APPENDIX E –
STATISTICAL ANALYSES

APPENDIX E.1

STATISTICAL ANALYSIS OF BACKGROUND SOIL DATA

Appendix E.1 – Statistical Analysis of Background Soil Data

TDEC Commissioner's Order:
Environmental Assessment Report
Watts Bar Fossil Plant
Spring City, Tennessee

March 31, 2024

Prepared for:

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APPENDIX E.1 – STATISTICAL ANALYSIS OF BACKGROUND SOIL DATA

REVISION LOG

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0	Submittal to TDEC	November 7, 2023
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Sign-off Sheet

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Abbreviations

BGS	Background Soil
BTVs	Background Threshold Values
CASRN	Chemical Abstracts Service Registry Number
CCR	Coal Combustion Residuals
CCR Parameters	Constituents listed in Appendices III and IV of 40 CFR 257 and five inorganic constituents included in Appendix I of Tennessee Rule 0400-11-01-.04
CCR Rule	Title 40, Code of Federal Regulations, Part 257
EAR	Environmental Assessment Report
EI	Environmental Investigation
ft bgs	Feet Below Ground Surface
IQR	Interquartile Range
NA	Not Available
%	Percent
QA/QC	Quality Assurance and Quality Control
SAR	Sampling and Analysis Report
Stantec	Stantec Consulting Services Inc.
TDEC	Tennessee Department of Environment and Conservation
TVA	Tennessee Valley Authority
UTLs	Upper Tolerance Limits
WBF Plant	Watts Bar Fossil Plant

March 31, 2024

1.0 INTRODUCTION

Stantec Consulting Services Inc. (Stantec) prepared this statistical analysis report on behalf of the Tennessee Valley Authority (TVA) to summarize the statistical analyses performed on background soil (BGS) data to support evaluations conducted for the Environmental Assessment Report (EAR) at the Watts Bar Fossil Plant (WBF Plant) located in Spring City, Tennessee. The BGS samples were collected as part of the Tennessee Department of Environment and Conservation (TDEC) Order Environmental Investigation (EI) on June 6 and July 8, 2019 from two background monitoring well borings, and between September 4 and 17, 2019 in the vicinity of the WBF Plant from locations where naturally occurring, *in situ*, native soils unaffected by Coal Combustion Residual (CCR) materials were present. Further details regarding the BGS sampling program and results are available in the Watts Bar Fossil Plant (*WBF Plant) BGS Investigation Sampling and Analysis Report* (SAR) (Appendix F.1), including the BGS investigation boring locations (Exhibit A.2), and a list of the BGS investigation borings and associated soil samples and analyses (Table B.1).

Twelve samples were excluded from the statistical analysis datasets for being collected in the saturated zone. The Constituents listed in Appendices III and IV of 40 CFR 257 and five inorganic constituents included in Appendix I of Tennessee Rule 0400-11-01-.04 (CCR Parameters) included in the analysis are presented below in Table E.1-1.

Table E.1-1 – CCR Parameters Evaluated in Statistical Analysis

Parameter	CASRN
CCR Rule Appendix III Parameters	
Boron	7440-42-8
Calcium	7440-70-2
Chloride	16887-00-6
Fluoride[1] (also Appendix IV)	16984-48-8
pH	Not Available (NA)
Sulfate	14808-79-8
TDS	NA
CCR Rule Appendix IV Parameters	
Antimony	7440-36-0
Arsenic	7440-38-2
Barium	7440-39-3
Beryllium	7440-41-7
Cadmium	7440-43-9
Chromium	7440-47-3
Cobalt	7440-48-4
Lead	7439-92-1
Lithium	7439-93-2
Mercury	7439-97-6
Molybdenum	7439-98-7
Radium-226+228	13982-63-3/ 15262-20-1
Selenium	7782-49-2
Thallium	7440-28-0
TDEC Appendix I Parameters	
Copper	7440-50-8
Nickel	7440-02-0
Silver	7440-22-4
Vanadium	7440-62-2
Zinc	7440-66-6
Other	
% Ash	NA

Notes: CASRN - Chemical Abstracts Service Registry Number; CCR Rule - Title 40, Code of Federal Regulations, Part 257; NA - Not available
[1]Fluoride is both a CCR Rule Appendix III and CCR Rule Appendix IV parameter. In this table, and in the results presented herein, fluoride has been grouped with the Appendix III parameters only to avoid duplication.

The following sections present the methods and results from general exploratory data analysis using summary statistics, data plots, outlier screening methods and the calculation of Background Threshold Values (BTVs).

2.0 METHODS

The statistical evaluation for the BGS data collected at the WBF Plant for the EI was conducted in two parts: 1) exploratory data analysis and 2) calculation of site-specific BTVs. The analyses relied on available background soil data collected as part of the BGS EI. Quality assurance and quality control (QA/QC) samples (e.g. field duplicates) were excluded from the statistical analysis.

2.1 EXPLORATORY DATA ANALYSIS

Exploratory data analysis is the initial step of statistical analysis. It utilizes simple summary statistics (e.g. mean, median, standard deviation, and percentiles) and graphical representations to identify important characteristics of an analytical dataset, such as the center of the data (mean, median), variation, distribution, spatial patterns, presence of outliers, and randomness.

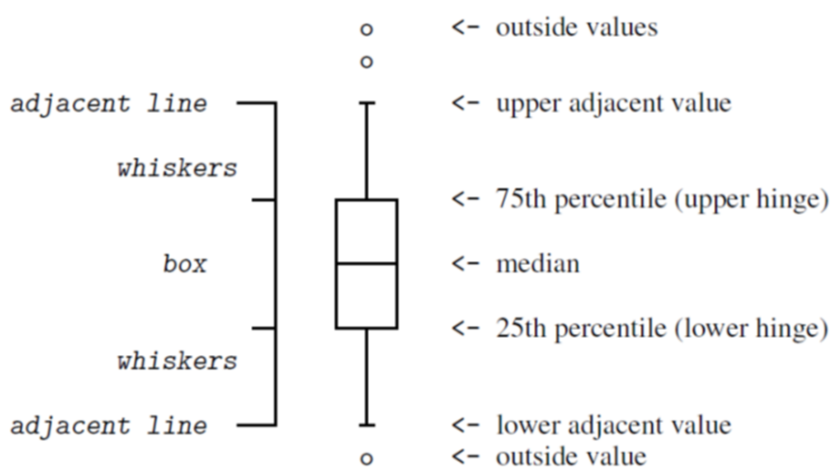
For the EI, surficial soil samples were typically collected at depths ranging from 0.0 to approximately 0.5 feet below ground surface (ft bgs). In addition to the CCR Parameters (Table E.1-1), these samples were analyzed for the presence of CCR Material (percent [%] Ash). Along with surficial samples, the field sampling personnel collected approximately two feet of soil from each 5-foot soil run (one foot in both directions from the midpoint of the 5-foot interval) for the total depth of the boring. For the statistical analysis, soil depths were aggregated into the following depth intervals: surficial (0 to approximately 0.5 ft bgs), approximately 0.5 to less than or equal to 10 ft bgs, and greater than 10 ft bgs.

2.1.1 Summary Statistics

Summary statistics were calculated for each CCR Parameter grouped by depth interval and the entire set of BGS samples (including all depth intervals and boring locations). Summary statistics include information such as the total numbers of available samples, the frequencies of detection, ranges of reporting limits, minimum and maximum detected concentrations, mean concentrations, standard deviations, median concentrations, and the 95th percentile concentrations. A summary statistics table is presented in Attachment E.1-A.

2.1.2 Exploratory Data Plots

Exploratory data plots (box plots) were constructed to support a visual review of the data. Box plots identify the center of the data, distribution, variability, and to visually identify potential outliers. The diagram below graphically depicts the basics of the construction of the box plots (StataCorp LLC 2017).



The box portion of the plot is the interquartile range (IQR), which represents the middle 50% of data, with the bottom of the box being the 25th percentile and the top of the box being the 75th percentile. The line inside the box is the median concentration. The top of the upper "whisker" represents the first observed concentration above the 75th percentile, whereas the bottom of the lower "whisker" represents the first observed concentration below the 25th percentile (upper adjacent value and lower adjacent value, respectively). Values that lie outside of the adjacent values represent outside concentrations (i.e. concentrations at the upper and lower ends of the distribution of the data). The method detection limit was used as the reported value in order to construct the box plot when analytical results were reported as non-detects.

Two sets of side-by-side box plots were constructed for the BGS CCR Parameter data: 1) results by depth interval and 2) results by BGS boring location. These box plots were useful in identifying differences in CCR Parameter concentrations between depth intervals and between boring locations and were especially useful for visually identifying potential outliers. Box plots for CCR Parameters aggregated by depth interval and by boring location are provided in Attachment E.1-B.

2.1.3 Outlier Screening

Outliers are data points that are abnormally high or low as compared to the rest of the measurements and may represent anomalous data or data errors but may also represent natural variation of CCR Parameter concentrations in environmental systems. Screening for outliers is a critical step because outliers can bias statistical estimates, statistical testing results, and inferences. The size of the datasets for each depth interval (a minimum of 10 samples) were sufficiently large to capture natural variation commonly seen in environmental datasets.

Outlier values were initially screened visually using the side-by-side box plots. If suspected visual outliers were identified, then Tukey's procedure was used to identify extreme outliers (Tukey 1977). This method relies on the IQR, which is defined as the 75th percentile value minus the 25th percentile value.

Values were identified as potential outliers as follows:

- **Lower extreme outliers** are less than the 25th percentile minus 3 x IQR
- **Upper extreme outliers** are greater than the 75th percentile plus 3 x IQR.

Multiple potential outliers were identified using Tukey's procedure as indicated in the Summary Statistics Tables in Attachment E.1-A; these values were flagged as potential outliers in the dataset. However, given the heterogeneity of naturally occurring inorganic compounds in soils, statistical outliers were not removed from the datasets prior to statistical analysis, but may be reevaluated if BTVs are used to inform future corrective actions.

2.2 ESTIMATES OF BACKGROUND CONDITIONS

BTVs were calculated as conservative estimates of CCR Parameter concentrations in BGS. Specifically, 95% upper tolerance limits (UTLs) with 95% coverage were calculated for each parameter at each soil depth interval defined for the statistical datasets and with all depths combined to establish conservative estimates of background soil concentrations. The UTL represents the upper bound of a pre-specified proportion of the underlying data population with a specified level of confidence. For example, for a "95% UTL with 95% coverage", there is 95% confidence that, on average, 95% of the data are below the UTL. The upper one-sided UTL is commonly used in environmental monitoring and is constructed using background data (Ofungwu 2014). In the case of pH, 95% tolerance intervals with 95% coverage were calculated to bound the range of pH values. BTVs aggregated by soil depth interval and with all depths combined are presented in Attachment E.1-A.

2.2.1 Tests for Normality of Background Data

Prior to the calculation of UTLs, the data were evaluated for normality. Parametric methods to establish background conditions (UTLs) can be applied to data that are normally distributed or to data that fit another defined statistical distribution (e.g., gamma distribution), or to data that can be transformed to normal using mathematical transformations (e.g., lognormal transformation). Testing data for normality was done using formal statistical methods, known as goodness-of-fit-testing (e.g., Shapiro-Wilk or Lilliefors tests). If the data did not fit a defined statistical distribution or could not be transformed to normal, then non-parametric methods were used.

2.2.2 Parametric UTLs

Parametric UTLs were used when the background data were normally distributed, gamma distributed or transformed using the lognormal transformation. A background sample size or dataset consisting of at least eight observations was required to generate an adequate tolerance limit.

The calculation of the UTL is straightforward:

$$UTL = \overline{x} + \tau s$$

Where:

$\overline{x}$ = mean CCR parameter concentration in the background dataset

s = standard deviation of CCR parameter in the background dataset

τ = multiplier based on size of dataset, confidence (95%) and desired coverage (95%).

2.2.3 Non-parametric UTLs

When the background data do not fit the normal or gamma distribution or cannot be normalized via the lognormal transformation, non-parametric UTLs were used. The non-parametric UTL is an order statistic, typically the maximum or the second largest observed concentration in the background dataset. Unlike parametric methods, the desired coverage and confidence interval cannot be pre-specified for non-parametric tolerance limits. In the case of non-parametric methods, the level of confidence increases with increasing sample size. If non-parametric methods were used, the approximate level of confidence was reported.

UTLs, especially non-parametric UTLs, are sensitive to outliers and are biased high in the presence of outliers. For this initial analysis, no suspect outliers were removed from the data set. If the UTLs presented in this report are going to be used to inform corrective actions, then additional analysis to account for the presence of outliers is warranted.

3.0 RESULTS AND DISCUSSION

3.1 SUMMARY STATISTICS, EXPLORATORY DATA PLOTS, AND OUTLIER SCREENING

Summary statistics for each CCR Parameter are provided in Attachment E.1-A, with results aggregated by depth interval and with all depths combined. Summary statistics are sorted by CCR Parameter type (i.e., CCR Rule Appendix III Parameters, CCR Rule Appendix IV Parameters, TDEC Appendix I Parameters, and Other). Box plots for each CCR Parameter aggregated by depth and boring location are provided in Attachment E.1-B.

The number of values identified as potential outliers using Tukey's procedure for each depth interval and with all depths combined is identified in Attachment E.1-A. For these potential outliers, no definitive reasons were identified for the outlier values and the values identified were assumed to be representative of natural conditions and natural variation within native soil. These values were flagged as statistical outliers in the dataset and retained for subsequent calculations and analysis if needed for future evaluations (see columns labelled "Number of Statistical Outliers" and "Number of Outliers Removed" in Attachment E.1-A).

3.2 ESTIMATES OF BACKGROUND CONDITIONS

BTVs for the BGS investigation at the WBF Plant were calculated using UTLs (and Tolerance Intervals in the case of pH). The resulting BTV concentrations and the statistical distribution and methods used to calculate the UTLs are identified for each CCR Parameter aggregated by depth interval and with all depths combined in Attachment E.1-A.

4.0 REFERENCES

Ofungwu, J. (2014). Statistical Applications for Environmental Analysis and Risk Assessment. Hoboken, New Jersey: John Wiley and Sons, Inc.

StataCorp. (2017). Stata Graphics Reference Manual Stata: Release 15. Statistical Software. College Station, TX: StataCorp LLC.

Tukey, J.W. (1977). Exploratory data analysis. Reading, Massachusetts: Addison-Wesley, 1977.

ATTACHMENT E.1-A
SUMMARY STATISTICS TABLES

Summary Statistics - Background Soil Investigation
Watts Bar Fossil Plant - Spring City, Tennessee

Parameter	Soil Depth (ft bgs)	Frequency of Detection	Range of Reporting Limits	% Non Detect	Statistics using Detected Data Only		Statistics using Detects & Non-Detects							
					Minimum Detect	Maximum Detect	Mean	Standard Deviation	50th Percentile	95th Percentile	Number of Statistical Outliers	Number of Outliers Removed	Background Threshold Value	Statistical Distribution & Method
Percent Ash														
Ash	Surficial	7/10	(1.0 - 1.0)	30.0%	1.0	3.0	1.4	0.66	1.0	2.6	0	0	NA	NA
CCR Rule Appendix IV Parameters														
Boron	Surficial	10/10	--	0.0%	1.93	3.81	2.97	0.545	2.98	3.69	2	0	4.56	95% UTL (Normal) 95% Coverage
	0.5' to 10'	17/20	(1.46 - 1.78)	15.0%	1.75	55.9	5.51	11.7	2.59	11.7			55.9	95% UTL (NP-64.2%) 95% Coverage
	>10'	19/27	(1.71 - 1.88)	29.6%	1.62	3.17	2.14	0.493	1.97	2.88			3.25	95% UTL (Normal) 95% Coverage
	All Depth	46/57	(1.46 - 1.88)	19.3%	1.62	55.9	3.46	7.10	2.41	3.90			9.32	95% UTL (NP-78.5%) 95% Coverage
Calcium	Surficial	10/10	--	0.0%	997	33,900	5,680	10,200	1,730	22,900	5	0	68,600	95% (Lognormal) 95% Coverage
	0.5' to 10'	20/20	--	0.0%	31.8	14,700	2,650	4,540	1,030	14,200			34,700	95% (Lognormal) 95% Coverage
	>10'	27/27	--	0.0%	22.0	3,320	1,080	816	834	2,710			3,990	95% WH Approximate Gamma UTL 95% Coverage
	All Depth	57/57	--	0.0%	22.0	33,900	2,440	5,180	1,030	10,700			14,700	95% UTL (NP-78.5%) 95% Coverage
Chloride	Surficial	3/10	(4.43 - 4.86)	70.0%	5.02	5.81	4.72	0.478	4.68	5.61	5	0	5.81	95% UTL (NP-40.1%) 95% Coverage
	0.5' to 10'	7/20	(4.17 - 4.87)	65.0%	4.76	10.3	4.88	1.42	4.69	6.91			10.3	95% UTL (NP-64.2%) 95% Coverage
	>10'	10/27	(4.78 - 5.32)	63.0%	4.51	19.8	6.00	3.49	5.02	13.5			19.8	95% UTL (NP-75%) 95% Coverage
	All Depth	20/57	(4.17 - 5.32)	64.9%	4.51	19.8	5.25	2.67	4.87	10.3			14.8	95% UTL (NP-78.5%) 95% Coverage
Fluoride	Surficial	7/10	(0.777 - 0.799)	30.0%	0.905	4.01	1.72	0.962	1.74	3.23	7	0	4.52	95% UTL (Normal) 95% Coverage
	0.5' to 10'	7/20	(0.759 - 0.853)	65.0%	0.912	14.6	2.11	3.32	0.832	8.63			9.17	95% WH Approximate Gamma UTL 95% Coverage
	>10'	18/27	(0.768 - 0.914)	33.3%	1.04	15.4	3.20	4.11	1.17	12.0			15.4	95% UTL (NP-75%) 95% Coverage
	All Depth	32/57	(0.759 - 0.914)	43.9%	0.905	15.4	2.56	3.52	1.05	10.8			14.6	95% UTL (NP-78.5%) 95% Coverage
pH (lab)	Surficial	10/10	--	0.0%	6.0	7.8	6.5	0.640	6.3	7.7	0	0	(6.0-7.8)	95% Tolerance Interval (NP-40.1%) 95% Coverage
	0.5' to 10'	20/20	--	0.0%	4.9	8.4	6.2	0.930	5.9	8.2			(3.7-8.7)	95% Tolerance Interval (Gamma) 95% Coverage
	>10'	27/27	--	0.0%	4.9	8.3	6.4	0.940	6.2	8.0			(4.1-8.6)	95% Tolerance Interval (Normal) 95% Coverage
	All Depth	57/57	--	0.0%	4.9	8.4	6.3	0.880	6.2	8.1			(4.9-8.3)	95% Tolerance Interval (NP-78.5%) 95% Coverage
pH (field)	Surficial	10/10	--	0.0%	5.22	7.55	6.23	0.703	6.21	7.33	0	0	(3.94-8.52)	95% Tolerance Interval (Normal) 95% Coverage
	0.5' to 10'	20/20	--	0.0%	4.19	8.41	5.78	1.08	5.60	7.45			(3.00-8.56)	95% Tolerance Interval (Normal) 95% Coverage
	>10'	27/27	--	0.0%	4.34	7.68	6.05	0.959	5.91	7.57			(3.75-8.36)	95% Tolerance Interval (Normal) 95% Coverage
	All Depth	57/57	--	0.0%	4.19	8.41	5.99	0.964	5.90	7.57			(3.95-8.03)	95% Tolerance Interval (Normal) 95% Coverage
Sulfate	Surficial	7/10	(7.98 - 8.51)	30.0%	10.1	16.8	11.2	2.92	10.8	16.0	1	0	19.7	95% UTL (Normal) 95% Coverage
	0.5' to 10'	18/20	(7.58 - 7.82)	10.0%	9.19	269	51.1	61.6	25.1	137			228	95% WH Approximate Gamma UTL 95% Coverage
	>10'	22/27	(8.44 - 8.82)	18.5%	9.97	138	37.4	34.4	21.6	96.9			184	95% UTL (NP-62.3%) 95% Coverage
	All Depth	47/57	(7.58 - 8.82)	17.5%	9.19	269	37.5	45.7	20.9	128			138	95% KM UTL (Lognormal) 95% Coverage
CCR Rule Appendix IV Parameters														
Antimony	Surficial	10/10	--	0.0%	0.108	0.198	0.153	0.0321	0.157	0.193	1	0	0.246	95% UTL (Normal) 95% Coverage
	0.5' to 10'	15/20	(0.0694 - 0.0779)	25.0%	0.0712	8.89	0.541	1.92	0.0947	0.602			8.89	95% UTL (NP-64.2%) 95% Coverage
	>10'	19/27	(0.07 - 0.0826)	29.6%	0.0875	0.229	0.105	0.0366	0.0969	0.171			0.194	95% WH Approximate Gamma UTL 95% Coverage
	All Depth	44/57	(0.0694 - 0.0826)	22.8%	0.0712	8.89	0.267	1.15	0.108	0.189			0.229	95% UTL (NP-78.5%) 95% Coverage
Arsenic	Surficial	10/10	--	0.0%	2.53	5.63	4.00	1.02	3.88	5.53	2	0	6.96	95% UTL (Normal) 95% Coverage
	0.5' to 10'	20/20	--	0.0%	2.06	12.7	4.16	2.21	3.86	6.19			9.52	95% (Lognormal) 95% Coverage
	>10'	27/27	--	0.0%	1.27	9.18	4.00	1.60	3.60	6.58			7.61	95% UTL (Normal) 95% Coverage
	All Depth	57/57	--	0.0%	1.27	12.7	4.05	1.74	3.79	6.22			7.91	95% (Lognormal) 95% Coverage
Barium	Surficial	10/10	--	0.0%	50.4	194	119	49.4	126	181	2	0	263	95% UTL (Normal) 95% Coverage
	0.5' to 10'	20/20	--	0.0%	34.9	755	174	164	120	375			640	95% WH Approximate Gamma UTL 95% Coverage
	>10'	27/27	--	0.0%	39.2	381	137	73.4	116	266			328	95% WH Approximate Gamma UTL 95% Coverage
	All Depth	57/57	--	0.0%	34.9	755	147	112	119	309			411	95% (Lognormal) 95% Coverage
Beryllium	Surficial	10/10	--	0.0%	0.345	1.48	1.06	0.392	1.27	1.42	1	0	2.20	95% UTL (Normal) 95% Coverage
	0.5' to 10'	20/20	--	0.0%	0.220	4.50	1.26	0.868	1.20	2.03			4.50	95% UTL (NP-64.2%) 95% Coverage
	>10'	27/27	--	0.0%	0.562	2.27	1.25	0.433	1.18	2.11			2.23	95% UTL (Normal) 95% Coverage
	All Depth	57/57	--	0.0%	0.220	4.50	1.22	0.611	1.20	2.03			2.27	95% UTL (NP-78.5%) 95% Coverage
Cadmium	Surficial	10/10	--	0.0%	0.0353	0.362	0.167	0.114	0.132	0.327	1	0	0.499	95% UTL (Normal) 95% Coverage
	0.5' to 10'	15/20	(0.0184 - 0.0224)	25.0%	0.0305	3.29	0.234	0.704	0.0500	0.390			1.16	95% KM UTL (Lognormal) 95% Coverage
	>10'	24/27	(0.0192 - 0.0236)	11.1%	0.0214	0.346	0.112	0.0808	0.0933	0.234			0.295	95% UTL (Normal) 95% Coverage
	All Depth	49/57	(0.0184 - 0.0236)	14.0%	0.0214	3.29	0.165	0.427	0.0811	0.296			0.633	95% KM UTL (Lognormal) 95% Coverage

Summary Statistics - Background Soil Investigation
Watts Bar Fossil Plant - Spring City, Tennessee

Parameter	Soil Depth (ft bgs)	Frequency of Detection	Range of Reporting Limits	% Non Detect	Statistics using Detected Data Only		Statistics using Detects & Non-Detects							
					Minimum Detect	Maximum Detect	Mean	Standard Deviation	50th Percentile	95th Percentile	Number of Statistical Outliers	Number of Outliers Removed	Background Threshold Value	Statistical Distribution & Method
Chromium	Surficial	10/10	--	0.0%	10.2	18.9	16.1	2.63	16.9	18.7	3	0	23.8	95% UTL (Normal) 95% Coverage
	0.5' to 10'	20/20	--	0.0%	9.96	43.1	21.3	8.46	20.0	41.1			44.8	95% WH Approximate Gamma UTL 95% Coverage
	>10'	27/27	--	0.0%	14.1	43.7	21.0	5.88	19.6	30.6			43.7	95% UTL (NP-75%) 95% Coverage
	All Depth	57/57	--	0.0%	9.96	43.7	20.3	6.72	18.9	33.3			43.1	95% UTL (NP-78.5%) 95% Coverage
Cobalt	Surficial	10/10	--	0.0%	3.76	13.2	9.20	2.78	9.84	12.4	2	0	17.3	95% UTL (Normal) 95% Coverage
	0.5' to 10'	20/20	--	0.0%	1.38	39.1	12.5	8.56	11.8	28.8			40.1	95% WH Approximate Gamma UTL 95% Coverage
	>10'	27/27	--	0.0%	3.72	19.8	11.1	3.64	10.8	16.2			19.3	95% UTL (Normal) 95% Coverage
	All Depth	57/57	--	0.0%	1.38	39.1	11.3	5.80	10.8	19.8			28.2	95% UTL (NP-78.5%) 95% Coverage
Fluoride	Surficial	7/10	(0.777 - 0.799)	30.0%	0.905	4.01	1.72	0.962	1.74	3.23	7	0	4.52	95% UTL (Normal) 95% Coverage
	0.5' to 10'	7/20	(0.759 - 0.853)	65.0%	0.912	14.6	2.11	3.32	0.832	8.63			9.17	95% WH Approximate Gamma UTL 95% Coverage
	>10'	18/27	(0.768 - 0.914)	33.3%	1.04	15.4	3.20	4.11	1.17	12.0			15.4	95% UTL (NP-75%) 95% Coverage
	All Depth	32/57	(0.759 - 0.914)	43.9%	0.905	15.4	2.56	3.52	1.050	10.8			14.6	95% UTL (NP-78.5%) 95% Coverage
Lead	Surficial	10/10	--	0.0%	9.35	22.3	15.7	3.79	15.5	21.2	0	0	26.7	95% UTL (Normal) 95% Coverage
	0.5' to 10'	20/20	--	0.0%	3.79	28.1	13.4	5.39	13.5	20.2			26.3	95% UTL (Normal) 95% Coverage
	>10'	27/27	--	0.0%	3.43	19.0	12.4	3.77	12.8	16.9			20.9	95% UTL (Normal) 95% Coverage
	All Depth	57/57	--	0.0%	3.43	28.1	13.3	4.49	13.6	19.8			22.5	95% UTL (Normal) 95% Coverage
Lithium	Surficial	10/10	--	0.0%	4.99	20.2	12.5	4.30	13.1	18.3	0	0	25.1	95% UTL (Normal) 95% Coverage
	0.5' to 10'	20/20	--	0.0%	6.03	27.9	17.2	6.39	17.2	25.9			32.5	95% UTL (Normal) 95% Coverage
	>10'	27/27	--	0.0%	2.89	27.7	16.6	5.99	16.8	26.2			30.1	95% UTL (Normal) 95% Coverage
	All Depth	57/57	--	0.0%	2.89	27.9	16.1	6.03	15.9	26.0			28.3	95% UTL (Normal) 95% Coverage
Mercury	Surficial	10/10	--	0.0%	0.0215	0.0766	0.0381	0.0157	0.0332	0.0649	1	0	0.0837	95% UTL (Normal) 95% Coverage
	0.5' to 10'	16/20	(0.0146 - 0.0163)	20.0%	0.0214	0.0799	0.0336	0.0167	0.0307	0.0681			0.0827	95% WH Approximate Gamma UTL 95% Coverage
	>10'	23/27	(0.0142 - 0.0197)	14.8%	0.0207	0.302	0.0404	0.0526	0.0320	0.0548			0.302	95% UTL (NP-75%) 95% Coverage
	All Depth	49/57	(0.0142 - 0.0197)	14.0%	0.0207	0.302	0.0376	0.0382	0.0320	0.0693			0.0799	95% UTL (NP-78.5%) 95% Coverage
Molybdenum	Surficial	10/10	--	0.0%	0.494	1.09	0.704	0.160	0.687	0.955	1	0	1.17	95% UTL (Normal) 95% Coverage
	0.5' to 10'	18/20	(0.182 - 0.187)	10.0%	0.287	4.41	0.780	0.871	0.544	1.16			3.03	95% KM UTL (Lognormal) 95% Coverage
	>10'	26/27	(0.184 - 0.184)	3.7%	0.351	1.25	0.660	0.206	0.634	0.949			1.13	95% UTL (Normal) 95% Coverage
	All Depth	54/57	(0.182 - 0.187)	5.3%	0.287	4.41	0.710	0.542	0.659	1.01			1.67	95% KM UTL (Lognormal) 95% Coverage
Radium-226+228	Surficial	10/10	--	0.0%	2.05	4.27	2.78	0.645	2.70	3.78	0	0	4.66	95% UTL (Normal) 95% Coverage
	0.5' to 10'	20/20	--	0.0%	1.68	4.29	3.07	0.602	3.08	4.20			4.51	95% UTL (Normal) 95% Coverage
	>10'	27/27	--	0.0%	1.41	4.62	2.98	0.692	2.93	3.94			4.54	95% UTL (Normal) 95% Coverage
	All Depth	57/57	--	0.0%	1.41	4.62	2.98	0.649	2.96	4.21			4.29	95% UTL (Normal) 95% Coverage
Selenium	Surficial	10/10	--	0.0%	0.405	1.30	0.812	0.319	0.678	1.29	1	0	1.74	95% UTL (Normal) 95% Coverage
	0.5' to 10'	20/20	--	0.0%	0.195	6.58	0.971	1.35	0.641	1.77			3.57	95% (Lognormal) 95% Coverage
	>10'	26/27	(0.138 - 0.138)	3.7%	0.219	0.972	0.587	0.232	0.563	0.936			1.11	95% UTL (Normal) 95% Coverage
	All Depth	56/57	(0.138 - 0.138)	1.8%	0.195	6.58	0.761	0.825	0.641	1.28			1.93	95% KM UTL (Lognormal) 95% Coverage
Thallium	Surficial	10/10	--	0.0%	0.139	0.527	0.295	0.112	0.267	0.490	1	0	0.622	95% UTL (Normal) 95% Coverage
	0.5' to 10'	20/20	--	0.0%	0.120	6.91	0.614	1.49	0.250	0.852			6.91	95% UTL (NP-64.2%) 95% Coverage
	>10'	24/27	(0.321 - 0.355)	11.1%	0.0892	0.439	0.272	0.0769	0.298	0.370			0.446	95% UTL (Normal) 95% Coverage
	All Depth	54/57	(0.321 - 0.355)	5.3%	0.0892	6.91	0.396	0.876	0.275	0.513			0.533	95% UTL (NP-78.5%) 95% Coverage

Summary Statistics - Background Soil Investigation
Watts Bar Fossil Plant - Spring City, Tennessee

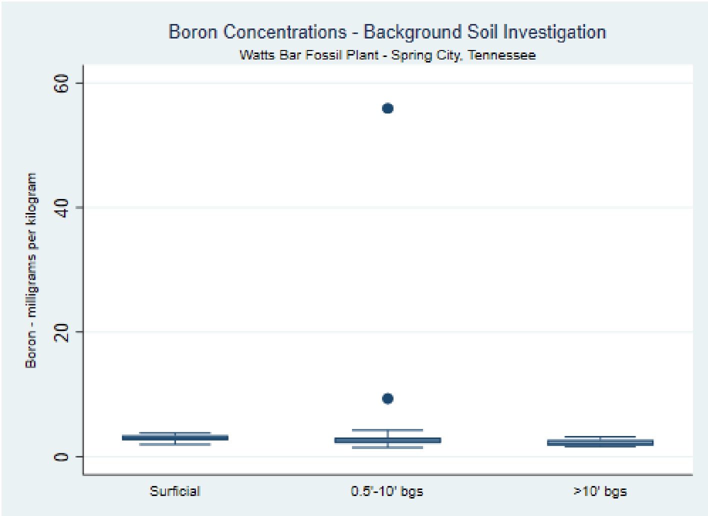
Parameter	Soil Depth (ft bgs)	Frequency of Detection	Range of Reporting Limits	% Non Detect	Statistics using Detected Data Only		Statistics using Detects & Non-Detects							
					Minimum Detect	Maximum Detect	Mean	Standard Deviation	50th Percentile	95th Percentile	Number of Statistical Outliers	Number of Outliers Removed	Background Threshold Value	Statistical Distribution & Method
TDEC Appendix I Parameters														
Copper	Surficial	10/10	--	0.0%	4.17	23.2	12.0	5.16	11.4	20.1	0	0	27.0	95% UTL (Normal) 95% Coverage
	0.5' to 10'	20/20	--	0.0%	2.45	27.6	14.3	6.23	14.9	23.6			29.2	95% UTL (Normal) 95% Coverage
	>10'	27/27	--	0.0%	4.66	27.0	14.9	4.36	14.5	21.4			24.7	95% UTL (Normal) 95% Coverage
	All Depth	57/57	--	0.0%	2.45	27.6	14.2	5.23	14.3	23.2			24.8	95% UTL (Normal) 95% Coverage
Nickel	Surficial	10/10	--	0.0%	4.41	17.3	12.3	3.89	13.4	16.3	3	0	23.7	95% UTL (Normal) 95% Coverage
	0.5' to 10'	20/20	--	0.0%	2.95	49.4	17.5	11.5	15.4	42.8			54.5	95% WH Approximate Gamma UTL 95% Coverage
	>10'	27/27	--	0.0%	5.44	49.8	17.7	8.12	17.5	26.4			38.1	95% WH Approximate Gamma UTL 95% Coverage
	All Depth	57/57	--	0.0%	2.95	49.8	16.7	9.05	15.1	30.5			49.4	95% UTL (NP-78.5%) 95% Coverage
Silver	Surficial	5/10	(0.0316 - 0.0354)	50.0%	0.0345	0.0552	0.0368	0.00725	0.0350	0.0495	5	0	0.0579	95% UTL (Normal) 95% Coverage
	0.5' to 10'	5/20	(0.0292 - 0.0356)	75.0%	0.0307	8.68	0.466	1.88	0.0323	0.503			8.68	95% UTL (NP-64.2%) 95% Coverage
	>10'	6/27	(0.0305 - 0.0375)	77.8%	0.0373	0.0996	0.0351	0.0134	0.0352	0.0461			0.0996	95% UTL (NP-75%) 95% Coverage
	All Depth	16/57	(0.0292 - 0.0375)	71.9%	0.0307	8.68	0.186	1.14	0.0342	0.0586			0.0996	95% UTL (NP-78.5%) 95% Coverage
Vanadium	Surficial	10/10	--	0.0%	14.7	27.4	22.4	3.70	23.6	26.6	0	0	33.2	95% UTL (Normal) 95% Coverage
	0.5' to 10'	20/20	--	0.0%	16.4	42.2	26.2	6.77	25.7	35.8			42.4	95% UTL (Normal) 95% Coverage
	>10'	27/27	--	0.0%	16.6	43.7	26.9	6.52	25.5	37.8			41.6	95% UTL (Normal) 95% Coverage
	All Depth	57/57	--	0.0%	14.7	43.7	25.9	6.34	24.6	37.5			39.9	95% WH Approximate Gamma UTL 95% Coverage
Zinc	Surficial	10/10	--	0.0%	22.5	74.8	50.8	17.2	56.2	73.3	1	0	101	95% UTL (Normal) 95% Coverage
	0.5' to 10'	20/20	--	0.0%	7.80	73.2	50.0	18.6	55.4	72.4			94.6	95% UTL (Normal) 95% Coverage
	>10'	27/27	--	0.0%	18.0	127	54.9	20.1	53.2	73.3			100	95% UTL (Normal) 95% Coverage
	All Depth	57/57	--	0.0%	7.80	127	52.5	18.9	55.0	73.3			90.8	95% UTL (Normal) 95% Coverage

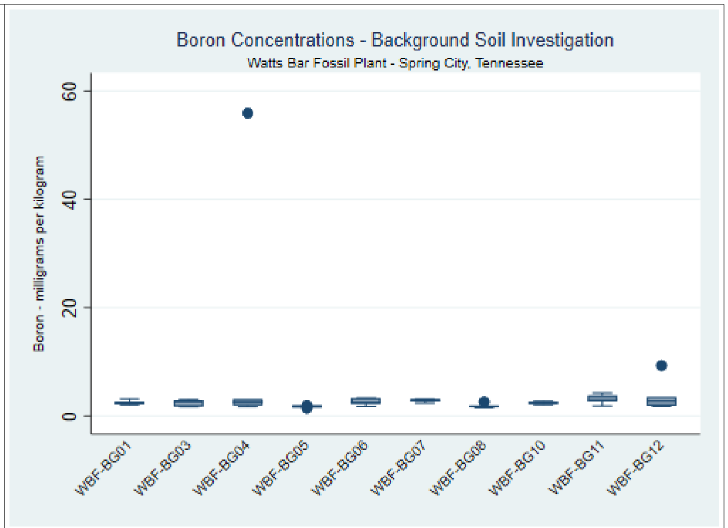
Notes:
CCR Rule - Title 40, Code of Federal Regulations, Part 257
ft bgs - feet below ground surface
KM - Kaplan-Meier, For Parameters with non-detects reported at the method detection limit, the mean, standard deviation, and background threshold values were calculated using Kaplan-Meier methods
'--' / NA - Not Applicable
NP-% - Non-parametric method and associated confidence level of the estimate
TDEC - Tennessee Department of Environment and Conservation
UTL - Upper Tolerance Limit
WH - Background Threshold Limits based on the gamma distribution utilize Wilson Hiferty (WH) estimates
% - Percent

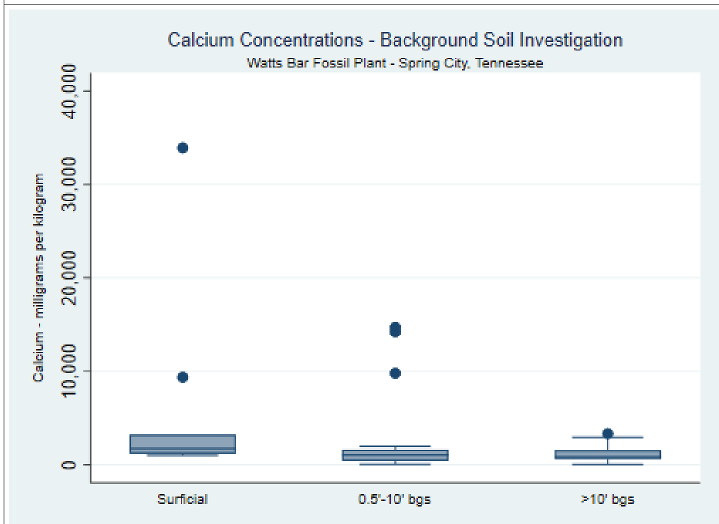
Except for Ash, pH & Radium 226 + 228, all units milligrams per kilogram (mg/kg)
Units for Ash are percent (%)
Units for pH are Standard Units (S.U.)
Units for Radium 226+228 are picocuries per gram (pCi/g)
All non-detects reported at the laboratory reporting limit
Surficial soil samples were collected in 0 to 0.5 feet below ground surface (bgs) soil depth interval

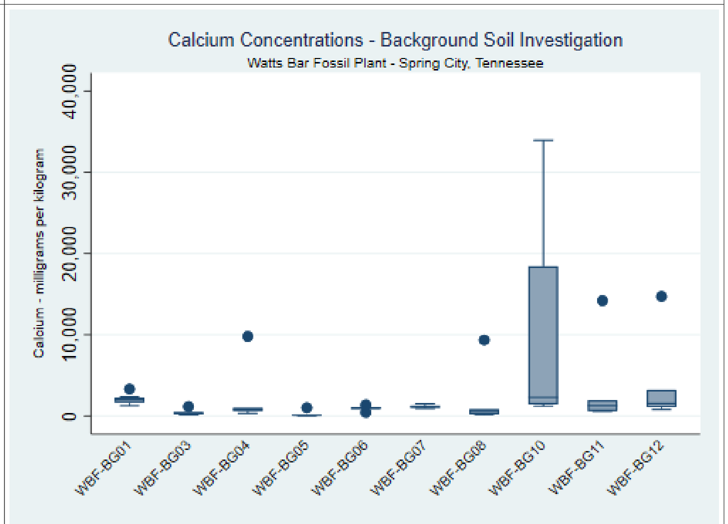
ATTACHMENT E.1-B
BOX PLOTS

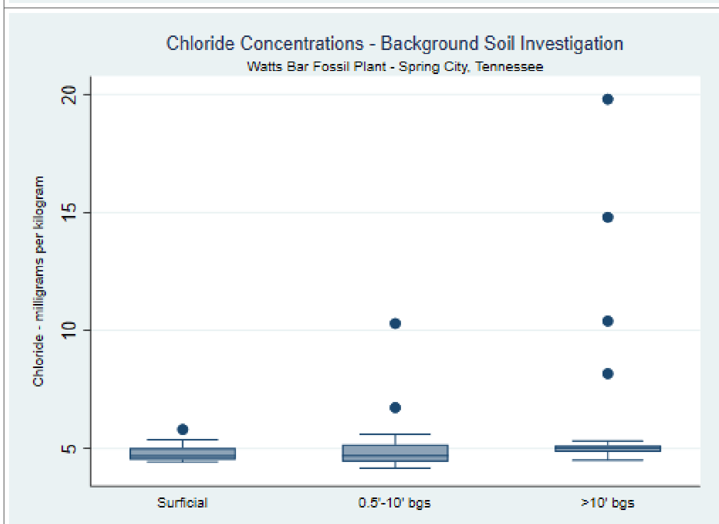
Box Plots
CCR Rule Appendix III Parameters
Background Soil Investigation
Watts Bar Fossil Plant - Spring City, Tennessee

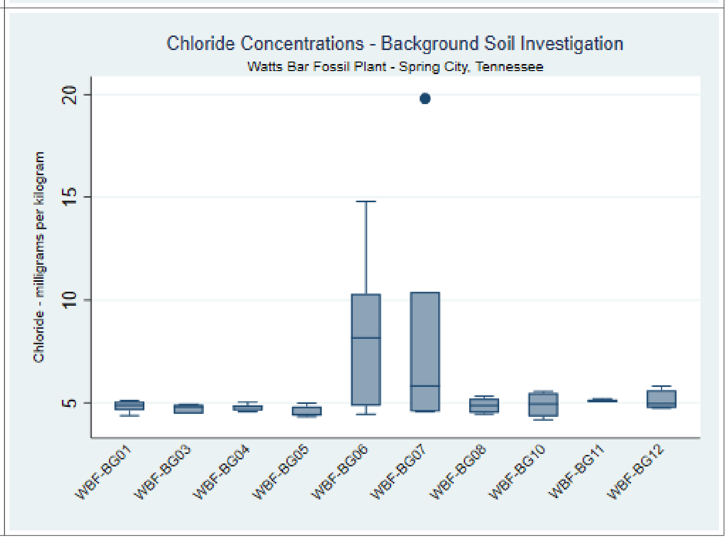


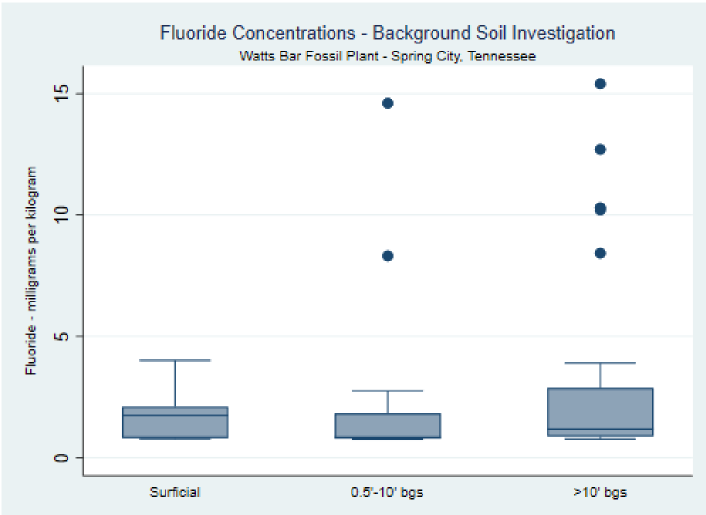


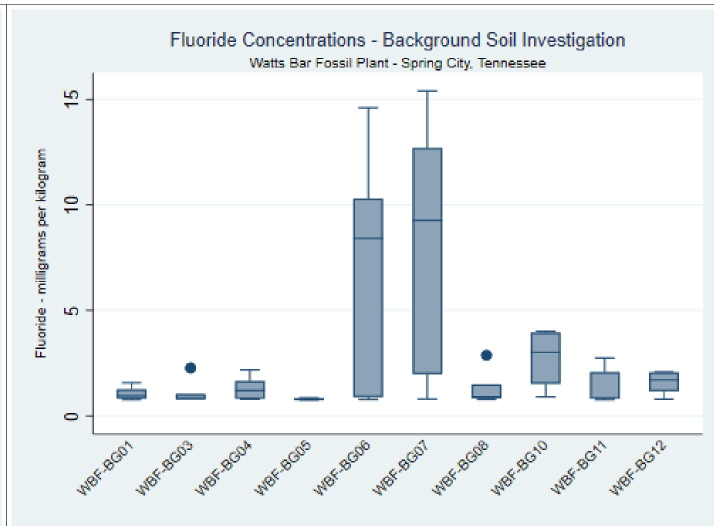


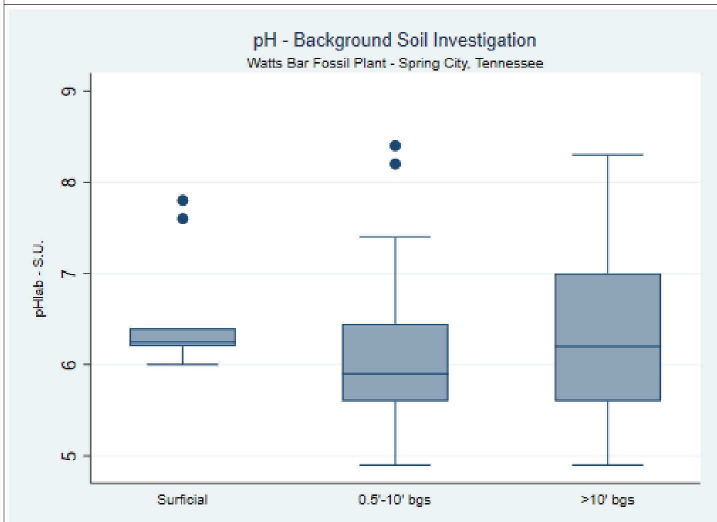


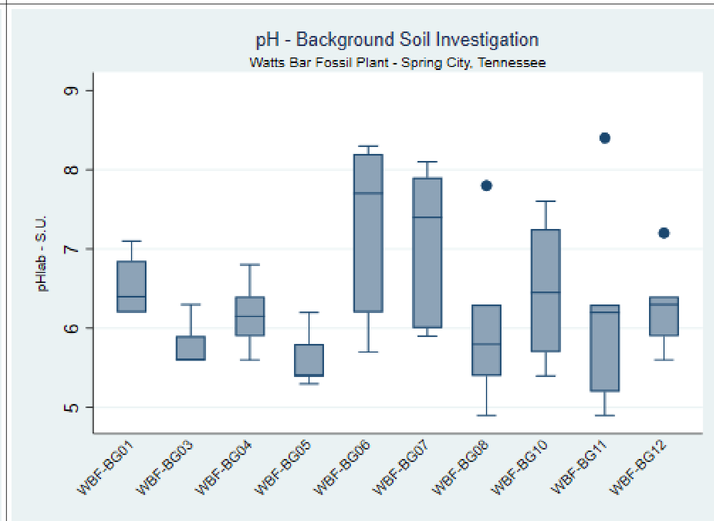


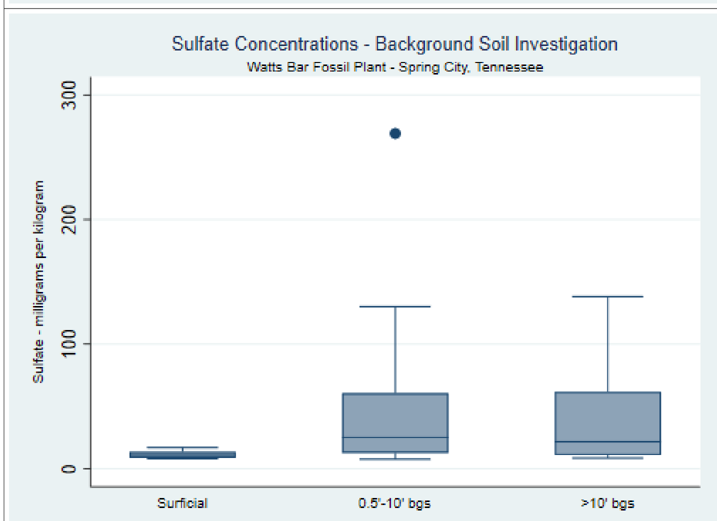


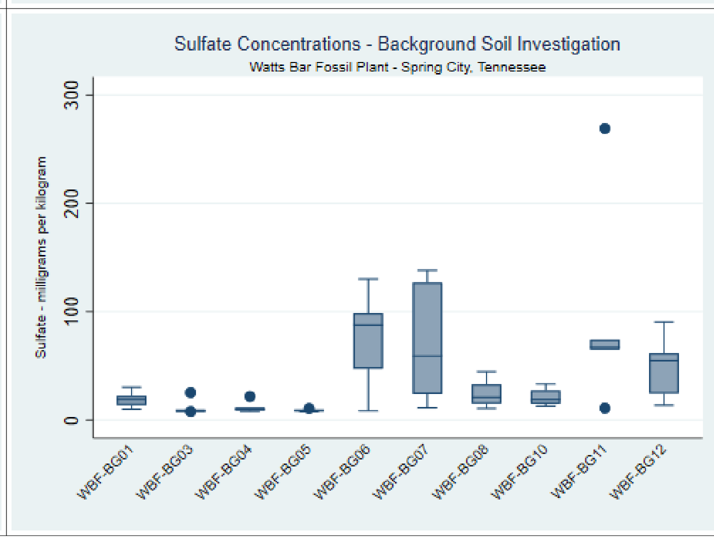

Fluoride Concentrations - Background Soil Investigation
Watts Bar Fossil Plant - Spring City, Tennessee
Fluoride - milligrams per kilogram
0
5
10
15
Surficial
0.5'-10' bgs
>10' bgs


