	7.48		7.53		7.4		7.47	

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

U - Analyte not detected

ug/L - micrograms per liter

mg/L - milligrams per liter

DEG_C - degrees Celsius

NTU - Nephelometric Turbidity Units

mV - millivolts

mS/cm - milliseimens per centimeter

SU - Standard Unit

Table 1B
Detection Monitoring
Groundwater Sampling
Results

Monitoring Well		G-5B							
Sample Date		09-Apr-19		20-Jun-19		11-Sep-19		09-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
Total Metals									
Boron	ug/L	300		335		315		234	
Calcium	ug/L	105000		103000		101000		98400	
Anions									
Chloride	mg/L	78.5		91.4		80.4		75.1	
Fluoride	mg/L	0.0975	J	0.0922	J	0.104		0.0785	J
Sulfate	mg/L	120	J	125		121		113	
General Chemistry									
Total Dissolved Solids	mg/L	535		586		631		485	
Field Parameters									
Temperature, Water	DEG_C	16.5		16.9		17.7		16.3	
Turbidity (field)	NTU	2.8		3.44		3.26		1.01	
ORP	mV	59.7		-78.8		-77.2		-118.8	
Specific Conductivity (field)	mS/cm	1.04		0.853		0.92		0.91	
Dissolved Oxygen	mg/L	0.97		1.1		0.47		0.43	
pH (field)	SU	7.21		7.27		7.14		7.16	

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

U - Analyte not detected

NTU - Nephelometric Turbidity Units

ug/L - micrograms per liter

mV - millivolts

mg/L - milligrams per liter

mS/cm - milliseimens per centimeter

DEG_C - degrees Celsius

SU - Standard Unit

Table 1B
Detection Monitoring
Groundwater Sampling
Results

Monitoring Well		G-7B							
Sample Date		10-Apr-19		19-Jun-19		11-Sep-19		08-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
Total Metals									
Boron	ug/L	< 30.3	U	< 30.3	U	< 38.6	U	< 47.9	U*
Calcium	ug/L	25700		20600		30400		29800	
Anions									
Chloride	mg/L	1.72		2.67		1.76		2.62	
Fluoride	mg/L	< 0.0263	U	< 0.0491	U*	0.0289	J	0.0395	J
Sulfate	mg/L	1.72		3.71		5.74		2.56	
General Chemistry									
Total Dissolved Solids	mg/L	176		237		199		196	
Field Parameters									
Temperature, Water	DEG_C	16.5		17.6		17.8		17.1	
Turbidity (field)	NTU	1.18		0.55		0.72		0.82	
ORP	mV	-49.3		-50.6		3		-59.7	
Specific Conductivity (field)	mS/cm	0.368		0.363		0.426		0.429	
Dissolved Oxygen	mg/L	0.8		0.63		1.27		0.4	
pH (field)	SU	7.94		7.98		7.5		7.69	

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

U - Analyte not detected

ug/L - micrograms per liter

mg/L - milligrams per liter

DEG_C - degrees Celsius

NTU - Nephelometric Turbidity Units

mV - millivolts

mS/cm - milliseimens per centimeter

SU - Standard Unit

Table 1B
Detection Monitoring
Groundwater Sampling
Results

Monitoring Well		G-8B							
Sample Date		10-Apr-19		19-Jun-19		12-Sep-19		08-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
Total Metals									
Boron	ug/L	< 30.3	U	< 30.3	U	< 38.6	U	< 38.6	U
Calcium	ug/L	36100		38900		40800		36900	
Anions									
Chloride	mg/L	0.981	J	1.42		0.992	J	1.33	
Fluoride	mg/L	< 0.0263	U	< 0.0522	U*	< 0.0263	U	0.0396	J
Sulfate	mg/L	4.28		4.45		4		4.6	
General Chemistry									
Total Dissolved Solids	mg/L	171		182		178		159	
Field Parameters									
Temperature, Water	DEG_C	15.7		15.8		17.1		16.5	
Turbidity (field)	NTU	0.73		1.63		1.9		0.38	
ORP	mV	25.4		209.6		201.7		71.3	
Specific Conductivity (field)	mS/cm	0.338		0.314		0.347		0.33	
Dissolved Oxygen	mg/L	4.24		3.21		2.41		2.14	
pH (field)	SU	7.51		7.15		7.11		7.33	