Fluoride Concentrations - Background Soil Investigation
Watts Bar Fossil Plant - Spring City, Tennessee
Fluoride - milligrams per kilogram
0
5
10
15
WBF-BG01
WBF-BG03
WBF-BG04
WBF-BG05
WBF-BG06
WBF-BG07
WBF-BG08
WBF-BG10
WBF-BG11
WBF-BG12

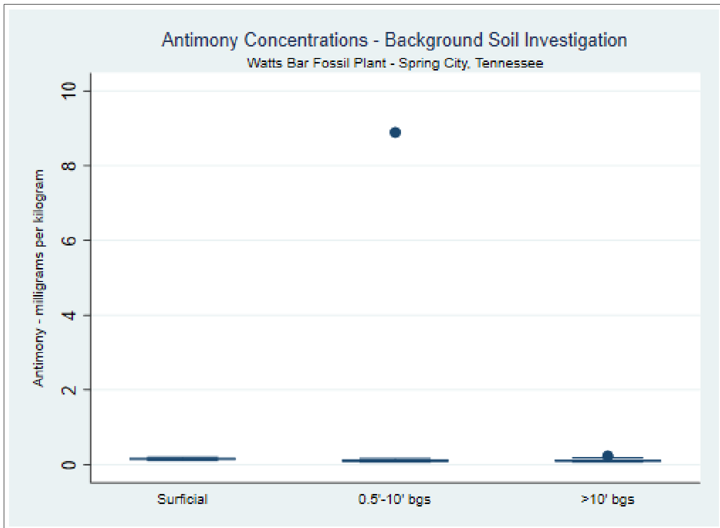

pH - Background Soil Investigation
Watts Bar Fossil Plant - Spring City, Tennessee
pHlab - S.U.
5
6
7
8
9
Surficial
0.5'-10' bgs
>10' bgs

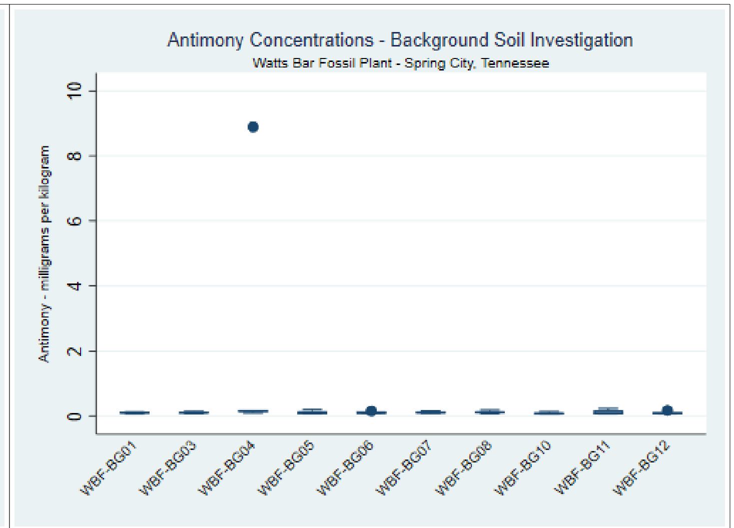

pH - Background Soil Investigation
Watts Bar Fossil Plant - Spring City, Tennessee
pHlab - S.U.
5
6
7
8
9
WBF-BG01
WBF-BG03
WBF-BG04
WBF-BG05
WBF-BG06
WBF-BG07
WBF-BG08
WBF-BG10
WBF-BG11
WBF-BG12

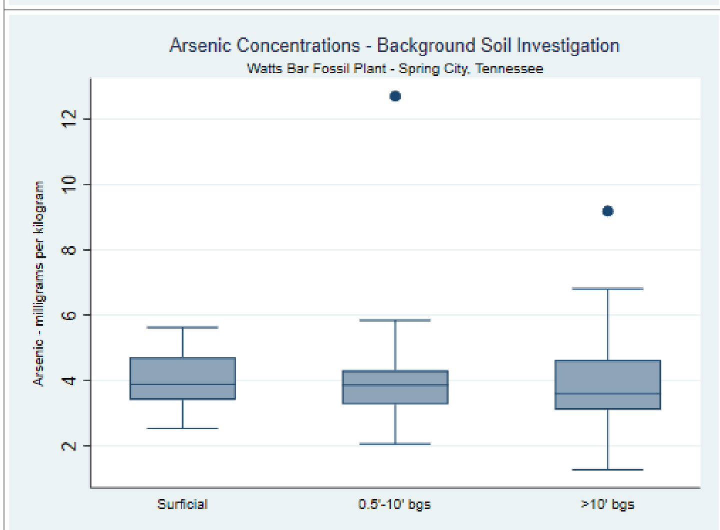

Sulfate Concentrations - Background Soil Investigation
Watts Bar Fossil Plant - Spring City, Tennessee
Sulfate - milligrams per kilogram
0
100
200
300
Surficial
0.5'-10' bgs
>10' bgs

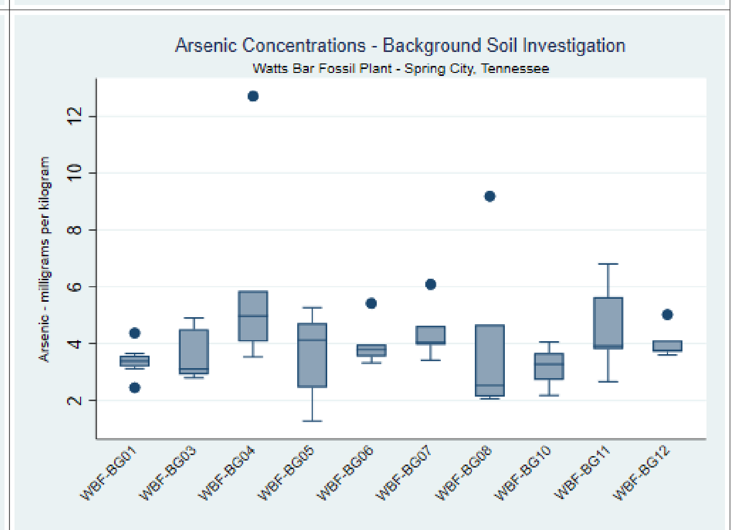

Sulfate Concentrations - Background Soil Investigation
Watts Bar Fossil Plant - Spring City, Tennessee
Sulfate - milligrams per kilogram
0
100
200
300
WBF-BG01
WBF-BG03
WBF-BG04
WBF-BG05
WBF-BG06
WBF-BG07
WBF-BG08
WBF-BG10
WBF-BG11
WBF-BG12

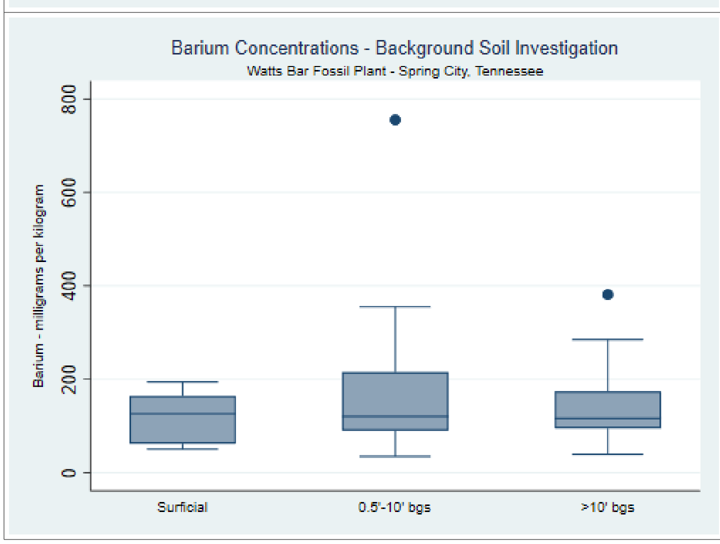
Box Plots - CCR Rule Appendix IV Parameters
CCR Rule Appendix IV Parameters
Background Soil Investigation
Watts Bar Fossil Plant - Spring City, Tennessee

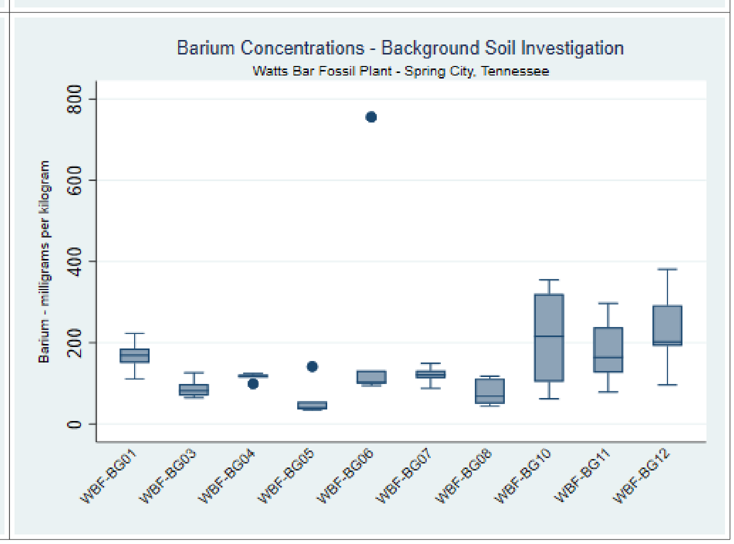


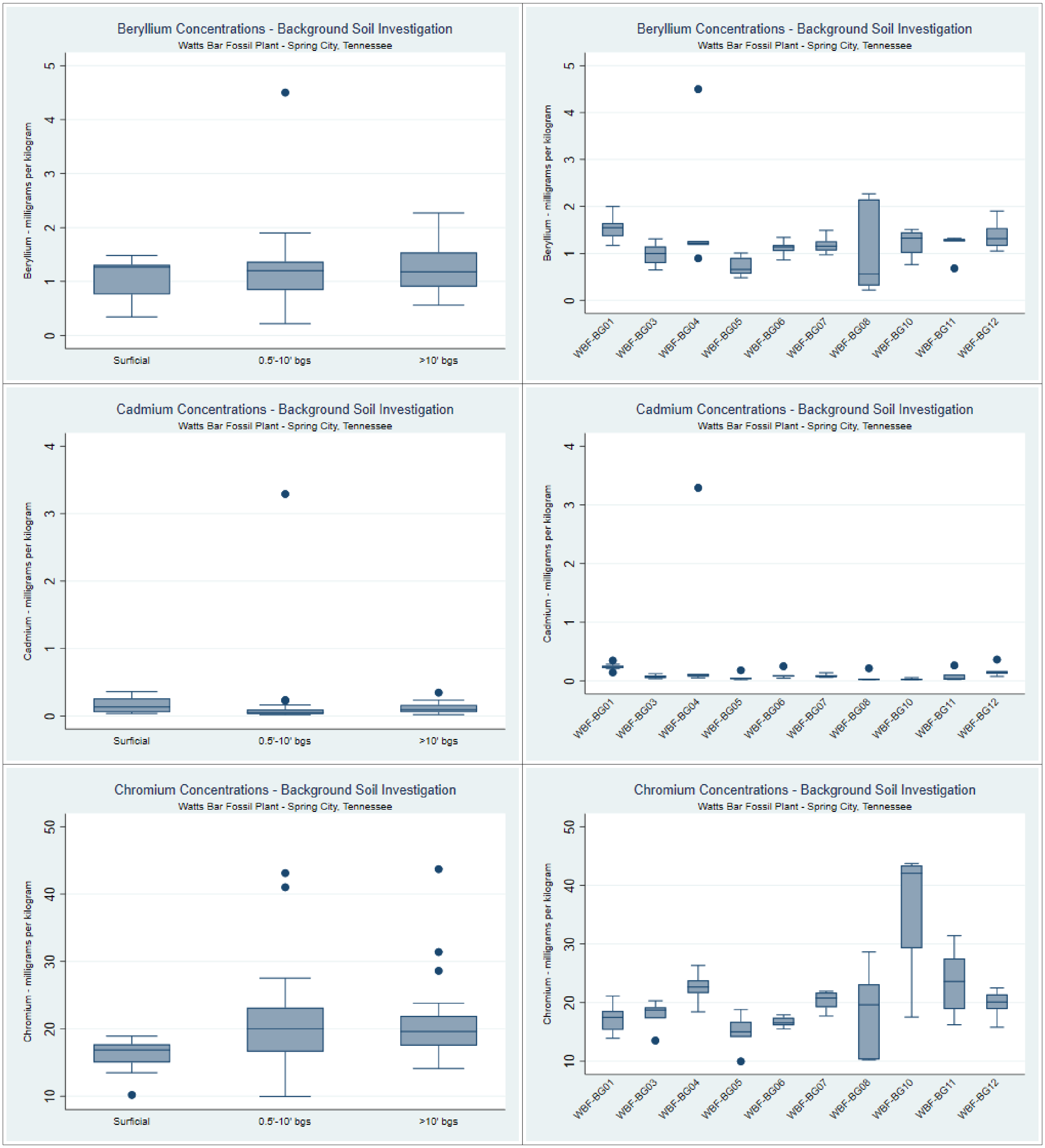


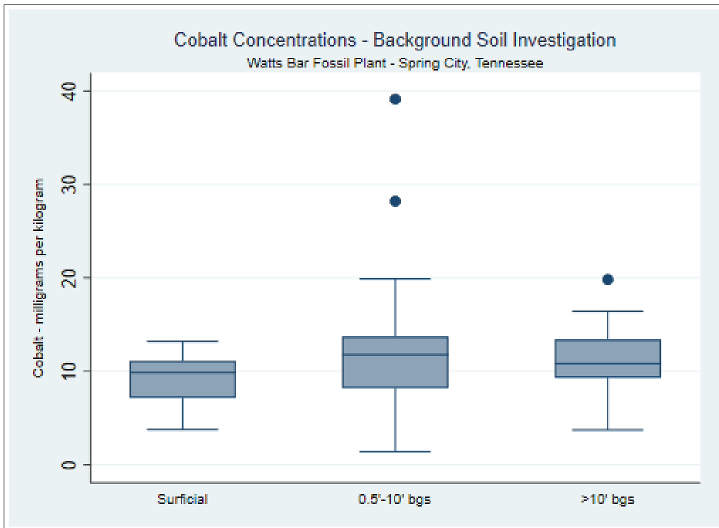


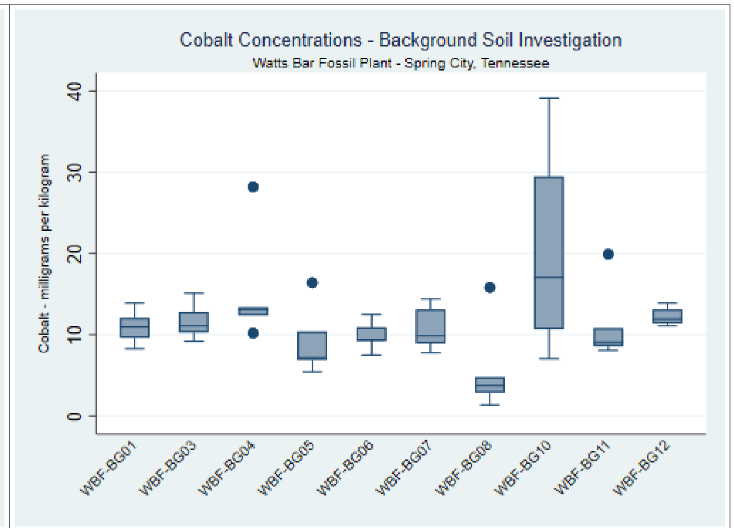


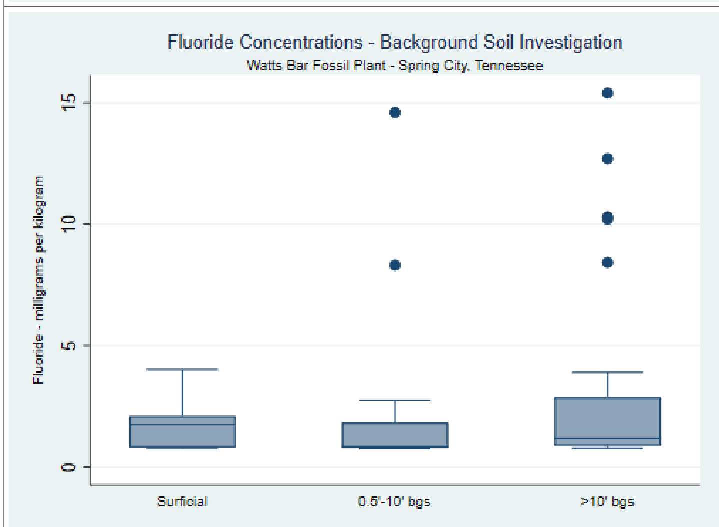


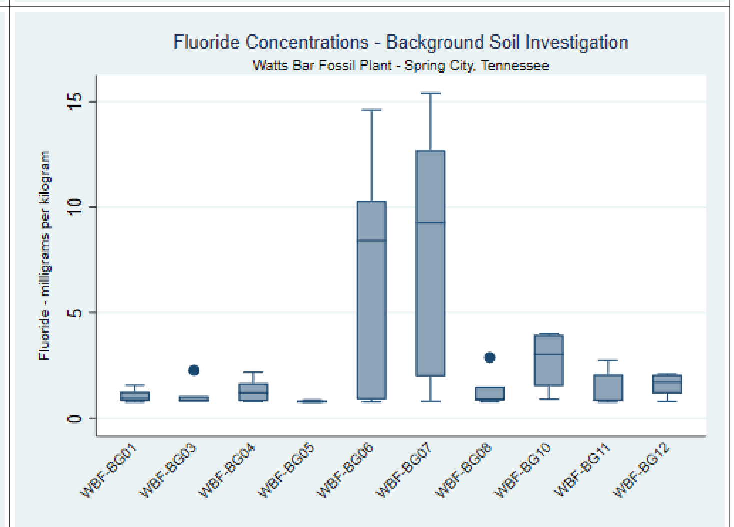


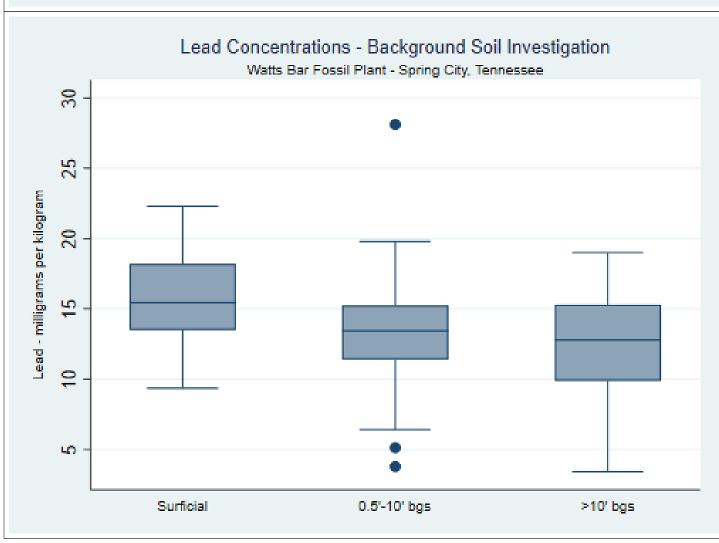

Beryllium Concentrations - Background Soil Investigation
Watts Bar Fossil Plant - Spring City, Tennessee
Beryllium - milligrams per kilogram
Surficial
0.5'-10' bgs
>10' bgs
Beryllium Concentrations - Background Soil Investigation
Watts Bar Fossil Plant - Spring City, Tennessee
Beryllium - milligrams per kilogram
WBF-BG01
WBF-BG03
WBF-BG04
WBF-BG05
WBF-BG06
WBF-BG07
WBF-BG08
WBF-BG10
WBF-BG11
WBF-BG12
Cadmium Concentrations - Background Soil Investigation
Watts Bar Fossil Plant - Spring City, Tennessee
Cadmium - milligrams per kilogram
Surficial
0.5'-10' bgs
>10' bgs
Cadmium Concentrations - Background Soil Investigation
Watts Bar Fossil Plant - Spring City, Tennessee
Cadmium - milligrams per kilogram
WBF-BG01
WBF-BG03
WBF-BG04
WBF-BG05
WBF-BG06
WBF-BG07
WBF-BG08
WBF-BG10
WBF-BG11
WBF-BG12
Chromium Concentrations - Background Soil Investigation
Watts Bar Fossil Plant - Spring City, Tennessee
Chromium - milligrams per kilogram
Surficial
0.5'-10' bgs
>10' bgs
Chromium Concentrations - Background Soil Investigation
Watts Bar Fossil Plant - Spring City, Tennessee
Chromium - milligrams per kilogram
WBF-BG01
WBF-BG03
WBF-BG04
WBF-BG05
WBF-BG06
WBF-BG07
WBF-BG08
WBF-BG10
WBF-BG11
WBF-BG12

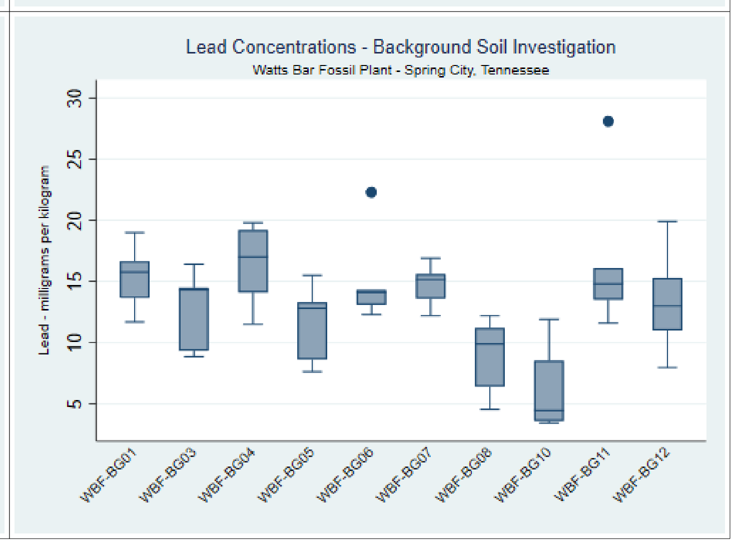

Cobalt Concentrations - Background Soil Investigation
Watts Bar Fossil Plant - Spring City, Tennessee
Cobalt - milligrams per kilogram
0
10
20
30
40
Surficial
0.5'-10' bgs
>10' bgs

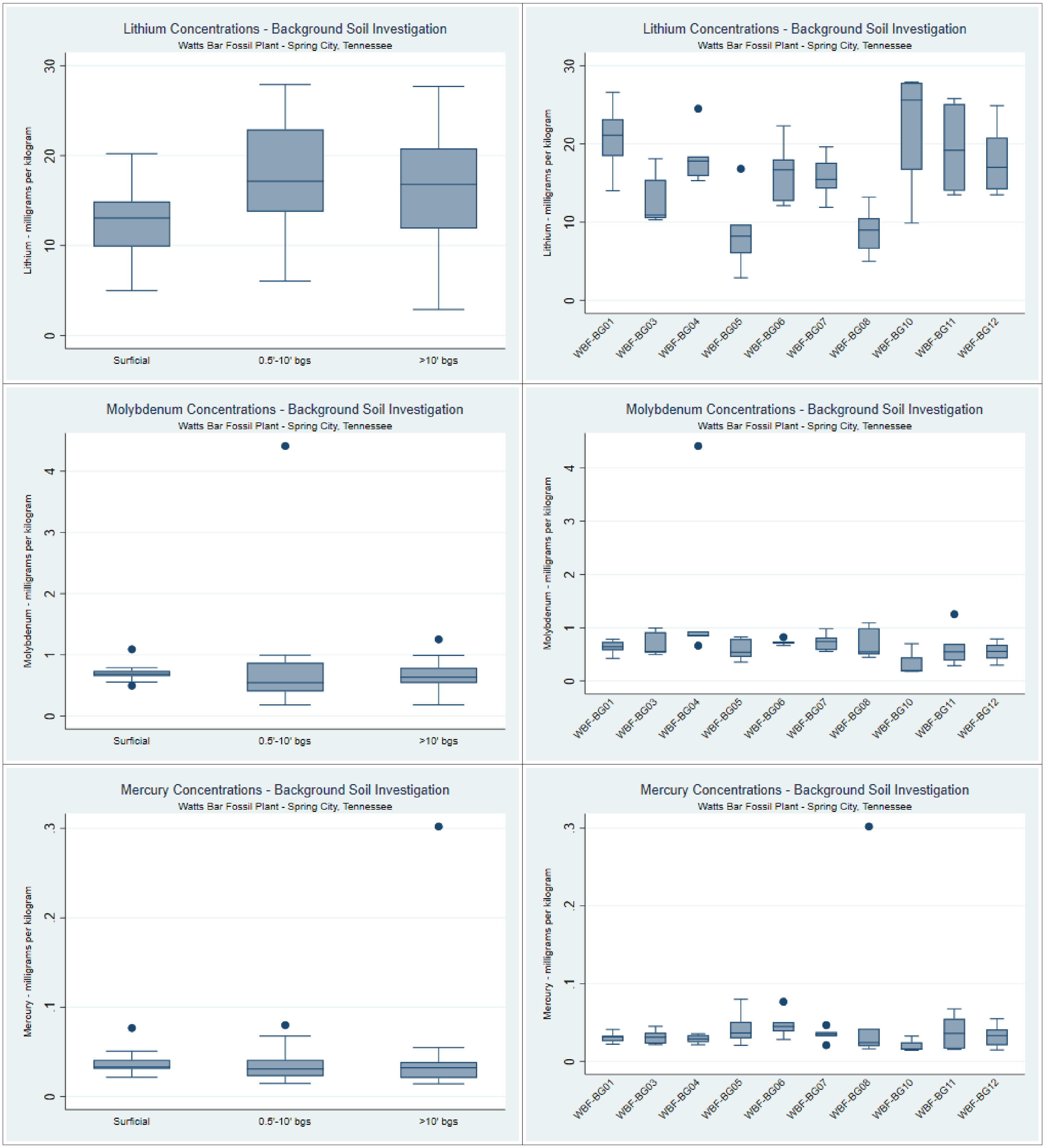

Cobalt Concentrations - Background Soil Investigation
Watts Bar Fossil Plant - Spring City, Tennessee
Cobalt - milligrams per kilogram
0
10
20
30
40
WBF-BG01
WBF-BG03
WBF-BG04
WBF-BG05
WBF-BG06
WBF-BG07
WBF-BG08
WBF-BG10
WBF-BG11
WBF-BG12


Fluoride Concentrations - Background Soil Investigation
Watts Bar Fossil Plant - Spring City, Tennessee
Fluoride - milligrams per kilogram
0
5
10
15
Surficial
0.5'-10' bgs
>10' bgs


Fluoride Concentrations - Background Soil Investigation
Watts Bar Fossil Plant - Spring City, Tennessee
Fluoride - milligrams per kilogram
0
5
10
15
WBF-BG01
WBF-BG03
WBF-BG04
WBF-BG05
WBF-BG06
WBF-BG07
WBF-BG08
WBF-BG10
WBF-BG11
WBF-BG12


Lead Concentrations - Background Soil Investigation
Watts Bar Fossil Plant - Spring City, Tennessee
Lead - milligrams per kilogram
5
10
15
20
25
30
Surficial
0.5'-10' bgs
>10' bgs


Lead Concentrations - Background Soil Investigation
Watts Bar Fossil Plant - Spring City, Tennessee
Lead - milligrams per kilogram
5
10
15
20
25
30
WBF-BG01
WBF-BG03
WBF-BG04
WBF-BG05
WBF-BG06
WBF-BG07
WBF-BG08
WBF-BG10
WBF-BG11
WBF-BG12


Lithium Concentrations - Background Soil Investigation
Watts Bar Fossil Plant - Spring City, Tennessee
Lithium - milligrams per kilogram
0
10
20
30
Surficial
0.5'-10' bgs
>10' bgs
Lithium Concentrations - Background Soil Investigation
Watts Bar Fossil Plant - Spring City, Tennessee
Lithium - milligrams per kilogram
0
10
20
30
WBF-BG01
WBF-BG03
WBF-BG04
WBF-BG05
WBF-BG06
WBF-BG07
WBF-BG08
WBF-BG10
WBF-BG11
WBF-BG12
Molybdenum Concentrations - Background Soil Investigation
Watts Bar Fossil Plant - Spring City, Tennessee
Molybdenum - milligrams per kilogram
0
1
2
3
4
Surficial
0.5'-10' bgs
>10' bgs
Molybdenum Concentrations - Background Soil Investigation
Watts Bar Fossil Plant - Spring City, Tennessee
Molybdenum - milligrams per kilogram
0
1
2
3
4
WBF-BG01
WBF-BG03
WBF-BG04
WBF-BG05
WBF-BG06
WBF-BG07
WBF-BG08
WBF-BG10
WBF-BG11
WBF-BG12
Mercury Concentrations - Background Soil Investigation
Watts Bar Fossil Plant - Spring City, Tennessee
Mercury - milligrams per kilogram
0
.1
.2
.3
Surficial
0.5'-10' bgs
>10' bgs
Mercury Concentrations - Background Soil Investigation
Watts Bar Fossil Plant - Spring City, Tennessee
Mercury - milligrams per kilogram
0
.1
.2
.3
WBF-BG01
WBF-BG03
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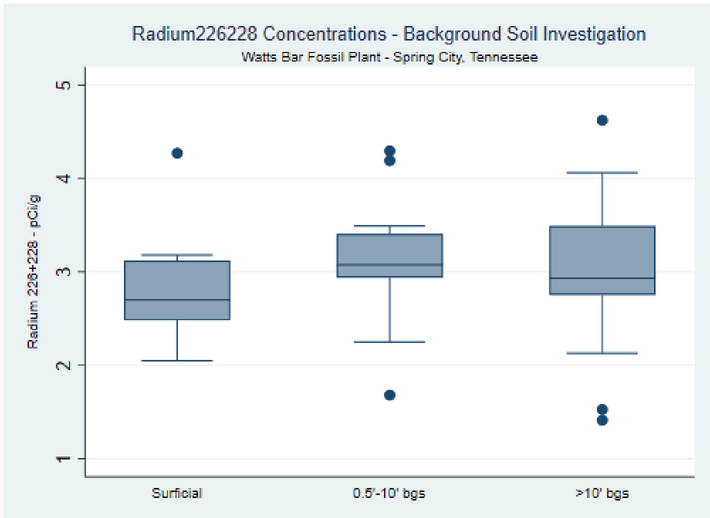
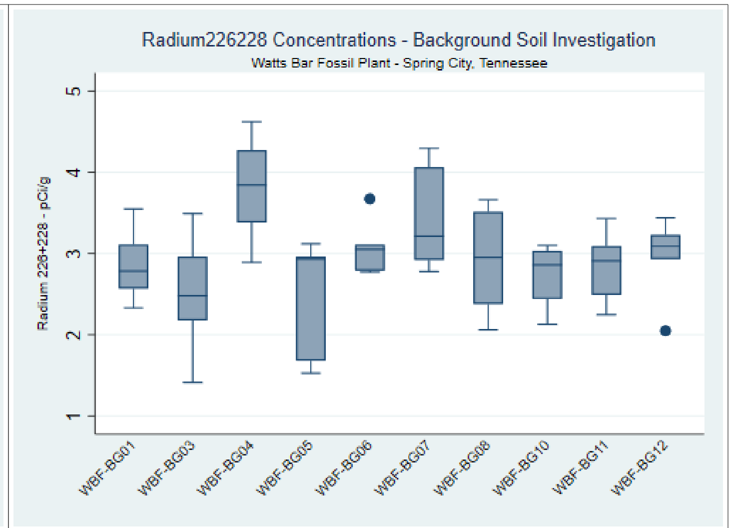
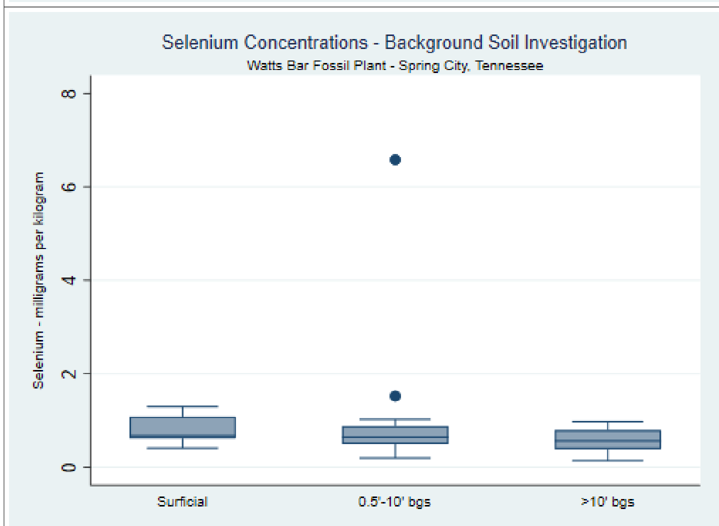
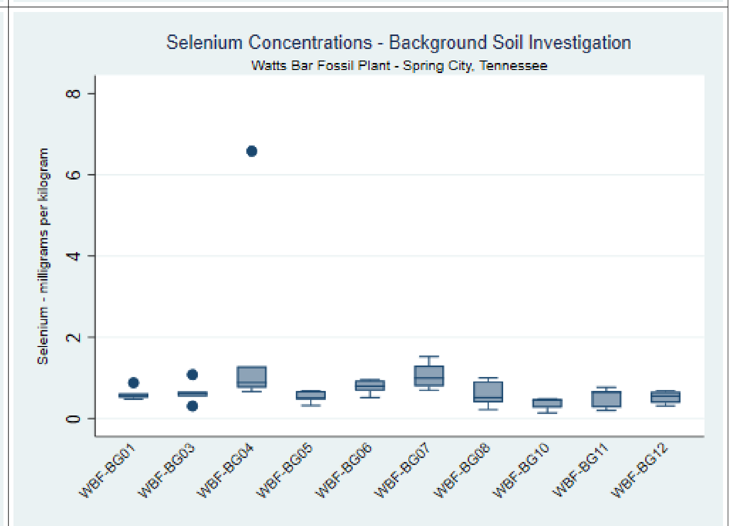
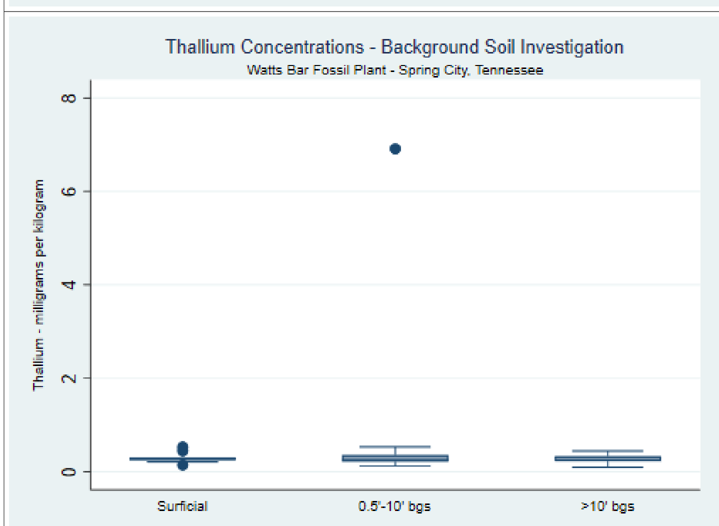
WBF-BG11
WBF-BG12

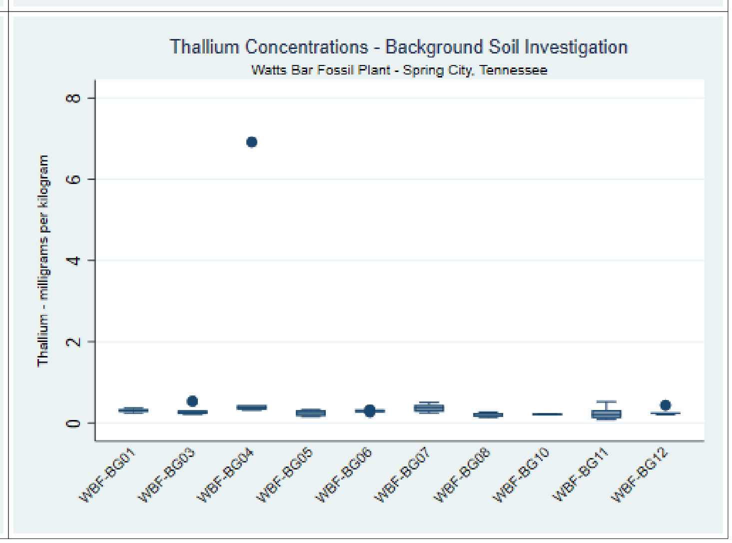

Radium226228 Concentrations - Background Soil Investigation
Watts Bar Fossil Plant - Spring City, Tennessee
Radium 226+228 - pCi/g
Surficial
0.5'-10' bgs
>10' bgs


Radium226228 Concentrations - Background Soil Investigation
Watts Bar Fossil Plant - Spring City, Tennessee
Radium 226+228 - pCi/g
WBF-BG01
WBF-BG03
WBF-BG04
WBF-BG05
WBF-BG06
WBF-BG07
WBF-BG08
WBF-BG10
WBF-BG11
WBF-BG12

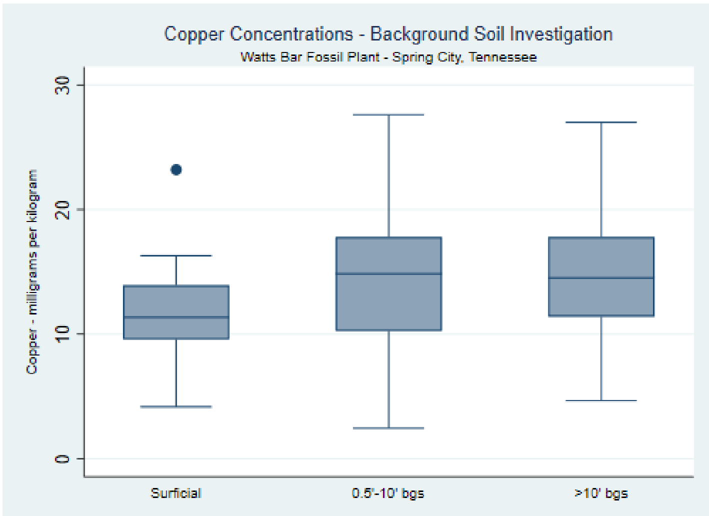

Selenium Concentrations - Background Soil Investigation
Watts Bar Fossil Plant - Spring City, Tennessee
Selenium - milligrams per kilogram
Surficial
0.5'-10' bgs
>10' bgs

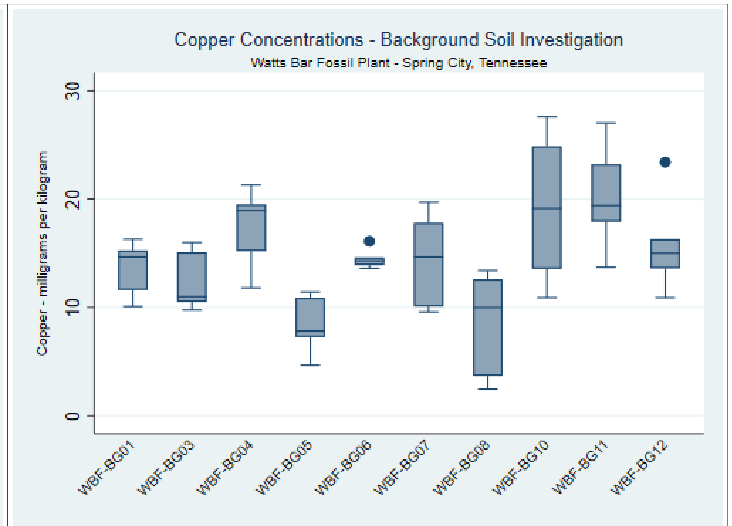

Selenium Concentrations - Background Soil Investigation
Watts Bar Fossil Plant - Spring City, Tennessee
Selenium - milligrams per kilogram
WBF-BG01
WBF-BG03
WBF-BG04
WBF-BG05
WBF-BG06
WBF-BG07
WBF-BG08
WBF-BG10
WBF-BG11
WBF-BG12

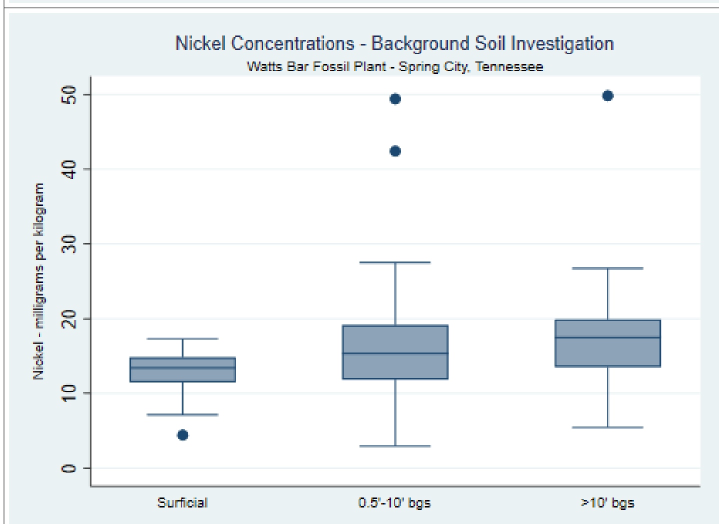

Thallium Concentrations - Background Soil Investigation
Watts Bar Fossil Plant - Spring City, Tennessee
Thallium - milligrams per kilogram
Surficial
0.5'-10' bgs
>10' bgs

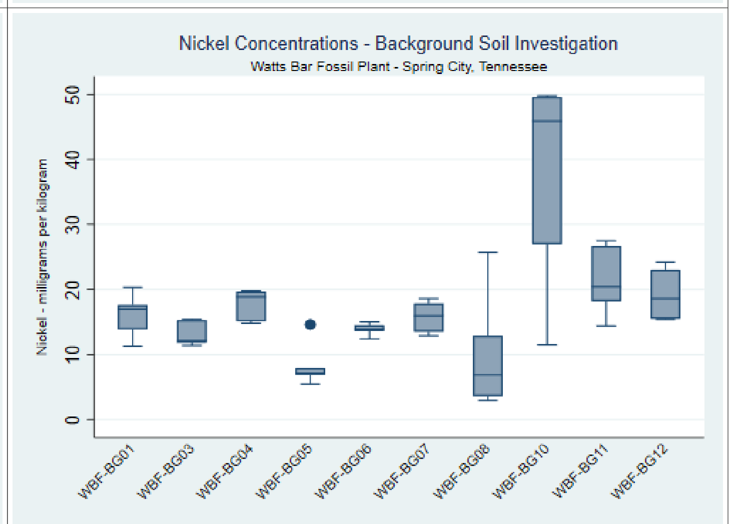

Thallium Concentrations - Background Soil Investigation
Watts Bar Fossil Plant - Spring City, Tennessee
Thallium - milligrams per kilogram
WBF-BG01
WBF-BG03
WBF-BG04
WBF-BG05
WBF-BG06
WBF-BG07
WBF-BG08
WBF-BG10
WBF-BG11
WBF-BG12

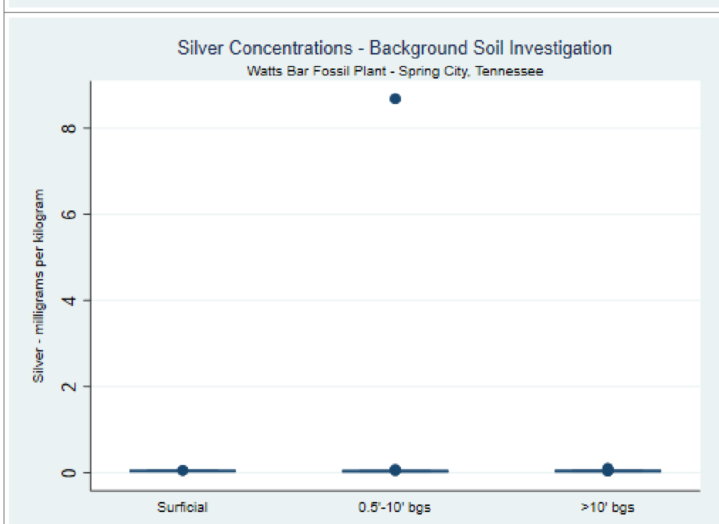
Box Plots - TDEC Appendix I Parameters
TDEC Appendix I Parameters
Background Soil Investigation
Watts Bar Fossil Plant - Spring City, Tennessee

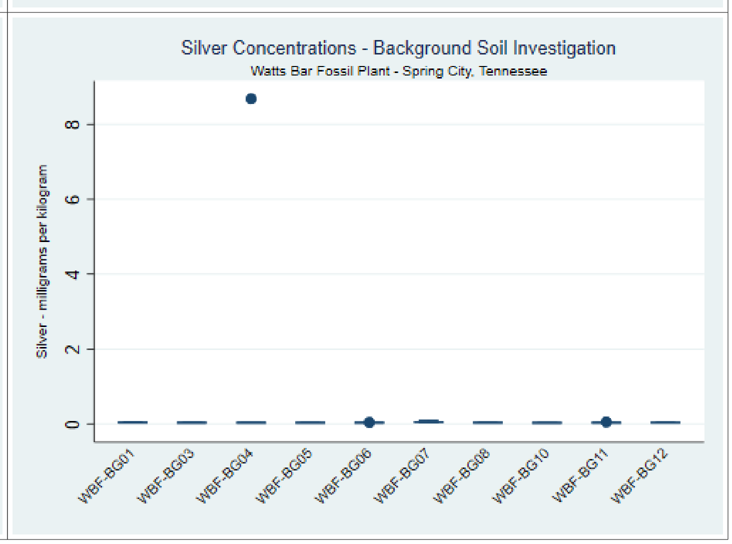


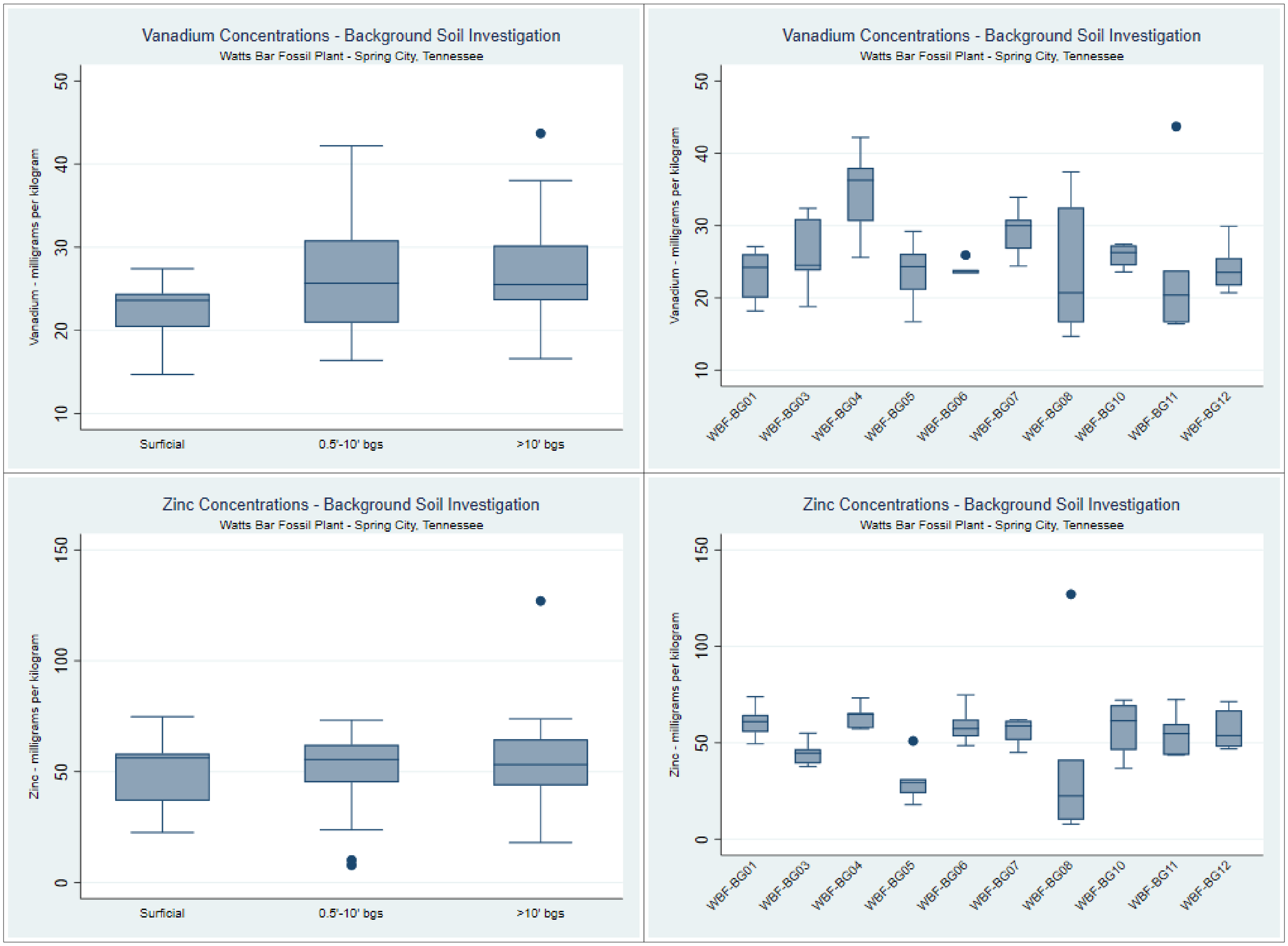











Vanadium Concentrations - Background Soil Investigation
Watts Bar Fossil Plant - Spring City, Tennessee
Vanadium - milligrams per kilogram
10
20
30
40
50
Surficial
0.5'-10' bgs
>10' bgs
Vanadium Concentrations - Background Soil Investigation
Watts Bar Fossil Plant - Spring City, Tennessee
Vanadium - milligrams per kilogram
WBF-BG01
WBF-BG03
WBF-BG04
WBF-BG05
WBF-BG06
WBF-BG07
WBF-BG08
WBF-BG10
WBF-BG11
WBF-BG12
Zinc Concentrations - Background Soil Investigation
Watts Bar Fossil Plant - Spring City, Tennessee
Zinc - milligrams per kilogram
0
50
100
150
Surficial
0.5'-10' bgs
>10' bgs
Zinc Concentrations - Background Soil Investigation
Watts Bar Fossil Plant - Spring City, Tennessee
Zinc - milligrams per kilogram
WBF-BG01
WBF-BG03
WBF-BG04
WBF-BG05
WBF-BG06
WBF-BG07
WBF-BG08
WBF-BG10
WBF-BG11
WBF-BG12

APPENDIX E.2

STATISTICAL ANALYSIS OF CCR MATERIAL CHARACTERISTICS DATA

Stantec

Appendix E.2 - Statistical Analysis of CCR Material Characteristics Data

TDEC Commissioner's Order:
Environmental Assessment Report
Watts Bar Fossil Plant
Spring City, Tennessee

March 31, 2024

Prepared for:

Tennessee Valley Authority
Chattanooga, Tennessee

TVA TENNESSEE VALLEY AUTHORITY

Prepared by:

Stantec Consulting Services Inc.
Lexington, Kentucky

Revision Log

Revision	Description	Date
0	Submittal to TDEC	November 7, 2023
1	Addresses January 31, 2024 TDEC Review Comments and Issued for TDEC	March 31, 2024

Sign-off Sheet

This document entitled Appendix E.2 - Statistical Analysis of CCR Material Characteristics Data was prepared by Stantec Consulting Services Inc. ("Stantec") for the account of Tennessee Valley Authority (the "Client"). Any reliance on this document by any third party is strictly prohibited. The material in it reflects Stantec's professional judgment in light of the scope, schedule and other limitations stated in the document and in the contract between Stantec and the Client. The opinions in the document are based on conditions and information existing at the time the document was published and do not consider any subsequent changes. In preparing the document, Stantec did not verify information supplied to it by others. Any use which a third party makes of this document is the responsibility of such third party. Such third party agrees that Stantec shall not be responsible for costs or damages of any kind, if any, suffered by it or any other third party as a result of decisions made or actions taken based on this document.