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

U - Analyte not detected

NTU - Nephelometric Turbidity Units

ug/L - micrograms per liter

mV - millivolts

mg/L - milligrams per liter

mS/cm - milliseimens per centimeter

DEG_C - degrees Celsius

SU - Standard Unit

Table 1B
Detection Monitoring
Groundwater Sampling
Results

Monitoring Well		G-9B							
Sample Date		10-Apr-19		18-Jun-19		12-Sep-19		08-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
Total Metals									
Boron	ug/L	< 30.3	U	< 30.3	U	< 60.3	U*	< 38.6	U
Calcium	ug/L	44000		48800		48100		51300	
Anions									
Chloride	mg/L	1.17		1.49		1.32		1.86	
Fluoride	mg/L	0.0345	J	0.0427	J	0.046	J	0.0548	J
Sulfate	mg/L	48.1		46.9		44		42.5	
General Chemistry									
Total Dissolved Solids	mg/L	233		219		250		259	
Field Parameters									
Temperature, Water	DEG_C	14.6		16.1		18		17	
Turbidity (field)	NTU	0.38		1.66		0.56		0.52	
ORP	mV	-41.5		-76.9		-72.5		-137.3	
Specific Conductivity (field)	mS/cm	0.418		0.399		0.449		0.448	
Dissolved Oxygen	mg/L	0.23		0.28		1.56		0.43	
pH (field)	SU	7.03		6.82		6.83		6.95	

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

U - Analyte not detected

NTU - Nephelometric Turbidity Units

ug/L - micrograms per liter

mV - millivolts

mg/L - milligrams per liter

mS/cm - milliseimens per centimeter

DEG_C - degrees Celsius

SU - Standard Unit

Table 1B
Detection Monitoring
Groundwater Sampling
Results

Monitoring Well		G-10B							
Sample Date		10-Apr-19		18-Jun-19		12-Sep-19		08-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
Total Metals									
Boron	ug/L	< 30.3	U	< 30.3	U	< 38.6	U	< 38.6	U
Calcium	ug/L	24300		25800		25400		25300	
Anions									
Chloride	mg/L	1.13		1.41		1.11		1.59	
Fluoride	mg/L	< 0.0263	U	< 0.0263	U	< 0.0263	U	0.0306	J
Sulfate	mg/L	2.23		2.17		2.35		2.99	J
General Chemistry									
Total Dissolved Solids	mg/L	119		219		183		120	
Field Parameters									
Temperature, Water	DEG_C	14.5		18.5		19.1		16.8	
Turbidity (field)	NTU	0.72		3.04		2.45		0.91	
ORP	mV	96.9		52.4		68.2		172.1	
Specific Conductivity (field)	mS/cm	0.232		0.212		0.232		0.227	
Dissolved Oxygen	mg/L	4.43		4.39		1.72		4.11	
pH (field)	SU	8.31		7.93		7.68		7.51	

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

U - Analyte not detected

ug/L - micrograms per liter

mg/L - milligrams per liter

DEG_C - degrees Celsius

NTU - Nephelometric Turbidity Units

mV - millivolts

mS/cm - milliseimens per centimeter

SU - Standard Unit

Table 2
Groundwater Sampling Summary

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

Well ID	Well Designation	Number of Samples Collected	April 8-10, 2019	June 18-20, 2019	September 10-12, 2019	October 7-9, 2019	Monitoring Program
Sample Round			1	1 - Retest	2	2 - Retest	
G-1B	Background	3	X	X	X	*	Detection Monitoring - 257.94(a); 257.94(b) - Appendix III Constituents
G-3A	Downgradient	4	X	X	X	X	Detection Monitoring - 257.94(a); 257.94(b) - Appendix III Constituents
G-3B	Downgradient	4	X	X	X	X	Detection Monitoring - 257.94(a); 257.94(b) - Appendix III Constituents
G-5A	Downgradient	4	X	X	X	X	Detection Monitoring - 257.94(a); 257.94(b) - Appendix III Constituents
G-5B	Downgradient	4	X	X	X	X	Detection Monitoring - 257.94(a); 257.94(b) - Appendix III Constituents
G-7A	Downgradient	4	X	X	X	X	Detection Monitoring - 257.94(a); 257.94(b) - Appendix III Constituents
G-7B	Downgradient	4	X	X	X	X	Detection Monitoring - 257.94(a); 257.94(b) - Appendix III Constituents
G-8B	Background	4	X	X	X	X	Detection Monitoring - 257.94(a); 257.94(b) - Appendix III Constituents
G-9B	Background	4	X	X	X	X	Detection Monitoring - 257.94(a); 257.94(b) - Appendix III Constituents
G-10B	Background	4	X	X	X	X	Detection Monitoring - 257.94(a); 257.94(b) - Appendix III Constituents
KIF-101	Background	4	X	X	X	X	Detection Monitoring - 257.94(a); 257.94(b) - Appendix III 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

'* - Monitoring well G-1B had insufficient water for sampling during the October 2019 sampling event

Table 3
Groundwater and Surface Water Elevation Summary

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

Groundwater Elevation Collection Date		08-Apr-19	17-Jun-19	09-Sep-19	07-Oct-19
Monitoring Well	**Units**	**Residuum**			
G-2A	ft-MSL	809.67	809.07	809.70	809.58
G-3A	ft-MSL	738.80	741.00	740.89	740.77
G-5A	ft-MSL	738.75	740.91	740.81	740.61
G-7A	ft-MSL	738.96	741.07	740.94	740.74
KIF-101	ft-MSL	739.24	741.05	740.90	740.95
Monitoring Well	**Units**	**Bedrock - Knox Group**			
G-1B	ft-MSL	744.09	744.77	743.85	NA
G-2B	ft-MSL	NM	795.85	795.46	794.90
G-3B	ft-MSL	738.74	740.88	740.77	740.56
G-5B	ft-MSL	738.72	740.85	740.77	740.60
G-7B	ft-MSL	739.00	741.09	740.95	740.79
G-8B	ft-MSL	738.85	738.00	740.73	740.60
G-9B	ft-MSL	743.51	742.16	740.06	739.43
G-10B	ft-MSL	740.87	741.66	741.08	740.87
		Surface Water			
Emory River	ft-MSL	738.85	740.61	740.52	740.54

Notes:

ft-MSL - feet above mean sea level

NA - not available - dry well / insufficient water level

NM - not measured - water level data collection at G-2B was initiated after April 2019

Table 4
Hydraulic Conductivity Data Summary

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

Well ID	Well Designation	Slug Test Hydraulic Conductivity (cm/sec)
Residuum		
G-3A	Downgradient	5.32E-04
G-5A	Downgradient	6.04E-04
G-7A	Downgradient	1.33E-03
KIF-101	Background	4.33E-03
Residuum Geometric Mean of Hydraulic Conductivity (cm/sec)		**1.17E-03**
Bedrock - Knox Group		
G-1B	Background	6.58E-03
G-3B	Downgradient	6.01E-06
G-5B	Downgradient	6.49E-06
G-7B	Downgradient	9.63E-05
G-8B	Background	NA
G-9B	Background	NA
G-10B	Background	NA
Bedrock Geometric Mean of Hydraulic Conductivity (cm/sec)		**7.05E-05**

Notes:

cm/sec - centimeters per second

NA - Not Available

Groundwater Elevation Collection Date	8-Apr-19	17-Jun-19	9-Sep-19	7-Oct-19
Sample Round	**1**	**1 - Retest**	**2**	**2 - Retest**
Horizontal Gradient	0.0414	0.0398	0.0403	0.0403
Hydraulic Conductivity (cm/sec)	1.17E-03	1.17E-03	1.17E-03	1.17E-03
Effective Porosity	27%	27%	27%	27%
Flow Direction (cardinal)	South	South	South	South
Linear Velocity (ft/yr)	184.9	178.0	180.0	180.1

Notes:

cm/sec - centimeters per second

ft/yr - feet per year

Groundwater Elevation Collection Date	8-Apr-19	17-Jun-19	9-Sep-19	7-Oct-19
Sample Round	**1**	**1 - Retest**	**2**	**2 - Retest**
Horizontal Gradient	0.0041	0.0038	0.0026	0.0063
Hydraulic Conductivity (cm/sec)	7.05E-05	7.05E-05	7.05E-05	7.05E-05
Effective Porosity	17%	17%	17%	17%
Flow Direction (cardinal)	South	South	South	South
Linear Velocity (ft/yr)	1.8	1.6	1.1	2.7