Prepared by ______________________

Chris La Londe, Senior Risk Assessor

Reviewed by ______________________

Matt Pontier, Staff Engineer

Approved by ______________________

Rebekah Brooks, PG, Senior Principal Hydrogeologist

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LIST OF TABLES

LIST OF ATTACHMENTS

Abbreviations

CASRN	Chemical Abstracts Service Registry Number
CCR	Coal Combustion Residuals
CCR Parameters	Constituents listed in Appendices III and IV of 40 CFR 257 and five inorganic constituents included in Appendix I of Tennessee Rule 0400-11-01-.04
CCR Rule	Title 40, Code of Federal Regulations, Part 257
EAR	Environmental Assessment Report
IQR	Interquartile Range
NA	Not Available
%	Percent
SPLP	Synthetic Precipitate Leaching Procedure
Stantec	Stantec Consulting Services Inc.
TDEC	Tennessee Department of Environment and Conservation
TVA	Tennessee Valley Authority
WBF Plant	Watts Bar Fossil Plant

1.0 INTRODUCTION

Stantec Consulting Services Inc. (Stantec) prepared this appendix on behalf of the Tennessee Valley Authority (TVA) to document the statistical analyses performed on data collected to characterize coal combustion residual (CCR) materials to support evaluations conducted for the Environmental Assessment Report (EAR) at the Watts Bar Fossil Plant (WBF Plant) located in Spring City, Tennessee. The CCR material characterization samples were collected in July 2019 within the CCR management units at the WBF Plant. Further details regarding the CCR material sampling and laboratory data results are presented in the WBF Plant *CCR Material Characteristics Sampling and Analysis Report* (Appendix G.5).

For the Environmental Investigation, CCR material and pore water samples were collected for characterization related to the leachability of constituents listed in Appendices III and IV of 40 CFR 257 and five additional inorganic constituents included in Appendix I of Tennessee Rule 0400-11-01-.04 (CCR Parameters) from material within two WBF Plant CCR management units: the Ash Pond and Slag Disposal Area. The Synthetic Precipitate Leaching Procedure (SPLP) was used to characterize leachability of CCR Parameters in CCR material. Temporary well/boring locations and the number of samples collected in each WBF Plant CCR management unit are presented in Table E.2-1. Table E.2-2 presents the list of CCR Parameters evaluated in this statistical evaluation.

Table E.2-1 – CCR Material Characteristics Sample Locations - WBF Plant

WBF Plant CCR Management Unit	Temporary Well/Boring Location	Number of Samples	
		CCR Material/SPLP	Pore Water
Ash Pond	WBF-TW01; WBF-TW02	8	0
Slag Disposal Area	WBF-TW03; WBF-TW-04; WBF-TW05	13	3

Table E.2-2 – CCR Parameters Evaluated in Statistical Analysis

CCR Parameter	CASRN
CCR Rule Appendix III Parameters	
Boron	7440-42-8
Calcium	7440-70-2
Chloride	16887-00-6
Fluoride[1] (also Appendix IV)	16984-48-8
pH	NA
Sulfate	14808-79-8
Total Dissolved Solids	NA
CCR Rule Appendix IV Parameters	
Antimony	7440-36-0
Arsenic	7440-38-2
Barium	7440-39-3
Beryllium	7440-41-7
Cadmium	7440-43-9
Chromium	7440-47-3
Cobalt	7440-48-4
Lead	7439-92-1
Lithium	7439-93-2
Mercury	7439-97-6
Molybdenum	7439-98-7
Radium-226+228	13982-63-3/ 15262-20-1
Selenium	7782-49-2
Thallium	7440-28-0
Additional TDEC Appendix I Parameters	
Copper	7440-50-8
Nickel	7440-02-0
Silver	7440-22-4
Vanadium	7440-62-2
Zinc	7440-66-6
Other	
Iron	7439-89-6
Manganese	7439-96-5
Total Organic Carbon	NA

Notes:
CASRN: Chemical Abstracts Service Registry Number; CCR Rule - Title 40, Code of Federal Regulations, Part 257; NA – Not Available; TDEC - Tennessee Department of Environment and Conservation
[1]Fluoride is both a CCR Rule Appendix III and CCR Rule Appendix IV CCR parameter. In this table, and in the results figures and tables for this report, fluoride has been grouped with the Appendix III CCR parameters only to avoid duplication.

The following sections present the methods and results used to evaluate the CCR material and pore water data, including: 1) general exploratory data analysis (summary statistics, data plots and outlier screening), 2) a regression analysis to evaluate correlation between SPLP results to CCR Parameter concentrations in CCR material, and 3) a comparison of SPLP results to pore water concentrations.

2.0 METHODS

The statistical evaluation was conducted in three parts: 1) exploratory data analysis, 2) regression analysis, and 3) comparison of SPLP results to CCR Parameter concentrations in pore water.

2.1 EXPLORATORY DATA ANALYSIS

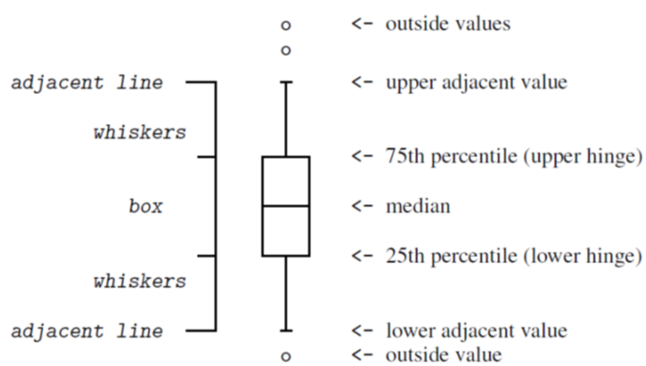
Exploratory data analysis is the initial step of statistical analysis. It utilizes simple summary statistics (e.g. mean, median, standard deviation and percentiles) and graphical representations to identify characteristics of an analytical dataset, such as the center of the data (mean, median), variation, distribution, patterns, presence of outliers, and randomness.

2.1.1 Summary Statistics

Summary statistics were calculated for CCR material, SPLP, and pore water for each CCR Parameter grouped by WBF Plant CCR management unit. Summary statistics include information such as the total numbers of available samples, the frequencies of detection, ranges of reporting limits, minimum and maximum detected concentrations, mean concentrations, standard deviations, median concentrations, and the 95th percentile concentrations. Summary statistics were also calculated for total metal and dissolved metal concentrations in pore water. Summary statistics tables are presented in Attachment E.2-A.

2.1.2 Exploratory Data Plots

Box plots were constructed of CCR Parameter concentrations in CCR material to support a visual review of the data. Box plots were used to identify the center of the data, distribution, variability, and to visually identify potential outliers. The diagram below graphically depicts the basics of the construction of the box plots (StataCorp LLC 2017).



The box portion of the plot is the interquartile range (IQR), which represents the middle 50 percent (%) of data, with the bottom of the box being the 25th percentile and the top of the box being the 75th percentile. The line inside the box is the median concentration. The top of the upper "whisker" represents the first observed concentration above the 75th percentile, whereas the bottom of the lower "whisker" represents the first observed concentration below the 25th percentile (upper adjacent value and lower adjacent value, respectively). Values that lie outside of the adjacent values represent outside (potential outliers) concentrations (i.e. concentrations at the upper and lower ends of the distribution of the data). The method detection limit was used as the reported value in order to construct the box plot when analytical results were reported as non-detects.

Side-by-side box plots were constructed for the CCR materials data and aggregated by temporary well/boring location and WBF Plant CCR management unit. These box plots were useful in identifying differences in CCR Parameter concentrations between each WBF Plant CCR management unit and are especially useful for visually identifying potential outliers. Box plots are presented in Attachment E.2-B.

2.1.3 Outlier Screening

Outliers are data points that are abnormally high or low as compared to other measurements and may represent anomalous data or data errors. Outliers may also represent natural variation of CCR Parameter concentrations in environmental systems. Screening for outliers is a critical step because outliers can bias statistical estimates, statistical testing results, and inferences.

Outlier values were initially screened visually using side-by-side box plots. If suspected visual outliers were identified, then Tukey's procedure was used to identify extreme outliers (Tukey 1977). This method relies on the IQR, which is defined as the 75th percentile value minus the 25th percentile value. Values were identified as potential outliers as follows:

- **Lower extreme outliers** are less than the 25th percentile minus 3 x IQR
- **Upper extreme outliers** are greater than the 75th percentile plus 3 x IQR.

Finally, when the potential outlier(s) were identified visually and by Tukey's procedure, then statistical testing for outliers (Dixon or Rosner's Test) was conducted to determine if the data points were statistically significant outliers.

Following confirmation of the outliers as statistically significant, a desktop evaluation was conducted to verify that the data points were not errors (e.g., laboratory or transcriptional error). Field forms, data validation reports, and other variables in the dataset that could influence analytical results were also evaluated. If a verifiable error was discovered, the outlier was removed and, if possible, replaced with a corrected value.

In the absence of a verifiable error, additional lines of evidence were reviewed to determine final outlier disposition (e.g., frequency of detection, spatial and temporal variability). If an outlier was identified as suitable for removal from further statistical analysis, a clear and defensible rationale based on multiple lines of evidence was provided. In addition, values that were identified as outliers and removed from further evaluation in the present statistical analysis were retained in the historical database and will be reevaluated for inclusion or exclusion in future statistical analyses of this dataset. The results of the outlier screening for the WBF Plant CCR material dataset are provided in Section 3.1.

2.2 REGRESSION ANALYSIS

The linear relationship between the concentrations of CCR Parameters in SPLP results and concentrations in CCR material was evaluated using regression analysis. Scatter plots were constructed to compare SPLP and CCR material results for the CCR Parameters. Using linear regression, the Pearson's correlation coefficient was estimated, and a regression line was fit to the data and added to the scatter plots. As part of the analysis, the SPLP results for the CCR Parameters were compared to the range of pore water concentrations from the Slag Disposal Area (pore water was not collected and analyzed at the Ash Pond). Analyses were conducted on data where CCR parameters were detected in greater than 50% of the samples in both the SPLP and CCR material datasets. Scatter plots, regression results, and range of pore water concentrations are presented in Attachment E.2-C.

3.0 RESULTS AND DISCUSSION

3.1 SUMMARY STATISTICS, EXPLORATORY DATA PLOTS, AND OUTLIER SCREENING

Summary statistics tables are presented in Attachment E.2-A, and box plots are presented in Attachment E.2-B.

No outliers were identified in the CCR material or SPLP datasets. The pore water dataset was not screened for outliers due to the small size of the dataset.

3.2 REGRESSION ANALYSIS

The purpose of the regression analysis was to evaluate whether the total concentrations of metals in CCR material could be used as a reliable predictor of leachable concentrations as represented by SPLP concentrations. Scatter plots, regression results, and range of pore water concentrations are presented in Attachment E.2-C. The correlation coefficient (R-squared) is a numerical measure that measures the strength of association between two variables (in this case, between total concentration and SPLP results for CCR material). Correlation coefficients range from zero to one; a high correlation coefficient (closer to one) demonstrates a strong relationship between the two variables, whereas a low correlation coefficient (closer to zero) demonstrates a weak relationship. The slope of the regression line indicates the direction of correlation. A positive slope indicates that SPLP concentrations increased as CCR Parameter concentrations in CCR material increased. Conversely, a negative slope indicates that as CCR Parameter concentrations increased, the SPLP concentrations decreased.

The statistical relationships between SPLP concentrations and CCR material concentrations were inconsistent and highly variable. One would expect SPLP concentrations to increase with increasing CCR constituent concentrations in CCR material (e.g. regression line with a positive slope). However, this relationship was inconsistent between different CCR constituents and between WBF Plant CCR management units. In some cases, even when there was a statistically significant correlation (e.g., arsenic in the Slag Disposal Area), the wide range of variability around the regression line limits the predictive value of the relationship. In addition, the relationship between the CCR parameter concentrations in SPLP and CCR parameter concentrations directly measured in pore water were inconsistent and variable.

The results indicate that the total concentrations of metals in CCR material is not a reliable predictor of the magnitude of the potentially leached concentrations measured using SPLP and that direct measurement of pore water concentrations is the most accurate way of characterizing potential leachability from CCR material.

4.0 REFERENCES

StataCorp. (2017). Stata Graphics Reference Manual Stata: Release 15. Statistical Software. College Station, Texas: StataCorp LLC.

Tukey, J.W. (1977). *Exploratory Data Analysis*. Reading, Massachusetts: Addison-Wesley. 1977.

ATTACHMENT E.2–A
SUMMARY STATISTICS

Summary Statistics - CCR Material Characteristics
Watts Barr Fossil Plant - Spring City, Tennessee

Parameter	Soil Depth	Frequency of Detection	Range of Reporting Limits	% Non Detect	Statistics using Detected Data Only		Statistics using Detects & Non-Detects			
					Minimum Detect	Maximum Detect	Mean	Standard Deviation	50th Percentile	95th Percentile
CCR Rule Appendix III Parameters										
Boron	Ash Pond	8/8	--	0%	38.4	117	70.8	28.7	67.9	111
	Slag Disposal Area	13/13	--	0%	2.01	300	63.1	81.8	35.1	190
Calcium	Ash Pond	8/8	--	0%	4,030	27,600	8,900	7,760	6,500	21,300
	Slag Disposal Area	13/13	--	0%	387	18,400	4,780	4,880	3,010	12,700
Chloride	Ash Pond	2/8	(4.53 - 5.95)	75.0%	6.17	30.8	8.02	8.63	5.12	22.2
	Slag Disposal Area	4/13	(4.15 - 5.64)	69.2%	6.74	11.2	5.60	2.37	4.97	10.3
Fluoride	Ash Pond	8/8	--	0%	1.92	5.85	4.39	1.18	4.46	5.66
	Slag Disposal Area	8/13	(0.730 - 0.934)	38.5%	1.11	6.80	2.23	2.14	1.24	6.27
pH (lab)	Ash Pond	8/8	--	0%	7.40	9.90	8.20	0.949	7.85	9.76
	Slag Disposal Area	13/13	--	0%	4.40	10.2	6.79	1.83	7.00	9.72
Sulfate	Ash Pond	8/8	--	0%	113	1580	594	498	458	1340
	Slag Disposal Area	13/13	--	0%	23.3	1050	327	333	175	879
CCR Rule Appendix IV Parameters										
Antimony	Ash Pond	8/8	--	0%	1.80	3.52	2.59	0.636	2.47	3.40
	Slag Disposal Area	12/13	(0.0819 - 0.0819)	7.69%	0.104	6.71	1.91	1.94	0.754	4.83
Arsenic	Ash Pond	8/8	--	0%	68.5	258	138	64.2	129	234
	Slag Disposal Area	13/13	--	0%	5.81	205	84.0	71.7	109	185
Barium	Ash Pond	8/8	--	0%	161	313	216	49.9	208	294
	Slag Disposal Area	13/13	--	0%	69.4	337	194	68.0	186	285
Beryllium	Ash Pond	8/8	--	0%	1.85	6.06	3.25	1.34	3.26	5.24
	Slag Disposal Area	13/13	--	0%	0.411	5.74	2.35	1.51	1.76	4.51
Cadmium	Ash Pond	8/8	--	0%	1.21	3.35	1.90	0.715	1.70	2.98
	Slag Disposal Area	12/13	(0.0224 - 0.0224)	7.69%	0.0283	5.64	1.36	1.71	0.208	4.68
Chromium	Ash Pond	8/8	--	0%	28.9	59.1	40.0	10.9	37.6	55.0
	Slag Disposal Area	13/13	--	0%	4.58	75.8	44.6	19.2	44.9	69.7
Cobalt	Ash Pond	8/8	--	0%	9.60	20.9	13.7	3.33	13.5	18.7
	Slag Disposal Area	13/13	--	0%	7.67	18.3	12.6	3.18	12.4	17.2
Lead	Ash Pond	8/8	--	0%	28.9	63.4	46.1	12.3	47.5	61.00
	Slag Disposal Area	13/13	--	0%	5.06	92.6	32.4	26.2	24.1	70.1
Lithium	Ash Pond	8/8	--	0%	20.9	39.2	29.1	7.21	28.3	38.6
	Slag Disposal Area	13/13	--	0%	3.29	37.8	25.2	9.77	29.2	37.3
Mercury	Ash Pond	8/8	--	0%	0.206	0.698	0.451	0.192	0.408	0.693
	Slag Disposal Area	10/13	(0.0156 - 0.140)	23.1%	0.0209	1.13	0.306	0.311	0.230	0.818

Summary Statistics - CCR Material Characteristics Watts Barr Fossil Plant - Spring City, Tennessee										
Parameter	**Soil Depth**	**Frequency of Detection**	**Range of Reporting Limits**	**% Non Detect**	**Statistics using Detected Data Only**		**Statistics using Detects & Non-Detects**			
					Minimum Detect	**Maximum Detect**	**Mean**	**Standard Deviation**	**50th Percentile**	**95th Percentile**
Molybdenum	Ash Pond	8/8	--	0%	8.75	16.3	11.2	2.39	10.3	15.0
	Slag Disposal Area	13/13	--	0%	0.489	14.9	6.50	4.41	6.12	12.9
Radium-226+228	Ash Pond	8/8	--	0%	4.50	6.89	5.59	0.896	5.65	6.81
	Slag Disposal Area	13/13	--	0%	0.945	9.09	4.90	2.31	5.16	8.86
Selenium	Ash Pond	8/8	--	0%	3.32	9.23	6.00	2.43	6.06	8.81
	Slag Disposal Area	12/13	(0.812 - 0.812)	7.69%	1.06	11.5	4.99	3.84	4.58	10.7
Thallium	Ash Pond	8/8	--	0%	2.65	9.30	5.07	2.31	4.730	8.61
	Slag Disposal Area	13/13	--	0%	0.243	10.9	3.99	3.56	4.48	9.50
TDEC Appendix I Parameters										
Copper	Ash Pond	8/8	--	0%	29.4	65.4	44.4	13.7	45.3	62.8
	Slag Disposal Area	13/13	--	0%	16.7	111	40.9	27.3	46.1	83.5
Nickel	Ash Pond	8/8	--	0%	23.8	57.8	35.4	11.4	37.2	51.4
	Slag Disposal Area	13/13	--	0%	15.3	57.0	30.4	13.1	25.8	50.6
Silver	Ash Pond	8/8	--	0%	0.0745	0.243	0.144	0.0567	0.155	0.220
	Slag Disposal Area	10/13	(0.0299 - 0.0357)	23.1%	0.0309	0.201	0.0975	0.0628	0.0757	0.187
Vanadium	Ash Pond	8/8	--	0%	50.5	121	75.5	23.3	73.0	109
	Slag Disposal Area	13/13	--	0%	7.55	226	78.0	61.1	49.2	181
Zinc	Ash Pond	8/8	--	0%	111	264	157	52.3	146	236
	Slag Disposal Area	13/13	--	0%	6.95	423	119	119	66.1	296
Additional Parameters										
Iron	Ash Pond	8/8	--	0%	28,000	42,100	33,500	5,520	32,700	41,800
	Slag Disposal Area	13/13	--	0%	28,300	106,000	53,700	20,100	51,600	87,400
Manganese	Ash Pond	8/8	--	0%	118	687	306	199	254	627
	Slag Disposal Area	13/13	--	0%	35.5	1180	311	332	161	883
TOC	Ash Pond	8/8	--	0%	30500	137,000	77,300	40,900	75,000	132,000
	Slag Disposal Area	12/13	(948 - 948)	7.69%	4100	312,000	60,400	82,400	25,500	207,000

Notes:
CCR Rule - Title 40, Code of Federal Regulations, Part 257
TDEC - Tennessee Department of Environment and Conservation
% - percent
"--" : Not Applicable
TOC - Total Organic Carbon

Except for pH & Radium 226 + 228, all units are milligrams per kilogram (mg/kg).
Units for pH are Standard Units (S.U.).
Units for Radium 226+228 are picocuries per gram (pCi/g).
All non-detects reported at the method detection limit.
For Parameters with non-detects reported at the method detection limit, the mean and standard deviation were calculated using Kaplan-Meier methods (KM).

Summary Statistics - CCR Material Characteristics - Synthetic Precipitate Leaching Procedure (SPLP) Watts Bar Fossil Plant - Spring City, Tennessee										
Parameter	**CCR Unit**	**Frequency of Detection**	**Range of Reporting Limits**	**% Non Detect**	**Statistics using Detected Data Only**		**Statistics using Detects and Non-Detects**			
					Minimum Detect	**Maximum Detect**	**Mean**	**Standard Deviation**	**50th Percentile**	**95th Percentile**
CCR Rule Appendix III Parameters										
Boron	Ash Pond	8/8	--	0%	178	807	457	217	400	760
	Slag Disposal Area	13/13	--	0%	47.0	1120	291	311	194	884
Calcium	Ash Pond	8/8	--	0%	9,170	45,900	23,400	13,000	19,800	43,900
	Slag Disposal Area	13/13	--	0%	878	49,300	15,500	12,600	14,800	33,500
CCR Rule Appendix IV Parameters										
Antimony	Ash Pond	8/8	--	0%	1.93	6.37	4.93	1.44	5.35	6.21
	Slag Disposal Area	12/13	(0.378 - 0.378)	7.69%	0.416	15.6	4.72	5.59	1.52	14.6
Arsenic	Ash Pond	8/8	--	0%	6.72	101	47.3	30.8	42.3	90.3
	Slag Disposal Area	13/13	--	0%	0.428	95.7	19.7	28.9	2.86	70.2
Barium	Ash Pond	8/8	--	0%	2.87	31.0	13.7	11.2	8.83	29.7
	Slag Disposal Area	11/13	(1.49 - 1.60)	15.4%	5.18	146	32.6	37.1	17.6	90.1
Beryllium	Ash Pond	1/8	(0.155 - 0.245)	87.5%	0.234	0.234	0.166	0.0276	0.184	0.241
	Slag Disposal Area	3/13	(0.155 - 0.182)	76.9%	0.319	0.356	0.198	0.0796	0.182	0.355
Cadmium	Ash Pond	0/8	(0.125 - 0.125)	100%	--	--	--	--	0.125	0.125
	Slag Disposal Area	1/13	(0.125 - 0.125)	92.3%	1.70	1.70	0.246	0.420	0.125	0.755
Chromium	Ash Pond	1/8	(1.53 - 1.53)	87.5%	2.86	2.86	1.7	0.440	1.53	2.40
	Slag Disposal Area	2/13	(1.53 - 5.40)	84.6%	1.56	1.65	1.57	0.0492	2.20	4.37
Cobalt	Ash Pond	2/8	(0.075 - 0.256)	75.0%	0.196	0.356	0.128	0.096	0.158	0.321
	Slag Disposal Area	9/13	(0.0750 - 0.0750)	30.8%	0.088	163	16.6	43.2	0.152	80.9
Lead	Ash Pond	6/8	(0.128 - 0.128)	25.0%	0.241	1.31	0.494	0.383	0.402	1.16
	Slag Disposal Area	9/13	(0.128 - 0.128)	30.8%	0.144	27.3	2.36	7.21	0.220	11.6
Lithium	Ash Pond	2/8	(3.14 - 3.14)	75.0%	6.00	14.8	4.96	3.84	3.14	11.7
	Slag Disposal Area	7/13	(3.14 - 3.39)	46.2%	4.09	17.1	5.07	3.68	4.09	11.5
Mercury	Ash Pond	0/8	(0.101 - 0.101)	100%	--	--	--	--	0.101	0.101
	Slag Disposal Area	0/13	(0.101 - 0.101)	100%	--	--	--	--	0.101	0.101
Molybdenum	Ash Pond	8/8	--	0%	6.89	283	94.2	88.1	62.5	232
	Slag Disposal Area	7/13	(0.610 - 0.610)	46.2%	2.75	87.6	17.6	24.6	2.75	57.7
Radium-226+228	Ash Pond	0/8	(0 - 0.216)	100%	--	--	--	--	0.0398	0.17
	Slag Disposal Area	1/13	(0 - 0.337)	92.3%	0.52	0.52	0.04	0.139	0.141	0.41

Summary Statistics - CCR Material Characteristics - Synthetic Precipitate Leaching Procedure (SPLP) Watts Bar Fossil Plant - Spring City, Tennessee										
Parameter	**CCR Unit**	**Frequency of Detection**	**Range of Reporting Limits**	**% Non Detect**	**Statistics using Detected Data Only**		**Statistics using Detects and Non-Detects**			
					Minimum Detect	**Maximum Detect**	**Mean**	**Standard Deviation**	**50th Percentile**	**95th Percentile**
Selenium	Ash Pond	5/8	(2.62 - 2.62)	37.5%	5.91	28.8	9.86	8.89	6.26	25.5
	Slag Disposal Area	7/13	(1.51 - 2.62)	46.2%	2.76	56.5	9.98	15.6	2.76	40.5
Thallium	Ash Pond	2/8	(0.128 - 0.375)	75.0%	0.401	1.25	0.302	0.369	0.163	0.953
	Slag Disposal Area	7/13	(0.128 - 0.148)	46.2%	0.19	13.2	1.19	3.47	0.190	5.51
TDEC Appendix I Parameters										
Copper	Ash Pond	7/8	(0.627 - 0.627)	12.5%	0.855	23.7	5.32	7.45	1.89	18.8
	Slag Disposal Area	5/13	(0.627 - 1.46)	61.5%	0.916	35.8	3.81	9.29	1.13	17.1
Nickel	Ash Pond	1/8	(0.423 - 1.81)	87.5%	8.72	8.72	1.46	2.74	1.21	6.30
	Slag Disposal Area	8/13	(0.336 - 0.849)	38.5%	0.354	308	31.3	82.3	0.849	169
Silver	Ash Pond	0/8	(0.121 - 0.121)	100%	--	--	--	--	0.121	0.121
	Slag Disposal Area	0/13	(0.121 - 0.177)	100%	--	--	--	--	0.177	0.177
Vanadium	Ash Pond	8/8	--	0%	3.08	130	44.8	40.8	46.1	105
	Slag Disposal Area	11/13	(0.991 - 0.991)	15.4%	0.978	150	27.4	42.3	2.49	99.0
Zinc	Ash Pond	6/8	(3.22 - 3.22)	25.0%	3.36	29.4	11.0	9.72	6.42	27.7
	Slag Disposal Area	5/13	(3.22 - 3.22)	61.5%	3.58	33.6	7.40	8.90	3.22	26.0
Additional Parameters										
Iron	Ash Pond	6/8	(14.1 - 14.1)	25.0%	54.5	727	207	215	197	558
	Slag Disposal Area	10/13	(19.5 - 19.5)	23.1%	20.8	20,900	1,760	5,540	31.8	9,150
Manganese	Ash Pond	6/8	(1.35 - 1.35)	25.0%	4.16	18.4	6.19	5.13	4.62	14.9
	Slag Disposal Area	11/13	(1.35 - 1.35)	15.4%	1.95	2,540	252	669	9.19	1,250

Notes:

CCR Rule - Title 40, Code of Federal Regulations, Part 257

TDEC - Tennessee Department of Environment and Conservation

% - percent

"--" : Not Applicable

Except for Radium 226 + 228, all units are micrograms per liter (µg/L).
Units for Radium 226+228 are picocuries per liter (pCi/L).

All non-detects reported at the method detection limit.

For Parameters with non-detects reported at the method detection limit, the mean and standard deviation were calculated using Kaplan-Meier methods (KM).

Summary Statistics - CCR Material Characteristics - Pore Water - Total Metals Watts Bar Fossil Plant - Spring City, Tennessee										
Parameter	CCR Unit	Frequency of Detection	Range of Reporting Limits	% Non Detect	Statistics using Detected Data Only		Statistics using Detects & Non-Detects			
					Minimum Detect	Maximum Detect	Mean	Standard Deviation	50th Percentile	95th Percentile
CCR Rule Appendix III Parameters										
Boron	Slag Disposal Area	3/3	--	0%	269	6,220	4,160	3,370	6,000	6,200
Calcium	Slag Disposal Area	3/3	--	0%	470,000	484,000	479,000	7,570	482,000	484,000
Chloride	Slag Disposal Area	3/3	--	0%	6,690	10,600	8,850	1,990	9,260	10,500
Fluoride	Slag Disposal Area	2/3	(65.8 - 65.8)	33.3%	76.6	137	93.1	31.3	76.6	131
pH (field)	Slag Disposal Area	3/3	--	0%	5.90	9.41	7.37	1.83	6.79	9.15
Sulfate	Slag Disposal Area	3/3	--	0%	913,000	1,430,000	1,170,000	259,000	1,160,000	1,400,000
TDS	Slag Disposal Area	3/3	--	0%	1,840,000	2,490,000	2,080,000	359,000	1,900,000	2,430,000
CCR Rule Appendix IV Parameters										
Antimony	Slag Disposal Area	0/3	(0.378 - 4.15)	100%	--	--	--	--	0.378	3.77
Arsenic	Slag Disposal Area	3/3	--	0%	17.4	71.6	49.2	28.3	58.7	70.3
Barium	Slag Disposal Area	3/3	--	0%	37.6	165	82.6	71.4	45.3	153
Beryllium	Slag Disposal Area	0/3	(0.620 - 0.976)	100%	--	--	--	--	0.942	0.973
Cadmium	Slag Disposal Area	1/3	(0.125 - 0.125)	66.7%	0.466	0.466	0.239	0.161	0.125	0.432
Chromium	Slag Disposal Area	1/3	(1.53 - 1.53)	66.7%	2.58	2.58	1.88	0.495	1.53	2.48
Cobalt	Slag Disposal Area	2/3	(0.369 - 0.369)	33.3%	1.15	3.93	1.82	1.53	1.150	3.65
Lead	Slag Disposal Area	1/3	(0.165 - 0.391)	66.7%	1.76	1.76	0.697	0.752	0.391	1.62
Lithium	Slag Disposal Area	2/3	(50.4 - 50.4)	33.3%	124	245	140	80.2	124	233
Mercury	Slag Disposal Area	0/3	(0.101 - 0.101)	100%	--	--	--	--	0.101	0.101
Molybdenum	Slag Disposal Area	2/3	(0.791 - 0.791)	33.3%	135	1360	499	612	135	1240
Radium-226+228	Slag Disposal Area	2/3	(0.337 - 0.337)	33.3%	0.848	1.01	0.73	0.285	0.848	0.99
Selenium	Slag Disposal Area	1/3	(1.51 - 1.51)	66.7%	3.68	3.68	2.23	1.02	1.51	3.46
Thallium	Slag Disposal Area	0/3	(0.148 - 0.791)	100%	--	--	--	--	0.148	0.727
TDEC Appendix I Parameters										
Copper	Slag Disposal Area	0/3	(1.15 - 2.58)	100%	--	--	--	--	1.82	2.50
Nickel	Slag Disposal Area	2/3	(4.34 - 4.34)	33.3%	3.09	9.25	5.14	2.90	4.34	8.76
Silver	Slag Disposal Area	0/3	(0.177 - 0.177)	100%	--	--	--	--	0.177	0.177
Vanadium	Slag Disposal Area	1/3	(0.991 - 0.991)	66.7%	84.5	84.5	28.8	39.4	0.991	76.2
Zinc	Slag Disposal Area	1/3	(9.01 - 13.4)	66.7%	23.6	23.6	13.9	6.88	13.4	22.6

Summary Statistics - CCR Material Characteristics - Pore Water - Total Metals Watts Bar Fossil Plant - Spring City, Tennessee										
Parameter	CCR Unit	Frequency of Detection	Range of Reporting Limits	% Non Detect	Statistics using Detected Data Only		Statistics using Detects & Non-Detects			
					Minimum Detect	Maximum Detect	Mean	Standard Deviation	50th Percentile	95th Percentile
Additional Water Quality Parameters										
Iron	Slag Disposal Area	3/3	--	0%	488	94,900	47,200	47,200	46,200	90,000
Manganese	Slag Disposal Area	3/3	--	0%	61.6	31,600	12,200	17,000	4,990	28,900
TOC	Slag Disposal Area	3/3	--	0%	837	1,810	1,270	497	1,150	1,740

Notes:
CCR Rule - Title 40, Code of Federal Regulations, Part 257
TDEC - Tennessee Department of Environment and Conservation
% - percent
TDS: Total Dissolved Solids
TOC: Total Organic Carbon
"--" - Not Applicable

Except for pH & Radium 226 + 228, all units micrograms per liter (µg/L).
Units for pH are Standard Units (S.U.).
Units for Radium 226+228 are picocuries per liter (pCi/L).
All non-detects reported at the laboratory detection limit.
For Parameters with non-detects reported at the method detection limit, the mean and standard deviation were calculated using Kaplan-Meier methods (KM).

Summary Statistics - CCR Material Characteristics - Pore Water - Dissolved Metals Watts Bar Fossil Plant - Spring City, Tennessee											
Parameter	Chemical Abstracts Service Registry Number (CASRN)	Soil Depth	Frequency of Detection	Range of Reporting Limits	% Non Detect	Statistics using Detected Data Only		Statistics using Detects & Non-Detects			
						Minimum Detect	Maximum Detect	Mean	Standard Deviation	50th Percentile	95th Percentile
CCR Rule Appendix III Parameters											
Boron	7440-42-8	Slag Disposal Area	3/3	--	0%	260	6,420	4,210	3,430	5,940	6,370
Calcium	7440-70-2	Slag Disposal Area	3/3	--	0%	477,000	504,000	490,000	13,500	490,000	503,000
CCR Rule Appendix IV Parameters											
Antimony	7440-36-0	Slag Disposal Area	0/3	(0.378 - 4.28)	100%	--	--	--	--	0.634	3.92
Arsenic	7440-38-2	Slag Disposal Area	3/3	--	0%	18.9	71.9	47.7	26.8	52.2	69.9
Barium	7440-39-3	Slag Disposal Area	3/3	--	0%	39.7	158	81.0	66.7	45.4	147
Beryllium	7440-41-7	Slag Disposal Area	0/3	(0.356 - 0.853)	100%	--	--	--	--	0.474	0.815
Cadmium	7440-43-9	Slag Disposal Area	1/3	(0.125 - 0.125)	66.7%	0.227	0.227	0.159	0.0481	0.125	0.217
Chromium	7440-47-3	Slag Disposal Area	0/3	(1.53 - 1.53)	100%	--	--	--	--	1.53	1.53
Cobalt	7440-48-4	Slag Disposal Area	2/3	(0.131 - 0.131)	33.3%	1.07	4.04	1.75	1.67	1.07	3.74
Lead	7439-92-1	Slag Disposal Area	0/3	(0.128 - 0.186)	100%	--	--	--	--	0.128	0.18
Lithium	7439-93-2	Slag Disposal Area	2/3	(54.9 - 54.9)	33.3%	119	235	136	74.5	119	223
Mercury	7439-97-6	Slag Disposal Area	0/3	(0.101 - 0.101)	100%	--	--	--	--	0.101	0.101
Molybdenum	7439-98-7	Slag Disposal Area	3/3	--	0%	0.920	1340	493	737	139	1220
Selenium	7782-49-2	Slag Disposal Area	1/3	(1.51 - 1.51)	66.7%	4.82	4.82	2.61	1.56	1.51	4.49
Thallium	7440-28-0	Slag Disposal Area	0/3	(0.148 - 0.768)	100%	--	--	--	--	0.148	0.706
TDEC Appendix I Parameters											
Copper	7440-50-8	Slag Disposal Area	1/3	(1.08 - 1.34)	66.7%	1.11	1.11	1.10	0.0150	1.11	1.32
Nickel	7440-02-0	Slag Disposal Area	1/3	(0.686 - 4.95)	66.7%	10.7	10.7	4.02	4.72	4.95	10.1
Silver	7440-22-4	Slag Disposal Area	0/3	(0.177 - 0.177)	100%	--	--	--	--	0.177	0.177
Vanadium	7440-62-2	Slag Disposal Area	1/3	(0.991 - 0.991)	66.7%	75.3	75.3	25.8	35.0	0.991	67.9
Zinc	7440-66-6	Slag Disposal Area	1/3	(3.57 - 13.1)	66.7%	25.0	25.0	10.7	10.1	13.1	23.8
Additional Water Quality Parameters											
Iron	7440-42-8	Slag Disposal Area	3/3	--	0%	50.4	101,000	49,500	50,500	47,400	95,600
Manganese	7440-70-2	Slag Disposal Area	3/3	--	0%	52.7	32,800	12,700	17,600	5,300	30,100

Notes:

CCR Rule - Title 40, Code of Federal Regulations, Part 257

TDEC - Tennessee Department of Environment and Conservation

% - percent

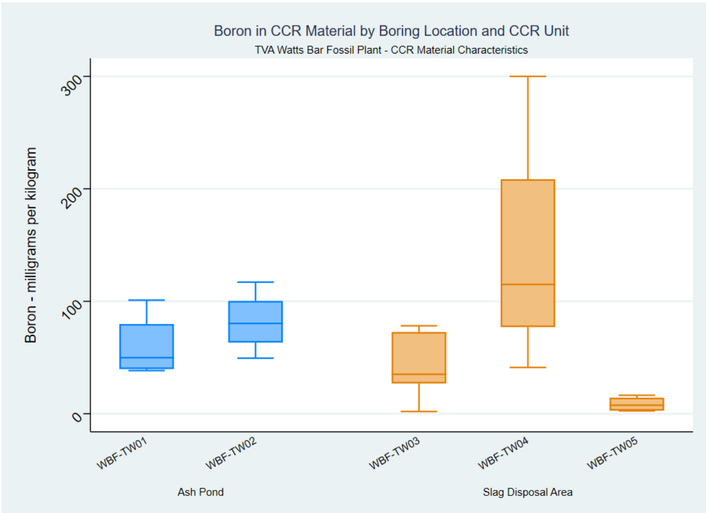
"--" : Not Applicable

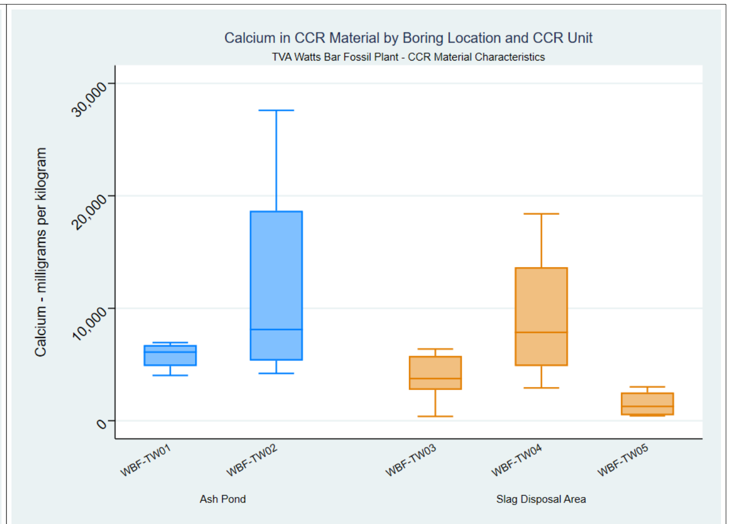
All non-detects reported at the laboratory detection limit

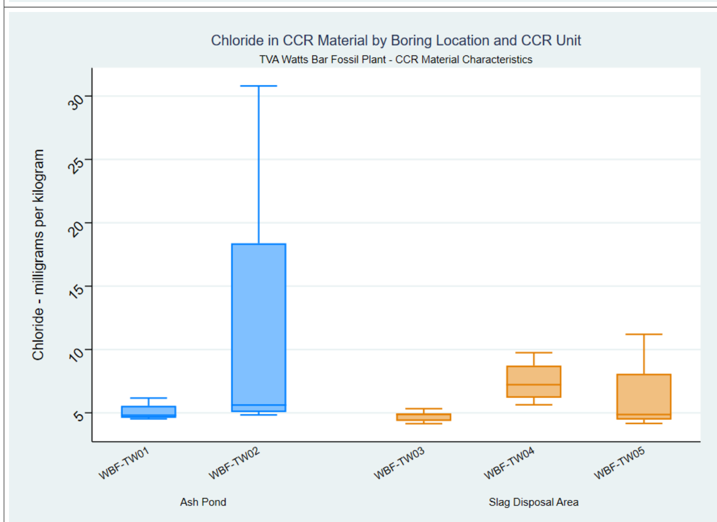
For Parameters with non-detects reported at the method detection limit, the mean and standard deviation were calculated using Kaplan-Meier methods (KM).