Notes:

cm/sec - centimeters per second

ft/yr - feet per year

Table 6A - Detection Monitoring Statistical Evaluation - Residuum

Constituent		Boron	Calcium	Chloride	Fluoride	pH	Sulfate	TDS
Unit		mg/L*	mg/L*	mg/L	mg/L	SU	mg/L	mg/L
2019 UPL		0.08	121.61	8.806	0.0959	5.88**-7.04	191.31	523.95
Well ID	Date							
G-3A	4/9/2019	<0.0303	20.6	1.34	<0.0263	6.06	23.4	112
	(6/20/2019)	(<0.0438)	(18.1)	(1.14)	(<0.0263)	(6.08)	(24)	(92)
	9/10/2019	<0.0386	38.7	1.61	<0.0466	6.50	22	137
	(10/9/2019)	(<0.0386)	(41.9)	(2.90)	(<0.0495)	(6.82)	(19.4)	(182)
G-5A	4/9/2019	**0.123**	63.4	**10.4**	**0.148**	6.85	18.4	264
	(6/20/2019)	**(<0.182)**	(60.2)	(7.6)	**(0.143)**	(6.81)	(16.5)	(280)
	9/11/2019	**0.128**	62	7.83	**0.166**	6.62	20.4	283
	(10/9/2019)	**(0.11)**	(62.1)	**(8.82)**	**(0.123)**	(6.91)	(20.0)	(256)
G-7A	4/10/2019	<0.0303	38.6	1.95	<0.0263	**7.47**	7.02	184
	(6/19/2019)	(<0.0303)	(45.3)	(2.51)	(<0.039)	**(7.19)**	(8.37)	(197)
	9/11/2019	<0.0386	44.2	1.92	0.0296	7.04	7.74	199
	(10/8/2019)	(<0.0559)	(42.7)	(2.53)	(0.0439)	**(7.34)**	(8.69)	(173)
KIF-101	4/8/2019	<0.0303	89.6	5.15	0.0435	6.59	75.7	362
	(6/18/2019)	(<0.0423)	(96.6)	(4.09)	(0.0524)	(6.58)	(91.7)	(378)
	9/10/2019	<0.0386	106	5.27	0.0683	6.59	121	417
	(10/7/2019)	(<0.0386)	(104)	(4.73)	(0.0657)	(6.55)	(122)	(438)

Notes:

Bold and underlined concentrations are higher than the UPL or, for pH, outside the prediction interval. However, to be a statistically significant increase (SSI), both the original sample and resample must be outside the bounds of the UPL

TDS - Total Dissolved Solids

mg/L - milligrams per liter [* - Boron and calcium concentrations presented in Table 1 are reported in micrograms per liter (µg/L)]

SU - Standard Units

UPL - Upper Prediction Limit

** indicates the lower bound of the range is the lower prediction limit (LPL). The upper bound is the UPL

"<": analyte was not detected and the Method Detection Limit (MDL) is presented

Parenthesized values represent resample results

Well KIF-101 is the background monitoring well

Table 6B - Detection Monitoring Statistical Evaluation - Bedrock

Constituent		Boron	Calcium	Chloride	Fluoride	pH	Sulfate	TDS
Unit		mg/L*	mg/L*	mg/L	mg/L	SU	mg/L	mg/L
2019 UPL		0.08	52.061	1.93	0.1	6.46**-8.17	52.3	275.39
Well ID	Date							
G-3B	4/9/2019	<0.0303	43.3	**2.57**	0.048	7.48	27.6	226
	(6/20/2019)	(<0.033)	(41.6)	**(1.99)**	(0.0541)	(7.53)	(24.6)	(213)
	9/10/2019	<0.0386	41	**2.54**	0.0584	7.40	28.8	202
	(10/9/2019)	(<0.0386)	(40.2)	**(2.51)**	(0.0563)	(7.47)	(25.6)	(207)
G-5B	4/9/2019	**0.3**	**105**	**78.5**	0.0975	7.21	**120**	**535**
	(6/20/2019)	**(0.335)**	**(103)**	**(91.4)**	(0.0922)	(7.27)	**(125)**	**(586)**
	9/11/2019	**0.315**	**101**	**80.4**	**0.1040**	7.14	**121**	**631**
	(10/9/2019)	**(0.234)**	**(98.4)**	**(75.1)**	(0.0785)	(7.16)	**(113)**	**(485)**
G-7B	4/10/2019	<0.0303	25.7	1.72	<0.0263	7.94	1.72	176
	(6/19/2019)	(<0.0303)	(20.6)	**(2.67)**	(<0.0491)	(7.98)	(3.71)	(237)
	9/11/2019	<0.0303	30.4	1.76	0.0289	7.5	5.74	199
	(10/8/2019)	(<0.0479)	(29.8)	**(2.62)**	(0.0395)	(7.69)	(2.56)	(196)
G-1B	4/8/2019	<0.0303	48.8	1.65	<0.0263	7.29	<0.958	208
	(6/18/2019)	(<0.0303)	(48.1)	(1.47)	(<0.0263)	(7.3)	(0.673)	(187)
	9/11/2019	<0.0386	45.3	1.55	0.0315	7.29	1.05	175

Notes:

Bold and underlined concentrations are higher than the UPL or, for pH, outside the prediction interval. However, to be a statistically significant increase (SSI), both the original sample and resample must be outside the bounds of the UPL

TDS - Total Dissolved Solids

mg/L - milligrams per liter [* - Boron and calcium concentrations presented in Table 1 are reported in micrograms per liter (µg/L)]

SU - Standard Units

UPL - Upper Prediction Limit

** indicates the lower bound of the range is the lower prediction limit (LPL). The upper bound is the UPL

"<": analyte was not detected and the Method Detection Limit (MDL) is presented

Parenthesized values represent resample results

Well G-1B is the background monitoring well

Well G-1B was not sampled in October 2019 due to insufficient water level

APPENDIX A
STATISTICAL ANALYSIS REPORT

STATISTICAL ANALYSIS REPORT FOR KINGSTON FOSSIL PLANT

2019

1/16/2020

Contents

1 Introduction

This report summarizes the statistical analysis performed on groundwater quality constituents monitored during the Coal Combustion Residuals (CCR) Rule's 2018 Annual Groundwater Monitoring (GWM) Program for the Peninsula Disposal Area at the Tennessee Valley Authority (TVA) Kingston Fossil Plant (KIF). The 2019 Annual GWM Program is the third year of the program. Statistically significant increases (SSIs) were present in several parameters based on the 2017 annual groundwater sampling results. An Alternate Source Determination (ASD) was made and the Unit remains in Detection Monitoring.

At the KIF plant's CCR Units, the sampling results used to identify potential SSIs were developed based on data obtained from a minimum of four distinct monitoring events performed between April and October of 2019 by 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 networks, as Certified by a Professional Engineer from AECOM, is presented in **Table 1**.

Table 1. CCR Rule Monitoring Well Networks

CCR Site Network	Background	Downgradient
Residuum	KIF-101	G-3A G-5A G-7A
Knox Group	G-1B G-8B G-9B G-10B	G-3B G-5B G-7B

The 'R' Statistical Analysis package (www.r-project.org) in conjunction with R-Studio (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 III of the CCR Rule. Only non-filtered sample results were utilized for the statistical analysis of Appendix III 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 III constituents, filtered samples were also collected to better understand and/or dispel the potential source(s) of falsely-identified SSIs. A summary of constituents included in the data analysis is provided in the first column of Table 2.

Table 2. CCR Rule Monitored Constituents

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

2 Statistical Analysis

The basic steps in the Detection Monitoring analysis for the 2019 data included the following:

1) Calculating the site testing configuration, and determining the statistical power associated with interwell parametric and nonparametric prediction limits under possible retesting schemes;
2) Assessing best-fitting statistical models for each background dataset, including identification of any statistical outliers, then computing interwell prediction limits; and
3) Comparing each prediction limit against the 2019 compliance data, including resamples if necessary, to assess whether an SSI occurred.

To accomplish these steps, the data were first summarized and modeled. The baseline or background data were examined initially, and recapped with descriptive statistics, as shown in **Table 3**. 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.

Table 3A. Summary of Background Dataset Descriptive Statistics, Residuum

Constituent	Units	N	No. of NDs	Minimum	Maximum	Mean	Median
Boron	mg/L	27	15	0.011	0.080	0.020	0.015
Calcium	mg/L	27	0	79.7	124.0	103.9	103.0
Chloride	mg/L	27	0	4.09	9.90	6.17	6.31
Fluoride	mg/L	27	3	0.039	0.135	0.063	0.059
pH	SU	28	0	5.88	7.04	6.60	6.59
Sulfate	mg/L	27	0	75.70	195.00	129.18	122.00
TDS	mg/L	27	0	362.0	517.0	452.5	449.0