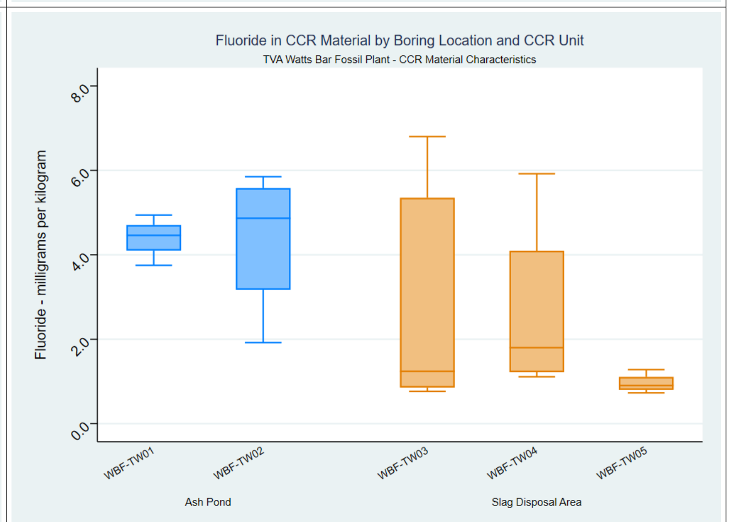
ATTACHMENT E.2-B
BOX PLOTS

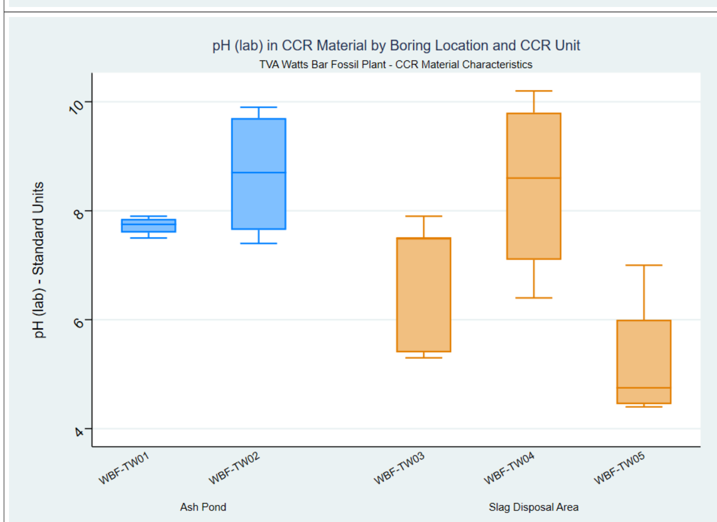
Box Plots
CCR Rule Appendix III Parameters
CCR Material Characteristics Investigation
Watts Bar Fossil Plant - Spring City, Tennessee

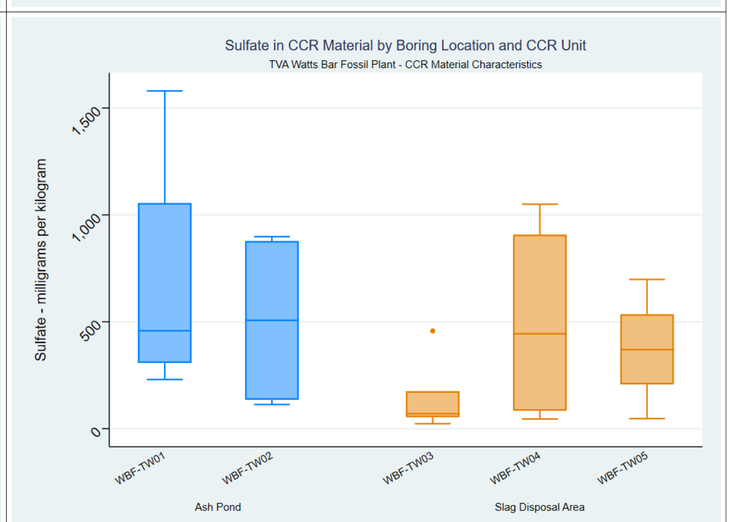










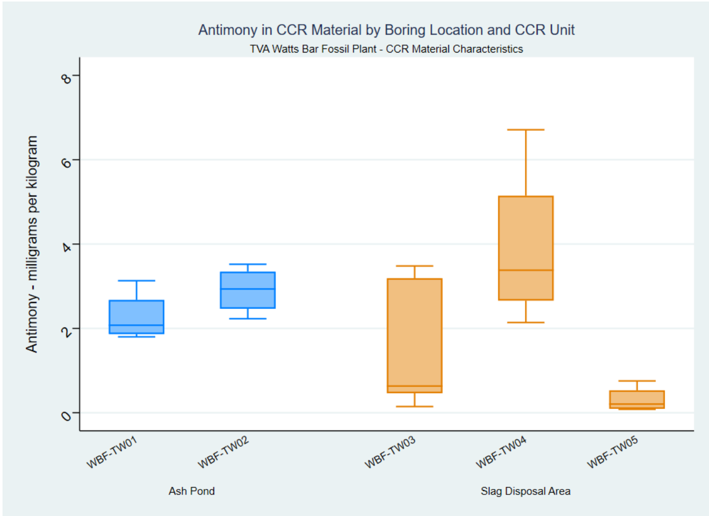


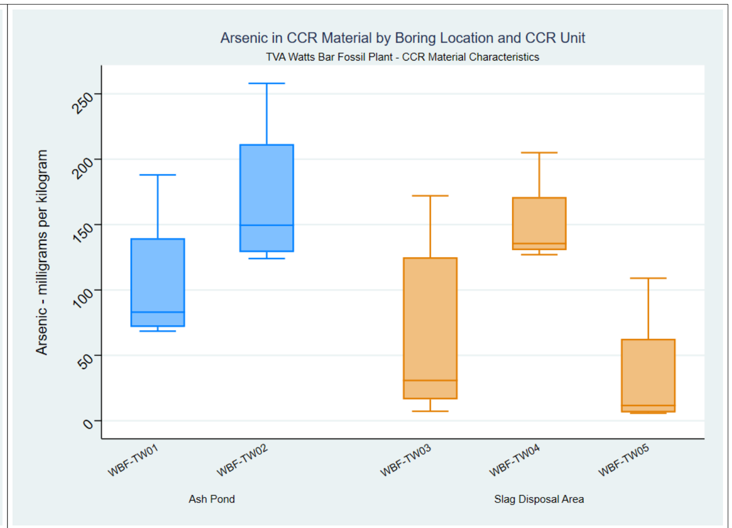
Box Plots

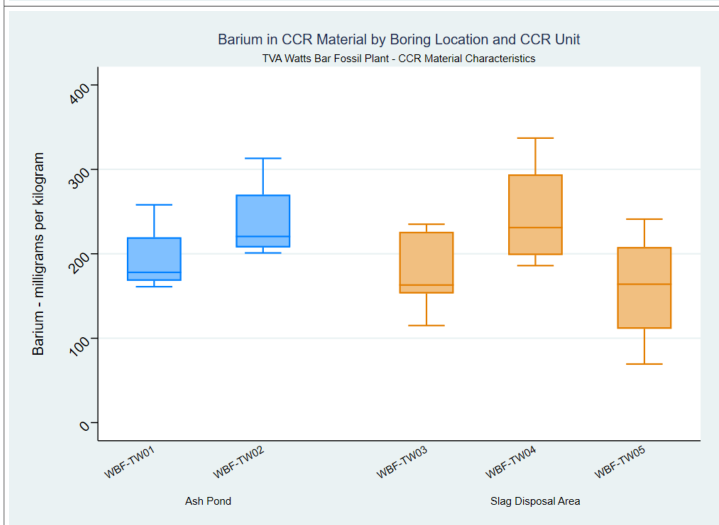
CCR Rule Appendix IV Parameters

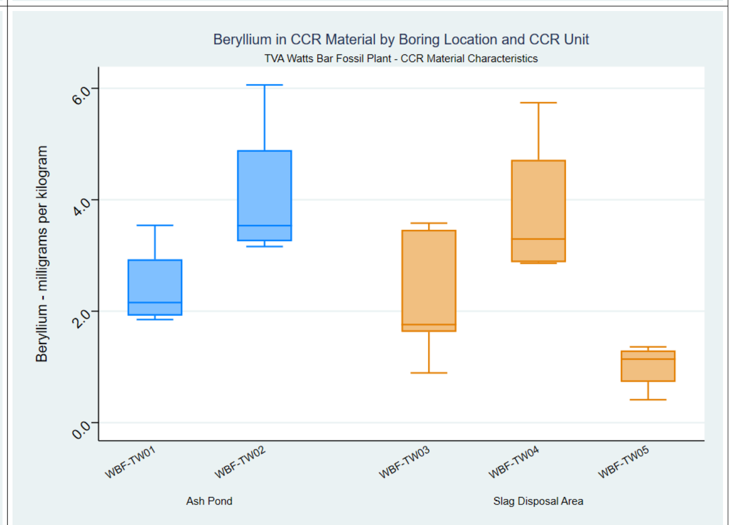
CCR Material Characteristics Investigation

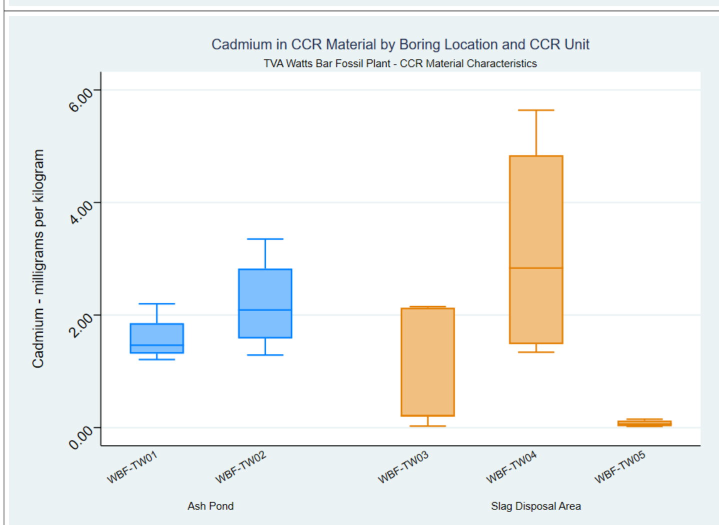
Watts Bar Fossil Plant - Spring City, Tennessee

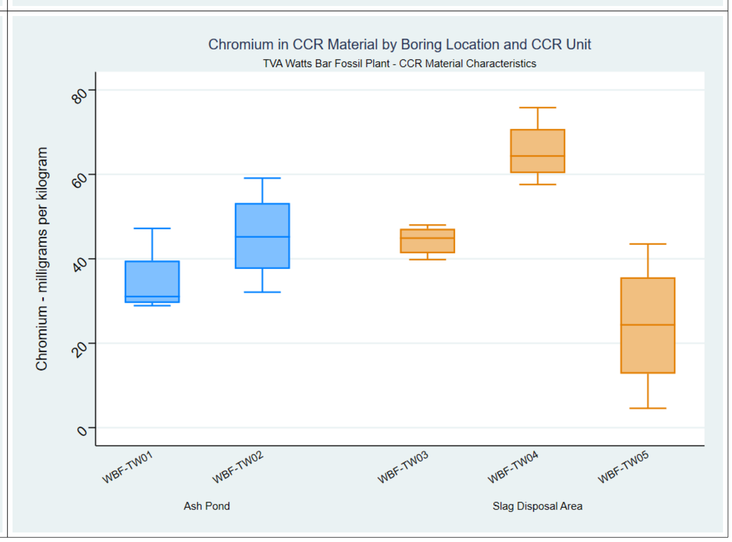


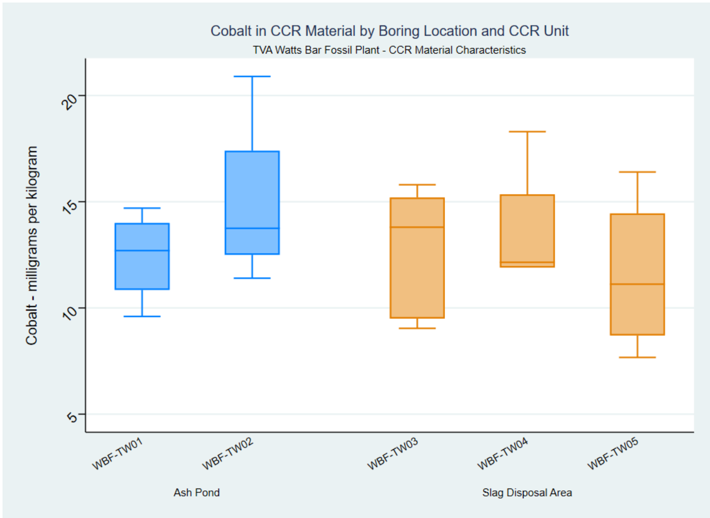


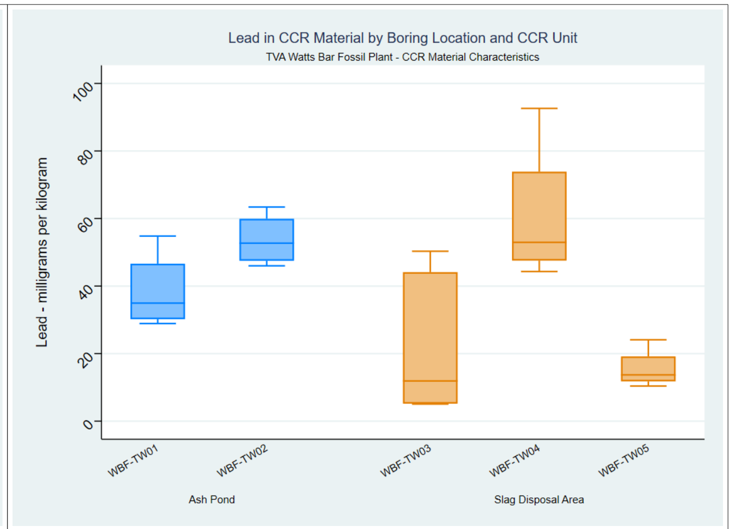


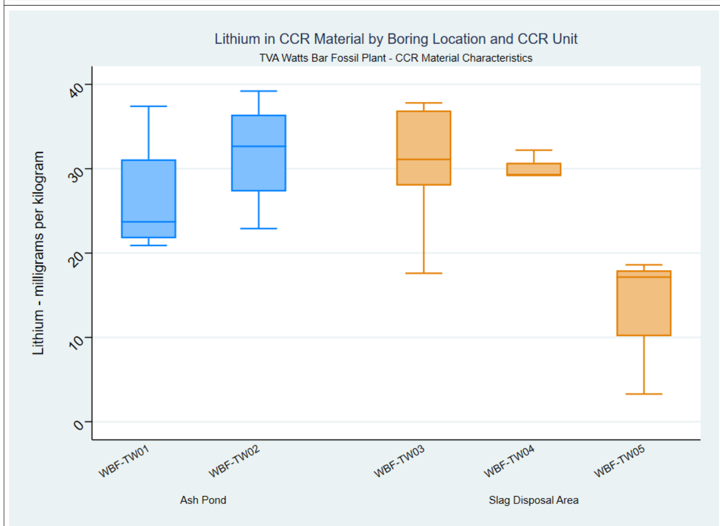







Cobalt in CCR Material by Boring Location and CCR Unit
TVA Watts Bar Fossil Plant - CCR Material Characteristics
Cobalt - milligrams per kilogram
5
10
15
20
WBF-TW01
WBF-TW02
WBF-TW03
WBF-TW04
WBF-TW05
Ash Pond
Slag Disposal Area


Lead in CCR Material by Boring Location and CCR Unit
TVA Watts Bar Fossil Plant - CCR Material Characteristics
Lead - milligrams per kilogram
0
20
40
60
80
100
WBF-TW01
WBF-TW02
WBF-TW03
WBF-TW04
WBF-TW05
Ash Pond
Slag Disposal Area


Lithium in CCR Material by Boring Location and CCR Unit
TVA Watts Bar Fossil Plant - CCR Material Characteristics
Lithium - milligrams per kilogram
0
10
20
30
40
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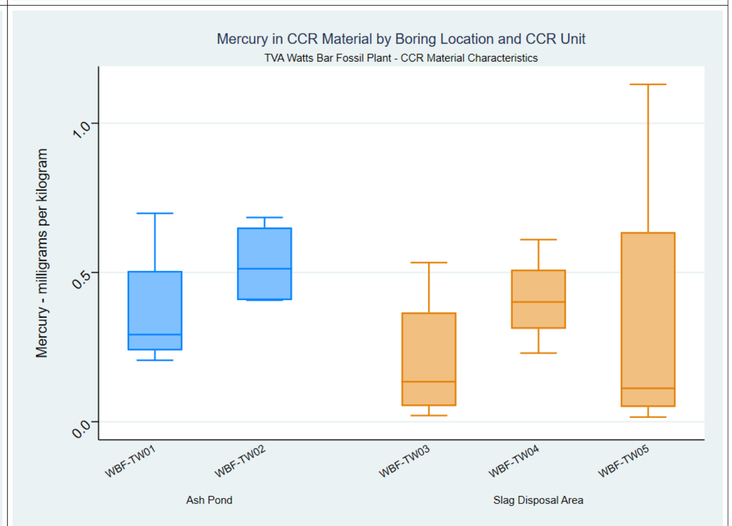
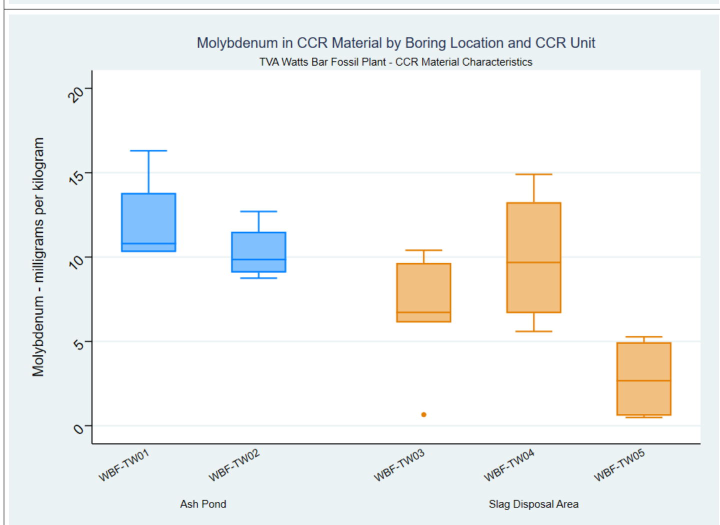
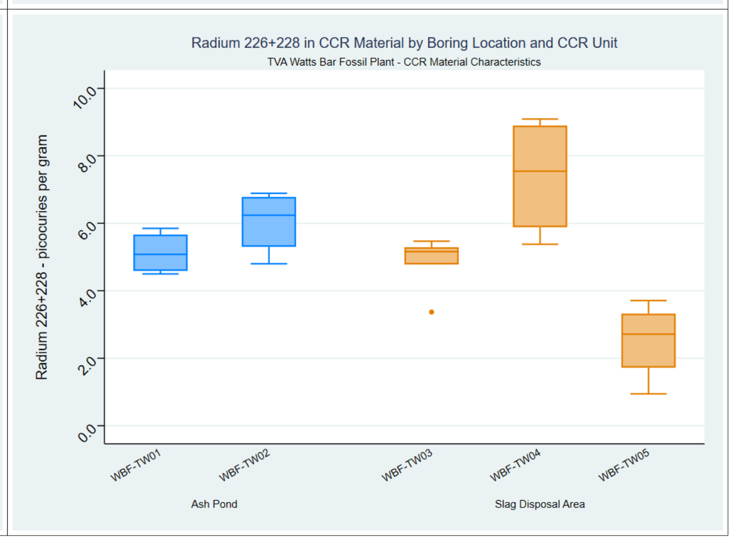
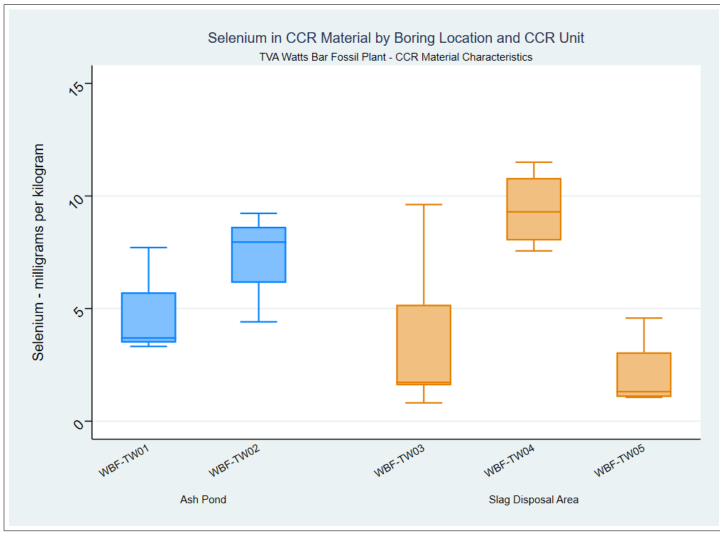
WBF-TW02
WBF-TW03
WBF-TW04
WBF-TW05
Ash Pond
Slag Disposal Area


Mercury in CCR Material by Boring Location and CCR Unit
TVA Watts Bar Fossil Plant - CCR Material Characteristics
Mercury - milligrams per kilogram
0.0
0.5
1.0
WBF-TW01
WBF-TW02
WBF-TW03
WBF-TW04
WBF-TW05
Ash Pond
Slag Disposal Area


Molybdenum in CCR Material by Boring Location and CCR Unit
TVA Watts Bar Fossil Plant - CCR Material Characteristics
Molybdenum - milligrams per kilogram
0
5
10
15
20
WBF-TW01
WBF-TW02
WBF-TW03
WBF-TW04
WBF-TW05
Ash Pond
Slag Disposal Area


Radium 226+228 in CCR Material by Boring Location and CCR Unit
TVA Watts Bar Fossil Plant - CCR Material Characteristics
Radium 226+228 - picocuries per gram
0.0
2.0
4.0
6.0
8.0
10.0
WBF-TW01
WBF-TW02
WBF-TW03
WBF-TW04
WBF-TW05
Ash Pond
Slag Disposal Area



Selenium in CCR Material by Boring Location and CCR Unit
TVA Watts Bar Fossil Plant - CCR Material Characteristics
Selenium - milligrams per kilogram
0
5
10
15
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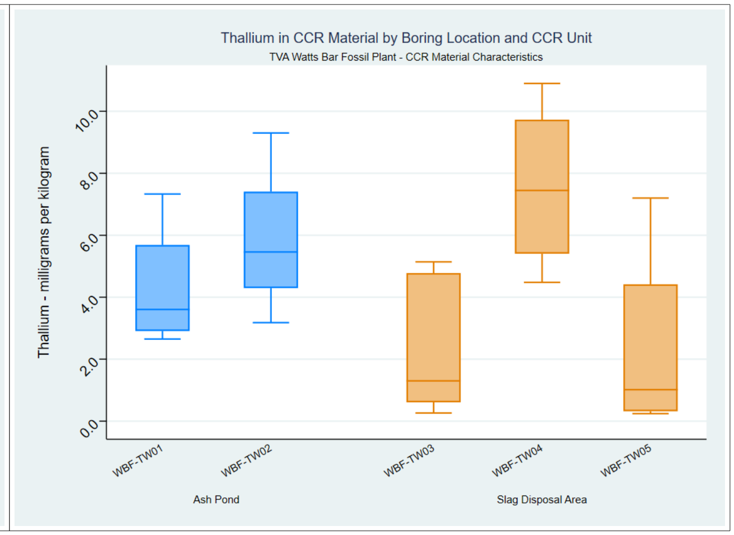
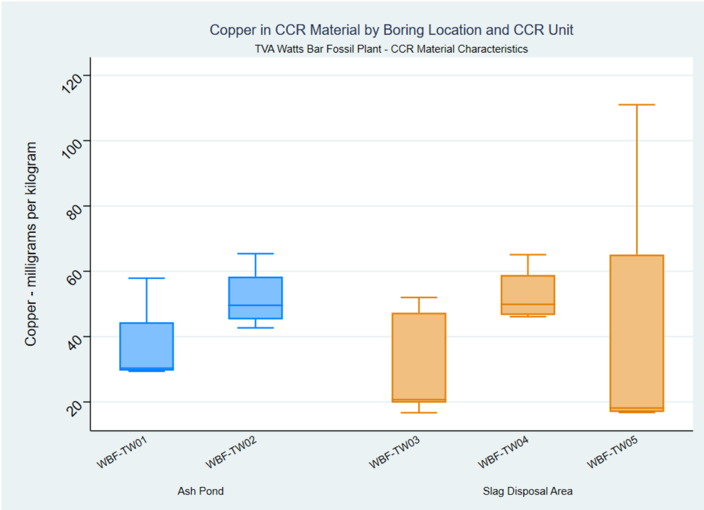
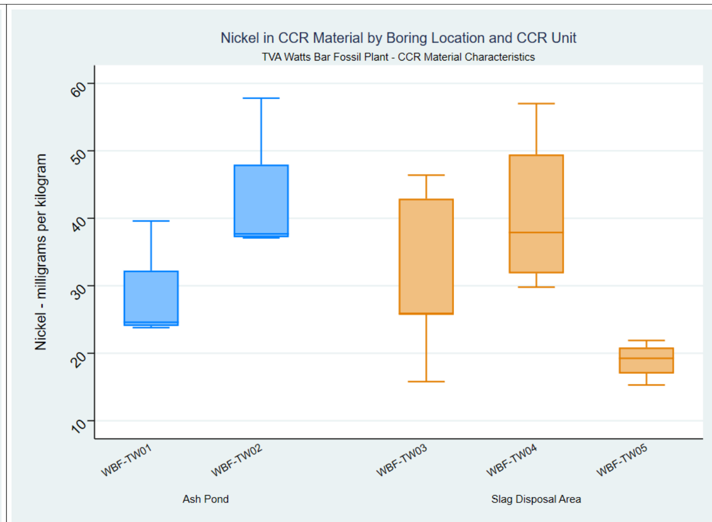
WBF-TW02
WBF-TW03
WBF-TW04
WBF-TW05
Ash Pond
Slag Disposal Area

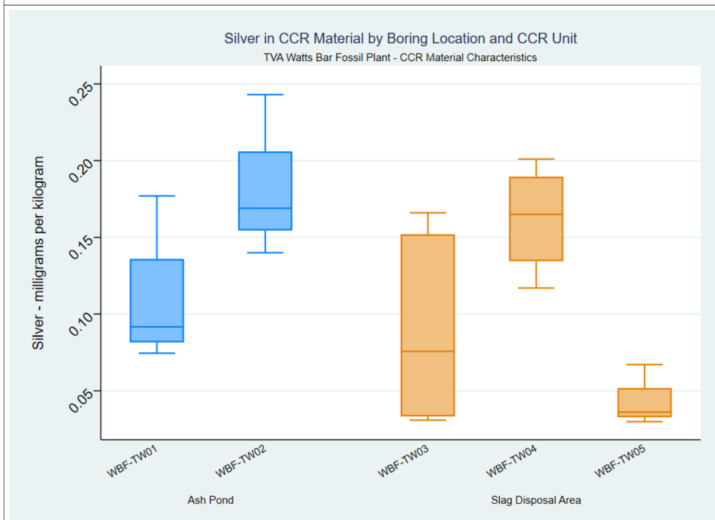


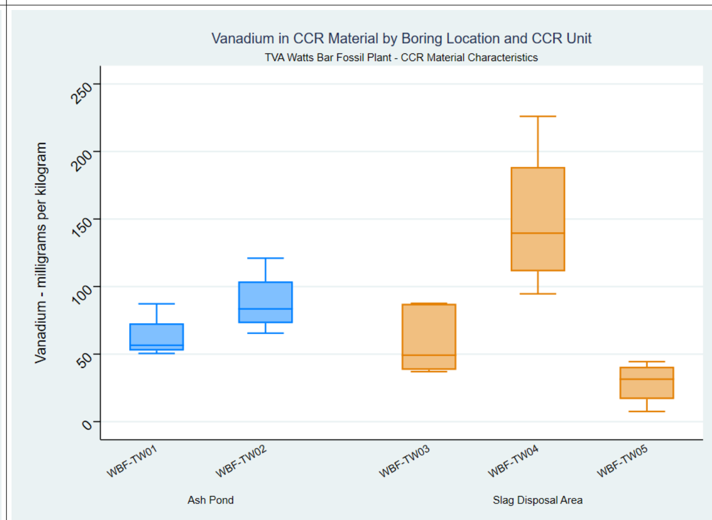
Thallium in CCR Material by Boring Location and CCR Unit
TVA Watts Bar Fossil Plant - CCR Material Characteristics
Thallium - milligrams per kilogram
0.0
2.0
4.0
6.0
8.0
10.0
WBF-TW01
WBF-TW02
WBF-TW03
WBF-TW04
WBF-TW05
Ash Pond
Slag Disposal Area

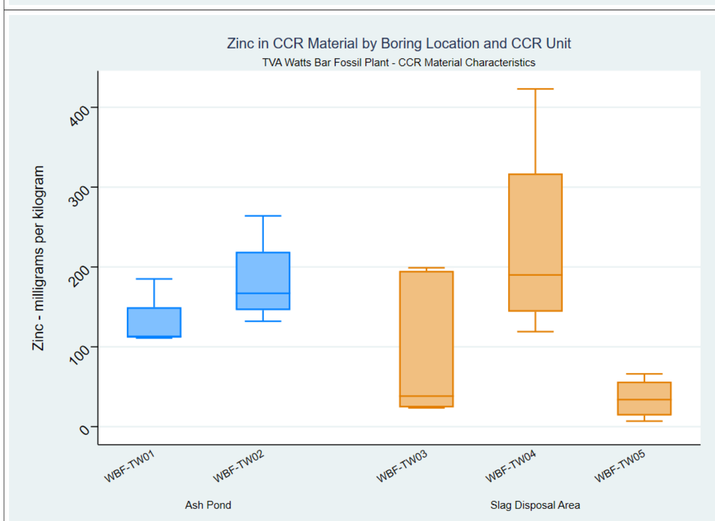
Box Plots
TDEC Appendix I Parameters
CCR Material Characteristics Investigation
Watts Bar Fossil Plant - Spring City, Tennessee











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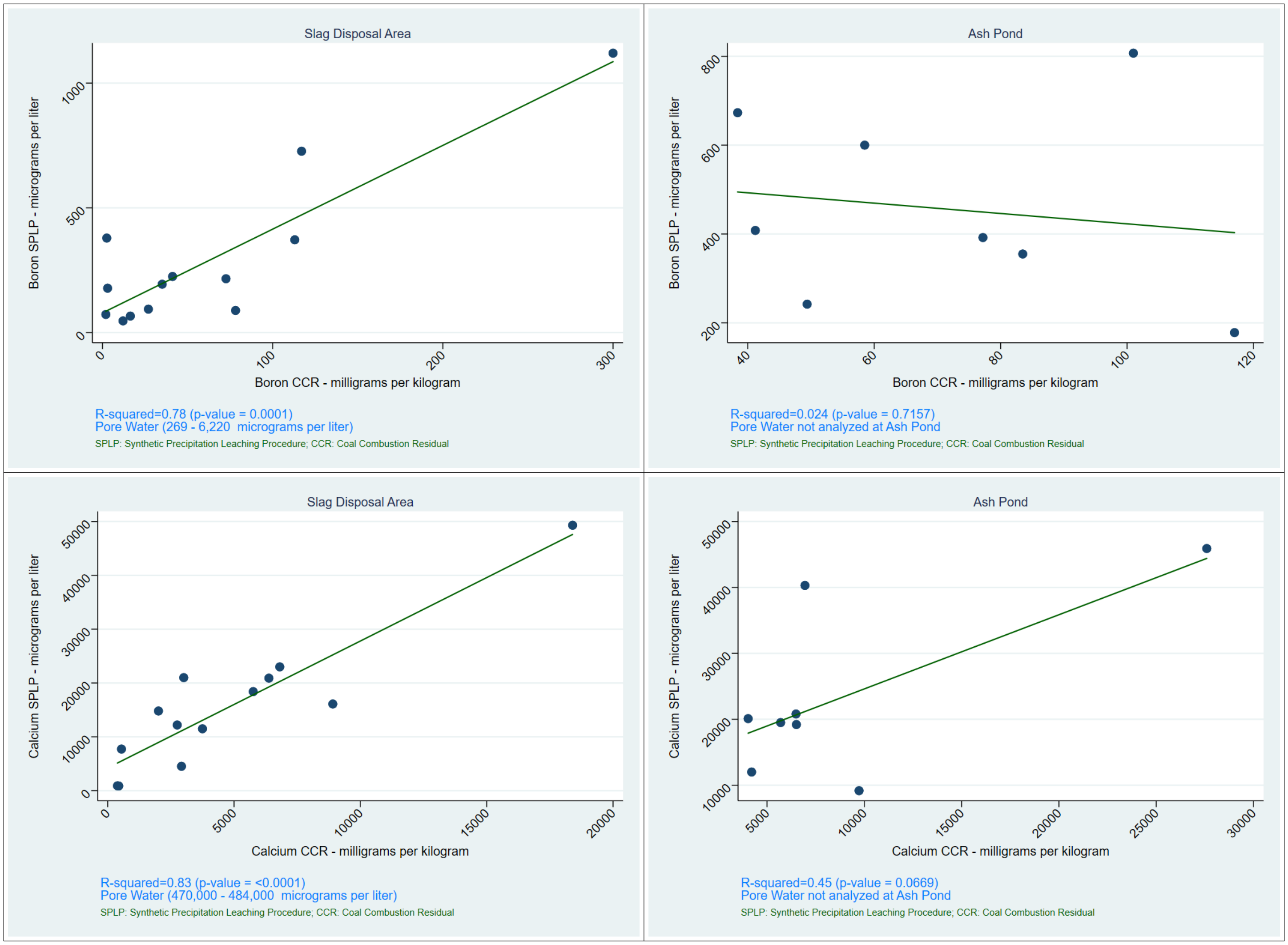
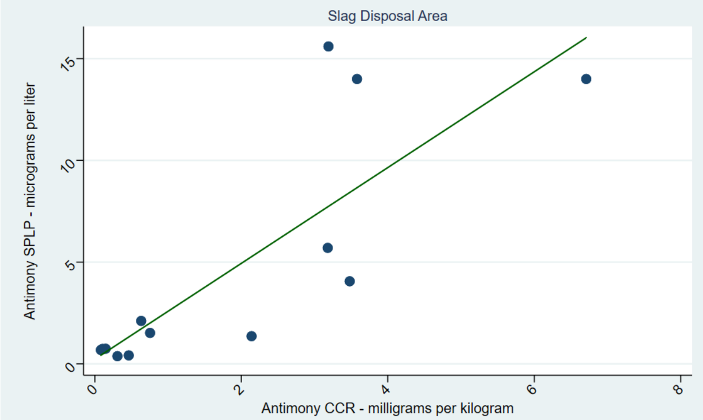
ATTACHMENT E.2-C
SCATTER PLOTS AND REGRESSION

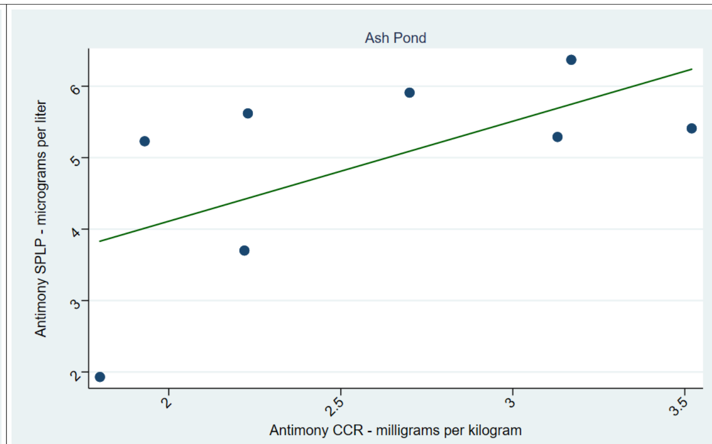
Scatter Plots (SPLP and CCR Material)
CCR Rule Appendix III Parameters
CCR Material Characteristics Investigation
Watts Bar Fossil Plant - Spring City, Tennessee



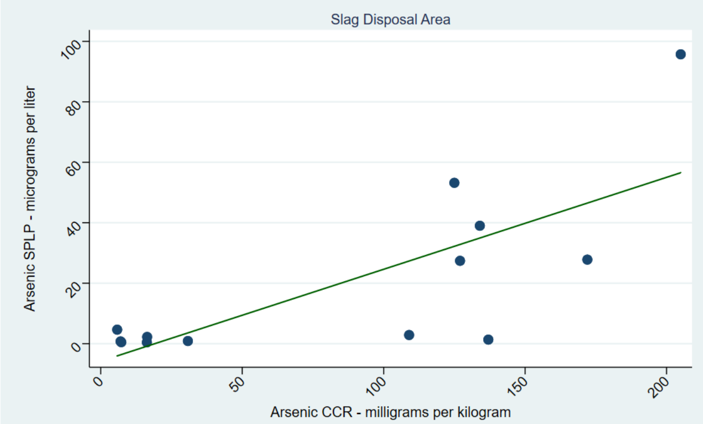
Scatter Plots (SPLP and CCR Material)
CCR Rule Appendix IV Parameters
CCR Material Characteristics Investigation
Watts Bar Fossil Plant - Spring City, Tennessee



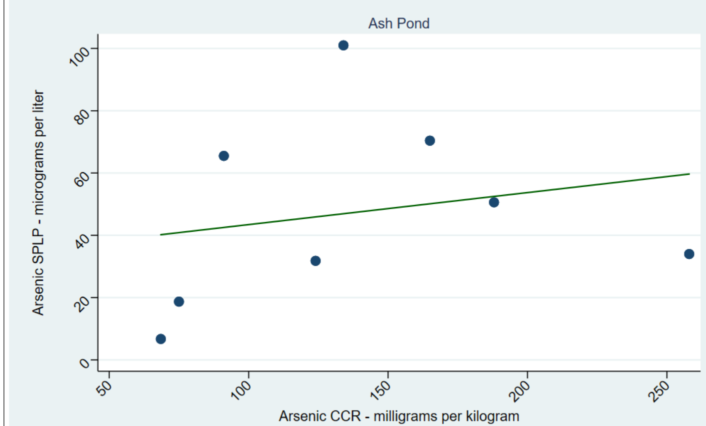
R-squared = 0.67 (p-value = 0.0006)
Pore Water (<0.378 - <4.15 micrograms per liter)
SPLP: Synthetic Precipitation Leaching Procedure; CCR: Coal Combustion Residual



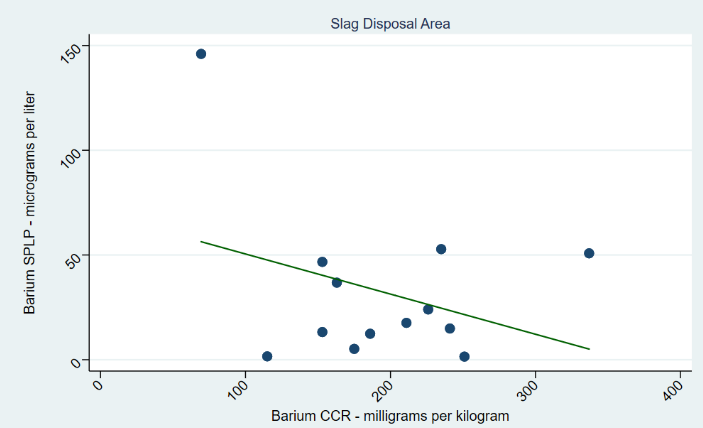
R-squared = 0.38 (p-value = 0.1017)
Pore Water not analyzed at Ash Pond
SPLP: Synthetic Precipitation Leaching Procedure; CCR: Coal Combustion Residual



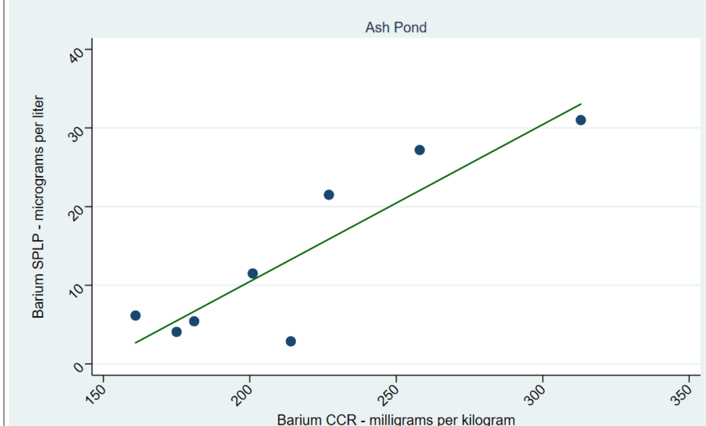
R-squared = 0.57 (p-value = 0.0028)
Pore Water (17.4 - 71.6 micrograms per liter)
SPLP: Synthetic Precipitation Leaching Procedure; CCR: Coal Combustion Residual



R-squared = 0.05 (p-value = 0.6106)
Pore Water not analyzed at Ash Pond)
SPLP: Synthetic Precipitation Leaching Procedure; CCR: Coal Combustion Residual

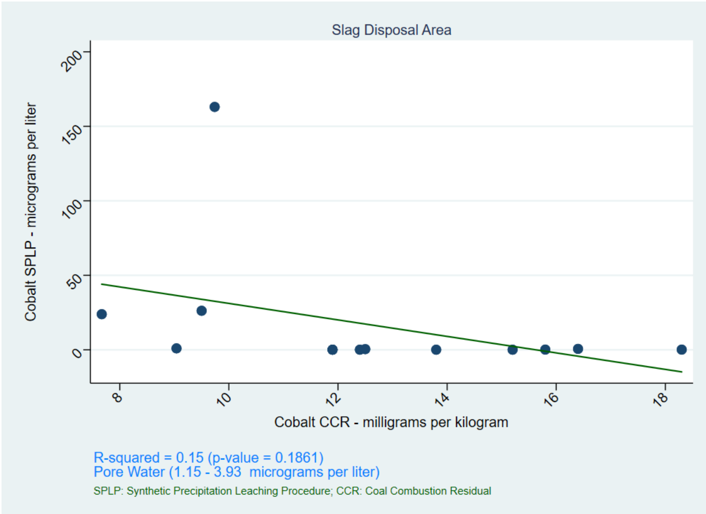
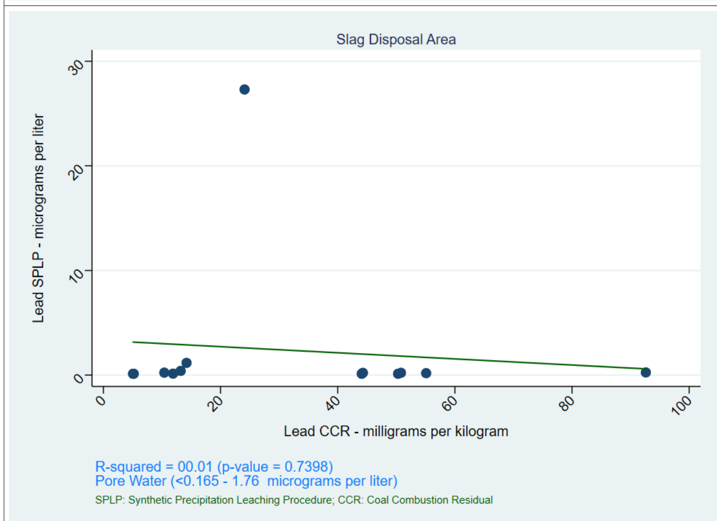
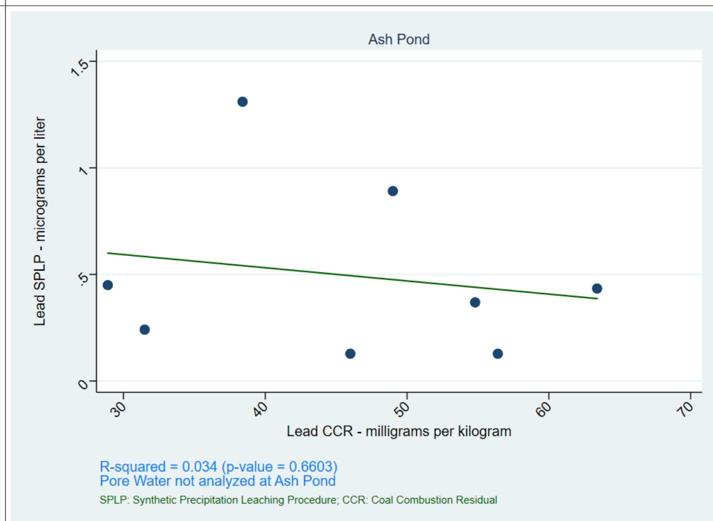
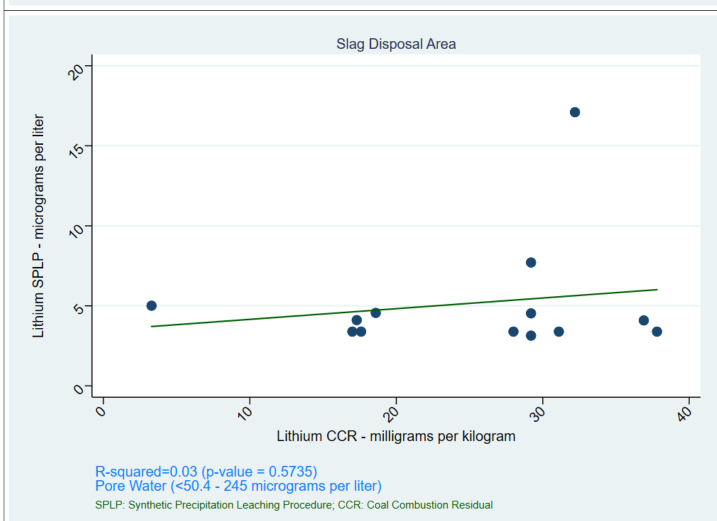


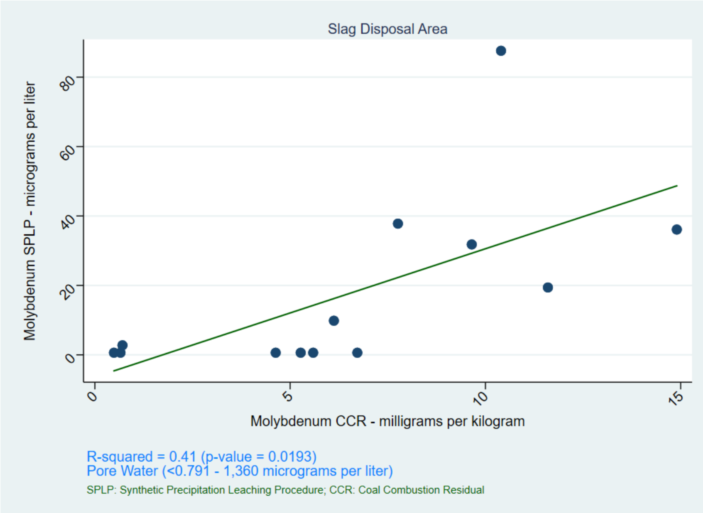
R-squared = 0.11 (p-value = 0.2600)
Pore Water (37.6 - 165 micrograms per liter)
SPLP: Synthetic Precipitation Leaching Procedure; CCR: Coal Combustion Residual

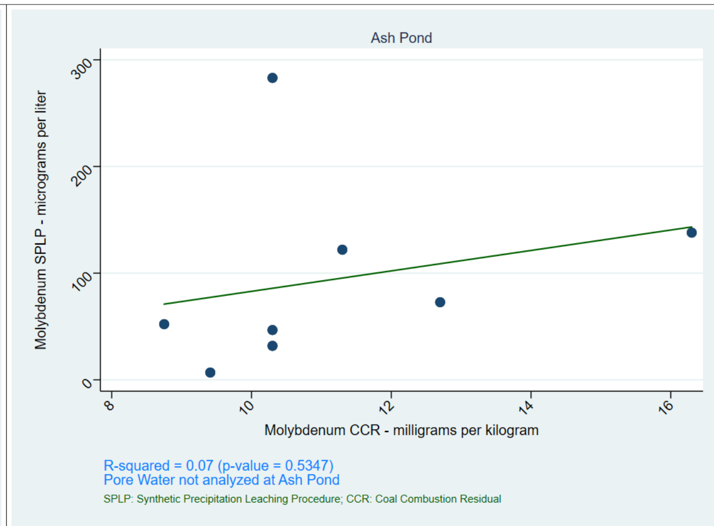


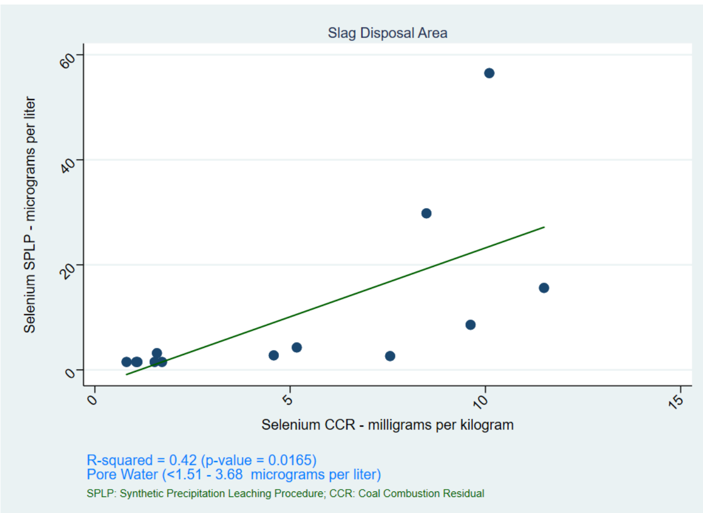
R-squared = 0.7884 (p-value = 0.0032)
Pore Water not analyzed at Ash Pond
SPLP: Synthetic Precipitation Leaching Procedure; CCR: Coal Combustion Residual

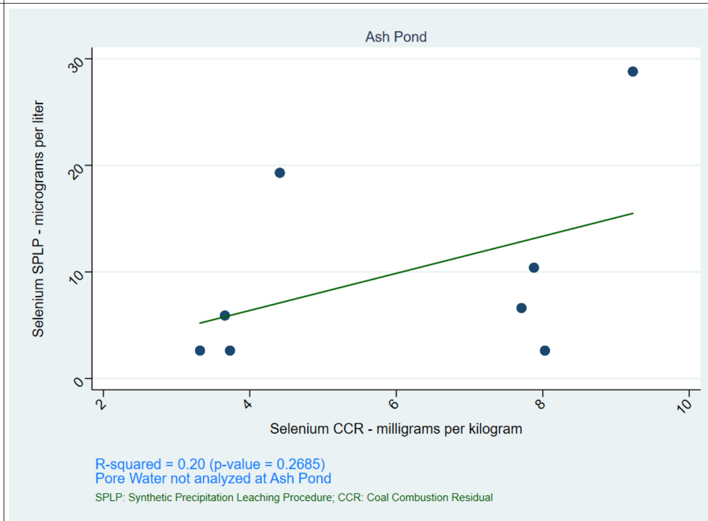
Beryllium/Slag Disposal Area, Insufficient Data, > 50% non-Detects in SPLP or CCR Material Data Sets	Beryllium/Ash Pond, Insufficient Data, > 50% non-Detects in SPLP or CCR Material Data Sets
Cadmium/Slag Disposal Area, Insufficient Data, >	Cadmium/Ash Pond, Insufficient Data, > 50%

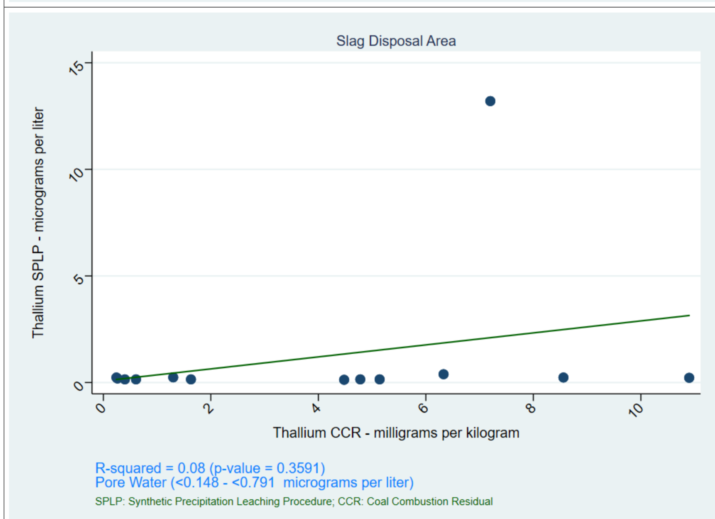
50% non-Detects in SPLP or CCR Material Data Sets	non-Detects in SPLP or CCR Material Data Sets
Chromium/Slag Disposal Area, Insufficient Data, > 50% non-Detects in SPLP or CCR Material Data Sets	Chromium/Ash Pond, Insufficient Data, > 50% non-Detects in SPLP or CCR Material Data Sets
	Cobalt/Ash Pond, Insufficient Data, > 50% non-Detects in SPLP or CCR Material Data Sets
	
	Lithium/Ash Pond, Insufficient Data, > 50% non-Detects in SPLP or CCR Material Data Sets
Mercury/Slag Disposal Area, Insufficient Data, > 50% non-Detects in SPLP or CCR Material Data Sets	Mercury/Ash Pond, Insufficient Data, > 50% non-Detects in SPLP or CCR Material Data Sets







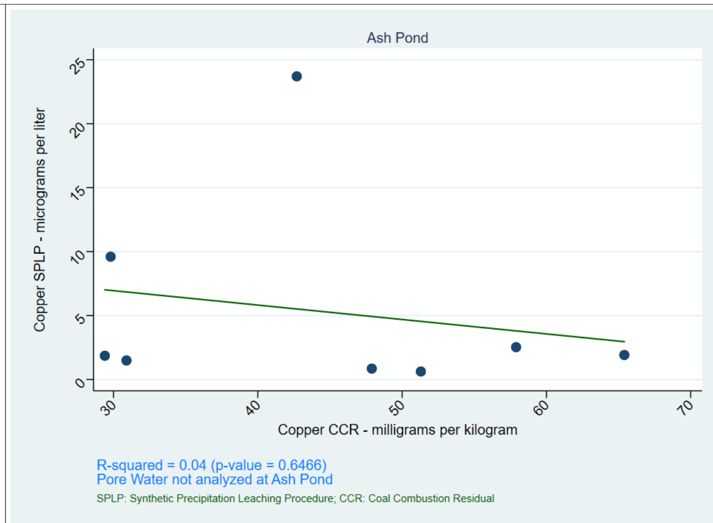


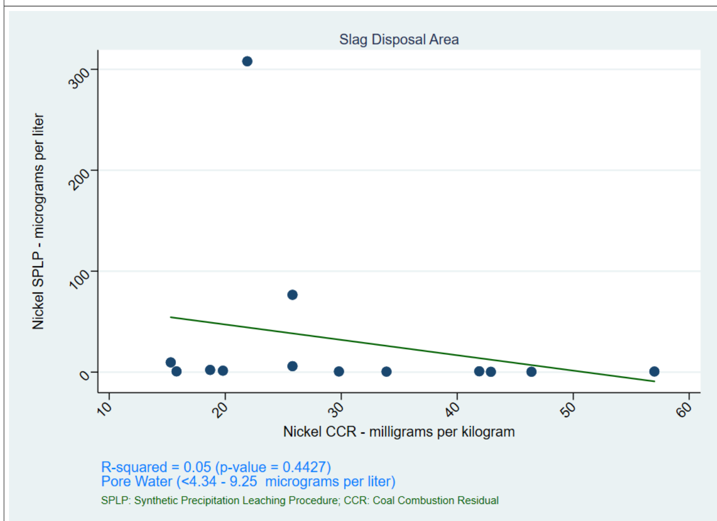


Thallium/Ash Pond, Insufficient Data, > 50% non-Detects in SPLP or CCR Material Data Sets

Scatter Plots (SPLP and CCR Material)
TDEC Appendix I Parameters
CCR Material Characteristics Investigation
Watts Bar Fossil Plant - Spring City, Tennessee

Copper/Slag Disposal Area, Insufficient Data, > 50% non-Detects in SPLP or CCR Material Data Sets

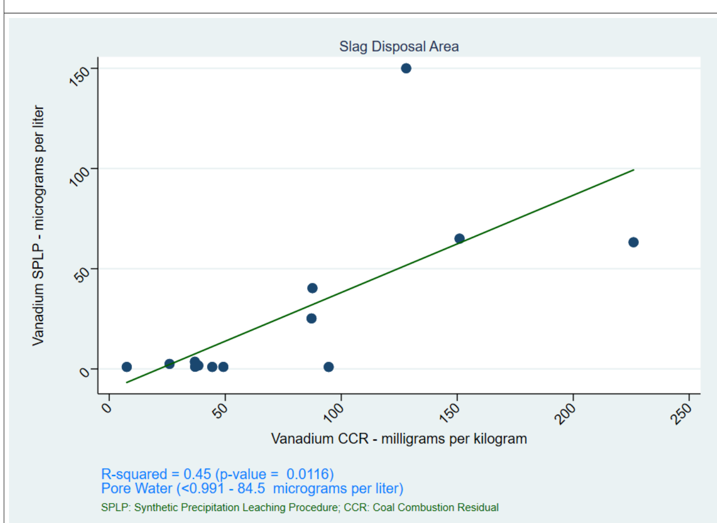


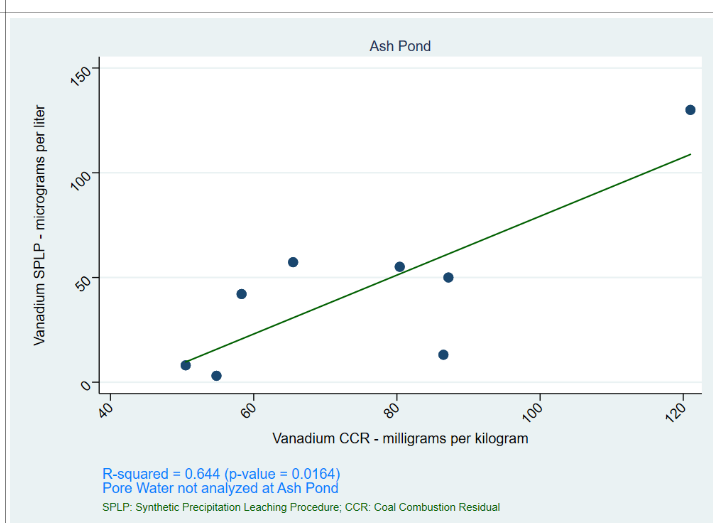


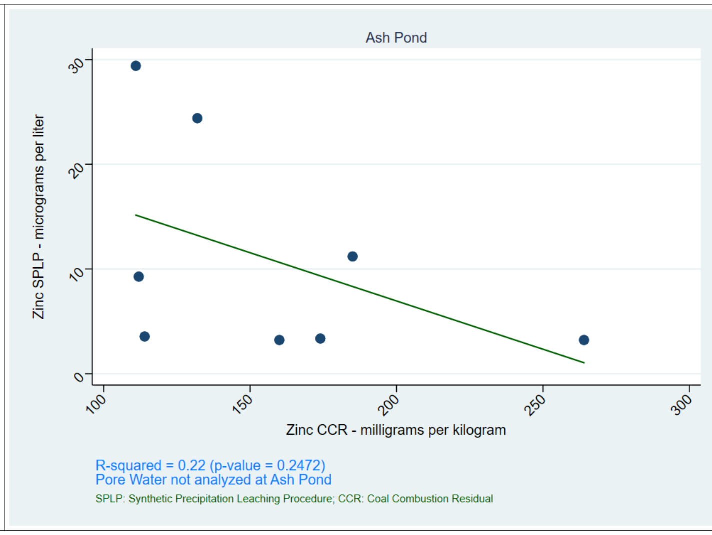
Nickel/Ash Pond, Insufficient Data, > 50% non-Detects in SPLP or CCR Material Data Sets

Silver/Slag Disposal Area, Insufficient Data, > 50% non-Detects in SPLP or CCR Material Data Sets

Silver/Ash Pond, Insufficient Data, > 50% non-Detects in SPLP or CCR Material Data Sets





Zinc/Slag Disposal Area, Insufficient Data, > 50% non-Detects in SPLP or CCR Material Data Sets	

APPENDIX E.3

STATISTICAL ANALYSIS OF GROUNDWATER ANALYTICAL RESULTS

Appendix E.3 - Statistical Analysis of Groundwater Analytical Results

TDEC Commissioner's Order:
Environmental Assessment Report
Watts Bar Fossil Plant
Spring City, Tennessee

March 31, 2024

Prepared for:

Tennessee Valley Authority
Chattanooga, Tennessee

Prepared by:

Stantec Consulting Services Inc.
Lexington, Kentucky

APPENDIX E.3 - STATISTICAL ANALYSIS OF GROUNDWATER ANALYTICAL RESULTS

REVISION LOG

Revision	Description	Date
0	Submittal to TDEC	November 7, 2023
1	Addresses January 31, 2024 TDEC Review Comments and Issued for TDEC	March 31, 2024

Sign-off Sheet

This document entitled Appendix E.3 - Statistical Analysis of Groundwater Analytical Results was prepared by Stantec Consulting Services Inc. ("Stantec") for the account of Tennessee Valley Authority (the "Client"). Any reliance on this document by any third party is strictly prohibited. The material in it reflects Stantec's professional judgment in light of the scope, schedule and other limitations stated in the document and in the contract between Stantec and the Client. The opinions in the document are based on conditions and information existing at the time the document was published and do not consider any subsequent changes. In preparing the document, Stantec did not verify information supplied to it by others. Any use which a third party makes of this document is the responsibility of such third party. Such third party agrees that Stantec shall not be responsible for costs or damages of any kind, if any, suffered by it or any other third party as a result of decisions made or actions taken based on this document.

Prepared by ________________________

Melissa Whitfield Aslund, PhD, Environmental Scientist

Reviewed by ________________________

Chris LaLonde, Risk Assessor

Approved by ________________________

Rebekah Brooks, PG, Senior Principal Hydrogeologist

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APPENDIX E.3 - STATISTICAL ANALYSIS OF GROUNDWATER ANALYTICAL RESULTS

Abbreviations

CASRN	Chemical Abstracts Service Registry Number
CCR	Coal Combustion Residuals
CCR Parameters	Constituents listed in Appendices III and IV of Title 40, Code of Federal Regulations, Part 257 and five inorganic constituents included in Appendix I of Tennessee Rule 0400-11-01-.04
CCR Rule	Title 40, Code of Federal Regulations, Part 257
EAR	Environmental Assessment Report
EI	Environmental Investigation
GSL	Groundwater Screening Level
µg/L	Micrograms Per Liter
NA	Not Available
%	Percent
RCRA	Resource Conservation and Recovery Act
Stantec	Stantec Consulting Services Inc.
TDEC	Tennessee Department of Environment and Conservation
TDS	Total Dissolved Solids
TVA	Tennessee Valley Authority
Unified Guidance	Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities: Unified Guidance
USEPA	United States Environmental Protection Agency
WBF Plant	Watts Bar Fossil Plant

1.0 INTRODUCTION

Stantec Consulting Services Inc. (Stantec) prepared this appendix on behalf of the Tennessee Valley Authority (TVA) to summarize the statistical analyses performed on groundwater quality data to support evaluations conducted for the Environmental Assessment Report (EAR) at the Watts Bar Fossil Plant (WBF Plant) located in Spring City, Tennessee. These statistical analyses include an evaluation of groundwater quality data collected at the WBF Plant for the Tennessee Department of Environment and Conservation (TDEC) Order Environmental Investigation (EI) and in compliance with the TDEC groundwater monitoring program for the Ash Pond coal combustion residuals (CCR) management unit. The statistical analysis in this appendix focused on the parameters listed in Appendices III and IV of Title 40, Code of Federal Regulations, Part 257 (CCR Rule) and five additional inorganic constituents included in Appendix I of Tennessee Rule 0400-11-01-.04 (CCR Parameters) (see Table E.3-1). The wells included in this statistical analysis are listed in Table E.3-2.

The dataset compiled for statistical analysis includes available analytical data for groundwater samples collected from the wells listed in Table E.3-2 between October 2014 and October 2022, although the specific start date and frequency of sampling may vary between wells based on date of well installation and the applicable monitoring program. This time period was selected because it includes the data that met the data quality objectives of the EI.

The complete groundwater quality results for the dataset compiled for statistical analysis are reported in Appendix H.1.

Table E.3-1 – CCR Parameters Evaluated in Statistical Analysis

Parameter	CASRN
CCR Rule Appendix III Parameters	
Boron	7440-42-8
Calcium	7440-70-2
Chloride	16887-00-6
Fluoride[1] (also Appendix IV)	16984-48-8
pH	NA
Sulfate	14808-79-8
TDS	NA
CCR Rule Appendix IV Parameters	
Antimony	7440-36-0
Arsenic	7440-38-2
Barium	7440-39-3
Beryllium	7440-41-7
Cadmium	7440-43-9
Chromium	7440-47-3
Cobalt	7440-48-4
Lead	7439-92-1
Lithium	7439-93-2
Mercury	7439-97-6
Molybdenum	7439-98-7
Radium-226+228	13982-63-3/ 15262-20-1
Selenium	7782-49-2
Thallium	7440-28-0
Additional TDEC Appendix I Parameters	
Copper	7440-50-8
Nickel	7440-02-0
Silver	7440-22-4
Vanadium	7440-62-2
Zinc	7440-66-6

Notes: CASRN - Chemical Abstracts Service Registry Number; CCR – Coal Combustion Residuals; NA - Not available; TDS - Total dissolved solids
[1]Fluoride is both a CCR Rule Appendix III and CCR Rule Appendix IV constituent. In this table and in the results figures and tables for this report, fluoride has been grouped with the Appendix III constituents only to avoid duplication.

Table E.3-2 - Groundwater Monitoring Wells and Parameters Included in Statistical Analysis

Well Location	Well	Program		Parameters Included in Statistical Analysis		
		EI Wells	TDEC Non-Registered Site Wells[1]	CCR Rule Appendix III	CCR Rule Appendix IV	TDEC Appendix I
Background	WBF-103	X	-	X	X	X
Upgradient	MW-1	-	X	X	X	X
	WBF-100	-	X	X	X	X
	WBF-102	X	-	X	X	X
Ash Pond	MW-2	-	X	X	X	X
	MW-3	-	X	X	X	X
	WBF-101	X	-	X	X	X
Slag Disposal Area	WBF-104	X	-	X	X	X
	WBF-105	X	-	X	X	X
	WBF-106	X	-	X	X	X

Notes:
For each well, the program to which the well belongs as well as the parameters evaluated in this statistical analysis are identified with an ‘X’ and highlighted gray. Programs or parameters that are not applicable to that well are indicated with a dash (-).
[1]TDEC Non-Registered Site Wells support the TDEC groundwater monitoring program for the Ash Pond coal combustion residuals (CCR) management unit.

2.0 METHODS

2.1 EXPLORATORY DATA ANALYSIS

The initial step of statistical analysis was the exploratory data analysis. The process of the exploratory data analysis utilizes simple summary statistics (e.g., mean, median, standard deviation, and percentiles) and graphical representations to identify important characteristics of an analytical dataset, such as the center of the data (i.e., mean, median), variation, distribution, patterns, presence of outliers, and randomness.

Summary statistics were calculated for each well-constituent pair. These summary statistics include information such as total number of available samples, frequency of detection, and maximum detected values and detected concentrations for each well-constituent pair. Exploratory data plots for each well-constituent pair (i.e., box plots and time series plots) were also constructed to support a visual review of the data and identify potential outliers.

Outliers are data points that are abnormally high or low as compared to other measurements and may represent anomalous data or data errors. Outliers may also represent natural variation of concentrations in environmental systems. Therefore, where potential outliers were visually identified in box plots or time-series plots, secondary statistical screening was completed using Tukey's procedure to identify extreme outliers (Tukey 1977) followed by statistical testing for outliers (Dixon or Rosner's test, $\alpha=0.05$). Following confirmation of the outliers as statistically significant, a desktop evaluation was conducted to verify that the data points were not errors (e.g., laboratory or transcriptional error). Field forms, data validation reports, and other variables in the dataset that could influence analytical results were also evaluated. If a verifiable error was discovered, the outlier was removed and, if possible, replaced with a corrected value.

In the absence of a verifiable error, additional lines of evidence were reviewed to determine final outlier disposition (e.g., frequency of detection, spatial and temporal variability). If an outlier was identified as suitable for removal from further statistical analysis, a clear and defensible rationale based on multiple lines of evidence was provided. In addition, values that were identified as outliers and removed from further evaluation in the present statistical analysis were retained in the historical database and will be reevaluated for inclusion or exclusion in future statistical analyses of this dataset.

2.2 COMPARISON OF GROUNDWATER QUALITY DATA TO GROUNDWATER SCREENING LEVELS

The United States Environmental Protection Agency (USEPA) document "*Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities: Unified Guidance*" (USEPA 2009; hereafter referred to as the Unified Guidance) describes statistical methods for comparing groundwater concentrations to fixed standards such as the TDEC-approved groundwater screening levels (GSLs) identified in Appendix A.2. In the Unified Guidance, a confidence interval approach is recommended for comparing groundwater monitoring data to a fixed numerical limit. If the underlying population is stable (i.e., no trend is present), then the Unified Guidance indicates that comparison to a fixed standard can be made based on a confidence interval around the mean. However, the Unified Guidance indicates that "*where the data exhibit a trend over time the interval will incorporate not only the natural variability in the underlying population, but also additional variation induced by the trend itself. The net result is a confidence interval that can be much wider than expected for a given confidence level and sample size (n).*" Therefore, in the presence of a statistically significant trend, the Unified Guidance recommends constructing a confidence band around a trend line, where the comparison is made to the fixed standard based on the confidence band as of the most recent evaluated sampling event, rather than a static confidence interval around the mean.

For the groundwater data reviewed herein, these approaches were applied to identify well-constituent pairs where the available data indicate a statistically significant concentration above or equal to the GSL for constituents other than pH, or statistically significant values outside the GSL range for pH. For this dataset, the null hypothesis was that the groundwater concentrations were less than the GSL for constituents other than pH and that levels were within the GSL range for pH. In accordance with the methods described in the Unified Guidance, constituent concentrations were determined to represent a statistically significant concentration above or equal to a GSL for constituents other than pH, only when there were sufficient data to support statistical confidence band or interval evaluation and the applicable lower confidence band or interval was greater than or equal to the GSL as of the most recent sampling event included in the statistical analysis. For pH, which has both an upper and lower GSL, a statistical difference was identified if there were sufficient data to support statistical analysis, and either the applicable lower confidence band or interval was greater than or equal to the upper GSL or the applicable upper confidence band or interval was less than or equal to the lower GSL as of the most recent sampling event included in the statistical analysis. Whether comparison should be made using a confidence band or confidence interval was determined for each well-constituent pair based on the results of a linear regression trend analysis for each well-constituent pair. If no significant linear trend was detected ($p \geq 0.05$ for the regression slope), comparison to the GSLs was completed based on a static confidence interval around the mean. If a statistically significant linear trend was present ($p < 0.05$ for the regression slope), comparison to the GSLs was completed based on a confidence band around the linear regression trend line at the most recent evaluated sampling event. In both cases, the confidence band or intervals were constructed with 98 percent (%) confidence, which correspond to a lower confidence limit with 99% confidence.

Additional details regarding the methods used to compare groundwater quality data to groundwater screening levels are provided below. As described below, the approach adopted for this comparison was dependent on the number of samples available and the proportion of detected concentrations for each well-constituent pair.

2.2.1 Linear Regression Trend Analysis and Confidence Interval/ Confidence Band Evaluation

For well-constituent pairs with five or more samples and at least four detected values, groundwater quality data were compared to GSLs using a linear regression trend analysis and confidence interval/ confidence band evaluation summarized in **Figure E.3-1** (below) and described in more detail in this section.

First, data were screened to identify if there were reported individual values greater than or equal to the GSL for constituents other than pH or outside the GSL range for pH. In the absence of such a value, well-constituent pairs were classified as ‘Green’. If such a value was observed, then linear regression analysis was completed to identify well-constituent pairs with a statistically significant linear trend ($p<0.05$) over the analyzed time period. As noted above, if no statistically significant linear trend was detected ($p\geq0.05$), a static confidence interval around the mean was used for comparison to the GSLs. If a statistically significant linear trend was present ($p<0.05$), a confidence band around the linear regression trend line at the most recent evaluated sampling event was used for comparison to the GSLs. In both cases, 98% confidence intervals were constructed, which correspond to a lower confidence limit with 99% confidence. Non-detect values were conservatively represented at the reported detection limit.

The resulting confidence intervals and confidence bands were then compared to the GSL for the analyzed well-constituent pairs as of the most recent sampling event included in the statistical analysis. For constituents other than pH, well-constituent pairs were classified as ‘Red’, indicating a statistically significant concentration above or equal to the GSL at a 99% confidence level only if the applicable lower confidence band or interval was greater than or equal to the GSL as of the most recent sampling event included in the statistical analysis (see examples in **Figure E.3-2** below). For pH, well-constituent pairs were classified as ‘Red’, indicating a statistically significant difference from the GSL range at a 99% confidence level, if the applicable lower confidence band or interval was greater than or equal to the upper GSL or if the applicable upper confidence interval was less than or equal to the lower GSL as of the most recent sampling event included in the statistical analysis (see examples in **Figure E.3-3** below). The remaining well-constituent pairs with five or more samples and at least four detected values that were not classified as ‘Red’ using the linear regression trend analysis and confidence interval/ confidence band evaluation described above were classified as ‘Green’. The ‘Green’ category indicates that as of the most recent sampling event included in the analysis, constituent levels were not statistically significantly greater than or equal to the GSL (for constituents other than pH) and not statistically greater than or equal to the upper GSL or less than or equal to the lower GSL for pH at a 99% confidence level.

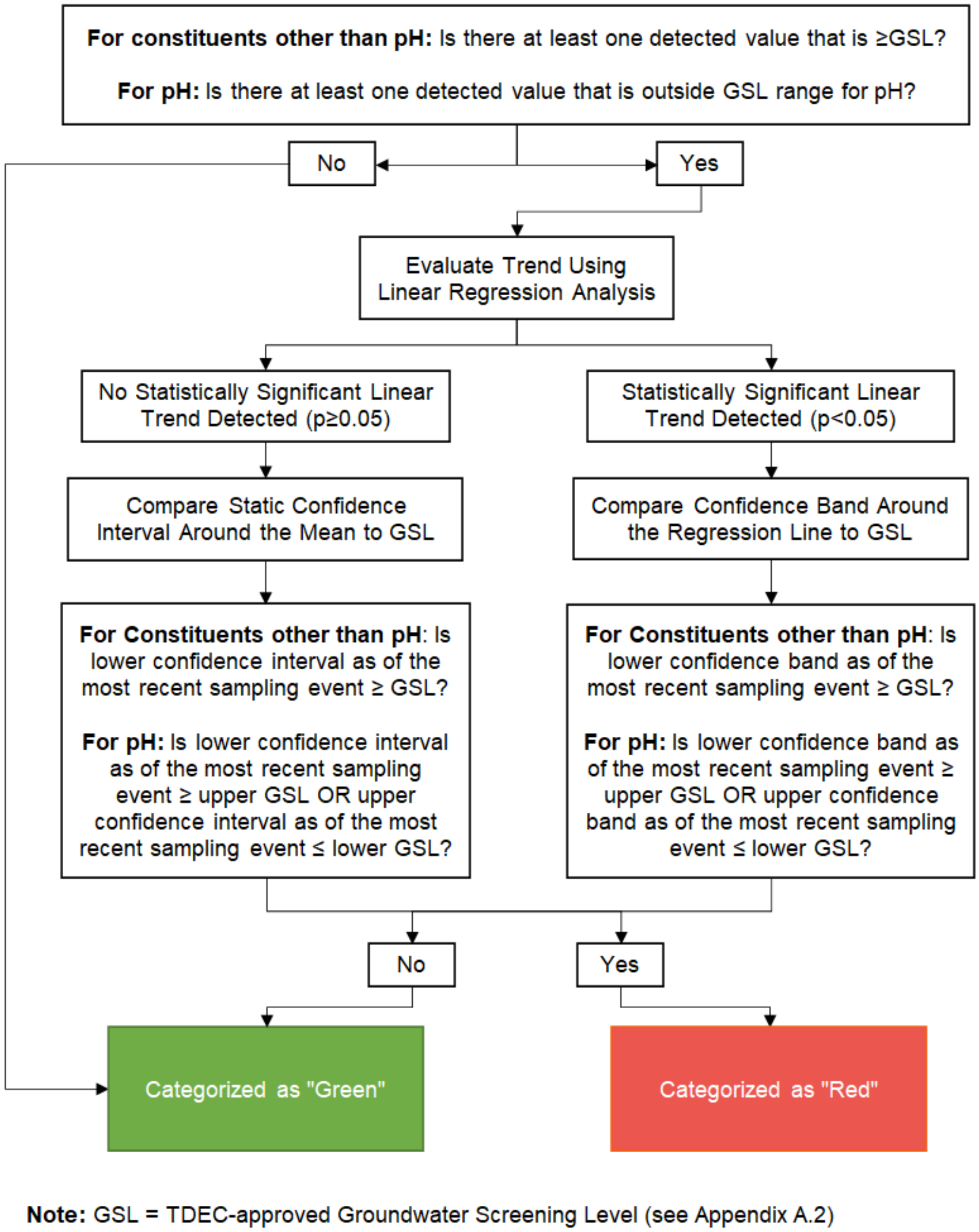

Figure E.3-1 – Flow chart summarizing linear regression trend analysis and confidence interval/ confidence band evaluation

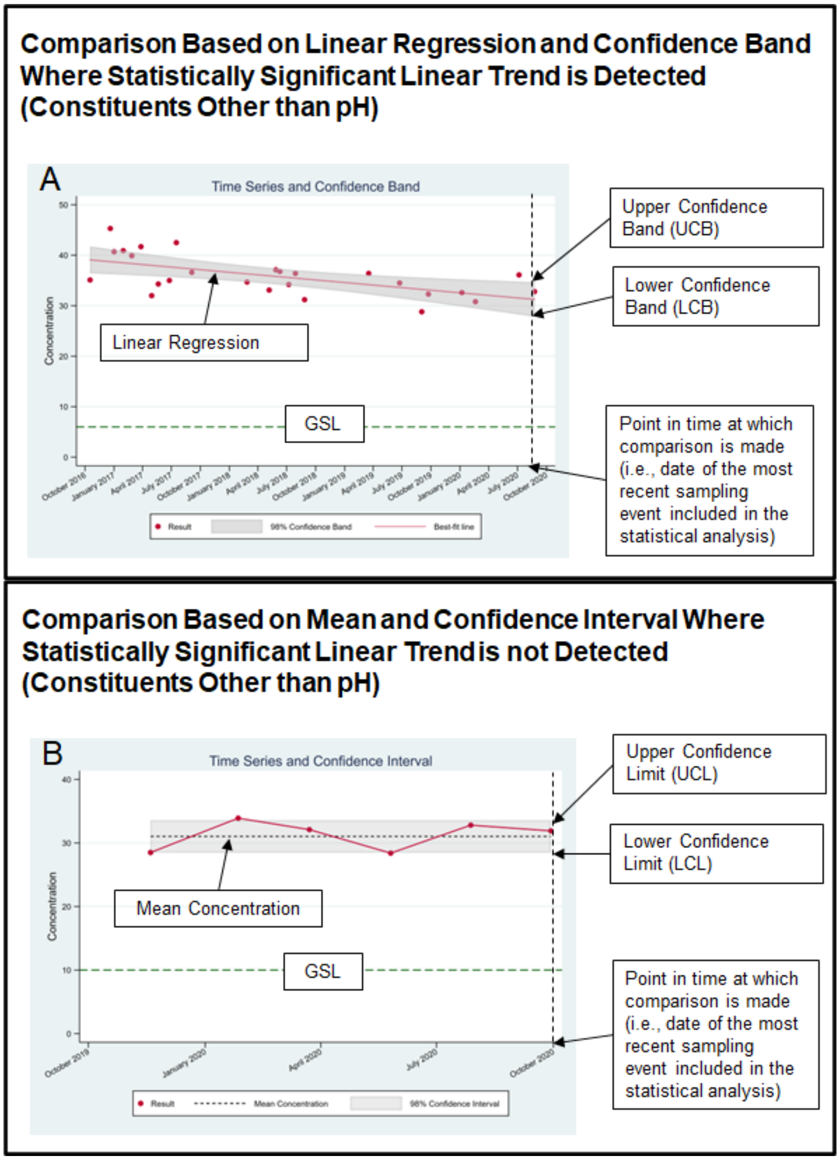

Figure E.3-2 – Examples of well-constituent pairs classified as ‘Red’ for constituents other than pH (A) in the presence of a statistically significant linear trend ($p<0.05$) and (B) in the absence of a statistically significant linear trend ($p\geq0.05$)

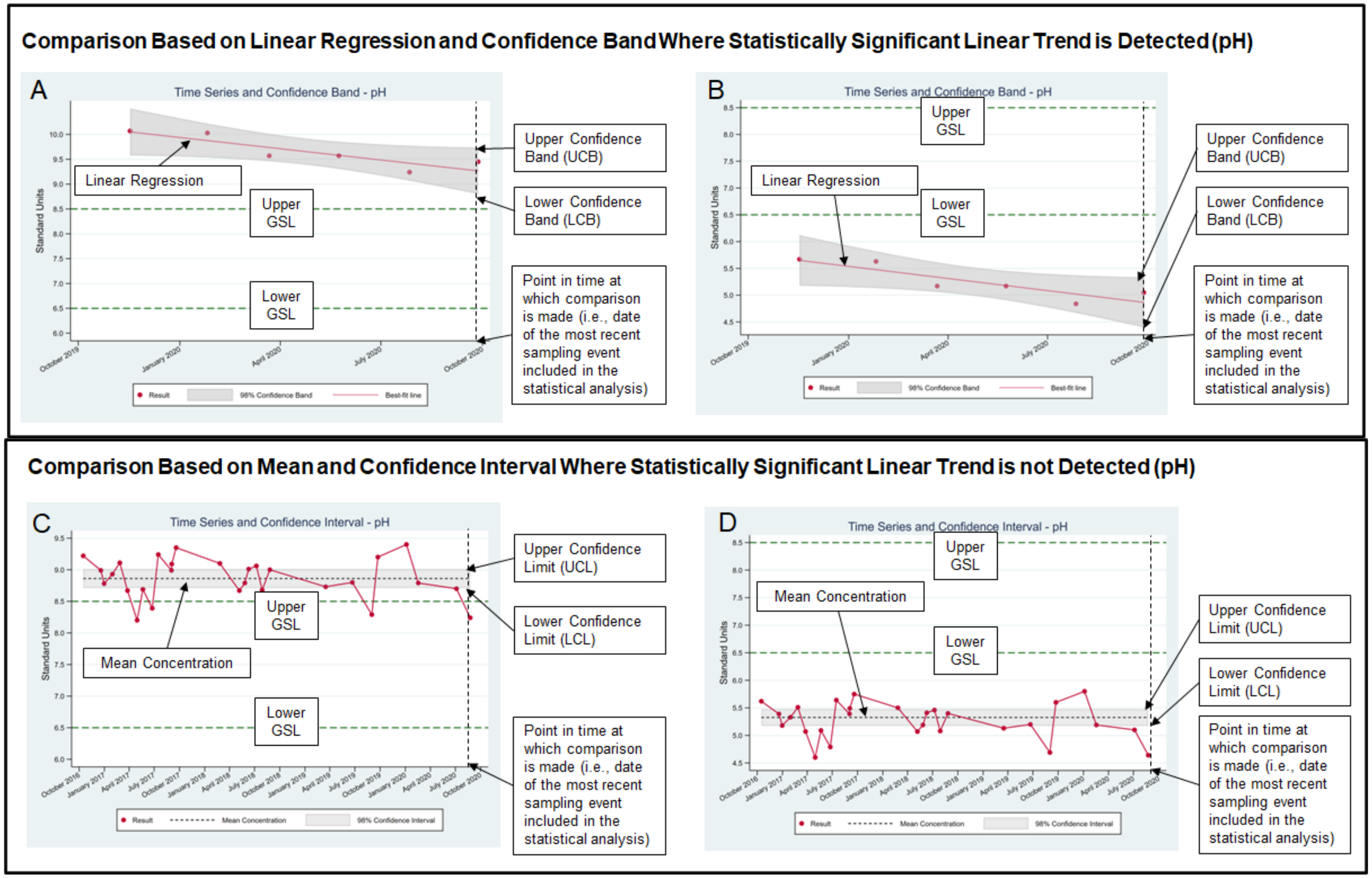

Figure E.3-3 - Examples of well-constituent pairs classified as ‘Red’ for pH (A, B) in the presence of a statistically significant linear trend ($p<0.05$) and (C, D) in the absence of a statistically significant linear trend ($p≥0.05$)

2.2.2 Evaluation for Well-Constituent Pairs Using Point-by-Point Method

Well-constituent pairs with less than five samples in the dataset or less than four detected results were not well suited to a linear regression trend analysis and confidence band or interval evaluation. Therefore, an alternate evaluation was completed for these well-constituent pairs based on a point-by-point comparison of the reported concentration for each sample to the applicable GSL. In this approach, well-constituent pairs were classified as 'Green*,' if there were no detected values that were greater than or equal to the GSL for constituents other than pH, or there were no detected values outside the GSL range for pH. However, if there was a limited dataset (i.e., less than five samples in the dataset or less than four detected results), and at least one value was greater than or equal to the GSL for constituents other than pH or there were detected values outside the GSL range for pH, this triggered further data review and an alternate evaluation of that well-constituent pair. For these well-constituent pairs, the available data were reviewed and alternate statistical approaches were considered (e.g., completing a statistical evaluation resulting in a 'Red' or 'Green' classification as described in Section 2.2.1 using the limited dataset). If such an alternate evaluation was required, then this was clearly identified and additional rationale provided in the applicable sub-sections of Section 3.0.

3.0 RESULTS AND DISCUSSION

3.1 EXPLORATORY DATA ANALYSIS

Summary statistics for each evaluated well-constituent pair are provided in Attachment E.3-A**,** with results grouped by well and sorted by constituent type. Exploratory data analysis plots for each well-constituent pair (i.e., box plots and time-series plots) are provided in Attachments E.3-B and E.3-C. These plots were reviewed to identify potential outliers and provide a qualitative evaluation of data distribution. The plots also provide a preliminary comparison of the results from individual sampling events to the applicable GSLs. There were no outliers removed from further statistical analysis based on this evaluation.

3.2 COMPARISON OF GROUNDWATER QUALITY DATA TO APPROVED GROUNDWATER SCREENING LEVELS

A summary of the results comparing groundwater quality data to GSLs is provided in Table E.3-3. The confidence bands or confidence intervals generated to support this comparison are provided in Attachment E.3-D, and the statistical results of the regression analyses are reported in Attachment E.3-E. Further discussion is provided below.

For most well-constituent pairs that were evaluated by linear regression, no statistically significant trend over time was observed based on the linear regression analyses. Comparison to the GSLs for these well-constituent pairs was completed based on a static confidence interval around the mean as shown in Attachment E.3-D. However, there were two well-constituent pairs where a statistically significant decreasing trend was detected and three well-constituent pairs where a statistically significant increasing trend was detected, as indicated in Attachment E.3-E. Comparison to the GSLs for these well-constituent pairs was completed based on a confidence band around the trend line as shown in in Attachment E.3-D.

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Table E.3-3 – Summary of Statistically Significant Concentrations/Values

Parameter	Background	Upgradient			Ash Pond			Slag Disposal Area		
	WBF-103	MW-1	WBF-100	WBF-102	MW-2	MW-3	WBF-101	WBF-104	WBF-105	WBF-106
CCR Rule Appendix III Parameters										
Boron	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Chloride	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Fluoride[1] (also Appendix IV)	Green	Green	Green	Green	Green	Green	Green	Green*	Green	Green
pH (field)	Red	Red	Red	Green	Red	Red	Green	Red	Green	Red
Sulfate	Green	Green	Green	Green	Green	Green	Green	Red	Red	Red
Total Dissolved Solids	Green	Green	Red	Green	Green	Green	Green	Red	Red	Red
CCR Rule Appendix IV Parameters										
Antimony	Green*	Green*	Green*	Green*	Green*	Green*	Green*	Green*	Green*	Green*
Arsenic	Green*	Green	Green	Green	Green*	Green	Green	Green	Green	Green
Barium	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Beryllium	Green*	Green*	Green*	Green*	Green*	Green*	Green*	Green	Green*	Green*
Cadmium	Green*	Green*	Green*	Green*	Green*	Green*	Green	Red	Green*	Green
Chromium	Green*	Green*	Green*	Green*	Green*	Green*	Green*	Green*	Green*	Green*
Cobalt	Green	Red	Green*	Green[2]	Green*	Green	Green	Red	Green*	Red
Lead	Green*	Green*	Green*	Green*	Green*	Green*	Green*	Green*	Green*	Green*
Lithium	Green*	Green	Green	Green*	Green	Green	Green*	Green	Green*	Green
Mercury	Green*	Green*	Green*	Green*	Green*	Green*	Green*	Green*	Green*	Green*
Molybdenum	Green*	Green*	Green*	Green	Green*	Green*	Green*	Green*	Green*	Green*
Radium-226+228	Green*	Green*	Green*	Green*	Green*	Green*	Green*	Green*	Green*	Green*
Selenium	Green*	Green*	Green*	Green	Green*	Green*	Green*	Green*	Green*	Green*
Thallium	Green*	Green*	Green*	Green	Green*	Green*	Green*	Green*	Green*	Green*
Additional TDEC Appendix I Parameters										
Copper	Green*	Green*	Green*	Green*	Green*	Green*	Green*	Green*	Green*	Green*
Nickel	Green	Green	Green	Green*	Green	Green	Green	Green	Green*	Green
Silver	Green*	Green*	Green*	Green*	Green*	Green*	Green*	Green*	Green*	Green*
Vanadium	Green*	Green	Green*	Green*	Green	Green	Green*	Green*	Green*	Green*
Zinc	Green*	Green	Green*	Green*	Green*	Green*	Green	Green	Green*	Green

Notes:
Green - No statistically significant concentration greater than or equal to the GSL for constituents other than pH and no statistically significant difference outside the GSL range for pH.
Green* - Limited dataset (sample size <5 or <4 detected values), but none of the available results are greater than or equal to the GSL or outside the GSL range for pH.
Red - Statistically significant concentration greater than or equal to the GSL for constituents other than pH or a statistically significant difference outside the GSL range for pH.
Bold colors are used to represent CCR Rule Appendix IV Parameter and TDEC Appendix I Parameter results; subdued colors represent CCR Rule Appendix III Parameter results.
[1]Fluoride is both a CCR Rule Appendix III and CCR Rule Appendix IV constituent. In this table, fluoride has been grouped only with the Appendix III constituents to avoid duplication of results.
[2]For Cobalt at WBF-102, a detected concentration of 11.1 µg/L, which was greater than the GSL (6 µg/L), was observed for a single sampling event in August, 2019. Since that sampling event, cobalt at WBF-102 has been analyzed for an additional eight sampling events that took place between October 2019 and April 2022. The cobalt concentration at WBF-102 has been less than the GSL for cobalt for all eight subsequent sampling events and has been non-detect with a reported detection limit of ≤0.261 for the last seven sampling events. Because there were only two detected values (both from 2019), this well-constituent pair was not initially categorized for analysis by linear regression and confidence band/confidence interval. However, due to the single exceedance of the GSL, a confidence interval was generated for this well-constituent pair based on a replacement of the non-detect values with the full detection limit. The results of this confidence interval analysis are shown in Appendix E.3-D.

In total, 11 well-constituent pairs were identified with CCR Parameters at statistically significant concentrations greater than or equal to the GSL for constituents other than pH. There were also seven wells where a statistically significant difference from the GSL range for pH was observed. The well-constituent pairs with statistically significant concentrations greater than or equal to the GSL or outside the GSL range for pH (i.e., categorized as ‘Red’ in Table E.3-3) are summarized in Table E.3-4.

Table E.3-4 – Summary of Statistically Significant Concentrations Greater than the GSL

Well Location	Well	Appendix III			Appendix IV	
		pH (field)	Sulfate	Total Dissolved Solids	Cadmium	Cobalt
Background	WBF-103	X	-	-	-	-
Upgradient	MW-1	X	-	-	-	X
	WBF-100	X	-	X	-	-
Ash Pond	MW-2	X	-	-	-	-
	MW-3	X	-	-	-	-
Slag Disposal Area	WBF-104	X	X	X	X	X
	WBF-105	-	X	X	-	-
	WBF-106	X	X	X	-	X

Notes
Well-constituent pairs with CCR Parameters at statistically significant concentrations greater than or equal to the GSL for constituents other than pH or outside the GSL range for pH are identified with an ‘X’ and highlighted gray.
Dash (-) indicates the absence of a statistically significant concentration greater than or equal to the GSL or outside the GSL range for pH for that well-constituent pair.

4.0 REFERENCES

Tukey, J.W. (1977). *Exploratory Data Analysis*. Reading, Massachusetts: Addison-Wesley. 1977.

United States Environmental Protection Agency. (2009). *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities: Unified Guidance*. EPA 530/R-09-007, 884 pp.

ATTACHMENT E.3-A
SUMMARY STATISTICS

Summary Statistics - Groundwater Investigation									
Watts Bar Fossil Plant - Spring City, Tennessee									
Parameter	Frequency of Detection	Range of Reporting Limits	% Non Detect	Statistics using Detected Data Only		Statistics using Detects & Non-Detects			
				Minimum Detect	Maximum Detect	Mean	Standard Deviation	50th Percentile	95th Percentile
Well: WBF-103									
CCR Rule Appendix III Parameters									
Boron	5/10	(38.6 - 82.7)	50.0%	41.8	79.5	52.09	13.47	59.45	81.58
Calcium	10/10	--	0.0%	12,800	44,200	24,820	11,232	21,100	42,400
Chloride	10/10	--	0.0%	4,410	6,680	5,223	697.6	5,280	6,208
Fluoride[1] (also Appendix IV)	4/10	(26 - 66.9)	60.0%	27.6	56.2	32.59	9.172	40.25	62.09
pH	9/9	--	0.0%	5.15	5.83	5.509	0.233	5.48	5.814
Sulfate	10/10	--	0.0%	32,900	102,000	65,210	22,298	64,500	95,070
TDS	10/10	--	0.0%	97,000	230,000	168,300	43,955	172,500	226,850
CCR Rule Appendix IV Parameters									
Antimony	0/10	(0.378 - 0.506)	100.0%	--	--	--	--	0.378	0.506
Arsenic	2/10	(0.282 - 0.781)	80.0%	0.324	0.373	0.297	0.03	0.313	0.597
Barium	10/10	--	0.0%	65.8	155	87.47	28.08	76.25	139.3
Beryllium	0/10	(0.182 - 0.274)	100.0%	--	--	--	--	0.182	0.274
Cadmium	0/10	(0.125 - 0.217)	100.0%	--	--	--	--	0.217	0.217
Chromium	1/10	(1.53 - 2.04)	90.0%	1.55	1.55	1.532	0.00629	1.53	1.82
Cobalt	9/10	(0.903 - 0.903)	10.0%	0.317	4.44	1.257	1.192	0.904	3.495
Lead	1/10	(0.128 - 0.167)	90.0%	6.21	6.21	0.736	1.825	0.128	3.491
Lithium	0/10	(0.831 - 4.97)	100.0%	--	--	--	--	3.39	4.259
Mercury	0/10	(0.101 - 0.13)	100.0%	--	--	--	--	0.13	0.13
Molybdenum	0/10	(0.61 - 0.61)	100.0%	--	--	--	--	0.61	0.61
Radium-226+228	0/10	(0 - 0.845)	100.0%	--	--	--	--	0.568	0.835
Selenium	1/10	(0.739 - 1.51)	90.0%	0.93	0.93	0.835	0.0955	1.51	1.51
Thallium	1/10	(0.148 - 0.649)	90.0%	0.172	0.172	0.151	0.0084	0.148	0.569
TDEC Appendix I Parameters									
Copper	1/10	(0.627 - 1.22)	90.0%	2.92	2.92	0.856	0.688	0.627	2.155
Nickel	7/10	(1.38 - 3.4)	30.0%	1.14	3.16	1.707	0.679	1.56	3.292
Silver	0/10	(0.177 - 0.223)	100.0%	--	--	--	--	0.177	0.223
Vanadium	1/10	(0.776 - 1.22)	90.0%	0.999	0.999	0.801	0.0701	0.991	1.121
Zinc	3/10	(2.88 - 8.94)	70.0%	4.66	9.38	4.244	2.145	3.94	9.182
Well: MW-1									
CCR Rule Appendix III Parameters									
Boron	17/17	--	0.0%	679	1320	863.5	141.4	834	1055
Calcium	17/17	--	0.0%	56,500	79,400	69,465	6,537	69,800	79,160
Chloride	17/17	--	0.0%	6,600	8,520	7,360	558.4	7,350	8,184
Fluoride[1] (also Appendix IV)	7/21	(25 - 100)	66.7%	23	42.2	32.51	7.032	100	100
pH	11/11	--	0.0%	5.54	6.34	5.869	0.204	5.87	6.17
Sulfate	17/17	--	0.0%	76,900	102,000	85,412	6,956	84,700	96,640
TDS	17/17	--	0.0%	234,000	432,000	292,941	42,130	287,000	340,800
CCR Rule Appendix IV Parameters									
Antimony	0/21	(0.071 - 2)	100.0%	--	--	--	--	2	2
Arsenic	6/21	(0.313 - 2)	71.4%	0.1	0.487	0.229	0.108	1	2
Barium	21/21	--	0.0%	37.7	53	43.31	4.031	43.1	48.8
Beryllium	2/21	(0.066 - 2)	90.5%	0.054	0.076	0.0613	0.0104	1	2
Cadmium	3/21	(0.084 - 1)	85.7%	0.061	0.071	0.0657	0.00411	1	1
Chromium	2/21	(0.26 - 5)	90.5%	0.29	2.12	0.367	0.402	2	2.12
Cobalt	21/21	--	0.0%	6.27	15.5	10.2	2.199	9.8	14.1
Lead	1/21	(0.037 - 2)	95.2%	0.045	0.045	0.0397	0.00377	1	2
Lithium	17/17	--	0.0%	6.85	12.7	10.16	1.851	10.1	12.54
Mercury	0/21	(0.07 - 0.2)	100.0%	--	--	--	--	0.2	0.2
Molybdenum	0/17	(0.075 - 5)	100.0%	--	--	--	--	0.61	5
Radium-226+228	3/17	(0.0202 - 0.883)	82.4%	0.394	1.876	0.218	0.455	0.426	1.082
Selenium	0/21	(0.067 - 10)	100.0%	--	--	--	--	2	5
Thallium	0/21	(0.041 - 2)	100.0%	--	--	--	--	1	2
TDEC Appendix I Parameters									
Copper	1/21	(0.33 - 10)	95.2%	69.1	69.1	3.605	14.65	2	10
Nickel	20/21	(10 - 10)	4.8%	5.4	11.6	7.255	1.534	6.9	10.5
Silver	0/21	(0.077 - 5)	100.0%	--	--	--	--	1	2
Vanadium	5/21	(0.16 - 4)	76.2%	2.1	5.71	0.935	1.498	1.44	4
Zinc	8/21	(3.22 - 50)	61.9%	0.0758	10.8	4.205	3.179	8.3	25