Table 3B. Summary of Background Dataset Descriptive Statistics, Knox Group

Constituent	Units	N	No. of NDs	Minimum	Maximum	Mean	Median
Boron	mg/L	78	62	0.008	0.080	0.012	0.010
Calcium	mg/L	78	0	23.2	54.6	38.58	39.3
Chloride	mg/L	78	1	0.98	3.13	1.48	1.54
Fluoride	mg/L	78	49	0.029	0.177	0.042	0.040
pH	SU	78	0	5.92	8.63	7.32	7.32
Sulfate	mg/L	78	2	0.57	55.5	14.2	2.99
TDS	mg/L	78	0	107.0	279.0	191.8	187.5

Notes:
1. ND = not detected above the laboratory reporting limit.
2. All computations involving non-detects handled using the Kaplan-Meier adjustment. In the case of 100% NDs, mean is computed by substituting half the reporting limit for each ND.

2.1 Site Testing Configuration and Statistical Power

TVA has established a statistical testing approach within its CCR detection monitoring program using the following decision logic:

1. For each Appendix III parameter and compliance well location, a comparison is made between each routinely collected sample and a site-specific upper prediction limit (UPL) computed from upgradient background data (or for pH, against a site-specific prediction interval).
2. If the routine observation exceeds the upper prediction limit (or for pH, is lower than the lower prediction limit), a potential SSI is identified. If the routine observation is within the bounds of the UPL or prediction interval, the test passes.
3. In the event of a potential SSI, one or more resamples — depending on the appropriate value of m — is (are) compared against the UPL or prediction interval. If any of the resamples falls within the bounds of prediction limit/interval, the test passes. If all the resamples exceed the bounds of the limit/interval, an SSI is confirmed for that well and constituent.

To determine the appropriate value of m for use in retesting, four different retesting strategies were assessed by computing the statistical power associated with possible prediction limits under a 1-of-1, 1-of-2, 1-of-3, and 1-of-4 approach (note that a 1-of-1 approach implies the lack of any retesting). Each of the prediction limits was computed under the constraint that the annual site-wide false positive rate (SWFPR) be no more than 10%, thus accounting for the available background sample size for each Appendix III constituent (n=23 for the Residuum network, n=63 for the Knox Group), along with the number of downgradient compliance wells (3), the number of constituents to be tested (7), and the number of statistical evaluations per year (2).

2.2 Background Statistical Models and Prediction Limits

To compute each upper threshold limit (UTL) (or prediction interval for pH), the following steps were taken:

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

At KIF, no outliers in the grouped background data were flagged at either monitoring network.

2) The grouped baseline data were also analyzed to determine whether they could be fit to a known statistical model. If so, a parametric UPL or prediction interval was computed; if not, a nonparametric UPL or interval 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.

3) The final statistical model for each COI was used to compute an upper prediction limit (UPL) or prediction interval associated with a 1-of-2 retesting scheme, and such that the limit or interval met EPA's twin performance criteria of controlling the site-wide false positive rate and having sufficient statistical power.

When a parametric model is appropriate, on the normalized scale, a UPL is computed using the standard normal theory equation (and similarly for a two-sided prediction interval):

$$UPL = \overline{x} + \kappa s$$

where $\overline{x}$ and s represent the mean and standard deviation of the (transformed) observations, and κ is a multiplier which depends on the number of baseline measurements, desired confidence level, retesting strategy, and network configuration (number of downgradient wells, number of constituents, and number of annual evaluations). If the data have been transformed, the final UPL or prediction interval is derived by back-transforming the scaled UPL or interval bounds, e.g., for a log transformation, the result is exponentiated; for a square-root transformation, the result is squared, etc.

For nonparametric models, the normal theory equation does not apply. Instead, the UPL is selected as one of the largest of the sample values, typically the maximum, while the LPL (if applicable) is selected as one of the smallest values (usually the minimum). Because there is no multiplier as in the parametric case, the confidence level associated with a nonparametric UPL is computed 'after the fact,' based on the sample size, desired confidence level, retesting strategy, etc.: the smaller the sample size, the lower the confidence; the bigger the sample size, the higher the confidence level.

For the KIF, **Table 4, included below,** lists the calculated UPLs (and LPL for pH) established for these particular CCR Units.