Summary Statistics - Groundwater Investigation									
Watts Bar Fossil Plant - Spring City, Tennessee									
Parameter	Frequency of Detection	Range of Reporting Limits	% Non Detect	Statistics using Detected Data Only		Statistics using Detects & Non-Detects			
				Minimum Detect	Maximum Detect	Mean	Standard Deviation	50th Percentile	95th Percentile
Well: WBF-100									
CCR Rule Appendix III Parameters									
Boron	14/14	--	0.0%	1,560	2,650	1,799	278.5	1,680	2,247
Calcium	14/14	--	0.0%	141,000	178,000	155,571	10,839	151,500	174,100
Chloride	14/14	--	0.0%	6,390	9,900	7,873	1,245	7,550	9,900
Fluoride[1] (also Appendix IV)	8/13	(100 - 100)	38.5%	25	54.3	35.93	9.205	45.9	100
pH	9/9	--	0.0%	6.01	6.39	6.304	0.12	6.36	6.39
Sulfate	14/14	--	0.0%	169,000	266,000	217,786	28,146	219,000	263,400
TDS	14/14	--	0.0%	488,000	725,000	578,786	58,442	568,500	665,200
CCR Rule Appendix IV Parameters									
Antimony	1/13	(0.071 - 2)	92.3%	0.088	0.088	0.0744	0.0068	0.378	2
Arsenic	5/13	(0.083 - 1)	61.5%	0.13	0.475	0.204	0.136	0.389	1
Barium	13/13	--	0.0%	40.2	108	62.67	19.95	63.4	101.2
Beryllium	0/13	(0.032 - 1)	100.0%	--	--	--	--	0.182	1
Cadmium	1/13	(0.016 - 1)	92.3%	0.029	0.029	0.0225	0.0065	0.217	1
Chromium	0/13	(0.47 - 2.09)	100.0%	--	--	--	--	1.53	2.036
Cobalt	2/13	(0.081 - 0.5)	84.6%	0.109	0.12	0.0922	0.0161	0.134	0.5
Lead	3/13	(0.043 - 1)	76.9%	0.061	0.541	0.149	0.173	0.541	1
Lithium	8/14	(5 - 5)	42.9%	1.6	3.65	2.425	0.912	3.63	5
Mercury	0/13	(0.07 - 0.2)	100.0%	--	--	--	--	0.101	0.2
Molybdenum	0/14	(0.081 - 5)	100.0%	--	--	--	--	0.61	5
Radium-226+228	1/14	(0.116 - 0.814)	92.9%	0.519	0.519	0.156	0.121	0.349	0.783
Selenium	2/13	(0.14 - 5)	84.6%	0.089	0.13	0.11	0.0205	1.51	5
Thallium	0/13	(0.026 - 1)	100.0%	--	--	--	--	0.386	1
TDEC Appendix I Parameters									
Copper	3/13	(0.43 - 2)	76.9%	0.468	0.677	0.498	0.0971	0.65	2
Nickel	8/13	(1 - 1.1)	38.5%	0.53	1.03	0.711	0.155	0.926	1.058
Silver	0/13	(0.077 - 1)	100.0%	--	--	--	--	0.177	1
Vanadium	2/13	(0.16 - 1.5)	84.6%	0.32	1.22	0.285	0.302	0.991	1.458
Zinc	3/13	(2 - 8.3)	76.9%	4.4	24.1	4.355	5.835	5	14.62
Well: WBF-102									
CCR Rule Appendix III Parameters									
Boron	7/9	(71.2 - 105)	22.2%	42	90.8	66.13	16.02	71.2	99.32
Calcium	9/9	--	0.0%	89,300	309,000	158,833	73,750	131,000	273,400
Chloride	9/9	--	0.0%	4,150	37,800	15,188	11,404	12,200	33,000
Fluoride[1] (also Appendix IV)	5/9	(41.5 - 126)	44.4%	43.9	98.9	59.69	19.34	62.9	115.2
pH	8/8	--	0.0%	6.52	6.98	6.771	0.175	6.79	6.966
Sulfate	9/9	--	0.0%	90,200	664,000	281,800	213,084	179,000	616,400
TDS	9/9	--	0.0%	386,000	1,280,000	704,222	347,094	562,000	1,224,000
CCR Rule Appendix IV Parameters									
Antimony	0/9	(0.378 - 0.506)	100.0%	--	--	--	--	0.378	0.455
Arsenic	5/9	(0.313 - 0.866)	44.4%	0.369	0.495	0.398	0.0713	0.464	0.718
Barium	9/9	--	0.0%	23.7	61.5	43.57	13.92	42.9	61.14
Beryllium	0/9	(0.182 - 0.486)	100.0%	--	--	--	--	0.182	0.401
Cadmium	2/9	(0.217 - 0.217)	77.8%	0.127	0.178	0.153	0.0255	0.217	0.217
Chromium	3/9	(1.53 - 2.74)	66.7%	1.91	2.39	1.738	0.299	1.53	2.6
Cobalt	2/9	(0.134 - 0.261)	77.8%	1.15	11.1	1.465	3.421	0.134	7.12
Lead	1/9	(0.128 - 0.128)	88.9%	0.199	0.199	0.136	0.0223	0.128	0.171
Lithium	1/9	(0.831 - 5.63)	88.9%	4.23	4.23	1.256	1.124	3.39	5.07
Mercury	3/9	(0.101 - 0.13)	66.7%	0.543	1.23	0.327	0.369	0.13	0.964
Molybdenum	5/9	(0.61 - 1.62)	44.4%	0.648	4.32	1.296	1.274	0.656	3.736
Radium-226+228	0/9	(0.15 - 1.394)	100.0%	--	--	--	--	0.6	1.216
Selenium	5/9	(1.51 - 1.51)	44.4%	1.89	5.48	2.281	1.194	1.89	4.28
Thallium	4/9	(0.148 - 0.148)	55.6%	0.23	0.589	0.229	0.135	0.148	0.459
TDEC Appendix I Parameters									
Copper	2/9	(0.627 - 2.06)	77.8%	0.67	1.02	0.701	0.143	0.804	1.92
Nickel	2/9	(0.336 - 1.31)	77.8%	0.397	2.21	0.558	0.585	0.517	1.85
Silver	0/9	(0.177 - 0.223)	100.0%	--	--	--	--	0.177	0.205
Vanadium	2/9	(0.776 - 0.991)	77.8%	1.57	1.68	0.965	0.354	0.991	1.636
Zinc	2/9	(3.22 - 7.24)	77.8%	3.07	4.14	3.223	0.374	3.22	6.844

Summary Statistics - Groundwater Investigation									
Watts Bar Fossil Plant - Spring City, Tennessee									
Parameter	Frequency of Detection	Range of Reporting Limits	% Non Detect	Statistics using Detected Data Only		Statistics using Detects & Non-Detects			
				Minimum Detect	Maximum Detect	Mean	Standard Deviation	50th Percentile	95th Percentile
Well: MW-2									
CCR Rule Appendix III Parameters									
Boron	17/17	--	0.0%	86.6	1740	355.5	525.8	125	1636
Calcium	17/17	--	0.0%	25,800	70,400	38,382	13,061	34,600	69,840
Chloride	17/17	--	0.0%	1,300	9,370	3,057	2,437	1,900	7,674
Fluoride[1] (also Appendix IV)	7/21	(60 - 100)	66.7%	53	84	62.76	8.789	100	100
pH	11/11	--	0.0%	5.89	6.33	6.205	0.147	6.28	6.33
Sulfate	17/17	--	0.0%	19,900	73,000	35,588	13,088	33,800	57,960
TDS	17/17	--	0.0%	86,000	299,000	163,294	58,909	148,000	297,400
CCR Rule Appendix IV Parameters									
Antimony	0/21	(0.071 - 2)	100.0%	--	--	--	--	2	2
Arsenic	1/21	(0.083 - 2)	95.2%	0.332	0.332	0.114	0.0823	1	2
Barium	21/21	--	0.0%	31.3	83.1	49.37	16.09	43.6	78.2
Beryllium	0/21	(0.032 - 2)	100.0%	--	--	--	--	1	2
Cadmium	2/21	(0.018 - 1)	90.5%	0.04	0.065	0.0318	0.0187	1	1
Chromium	1/21	(0.2 - 5)	95.2%	2.97	2.97	0.339	0.604	2	2.97
Cobalt	2/21	(0.081 - 2)	90.5%	0.079	0.65	0.127	0.158	0.5	2
Lead	0/21	(0.028 - 2)	100.0%	--	--	--	--	1	2
Lithium	5/17	(2.56 - 50)	70.6%	0.42	0.59	0.534	0.0618	3.39	14
Mercury	0/21	(0.07 - 0.2)	100.0%	--	--	--	--	0.2	0.2
Molybdenum	0/17	(0.081 - 5)	100.0%	--	--	--	--	0.61	5
Radium-226+228	3/17	(0.015 - 0.713)	82.4%	0.33	0.605	0.12	0.195	0.33	0.678
Selenium	0/21	(0.067 - 10)	100.0%	--	--	--	--	2	5
Thallium	0/21	(0.026 - 2)	100.0%	--	--	--	--	1	2
TDEC Appendix I Parameters									
Copper	2/21	(0.33 - 10)	90.5%	0.59	0.816	0.429	0.172	2	2
Nickel	4/21	(0.18 - 10)	81.0%	0.21	2.15	0.329	0.421	1	2.15
Silver	1/21	(0.077 - 5)	95.2%	0.087	0.087	0.082	0.005	1	2
Vanadium	10/21	(0.27 - 4)	52.4%	0.16	5.66	1.3	1.734	1.42	5.61
Zinc	1/21	(1.9 - 50)	95.2%	2.3	2.3	1.98	0.16	8.3	25
Well: MW-3									
CCR Rule Appendix III Parameters									
Boron	16/16	--	0.0%	147	2,030	749.6	494.4	600	1,490
Calcium	16/16	--	0.0%	29,800	79,200	55,088	12,052	54,100	72,300
Chloride	16/16	--	0.0%	1,890	7,040	3,716	1,560	3,175	6,253
Fluoride[1] (also Appendix IV)	8/21	(100 - 100)	61.9%	51	80.9	57.59	9.078	100	100
pH	10/10	--	0.0%	5.96	6.29	6.129	0.0985	6.125	6.259
Sulfate	16/16	--	0.0%	21,800	118,000	47,319	27,571	37,150	102,175
TDS	16/16	--	0.0%	129,000	343,000	210,500	57,467	203,000	316,750
CCR Rule Appendix IV Parameters									
Antimony	0/21	(0.071 - 2)	100.0%	--	--	--	--	2	2
Arsenic	5/21	(0.14 - 2)	76.2%	0.099	0.38	0.149	0.0884	1	2
Barium	21/21	--	0.0%	34.7	132	91.05	25.2	94.3	120
Beryllium	0/21	(0.032 - 2)	100.0%	--	--	--	--	1	2
Cadmium	1/21	(0.016 - 1)	95.2%	0.12	0.12	0.0368	0.0416	1	1
Chromium	2/21	(0.64 - 5)	90.5%	1.4	2.74	0.889	0.518	2	2.74
Cobalt	4/21	(0.081 - 2)	81.0%	0.264	0.87	0.249	0.256	0.687	2
Lead	1/21	(0.028 - 2)	95.2%	0.138	0.138	0.0437	0.0385	1	2
Lithium	5/16	(2.56 - 50)	68.8%	0.55	0.8	0.64	0.108	3.39	16.25
Mercury	0/21	(0.07 - 0.2)	100.0%	--	--	--	--	0.2	0.2
Molybdenum	2/16	(0.08 - 5)	87.5%	0.089	0.13	0.0936	0.0186	0.61	5
Radium-226+228	3/16	(0.0834 - 0.794)	81.3%	0.16	0.68	0.171	0.183	0.403	0.787
Selenium	3/21	(0.14 - 10)	85.7%	0.075	0.2	0.115	0.05	2	5
Thallium	0/21	(0.026 - 2)	100.0%	--	--	--	--	1	2
TDEC Appendix I Parameters									
Copper	2/21	(0.42 - 10)	90.5%	0.405	1.7	0.567	0.428	2	2
Nickel	6/21	(0.17 - 10)	71.4%	0.44	1.3	0.559	0.367	1.02	2
Silver	0/21	(0.077 - 5)	100.0%	--	--	--	--	1	2
Vanadium	13/21	(0.991 - 4)	38.1%	0.35	5.7	1.52	1.589	1.57	4.29
Zinc	2/21	(1.9 - 50)	90.5%	2.4	3.8	2.279	0.653	5	25

Summary Statistics - Groundwater Investigation									
Watts Bar Fossil Plant - Spring City, Tennessee									
Parameter	Frequency of Detection	Range of Reporting Limits	% Non Detect	Statistics using Detected Data Only		Statistics using Detects & Non-Detects			
				Minimum Detect	Maximum Detect	Mean	Standard Deviation	50th Percentile	95th Percentile
Well: WBF-101									
CCR Rule Appendix III Parameters									
Boron	7/10	(38.6 - 76.4)	30.0%	42.5	2,030	503.4	674	83.4	1,783
Calcium	10/10	--	0.0%	105,000	302,000	164,400	66,029	145,000	279,050
Chloride	10/10	--	0.0%	4,600	9,960	6,656	1,480	6,575	8,781
Fluoride[1] (also Appendix IV)	6/10	(60.2 - 110)	40.0%	39.6	128	62.12	23.29	62	119.9
pH	9/9	--	0.0%	5.76	6.79	6.416	0.355	6.48	6.742
Sulfate	10/10	--	0.0%	158,000	884,000	406,800	249,260	349,000	844,850
TDS	10/10	--	0.0%	425,000	1,340,000	740,900	332,465	640,500	1,317,500
CCR Rule Appendix IV Parameters									
Antimony	0/10	(0.378 - 1.07)	100.0%	--	--	--	--	0.378	0.816
Arsenic	8/10	(1.19 - 2.18)	20.0%	0.644	1.94	1.121	0.456	1.25	2.072
Barium	10/10	--	0.0%	29.9	466	204.2	157.5	169.5	443.5
Beryllium	2/10	(0.182 - 0.317)	80.0%	0.213	0.338	0.202	0.0466	0.198	0.329
Cadmium	4/10	(0.125 - 0.414)	60.0%	0.668	3.76	0.821	1.179	0.316	3.121
Chromium	0/10	(1.53 - 1.53)	100.0%	--	--	--	--	1.53	1.53
Cobalt	10/10	--	0.0%	0.462	297	72.7	111.4	4.045	275
Lead	1/10	(0.128 - 0.167)	90.0%	0.238	0.238	0.139	0.033	0.128	0.206
Lithium	3/10	(0.831 - 3.39)	70.0%	2.24	4.23	2.031	1.179	3.39	4.037
Mercury	1/10	(0.101 - 0.13)	90.0%	0.16	0.16	0.107	0.0177	0.13	0.147
Molybdenum	0/10	(0.61 - 0.61)	100.0%	--	--	--	--	0.61	0.61
Radium-226+228	1/10	(0 - 1.159)	90.0%	0.948	0.948	0.105	0.298	0.705	1.064
Selenium	0/10	(0.739 - 1.51)	100.0%	--	--	--	--	1.51	1.51
Thallium	1/10	(0.148 - 0.692)	90.0%	0.19	0.19	0.155	0.0157	0.169	0.593
TDEC Appendix I Parameters									
Copper	0/10	(0.627 - 4.36)	100.0%	--	--	--	--	0.627	2.911
Nickel	4/10	(0.336 - 1.72)	60.0%	10.5	47.3	11.82	17.04	1.126	44.15
Silver	0/10	(0.177 - 0.223)	100.0%	--	--	--	--	0.177	0.223
Vanadium	0/10	(0.776 - 0.991)	100.0%	--	--	--	--	0.991	0.991
Zinc	6/10	(2.88 - 3.88)	40.0%	8.02	145	38.52	51.83	8.815	137.4
Well: WBF-104									
CCR Rule Appendix III Parameters									
Boron	10/10	--	0.0%	1,910	5,320	4,095	1,020	4,095	5,244
Calcium	10/10	--	0.0%	208,000	604,000	487,000	113,641	509,500	593,650
Chloride	10/10	--	0.0%	2,950	11,100	6,410	2,116	6,220	9,480
Fluoride[1] (also Appendix IV)	2/10	(32.8 - 149)	80.0%	36.8	77.7	39.57	13.61	65	116.9
pH	10/10	--	0.0%	5.32	5.78	5.464	0.137	5.48	5.672
Sulfate	10/10	--	0.0%	726,000	1,970,000	1,550,600	359,610	1,640,000	1,920,500
TDS	10/10	--	0.0%	1,050,000	2,810,000	2,093,000	573,257	2,225,000	2,769,500
CCR Rule Appendix IV Parameters									
Antimony	0/10	(0.378 - 0.506)	100.0%	--	--	--	--	0.378	0.506
Arsenic	5/10	(0.282 - 0.872)	50.0%	0.318	0.701	0.451	0.14	0.538	0.795
Barium	10/10	--	0.0%	19.7	43.4	27.13	8.436	22.85	41.11
Beryllium	5/10	(0.182 - 0.274)	50.0%	0.182	0.309	0.214	0.0395	0.227	0.293
Cadmium	10/10	--	0.0%	6.08	10.9	8.47	1.576	8.37	10.72
Chromium	0/10	(1.53 - 1.7)	100.0%	--	--	--	--	1.53	1.624
Cobalt	10/10	--	0.0%	167	598	404.8	149.7	408	597.1
Lead	2/10	(0.128 - 0.218)	80.0%	0.178	0.232	0.145	0.0335	0.167	0.226
Lithium	4/10	(3.39 - 7.07)	60.0%	3.54	4.06	3.584	0.248	3.565	6.58
Mercury	0/10	(0.101 - 0.13)	100.0%	--	--	--	--	0.13	0.13
Molybdenum	0/10	(0.61 - 0.61)	100.0%	--	--	--	--	0.61	0.61
Radium-226+228	3/10	(0.0847 - 1.002)	70.0%	0.758	1.366	0.403	0.463	0.739	1.202
Selenium	0/10	(0.739 - 1.51)	100.0%	--	--	--	--	1.51	1.51
Thallium	1/10	(0.148 - 0.472)	90.0%	0.158	0.158	0.15	0.00373	0.153	0.472
TDEC Appendix I Parameters									
Copper	1/10	(0.627 - 2.1)	90.0%	1.06	1.06	0.689	0.152	0.753	1.668
Nickel	10/10	--	0.0%	32.2	105	70.71	23.25	67.2	102.3
Silver	0/10	(0.177 - 0.223)	100.0%	--	--	--	--	0.177	0.223
Vanadium	1/10	(0.776 - 1.18)	90.0%	1.02	1.02	0.803	0.0767	0.991	1.108
Zinc	10/10	--	0.0%	48	241	131.2	56.41	119	215.8

Summary Statistics - Groundwater Investigation Watts Bar Fossil Plant - Spring City, Tennessee									
Parameter	**Frequency of Detection**	**Range of Reporting Limits**	**% Non Detect**	**Statistics using Detected Data Only**		**Statistics using Detects & Non-Detects**			
				Minimum Detect	**Maximum Detect**	**Mean**	**Standard Deviation**	**50th Percentile**	**95th Percentile**
Well: WBF-105									
CCR Rule Appendix III Parameters									
Boron	5/10	(38.6 - 114)	50.0%	47.8	64.5	48.2	8.119	51	91.73
Calcium	10/10	--	0.0%	127,000	140,000	133,300	4,322	133,000	139,550
Chloride	10/10	--	0.0%	4,240	7,860	5,710	898.6	5,570	7,032
Fluoride[1] (also Appendix IV)	5/10	(74.1 - 139)	50.0%	53	79.3	68.09	10.1	79.15	135.9
pH	10/10	--	0.0%	6.51	6.73	6.618	0.091	6.635	6.721
Sulfate	10/10	--	0.0%	326,000	354,000	341,600	9,192	342,500	352,200
TDS	10/10	--	0.0%	640,000	716,000	680,300	26,411	678,500	713,300
CCR Rule Appendix IV Parameters									
Antimony	1/10	(0.378 - 0.563)	90.0%	0.584	0.584	0.399	0.0618	0.378	0.575
Arsenic	7/10	(1.27 - 1.7)	30.0%	1.22	1.54	1.317	0.0972	1.32	1.628
Barium	10/10	--	0.0%	92	112	100.1	6.377	98.3	111.1
Beryllium	0/10	(0.182 - 0.347)	100.0%	--	--	--	--	0.182	0.314
Cadmium	0/10	(0.125 - 0.217)	100.0%	--	--	--	--	0.217	0.217
Chromium	0/10	(1.53 - 10.9)	100.0%	--	--	--	--	1.53	6.913
Cobalt	2/10	(0.134 - 0.262)	80.0%	0.113	0.151	0.119	0.0142	0.143	0.262
Lead	0/10	(0.128 - 0.167)	100.0%	--	--	--	--	0.128	0.167
Lithium	1/10	(0.831 - 6.41)	90.0%	1.16	1.16	0.996	0.165	3.39	5.983
Mercury	0/10	(0.101 - 0.13)	100.0%	--	--	--	--	0.13	0.13
Molybdenum	2/10	(0.61 - 0.61)	80.0%	0.615	1.4	0.69	0.237	0.61	1.047
Radium-226+228	3/10	(0.438 - 0.939)	70.0%	1.236	1.512	0.713	0.424	0.764	1.423
Selenium	0/10	(0.739 - 1.51)	100.0%	--	--	--	--	1.51	1.51
Thallium	1/10	(0.148 - 0.472)	90.0%	0.294	0.294	0.169	0.0511	0.148	0.472
TDEC Appendix I Parameters									
Copper	1/10	(0.627 - 1.14)	90.0%	0.93	0.93	0.67	0.106	0.682	1.14
Nickel	0/10	(0.336 - 0.865)	100.0%	--	--	--	--	0.336	0.708
Silver	0/10	(0.177 - 0.223)	100.0%	--	--	--	--	0.177	0.223
Vanadium	2/10	(0.776 - 0.991)	80.0%	1.01	1.4	0.862	0.192	0.991	1.225
Zinc	2/10	(2.88 - 4.51)	80.0%	3.05	4.39	3.123	0.455	3.22	4.456
Well: WBF-106									
CCR Rule Appendix III Parameters									
Boron	7/10	(57.7 - 252)	30.0%	66.4	260	168.2	78.81	206	256.4
Calcium	10/10	--	0.0%	132,000	163,000	152,300	11,870	159,000	162,550
Chloride	10/10	--	0.0%	3,300	7,790	4,936	1,438	4,690	7,484
Fluoride[1] (also Appendix IV)	6/10	(77.8 - 133)	40.0%	26.7	89.9	53.69	20.57	71	132.6
pH	10/10	--	0.0%	5.46	6.32	5.738	0.311	5.6	6.235
Sulfate	10/10	--	0.0%	427,000	550,000	485,500	41,674	482,500	539,650
TDS	10/10	--	0.0%	636,000	891,000	794,300	84,782	792,000	888,300
CCR Rule Appendix IV Parameters									
Antimony	0/10	(0.378 - 0.506)	100.0%	--	--	--	--	0.378	0.506
Arsenic	5/10	(0.282 - 1.66)	50.0%	0.382	1.7	0.57	0.4	0.732	1.682
Barium	10/10	--	0.0%	17.6	51.4	31.58	10.32	31.7	47.22
Beryllium	2/10	(0.182 - 0.642)	80.0%	0.186	0.198	0.185	0.00554	0.184	0.476
Cadmium	8/10	(0.125 - 0.217)	20.0%	0.218	0.98	0.519	0.307	0.495	0.97
Chromium	0/10	(1.53 - 1.76)	100.0%	--	--	--	--	1.53	1.657
Cobalt	10/10	--	0.0%	2.19	80.7	52.54	28.75	64.15	79.67
Lead	2/10	(0.128 - 0.223)	80.0%	0.137	0.251	0.142	0.0365	0.138	0.238
Lithium	4/10	(3.39 - 3.81)	60.0%	2.1	3.93	2.524	0.683	3.39	3.885
Mercury	0/10	(0.101 - 0.13)	100.0%	--	--	--	--	0.13	0.13
Molybdenum	0/10	(0.61 - 0.61)	100.0%	--	--	--	--	0.61	0.61
Radium-226+228	2/10	(0.0967 - 1.334)	80.0%	0.659	1.785	0.338	0.517	0.626	1.582
Selenium	0/10	(0.739 - 1.51)	100.0%	--	--	--	--	1.51	1.51
Thallium	0/10	(0.148 - 0.57)	100.0%	--	--	--	--	0.151	0.526
TDEC Appendix I Parameters									
Copper	0/10	(0.627 - 3.89)	100.0%	--	--	--	--	0.627	2.909
Nickel	9/10	(1.79 - 1.79)	10.0%	0.359	16.5	10.12	5.751	12.75	16.19
Silver	0/10	(0.177 - 0.223)	100.0%	--	--	--	--	0.177	0.223
Vanadium	1/10	(0.776 - 0.991)	90.0%	1.01	1.01	0.799	0.0702	0.991	1.001
Zinc	9/10	(5.44 - 5.44)	10.0%	6.09	42.1	25.53	12.53	30.2	39.13

Notes

CCR Rule - Title 40, Code of Federal Regulations, Part 257

TDEC - Tennessee Department of Environment and Conservation

"--" - Not Applicable

Except for Radium-226 + 228, and pH, all units micrograms per liter (μg/L).

Units for Radium 226+228 are picocuries per liter (pCi/L).

Units for pH are standard units (SU).

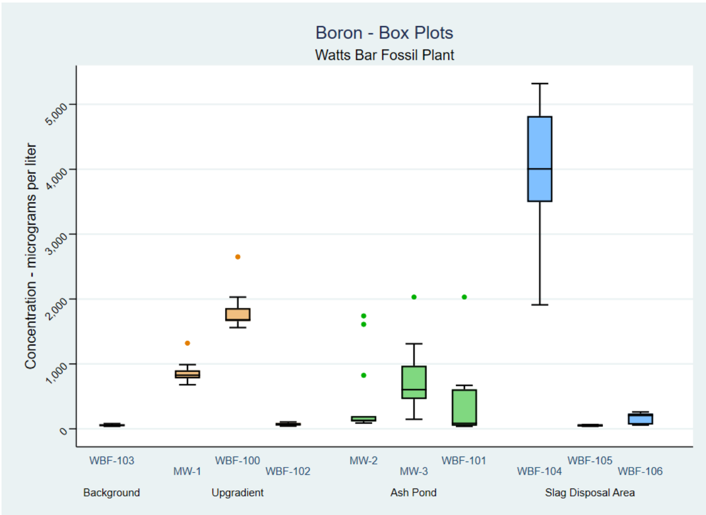
Mean and Standard Deviation are Kaplan Meier (KM) Mean and Standard Deviation for data with reported non-detect values.

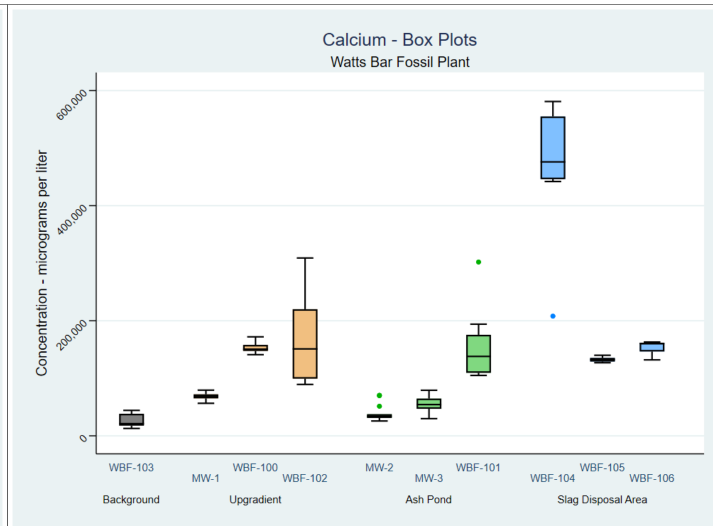
All non-detects reported at the laboratory reporting limit

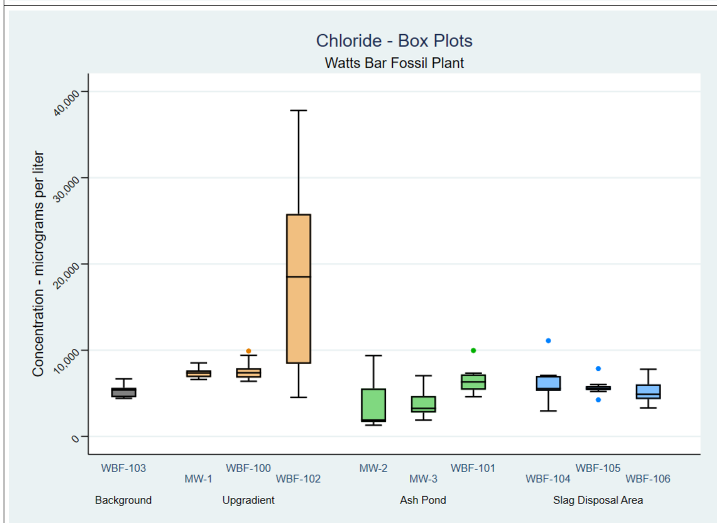
[1]Fluoride is both a CCR Rule Appendix III and CCR Rule Appendix IV constituent. In this table, fluoride has been grouped with the Appendix III constituents only to avoid duplication of results.

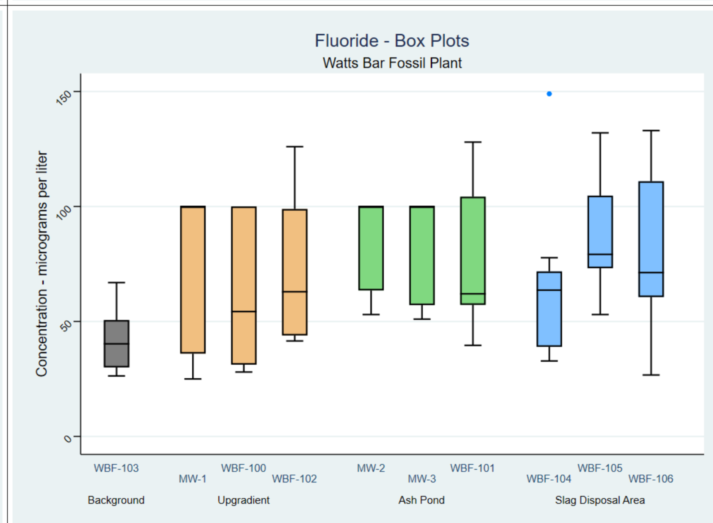
ATTACHMENT E.3-B
BOX PLOTS

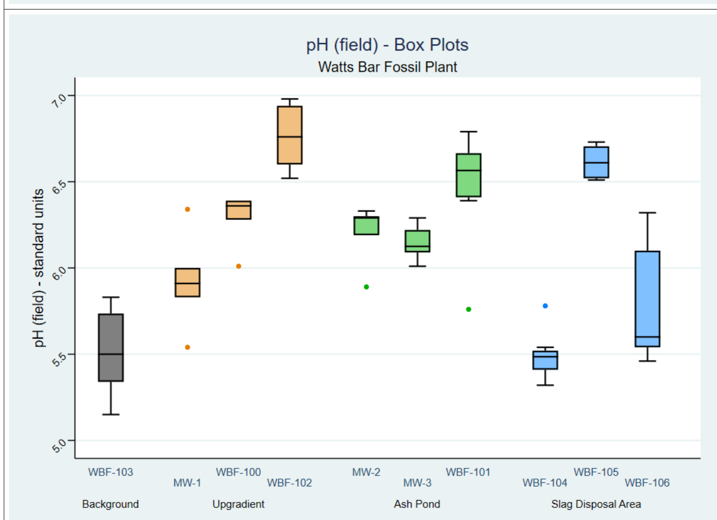
Box Plots
CCR Rule Appendix III Parameters
Watts Bar Fossil Plant - Spring City, Tennessee

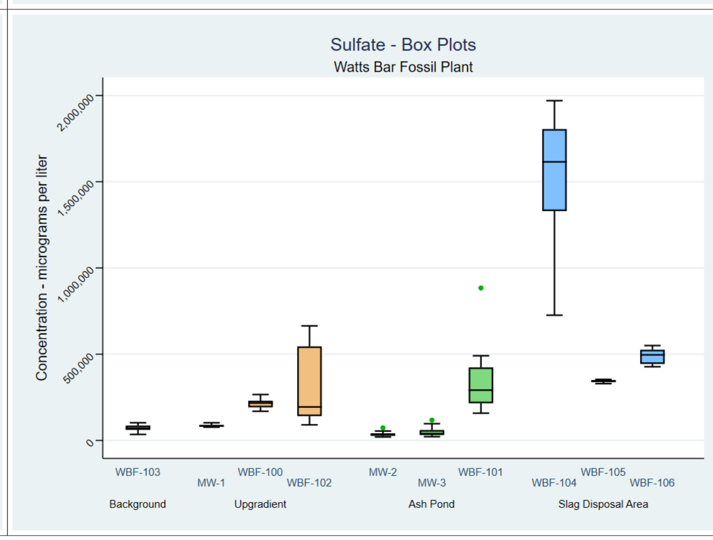


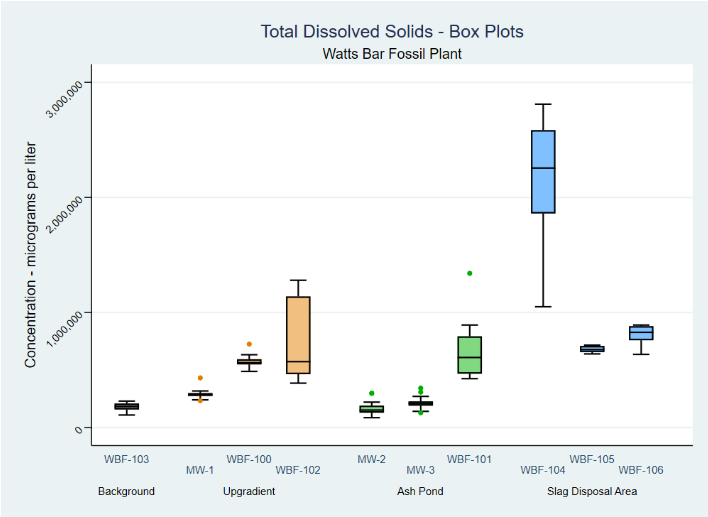












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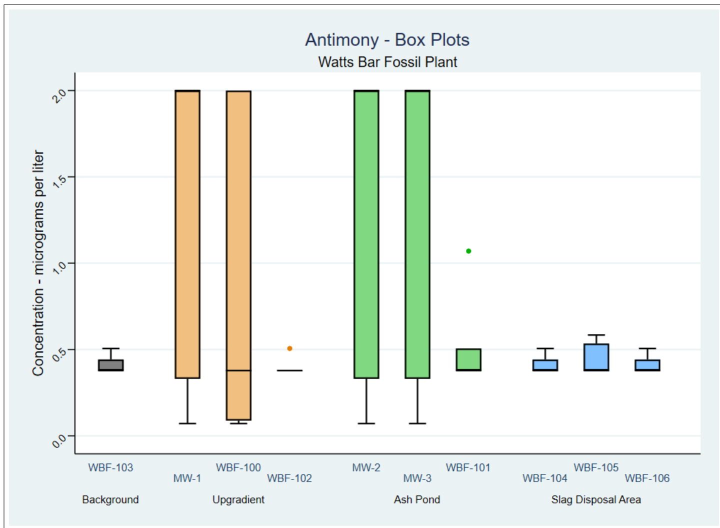
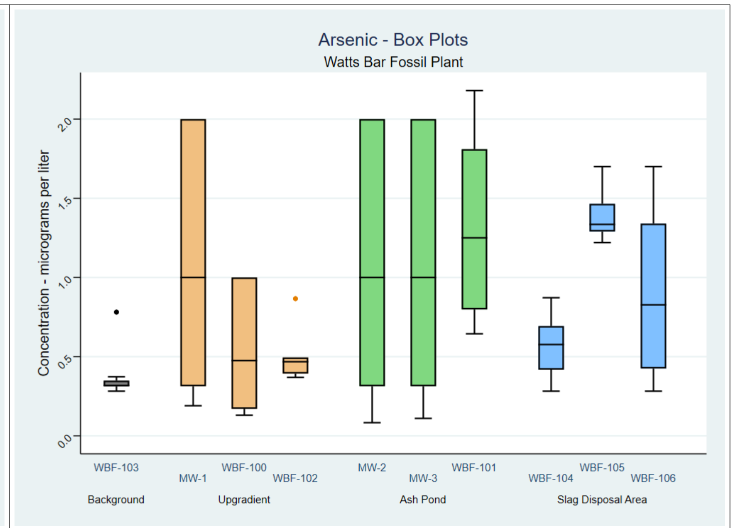
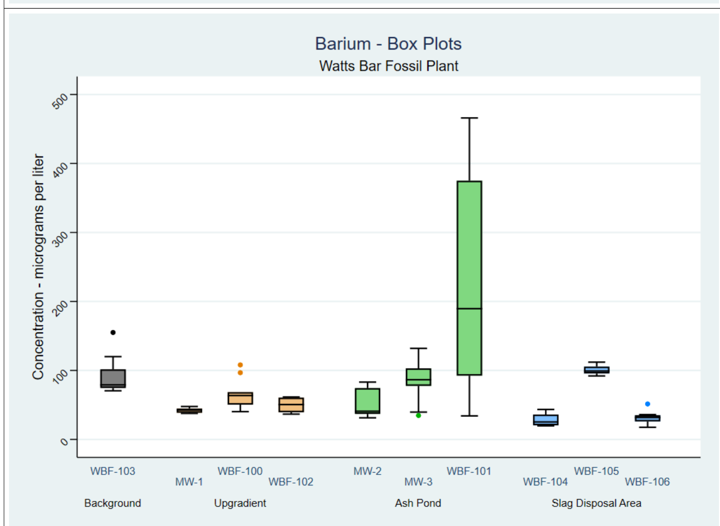
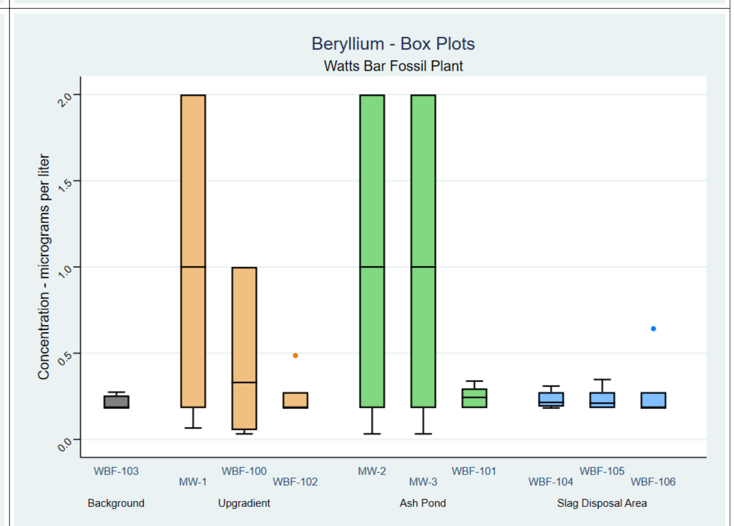
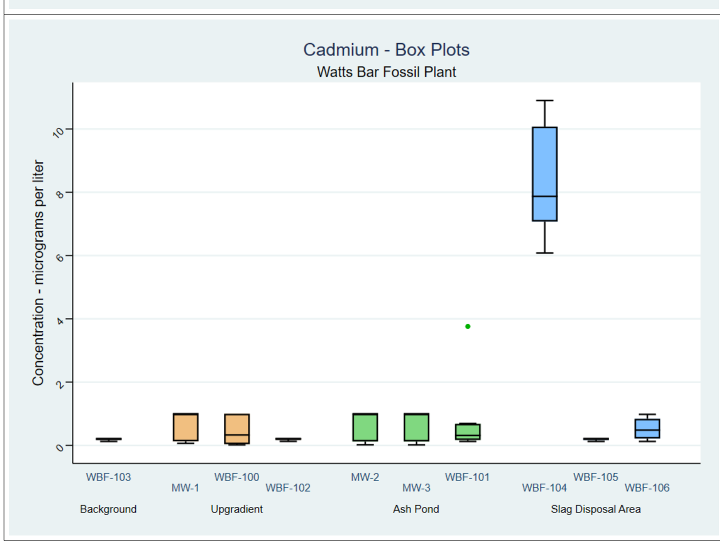
Box Plots
CCR Rule Appendix IV Parameters
Watts Bar Fossil Plant - Spring City, Tennessee

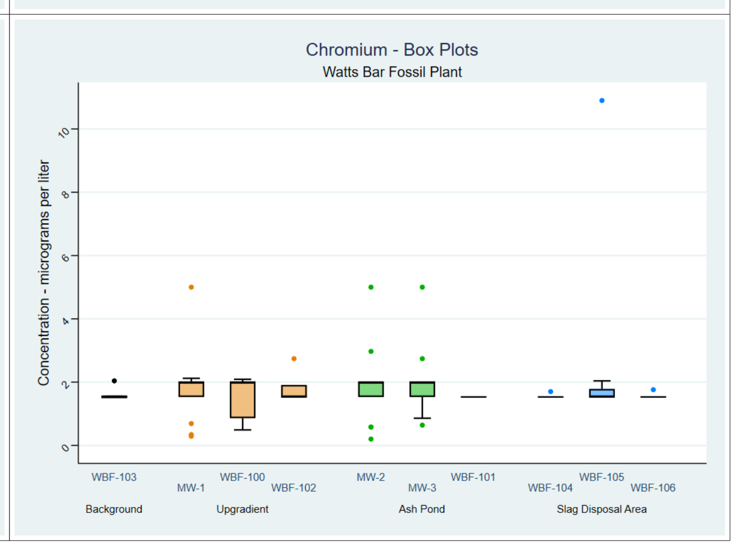


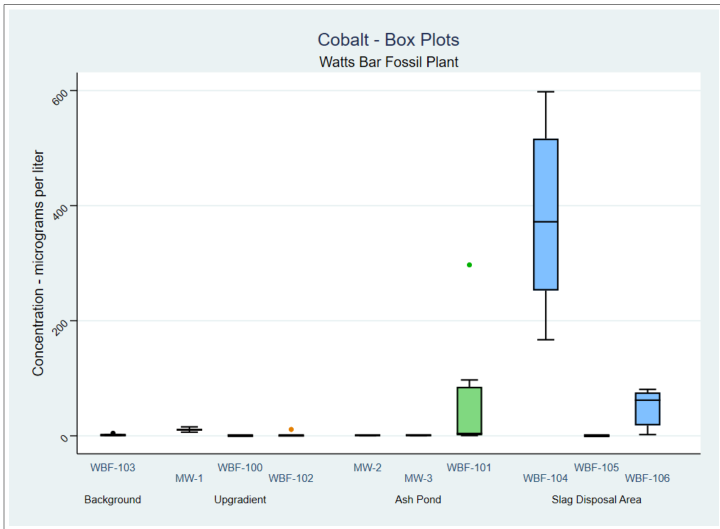


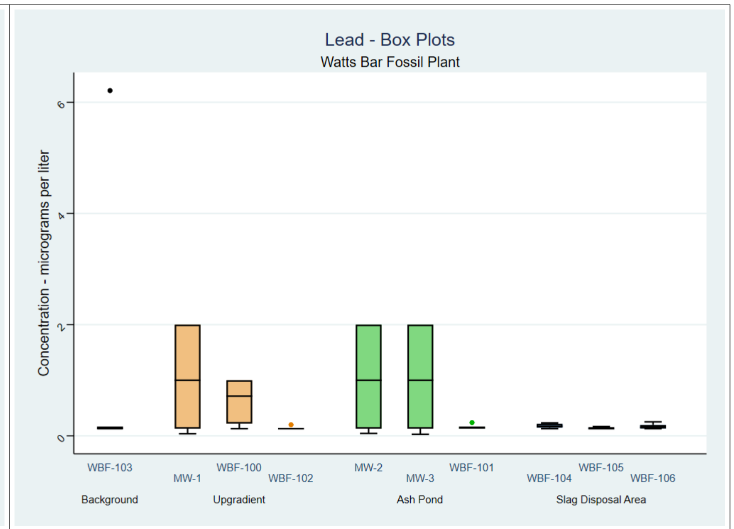


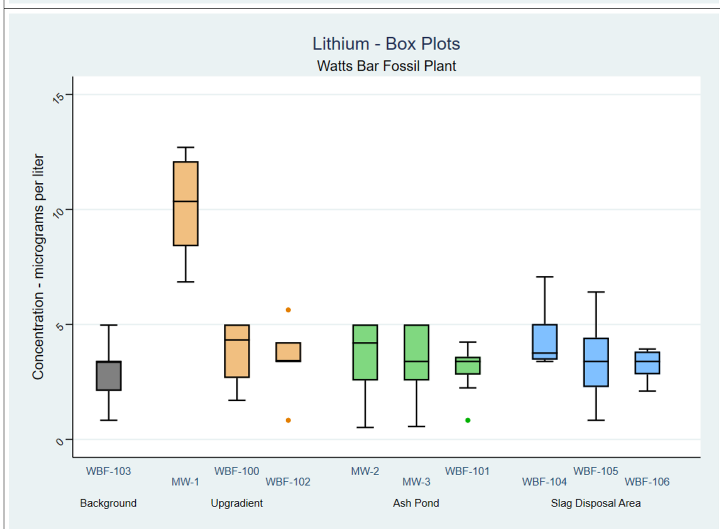


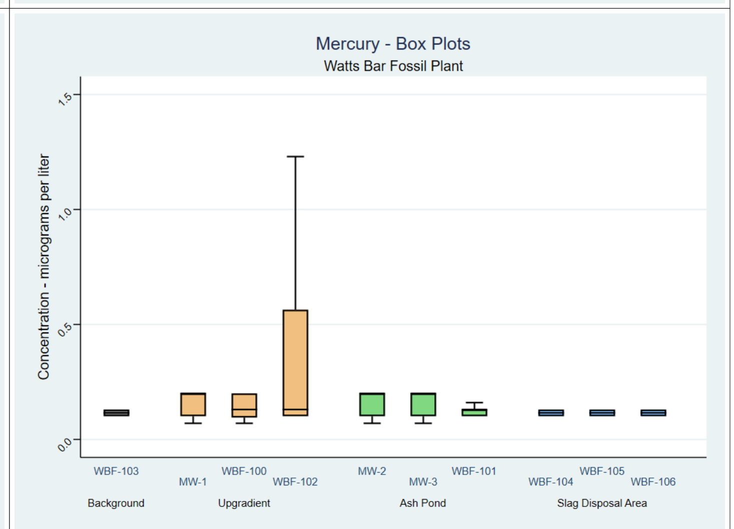


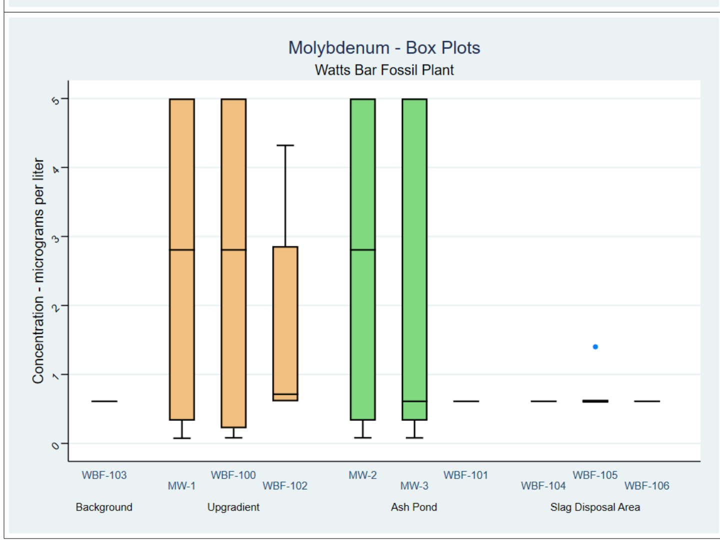


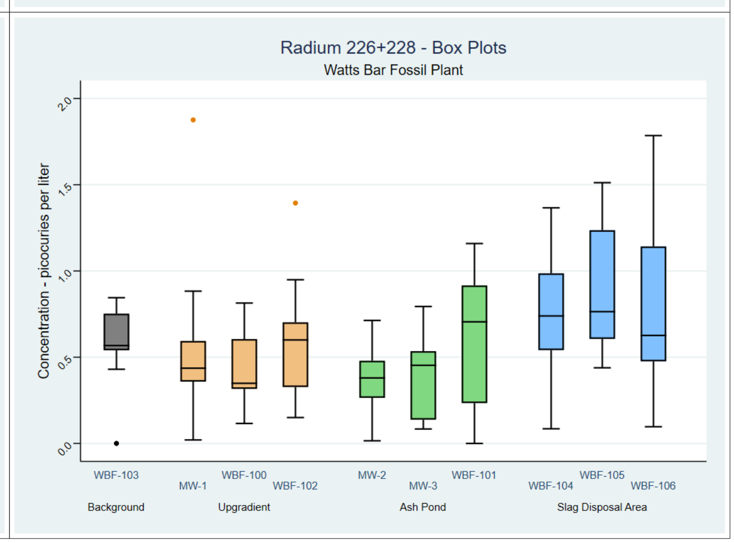

Cobalt - Box Plots
Watts Bar Fossil Plant
Concentration - micrograms per liter
0
200
400
600
WBF-103
MW-1
WBF-100
WBF-102
MW-2
MW-3
WBF-101
WBF-104
WBF-105
WBF-106
Background
Upgradient
Ash Pond
Slag Disposal Area

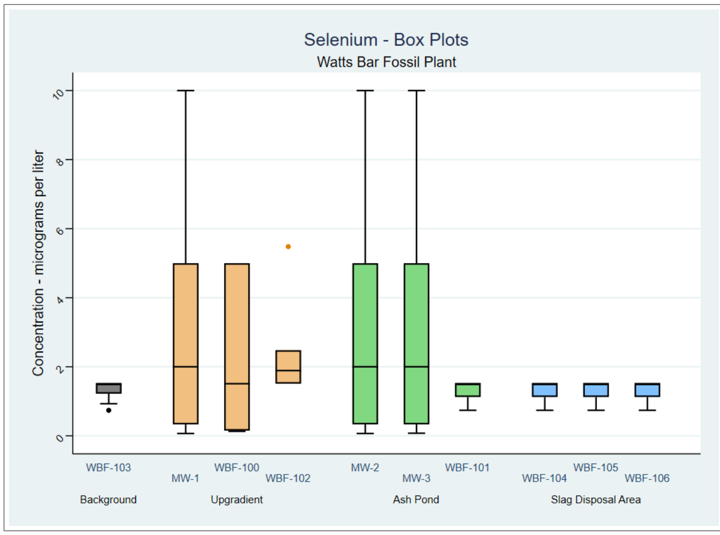

Lead - Box Plots
Watts Bar Fossil Plant
Concentration - micrograms per liter
0
2
4
6
WBF-103
MW-1
WBF-100
WBF-102
MW-2
MW-3
WBF-101
WBF-104
WBF-105
WBF-106
Background
Upgradient
Ash Pond
Slag Disposal Area

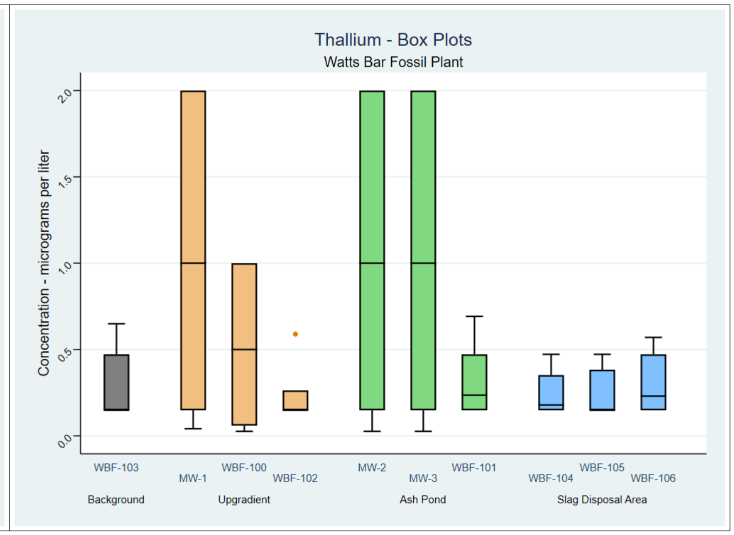

Lithium - Box Plots
Watts Bar Fossil Plant
Concentration - micrograms per liter
0
5
10
15
WBF-103
MW-1
WBF-100
WBF-102
MW-2
MW-3
WBF-101
WBF-104
WBF-105
WBF-106
Background
Upgradient
Ash Pond
Slag Disposal Area


Mercury - Box Plots
Watts Bar Fossil Plant
Concentration - micrograms per liter
0.0
0.5
1.0
1.5
WBF-103
MW-1
WBF-100
WBF-102
MW-2
MW-3
WBF-101
WBF-104
WBF-105
WBF-106
Background
Upgradient
Ash Pond
Slag Disposal Area


Molybdenum - Box Plots
Watts Bar Fossil Plant
Concentration - micrograms per liter
0
1
2
3
4
5
WBF-103
MW-1
WBF-100
WBF-102
MW-2
MW-3
WBF-101
WBF-104
WBF-105
WBF-106
Background
Upgradient
Ash Pond
Slag Disposal Area


Radium 226+228 - Box Plots
Watts Bar Fossil Plant
Concentration - picocuries per liter
0.0
0.5
1.0
1.5
2.0
WBF-103
MW-1
WBF-100
WBF-102
MW-2
MW-3
WBF-101
WBF-104
WBF-105
WBF-106
Background
Upgradient
Ash Pond
Slag Disposal Area

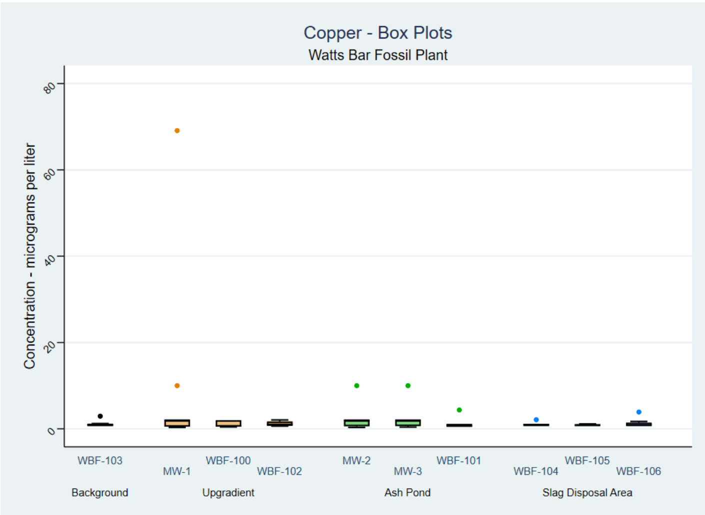

Selenium - Box Plots
Watts Bar Fossil Plant
Concentration - micrograms per liter
0
2
4
6
8
10
WBF-103
MW-1
WBF-100
WBF-102
MW-2
MW-3
WBF-101
WBF-104
WBF-105
WBF-106
Background
Upgradient
Ash Pond
Slag Disposal Area

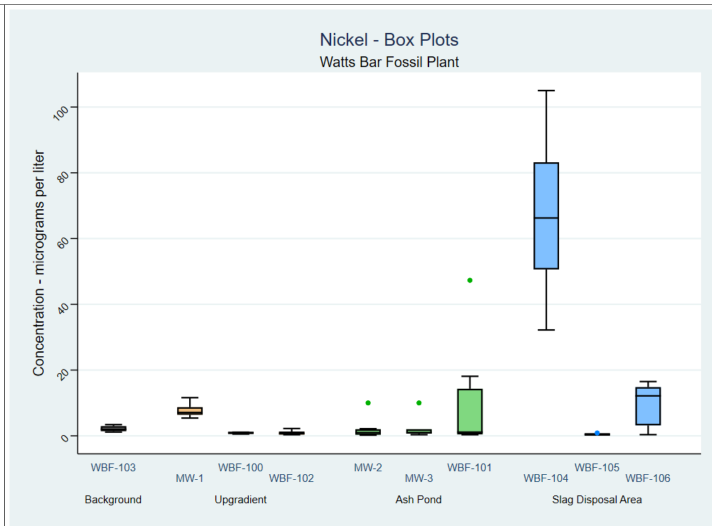

Thallium - Box Plots
Watts Bar Fossil Plant
Concentration - micrograms per liter
0.0
0.5
1.0
1.5
2.0
WBF-103
MW-1
WBF-100
WBF-102
MW-2
MW-3
WBF-101
WBF-104
WBF-105
WBF-106
Background
Upgradient
Ash Pond
Slag Disposal Area

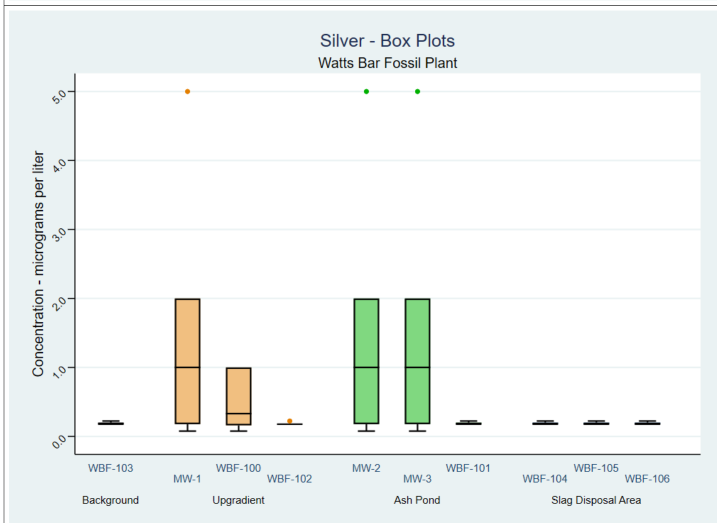
Box Plots

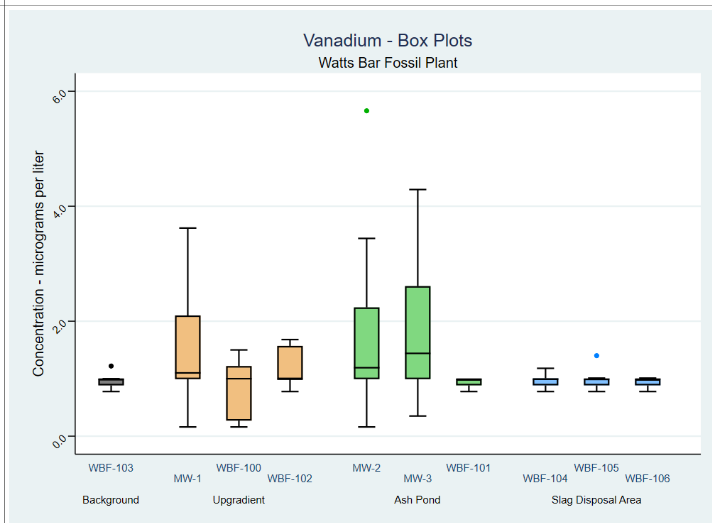
TDEC Appendix I Parameters

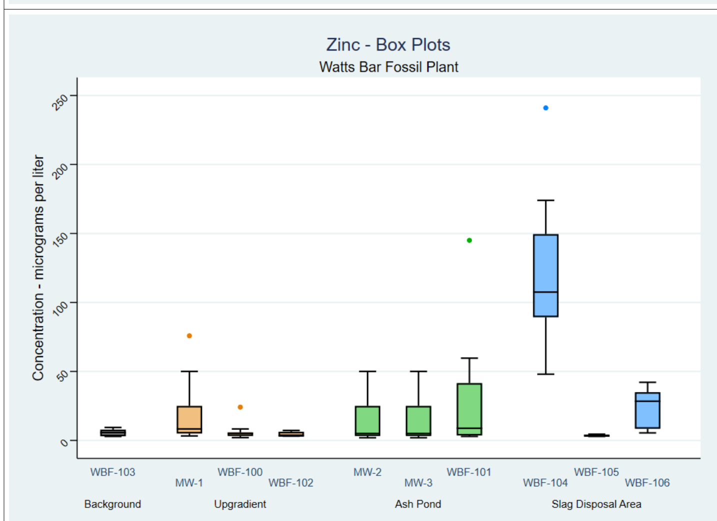
Watts Bar Fossil Plant - Spring City, Tennessee











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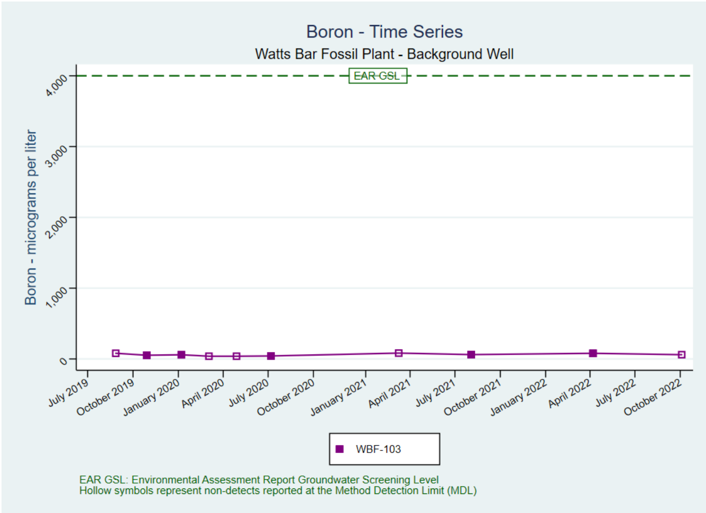
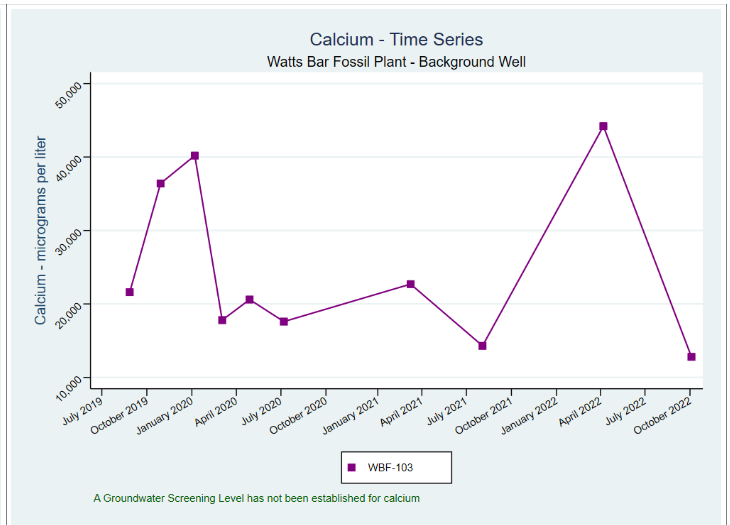
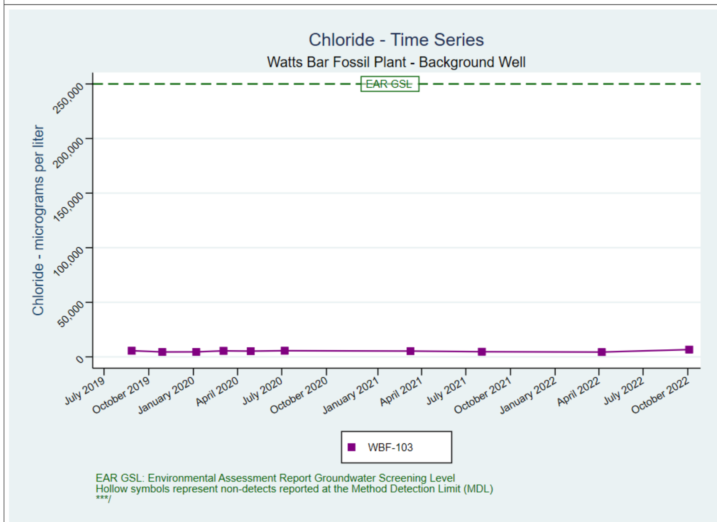
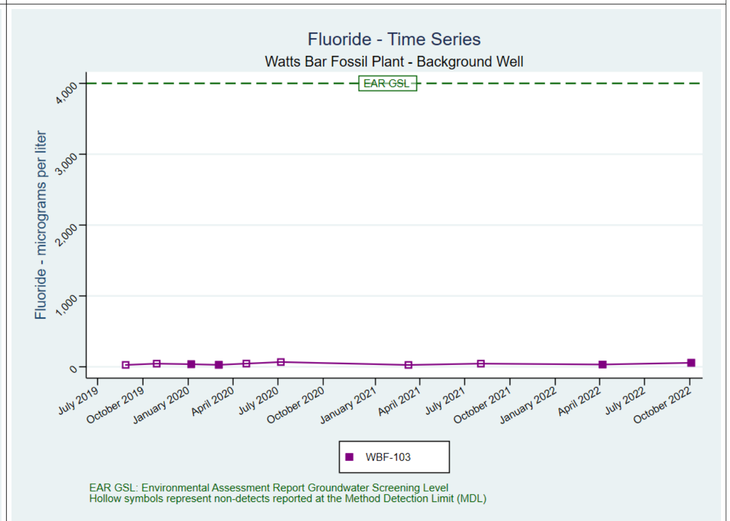
ATTACHMENT E.3-C
TIME SERIES PLOTS

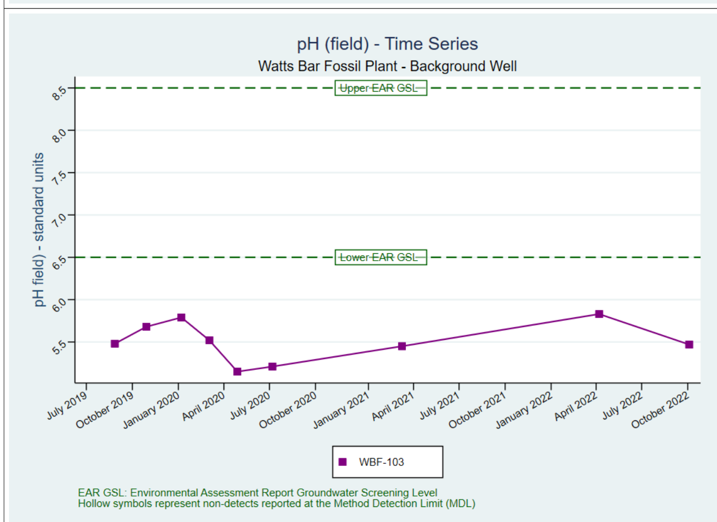
Time Series Plots
Background Well
CCR Rule Appendix III Parameters
Watts Bar Fossil Plant - Spring City, Tennessee

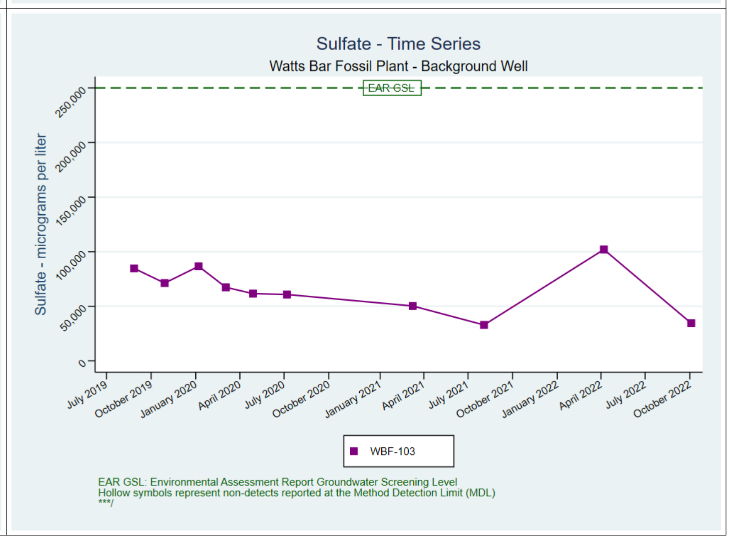


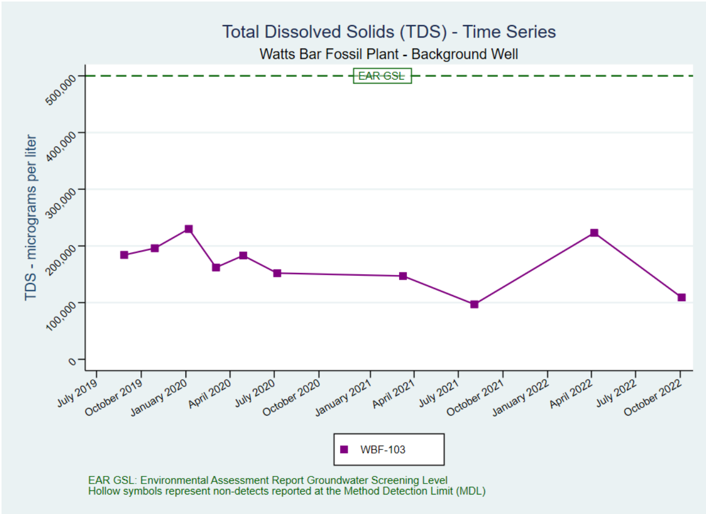












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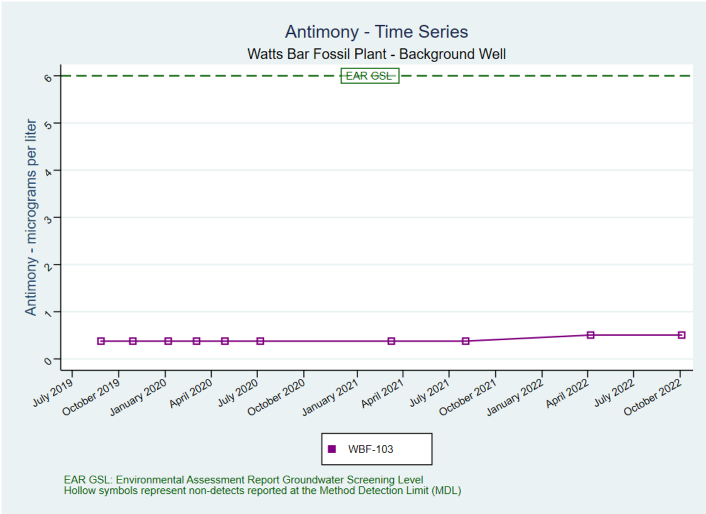
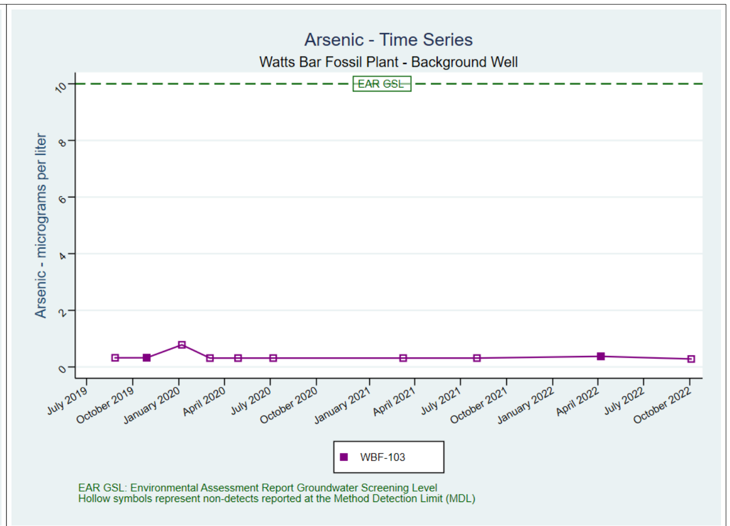
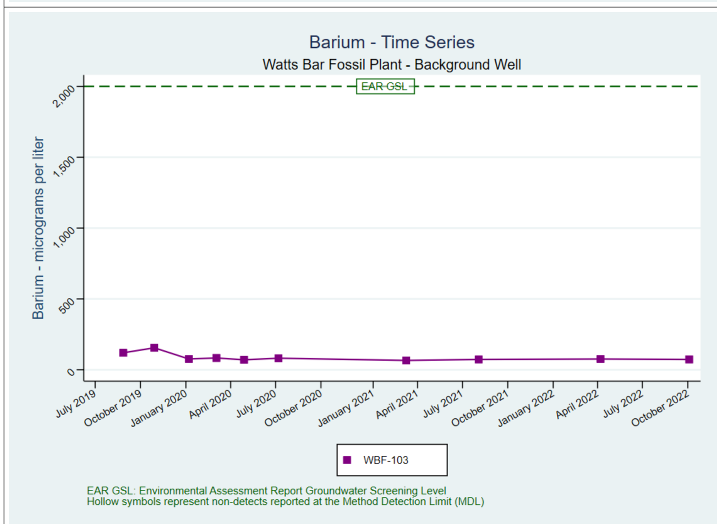
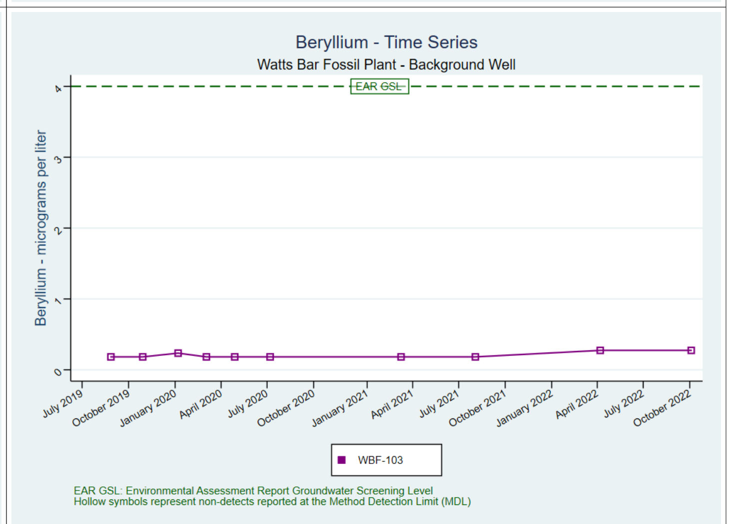
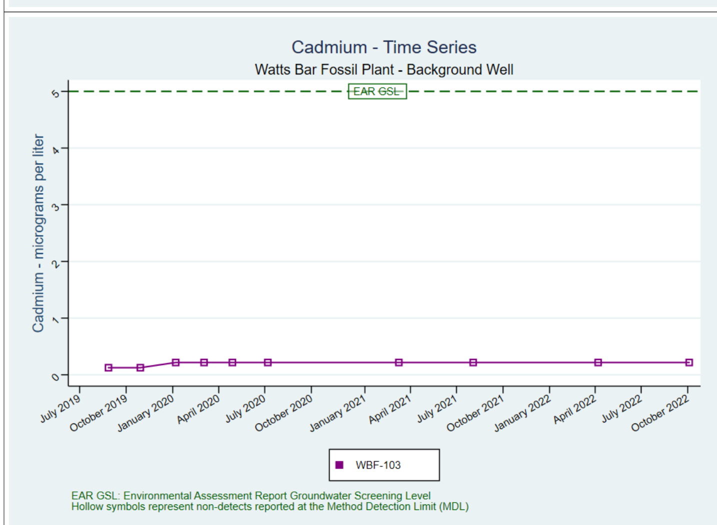
Time Series Plots
Background Well
CCR Rule Appendix IV Parameters
Watts Bar Fossil Plant - Spring City, Tennessee

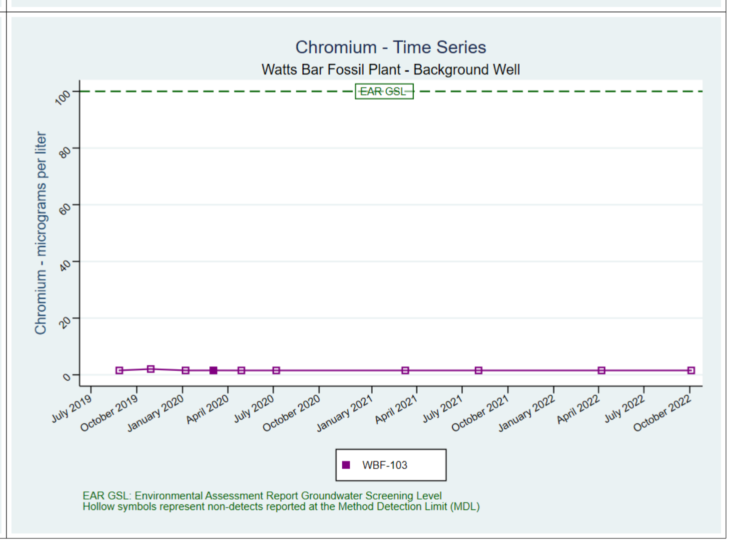


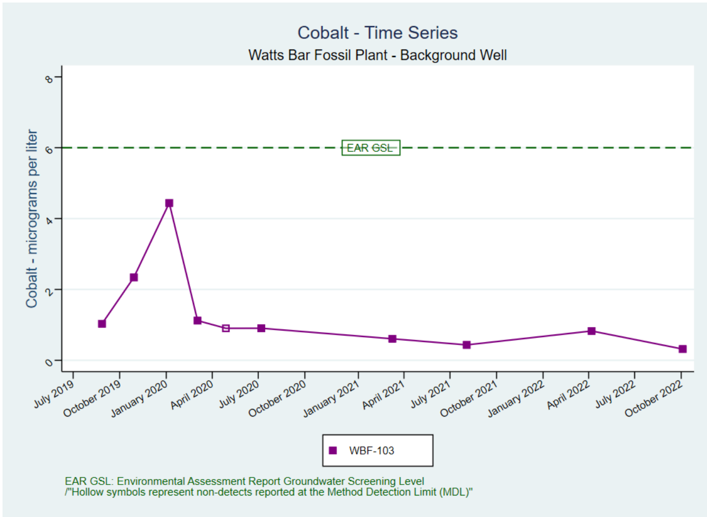


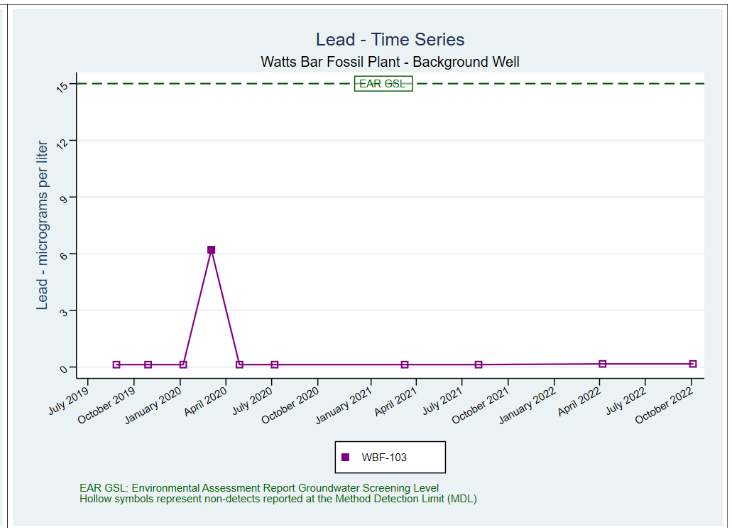


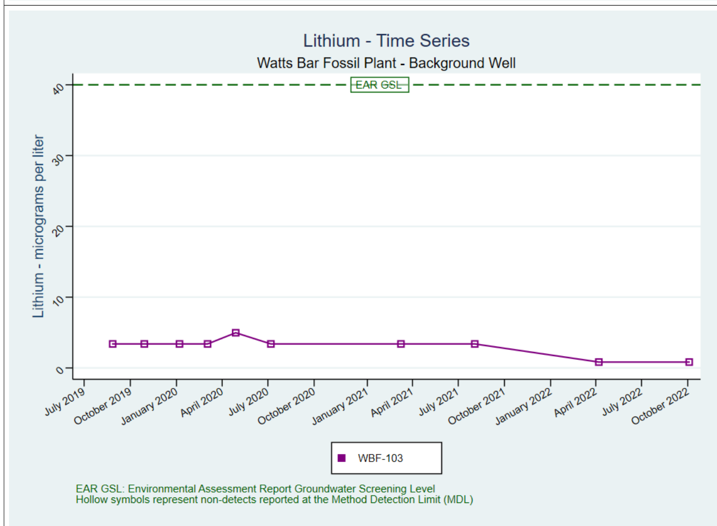


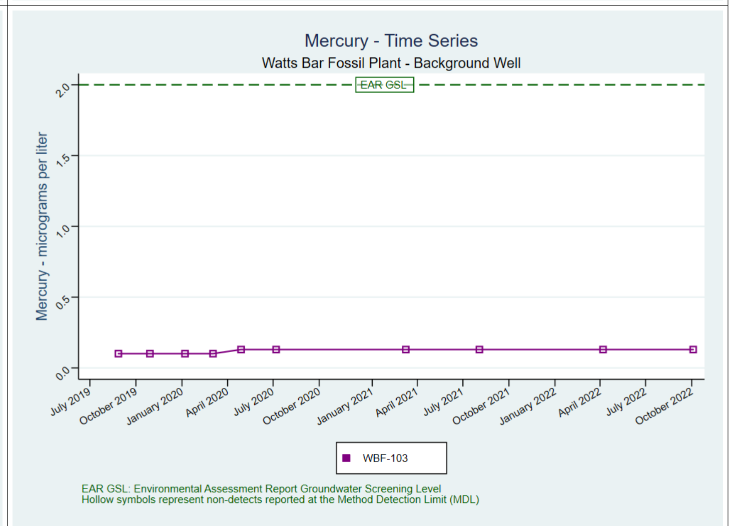


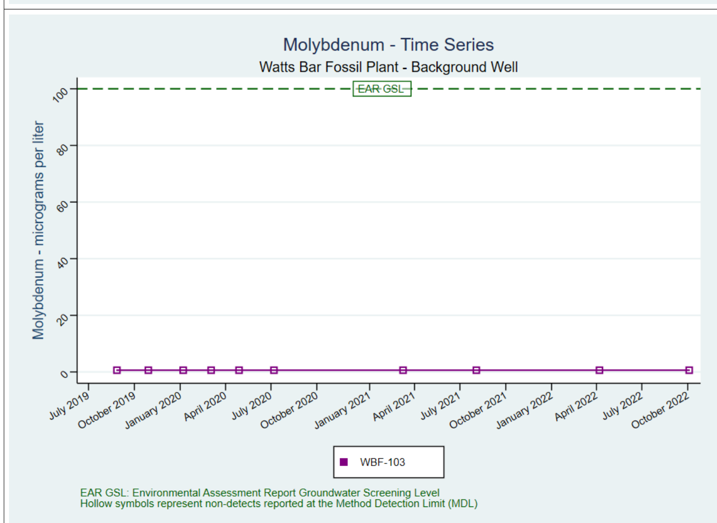


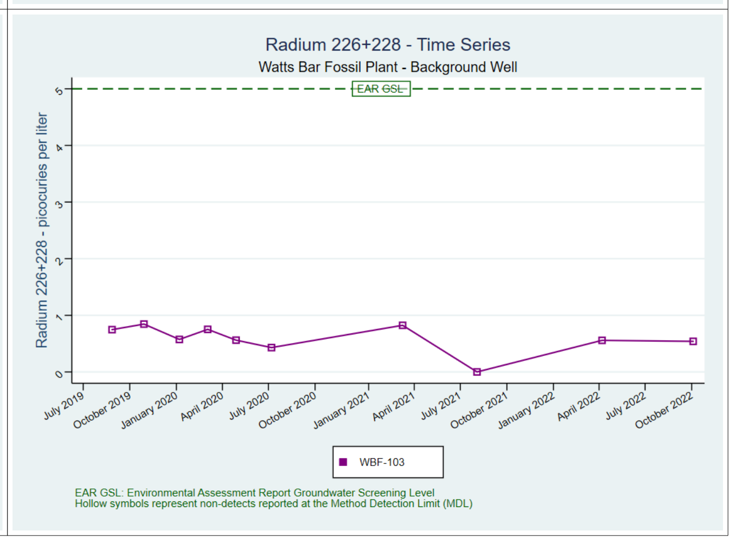

Cobalt - Time Series
Watts Bar Fossil Plant - Background Well
Cobalt - micrograms per liter
EAR GSL
WBF-103
EAR GSL: Environmental Assessment Report Groundwater Screening Level
/"Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)"

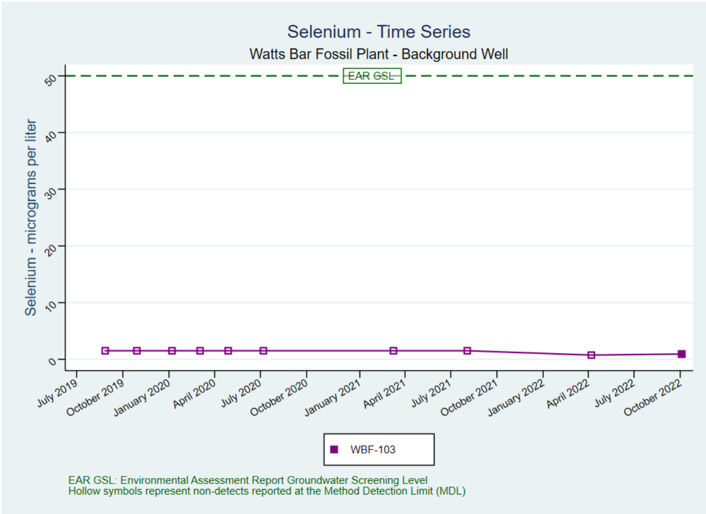

Lead - Time Series
Watts Bar Fossil Plant - Background Well
Lead - micrograms per liter
EAR GSL
WBF-103
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)


Lithium - Time Series
Watts Bar Fossil Plant - Background Well
Lithium - micrograms per liter
EAR GSL
WBF-103
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)

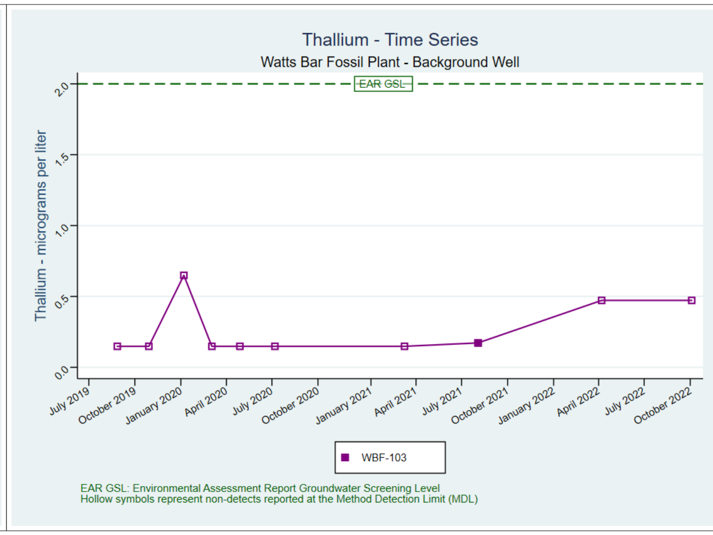

Mercury - Time Series
Watts Bar Fossil Plant - Background Well
Mercury - micrograms per liter
EAR GSL
WBF-103
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)


Molybdenum - Time Series
Watts Bar Fossil Plant - Background Well
Molybdenum - micrograms per liter
EAR GSL
WBF-103
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)


Radium 226+228 - Time Series
Watts Bar Fossil Plant - Background Well
Radium 226+228 - picocuries per liter
EAR GSL
WBF-103
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)

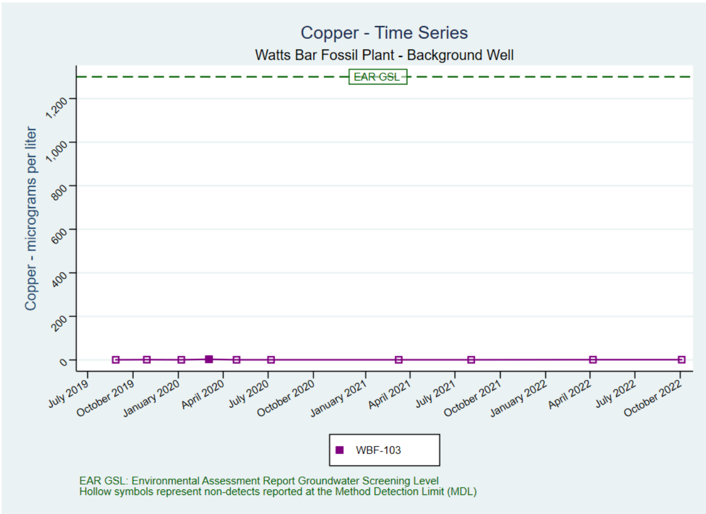


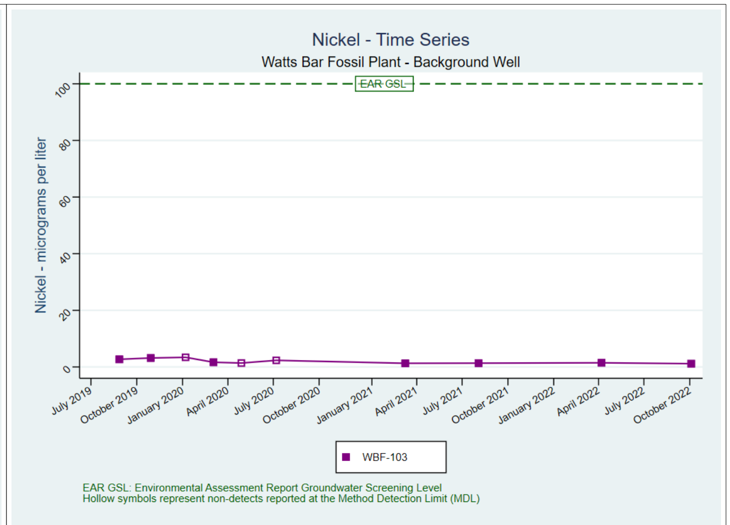
Selenium - Time Series
Watts Bar Fossil Plant - Background Well
Selenium - micrograms per liter
EAR GSL
WBF-103
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)

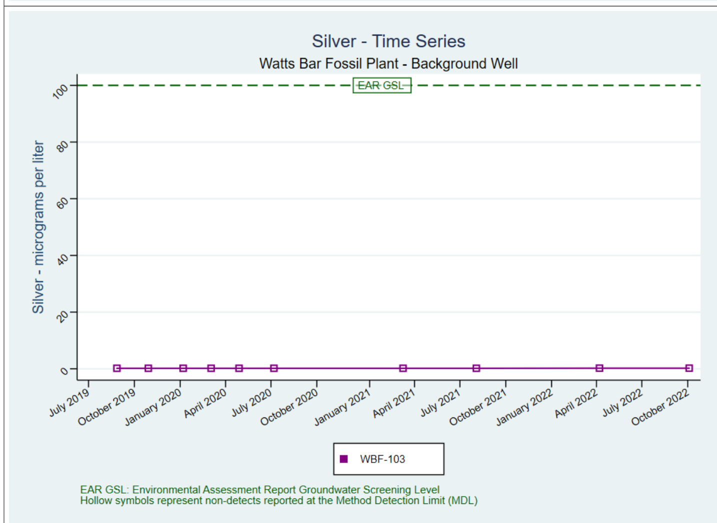


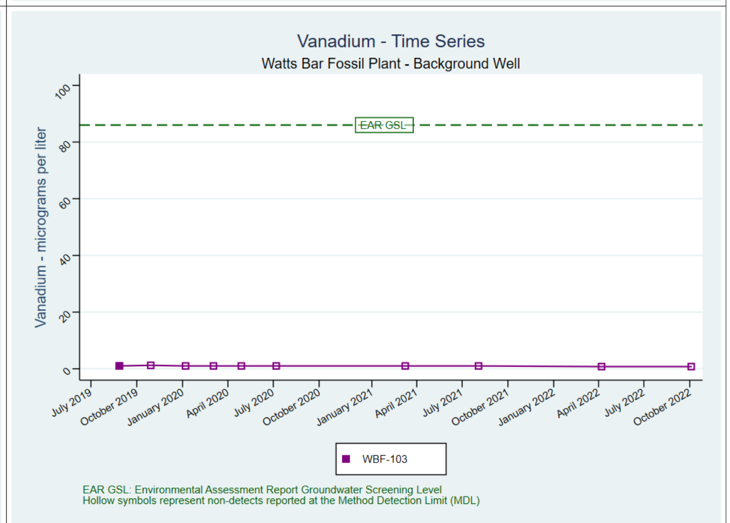
Thallium - Time Series
Watts Bar Fossil Plant - Background Well
Thallium - micrograms per liter
EAR GSL
WBF-103
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)

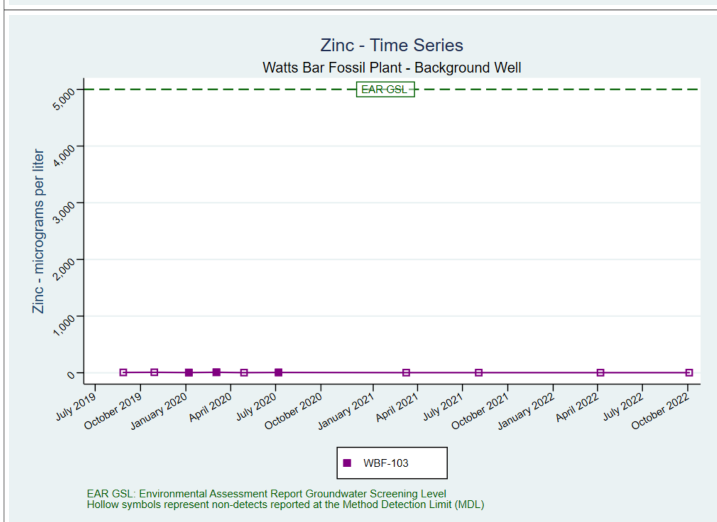
Time Series Plots
Background Well
TDEC Appendix I Parameters
Watts Bar Fossil Plant - Spring City, Tennessee











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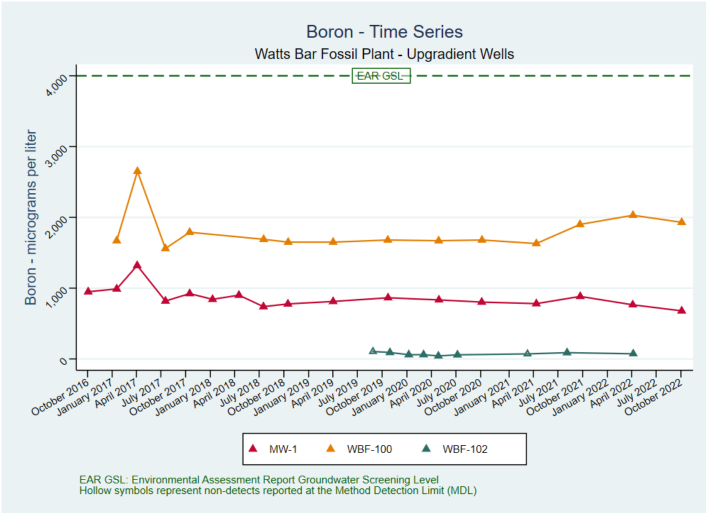
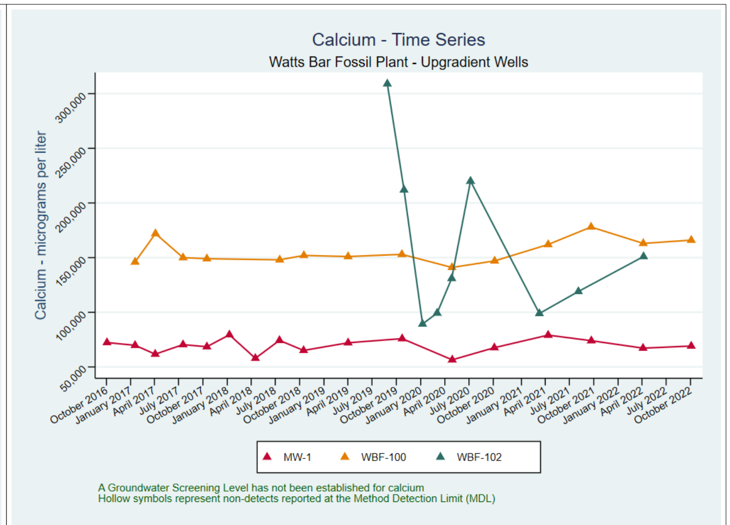
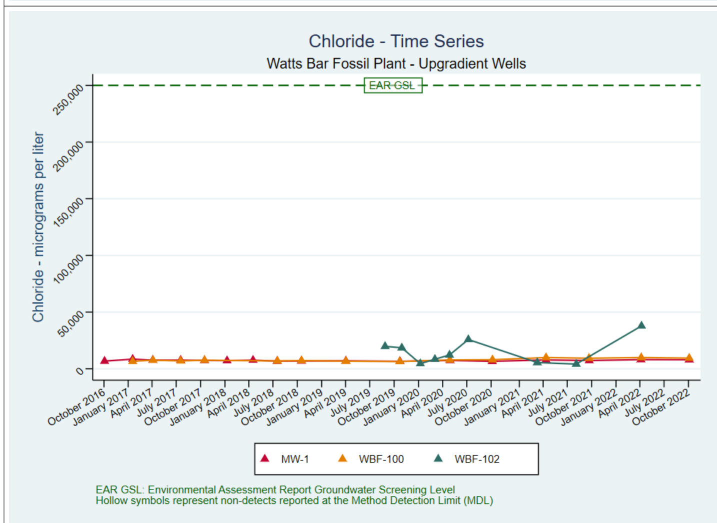
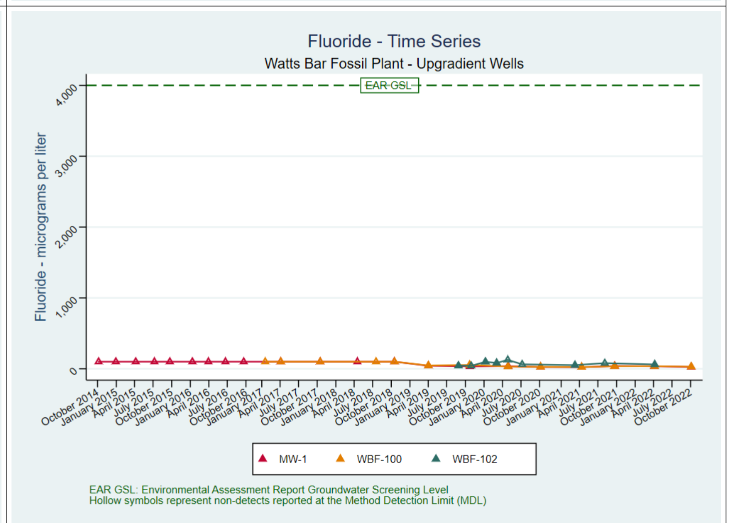
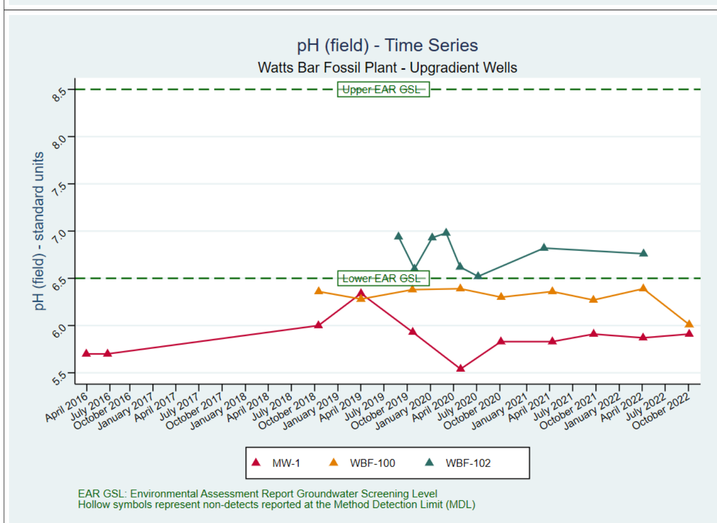
Time Series Plots
Upgradient Wells
CCR Rule Appendix III Parameters
Watts Bar Fossil Plant - Spring City, Tennessee