Table 4A. KIF Residuum Interwell Prediction Limits

COI	N	ND.PCT	MODEL	1-of-m	FPR	UNITS	LPL	UPL
Boron	27	55.6	NP	2	0.0143	mg/L	0	0.08
Calcium	27	0	Square	2	0.0149	mg/L	0	121.61
Chloride	27	0	Log	2	0.0149	mg/L	0	8.81
Fluoride	27	11.1	Log	2	0.0149	mg/L	0	0.096
pH	28	0	NP	2	0.0268	SU	5.88	7.04
Sulfate	27	0	Log	2	0.0149	mg/L	0	191.31
TDS	27	0	Cube	2	0.0149	mg/L	0	523.95

Table 4B. KIF Knox Group Interwell Prediction Limits

COI	N	ND.PCT	MODEL	1-of-m	FPR	UNITS	LPL	UPL
Boron	78	79.5	NP	2	0.0113	mg/L	0	0.08
Calcium	78	0	Square	2	0.0149	mg/L	0	52.1
Chloride	78	1.3	NORMAL	2	0.0149	mg/L	0	1.93
Fluoride	78	62.8	NP	2	0.0113	mg/L	0	0.1
pH	78	0	NORMAL	2	0.0149	SU	6.46	8.17
Sulfate	78	2.6	NP	2	0.0113	mg/L	0	52.3
TDS	78	0	NORMAL	2	0.0149	mg/L	0	275.4

2.3 Comparing Compliance Data Against Prediction Limits

To assess whether any SSIs occurred during the 2019 Detection Monitoring at TVA's KIF CCR units, the routine sampling events from sampling rounds 1 and 3 at each COI-well pair were compared against their respective prediction limits. Under a 1-of-2 retesting strategy, sampling rounds 2 and 4 were reserved as possible resamples. This enabled sufficient lag time between any of the routine and resample measurements.

If either routine observation (sampling rounds 1 and 3) exceeded the upper prediction limit (UPL), or for pH, was outside the bounds of the prediction interval on either side, a potential SSI was flagged. Then the reserved resample associated with the routine event (sampling rounds 2 and 4) was compared against the same limit or interval. Only if the routine observation and its resample both were outside the bounds of the prediction limit/interval was a confirmed SSI identified.

3 Summary of Statistical Analysis

To facilitate an ‘at-a-glance’ summary of the statistical comparison results, Tables 5A and 5B are ‘traffic light’ matrices, showing a compact representation of each well location matched against each constituent in Appendix III. This summary is useful in planning for mitigation actions. Green cells indicate that no SSI was observed in 2019. Red cells indicate that: an SSI was flagged during one or both of the semi-annual evaluation events.

At the KIF Residuum CCR network (Table 5A), Detection Monitoring SSIs during the 2019 annual sampling were recorded for boron and fluoride at downgradient well G-5A, and for pH at well G-7A. At the Knox Group CCR network (Table 5B), SSIs were recorded for boron, calcium, chloride, sulfate, and TDS at well G-5B, and for chloride at well G-3B. In summary, a total of three SSIs were identified at Program network wells located near the KIF plant’s Residuum CCR Unit during the 2019 Detection Monitoring phase, along with a total of six SSIs at the KIF plant’s Knox Group CCR Unit.

Table 5A. Traffic Light Matrix Based on Comparative Analysis of Statistical Analysis Results versus Prediction Limits, KIF Residuum

ITEM No.	TRAFFIC LIGHT MATRIX			
	Constituent of Interest	GROUNDWATER QUALITY MONITORING WELL LOCATIONS		
		G-3A	G-5A	G-7A
1.	Boron	GREEN	RED	GREEN
2.	Calcium	GREEN	GREEN	GREEN
3.	Chloride	GREEN	GREEN	GREEN
4.	Fluoride	GREEN	RED	GREEN
5.	pH	GREEN	GREEN	RED
6.	Sulfate	GREEN	GREEN	GREEN
7.	TDS	GREEN	GREEN	GREEN

COLOR-CODING KEY:	
	Monitored data for the specific COI are deemed to fall within prediction limit bounds
	Monitored data for the specific COI are deemed to exceed prediction limit bounds

Table 5B. Traffic Light Matrix Based on Comparative Analysis of Statistical Analysis Results versus Prediction Limits, KIF Knox Group

ITEM No.	TRAFFIC LIGHT MATRIX			
	Constituent of Interest	GROUNDWATER QUALITY MONITORING WELL LOCATIONS		
		G-3B	G-5B	G-7B
1.	Boron	GREEN	RED	GREEN
2.	Calcium	GREEN	RED	GREEN
3.	Chloride	RED	RED	GREEN
4.	Fluoride	GREEN	GREEN	GREEN
5.	pH	GREEN	GREEN	GREEN
6.	Sulfate	GREEN	RED	GREEN
7.	TDS	GREEN	RED	GREEN

COLOR-CODING KEY:	
	Monitored data for the specific COI are deemed to fall within prediction limit bounds
	Monitored data for the specific COI are deemed to exceed prediction limit bounds

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 2046

APPENDIX B
ALTERNATE SOURCE DEMONSTRATION DOCUMENTATION

NOTICE OF SUCCESSFUL ALTERNATE SOURCE DEMONSTRATION

KINGSTON FOSSIL PLANT

PENINSULA DISPOSAL AREA

In accordance with the provisions of 40 C.F.R. 257.94(e)(2), Tennessee Valley Authority (TVA) commissioned an Alternate Source Demonstration (ASD) study for the above-named CCR unit located within the Kingston Fossil plant's reservation. The study provided successful proof that the ASD of Appendix III constituents measured were due to sources other than the CCR unit named above. As required by 40 C.F.R. 257.94(e)(2), TVA will include the demonstration, as certified by the qualified Professional Engineer (PE) named below, in its "Annual Groundwater Monitoring and Corrective Action Report". TVA will continue its detection monitoring program for the Peninsula Disposal Area.

QUALIFIED PROFESSIONAL ENGINEER CERTIFICATION

I, Stephen H. Bickel, being a Professional Engineer in good standing in the State of Tennessee do hereby certify, to the best of my knowledge, information, and belief, that the information contained in this certification is prepared in accordance with the accepted practice of engineering; that the information contained herein is accurate as of the date of my signature below; and that the successful Alternate Source Demonstration (ASD) as described above meets the requirements of 40 CFR § 257.94(e)(2). Opinions relating to this ASD, environmental, geologic, and hydrogeologic conditions or other conclusions are based on available data; actual conditions may vary from those encountered at the times and locations where data are obtained, despite the use of due care.

SIGNATURE: _____

PRINTED NAME: Stephen Bickel, PE

ADDRESS: 10509 Timberwood Circle, Suite 100, Louisville, KY 40223

TELEPHONE: (502) 212-5075

Attachments:

ASD for CCR Unit Peninsula Disposal Area located within the boundaries of the Kingston Fossil Plant's Reservation.

DATE: 4/13/18

SUCCESSFUL ALTERNATE SOURCE DEMONSTRATION EXECUTIVE SUMMARY

KINGSTON FOSSIL PLANT

PENINSULA DISPOSAL AREA

A successful Alternate Source Demonstration (ASD) was conducted on behalf of the Tennessee Valley Authority (TVA) for Kingston Fossil (KIF) Plant in accordance with 40 C.F.R. 257.94(e)(2) of the Coal Combustion Residuals (CCR) rule. This ASD was conducted in response to the identification of potential statistically significant increases (SSIs) during sampling conducted under the Detection Monitoring program [40 C.F.R. 257.94] in connection with the regulated Peninsula Disposal Area unit.

The ASD determined that the potential SSIs identified in the Peninsula Disposal Area Detection Monitoring program are not related to a release from the regulated CCR unit, but rather were attributable to the 2010 failure of a clay liner and associated release of CCR materials. The conclusion that the potential SSIs are due to sources other than the Peninsula Disposal Area is supported by the following lines of evidence:

- The Appendix III constituents with potential SSIs had been detected in downgradient monitoring wells prior to the construction of the Peninsula Disposal Area in 2011 and start of operation in 2012.
- During 2010, failure of the clay liner for a former gypsum pond was observed.
- After mitigation of the former gypsum pond clay liner failure, the Peninsula Disposal Area was constructed over the location of the former gypsum pond. The Peninsula Disposal Area was constructed with a geomembrane liner and leachate collection system.
- Groundwater monitoring data in downgradient monitoring wells exhibited a sharp increase in concentrations of Appendix III constituents that peaked in the year following the failure of the clay liner and have since declined substantially. This pattern of constituent concentrations is consistent with the release that has been mitigated and inconsistent with an ongoing release from the Peninsula Disposal Area.

The constituents that caused the apparent SSIs were detected prior to the placement of CCR in the new Peninsula Disposal Area's lined landfill and their pattern of detection is inconsistent with a release from the regulated CCR unit.

SUMMARY

Based on completion of the successful ASD for the Peninsula Disposal Area, and in accordance with 40 C.F.R. 257.94(e)(2), the site will remain in detection monitoring as of April 15, 2018.