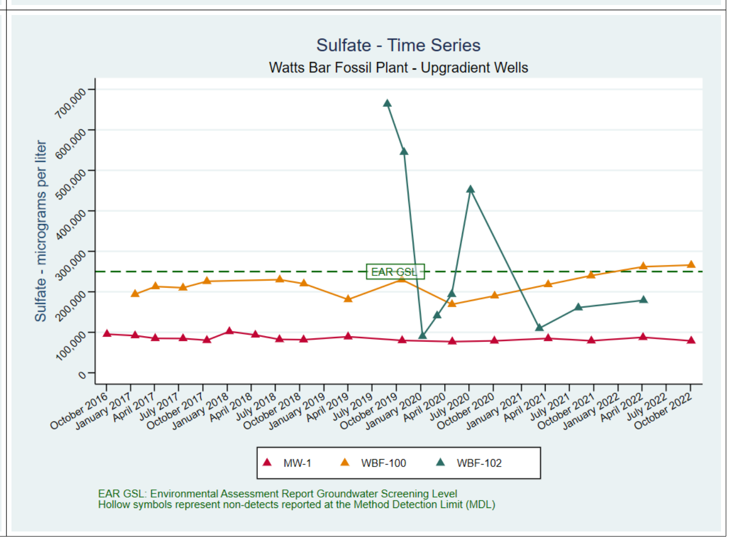


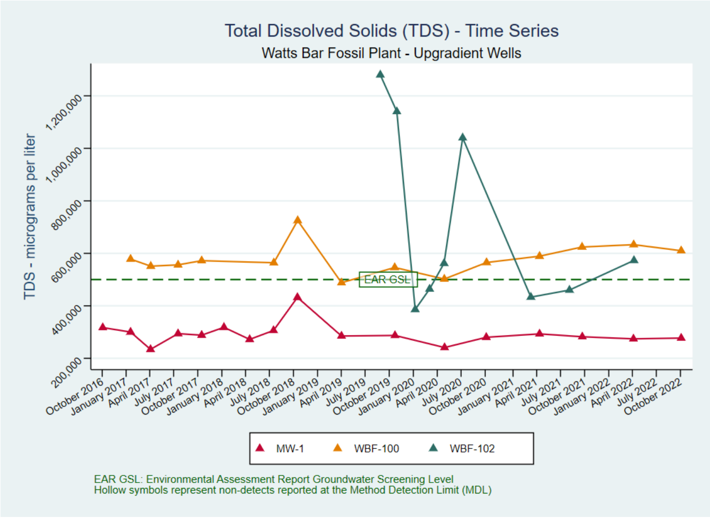












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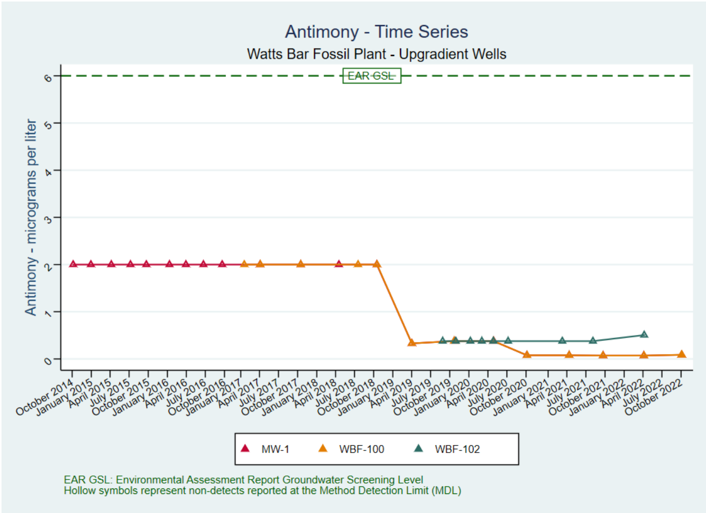
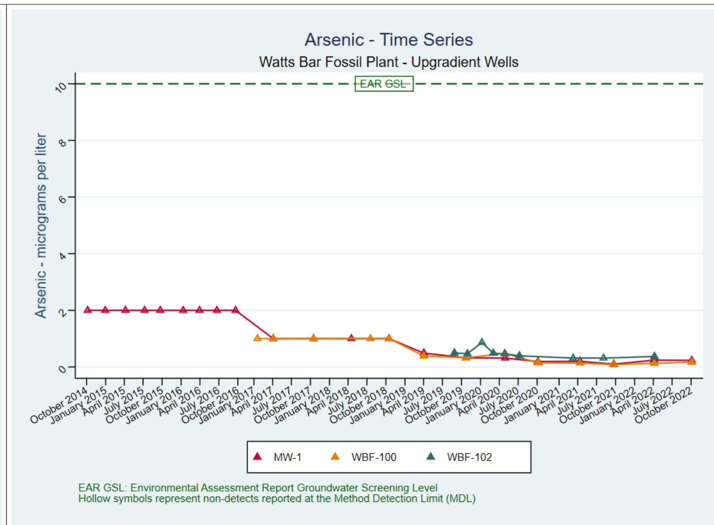
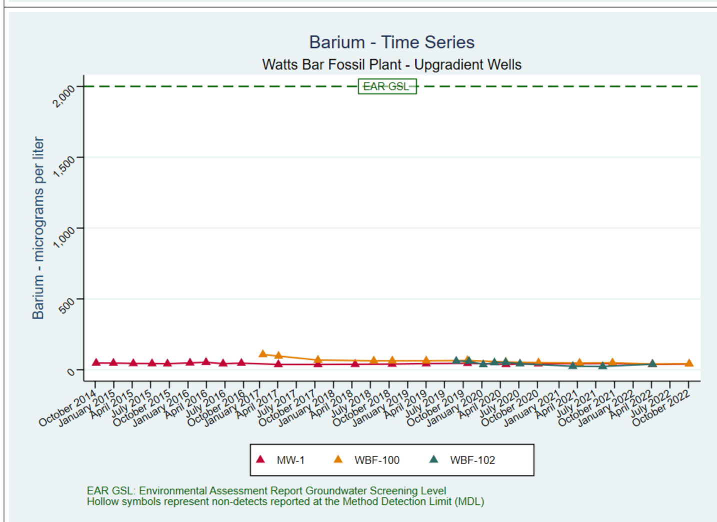
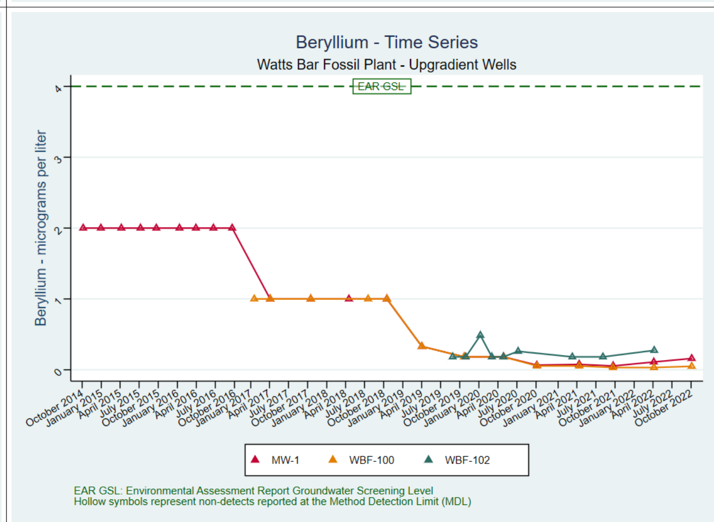
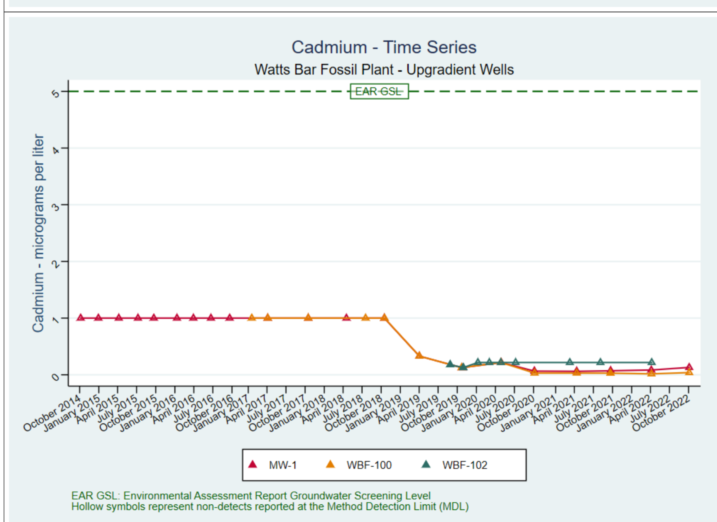
Time Series Plots
Upgradient Wells
CCR Rule Appendix IV Parameters
Watts Bar Fossil Plant - Spring City, Tennessee

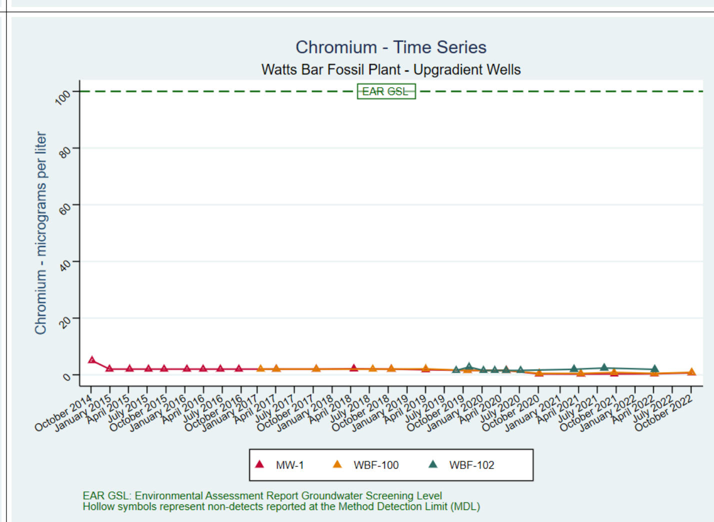


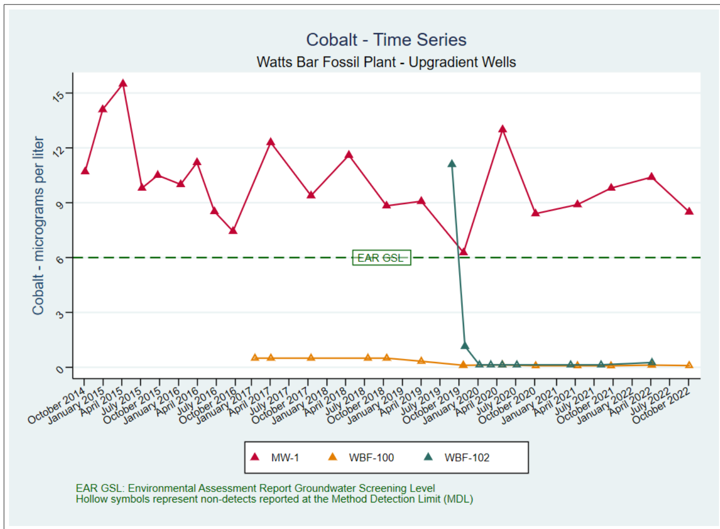


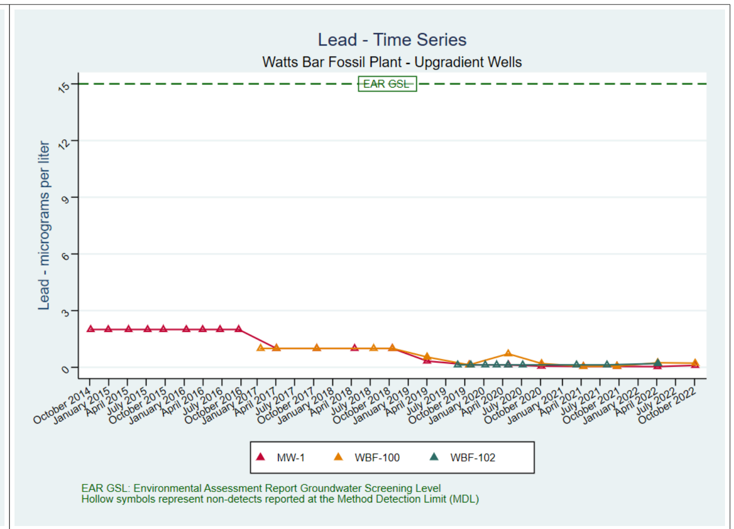


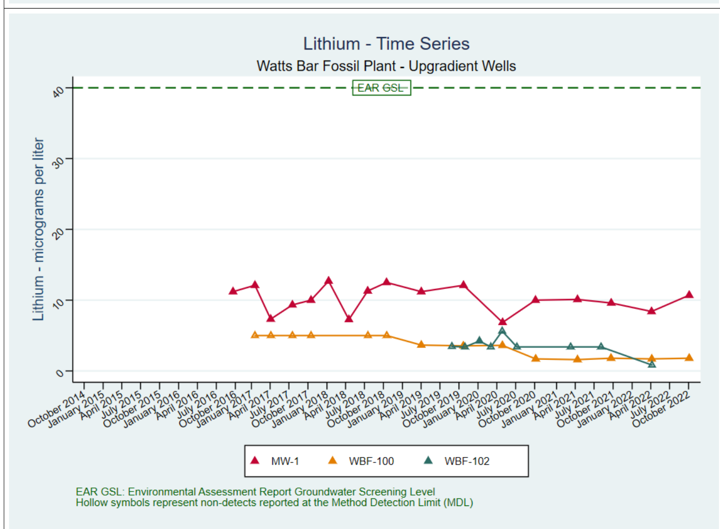


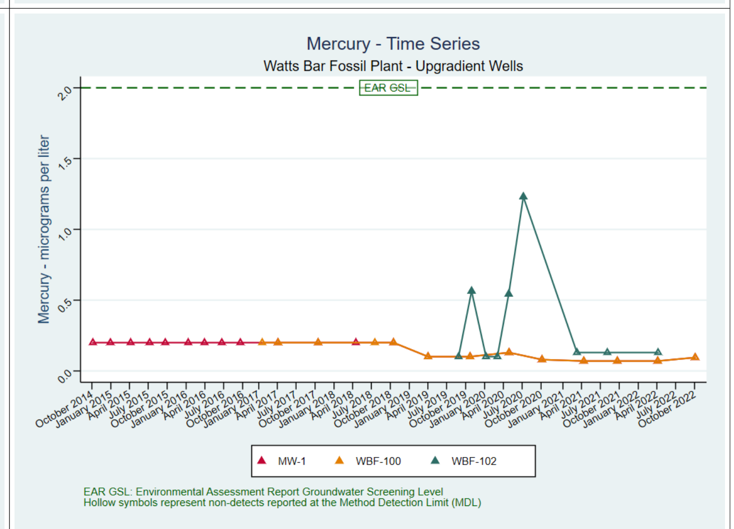


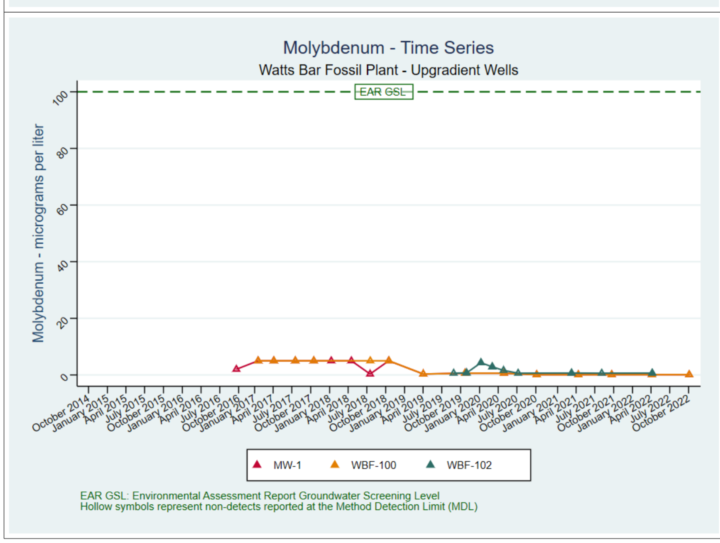


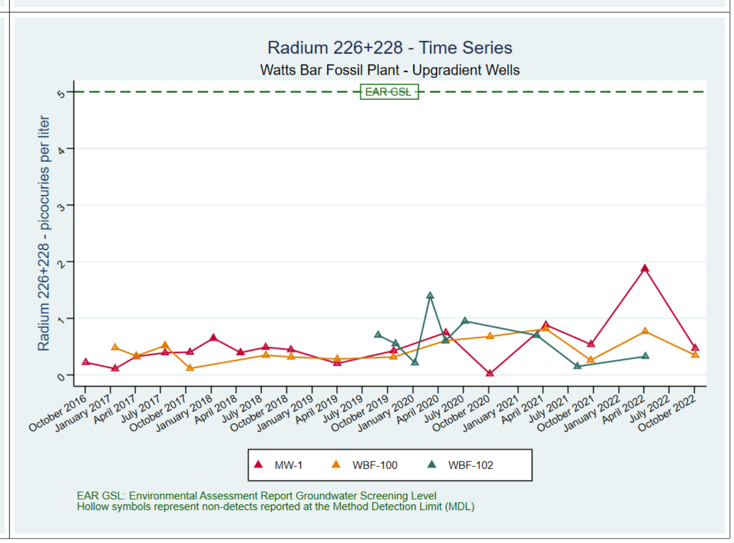

Cobalt - Time Series
Watts Bar Fossil Plant - Upgradient Wells
Cobalt - micrograms per liter
EAR GSL
MW-1
WBF-100
WBF-102
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)

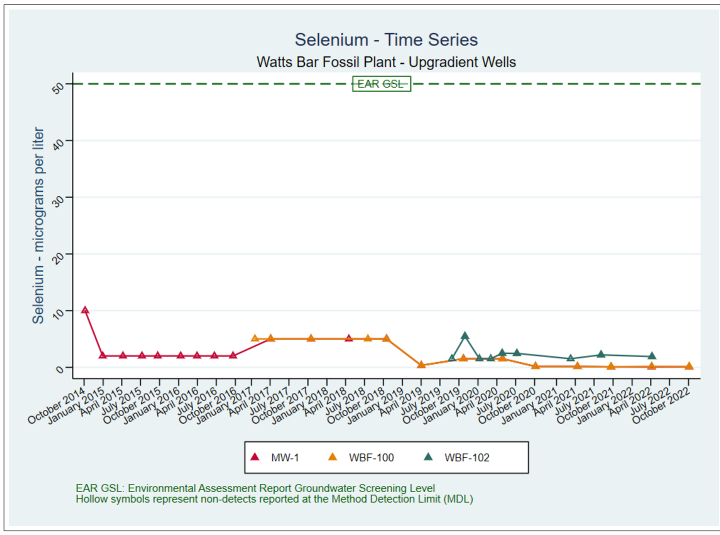

Lead - Time Series
Watts Bar Fossil Plant - Upgradient Wells
Lead - micrograms per liter
EAR GSL
MW-1
WBF-100
WBF-102
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)

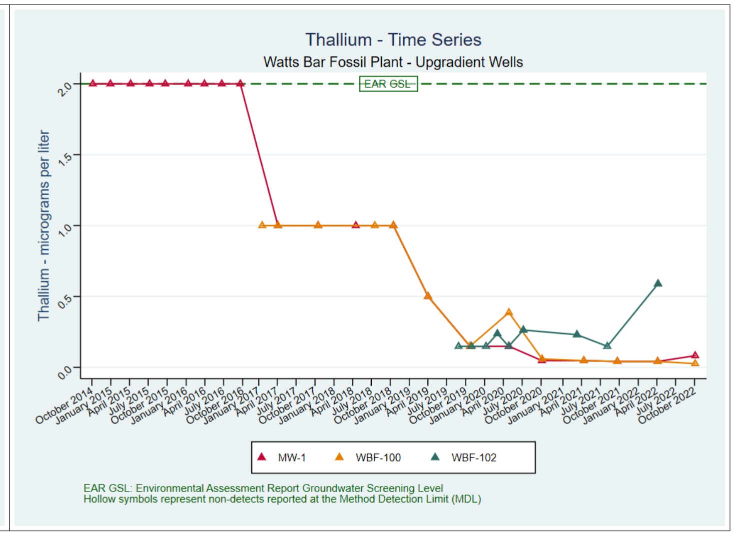

Lithium - Time Series
Watts Bar Fossil Plant - Upgradient Wells
Lithium - micrograms per liter
EAR GSL
MW-1
WBF-100
WBF-102
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)


Mercury - Time Series
Watts Bar Fossil Plant - Upgradient Wells
Mercury - micrograms per liter
EAR GSL
MW-1
WBF-100
WBF-102
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)

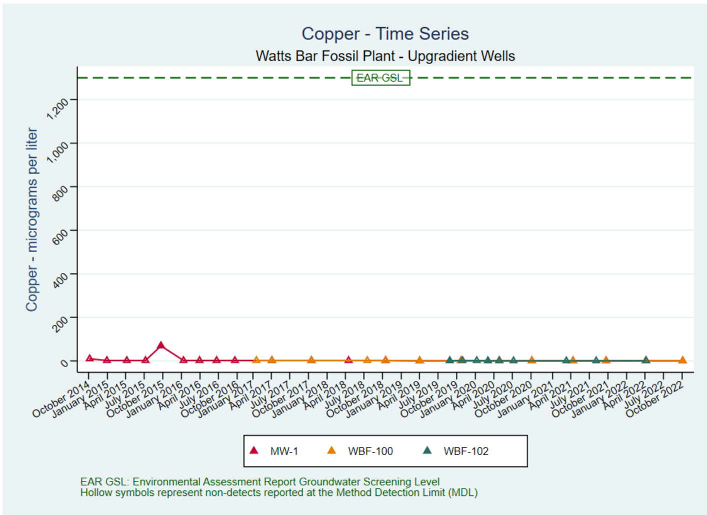

Molybdenum - Time Series
Watts Bar Fossil Plant - Upgradient Wells
Molybdenum - micrograms per liter
EAR GSL
MW-1
WBF-100
WBF-102
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)

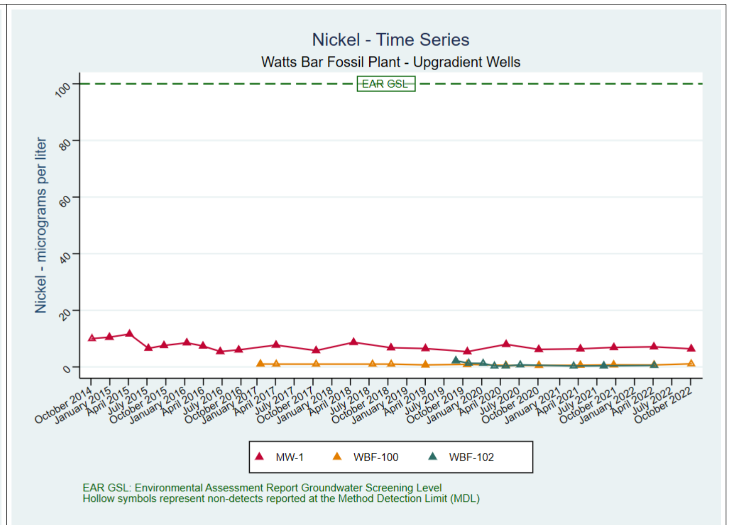

Radium 226+228 - Time Series
Watts Bar Fossil Plant - Upgradient Wells
Radium 226+228 - picocuries per liter
EAR GSL
MW-1
WBF-100
WBF-102
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)

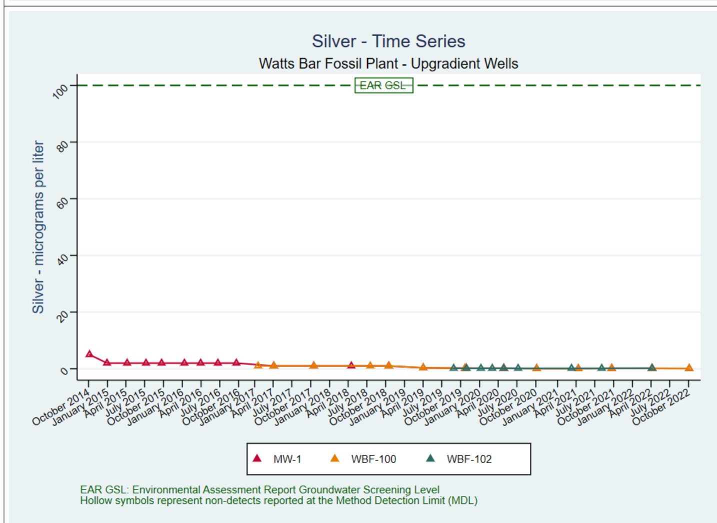

Selenium - Time Series
Watts Bar Fossil Plant - Upgradient Wells
Selenium - micrograms per liter
EAR GSL
0
10
20
30
40
50
MW-1
WBF-100
WBF-102
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)

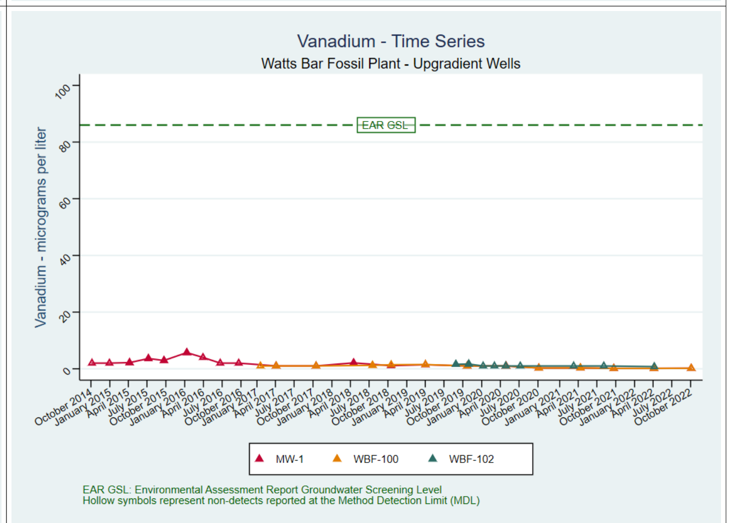

Thallium - Time Series
Watts Bar Fossil Plant - Upgradient Wells
Thallium - micrograms per liter
EAR GSL
0.0
0.5
1.0
1.5
2.0
MW-1
WBF-100
WBF-102
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)

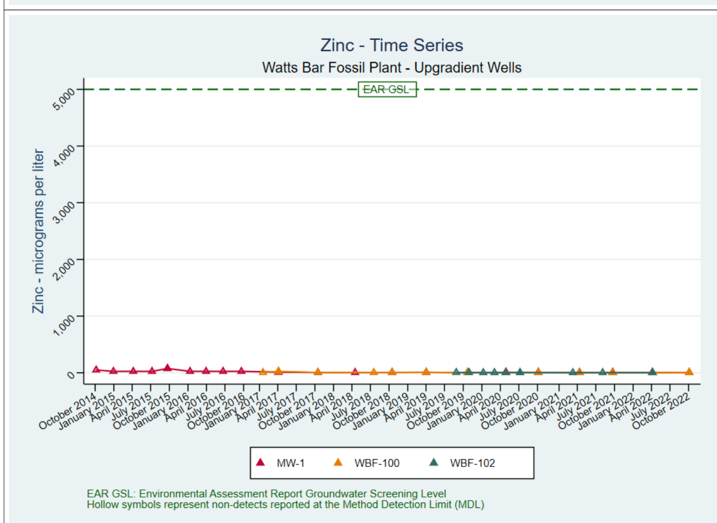
Time Series Plots
Upgradient Wells
TDEC Appendix I Parameters
Watts Bar Fossil Plant - Spring City, Tennessee











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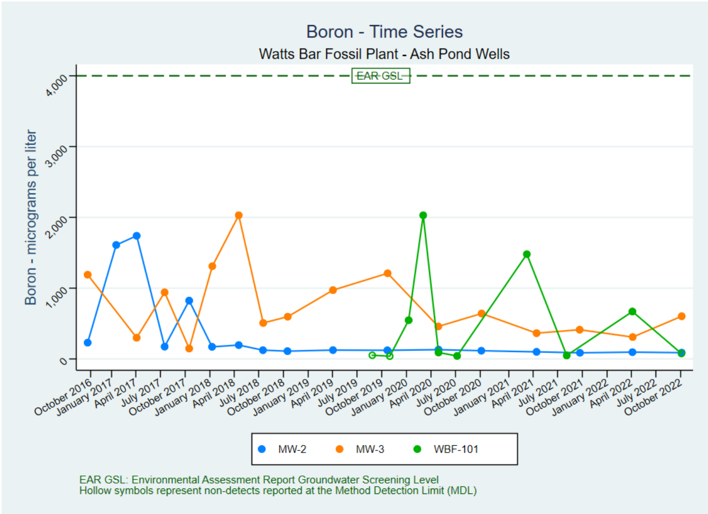
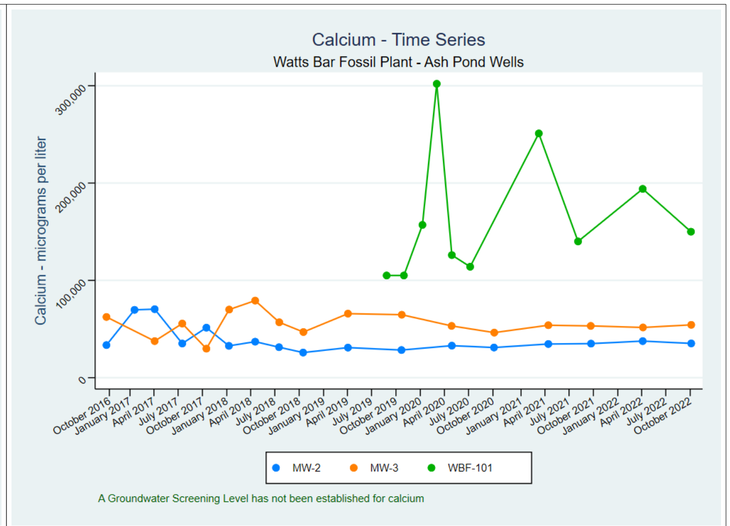
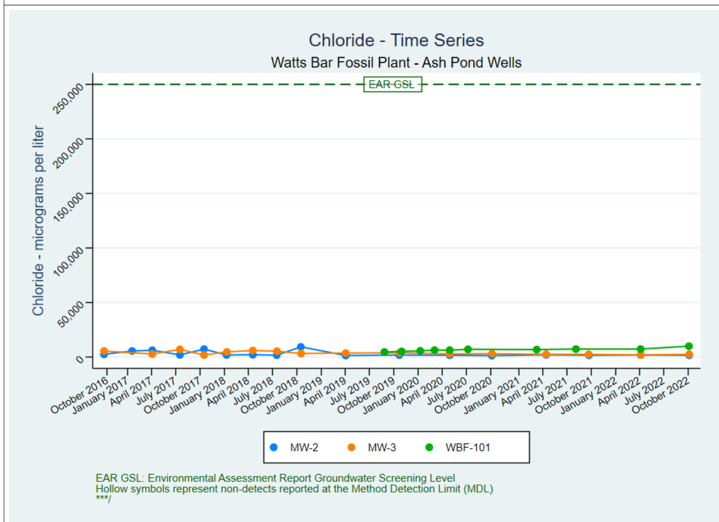
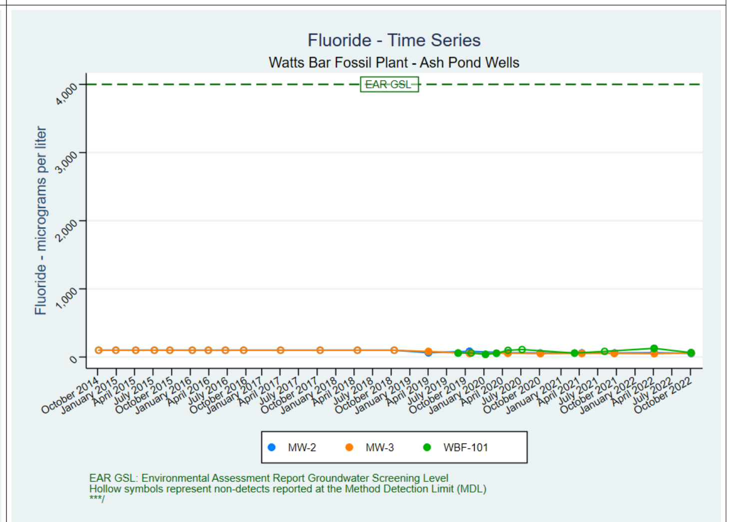
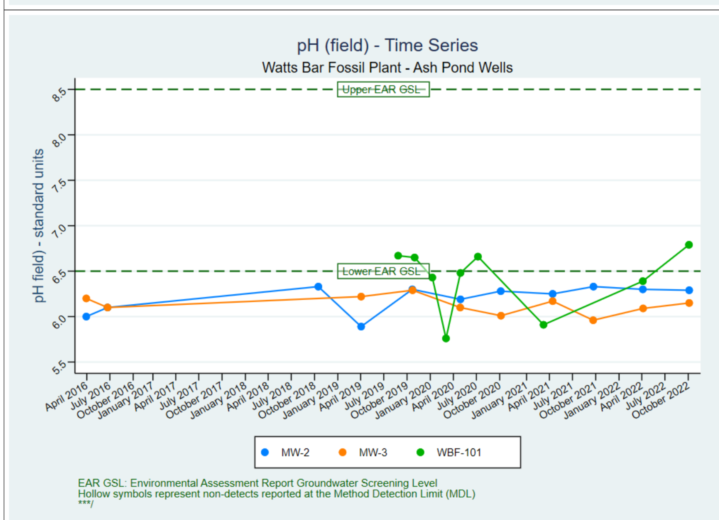
Time Series Plots
Ash Pond Wells
CCR Rule Appendix III Parameters
Watts Bar Fossil Plant - Spring City, Tennessee

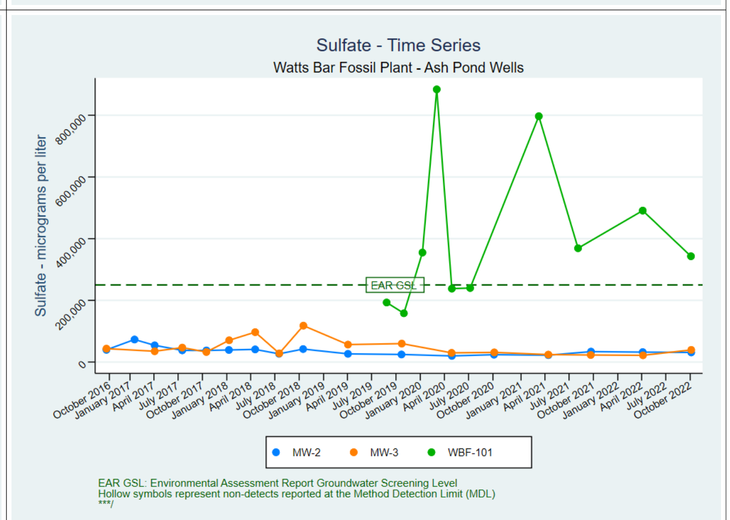


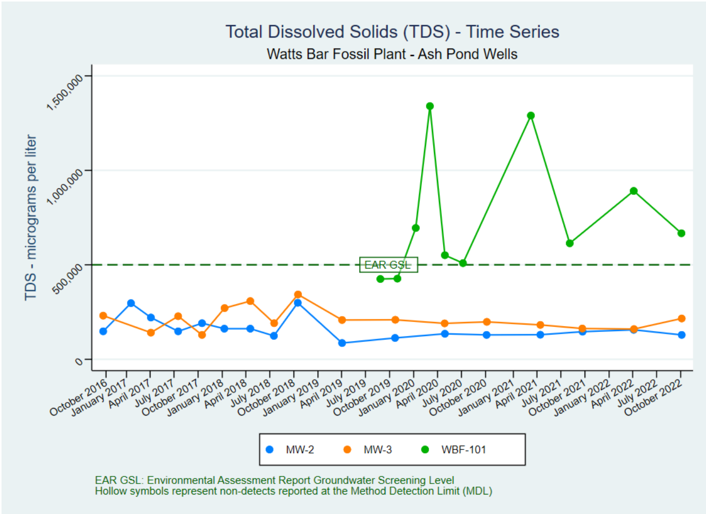












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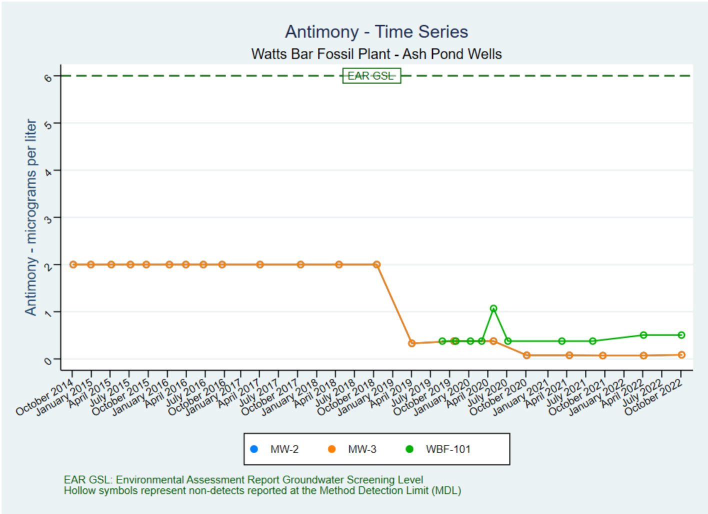
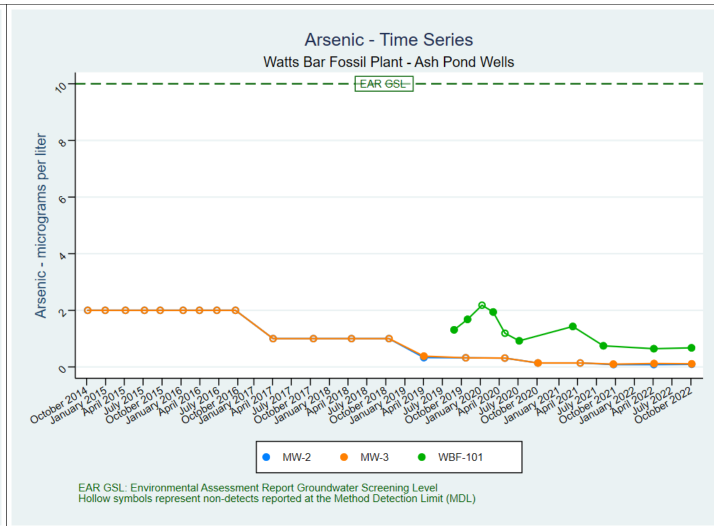
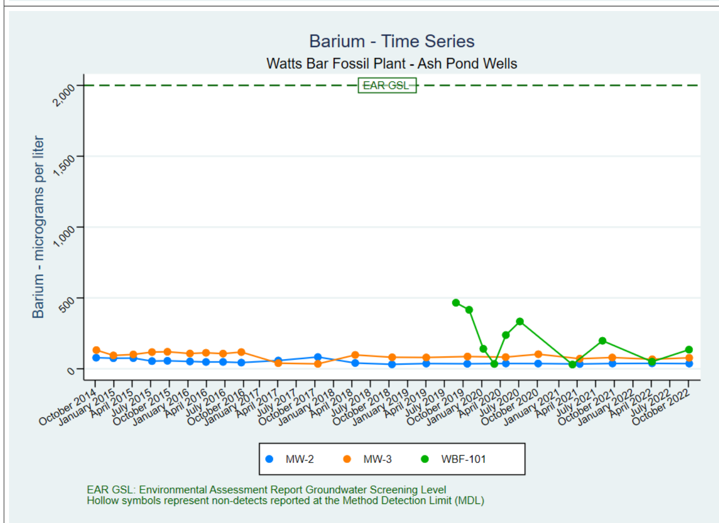
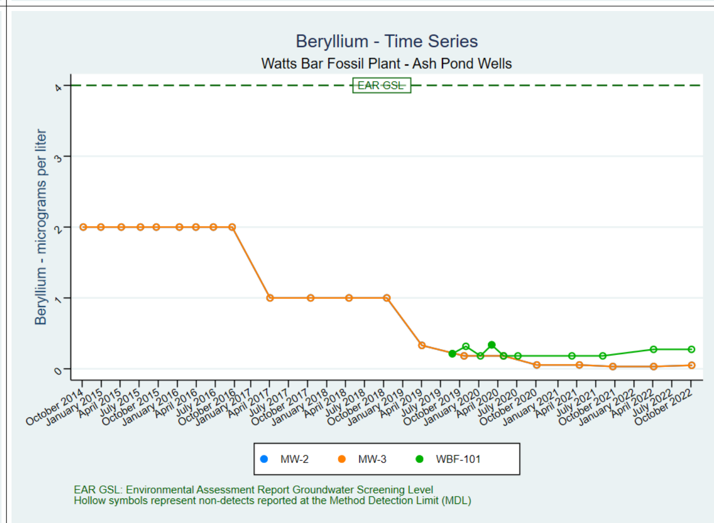
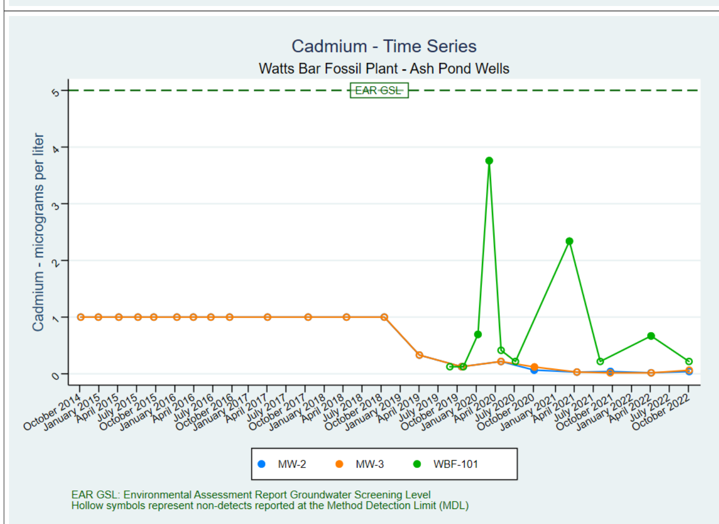
Time Series Plots
Ash Pond Wells
CCR Rule Appendix IV Parameters
Watts Bar Fossil Plant - Spring City, Tennessee

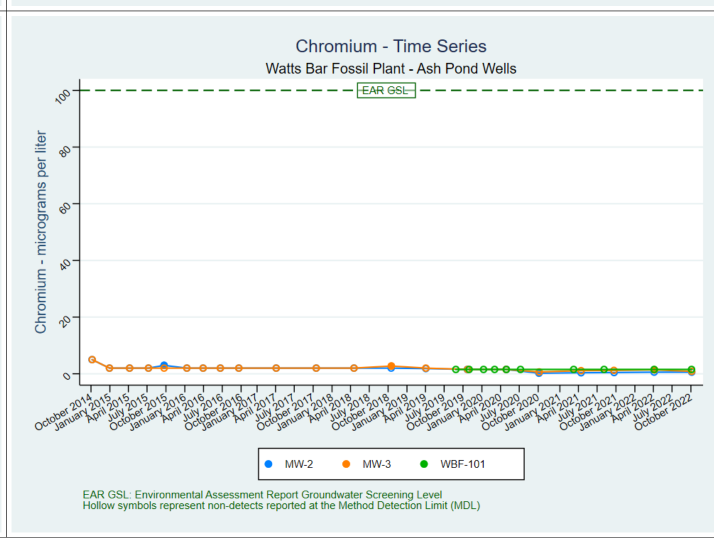


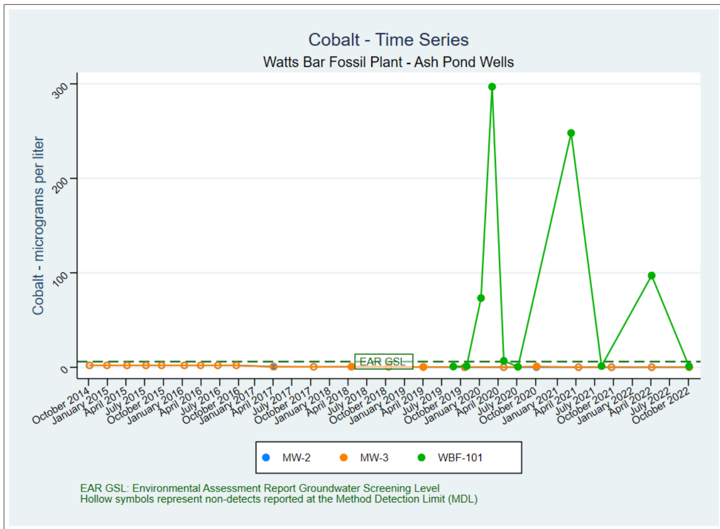




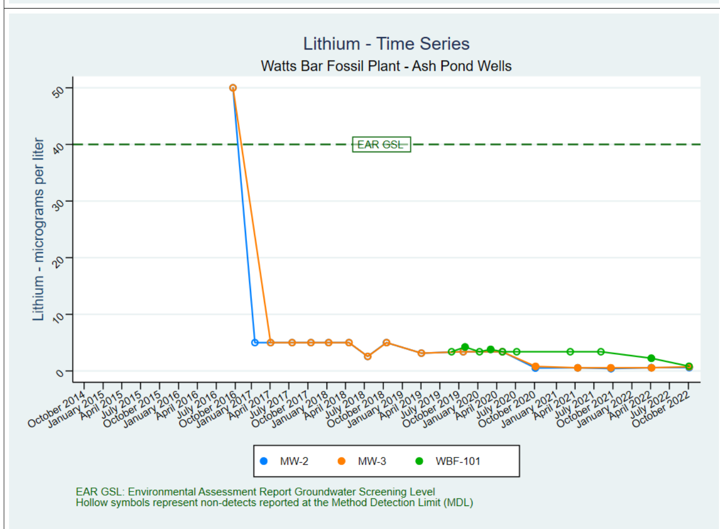


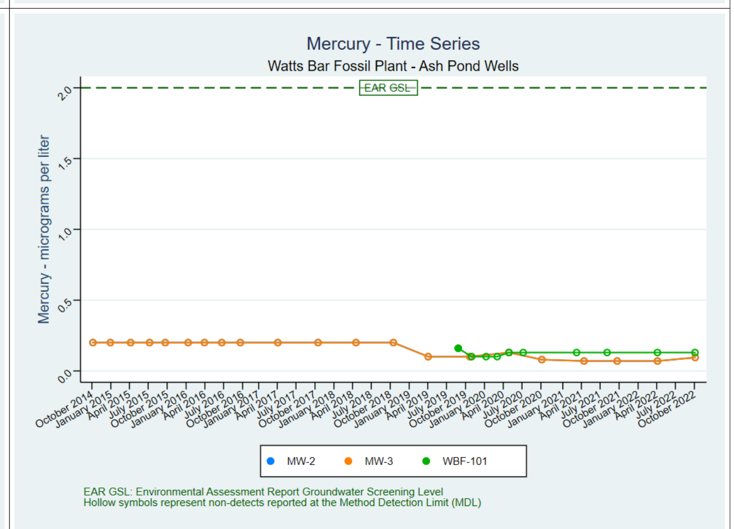


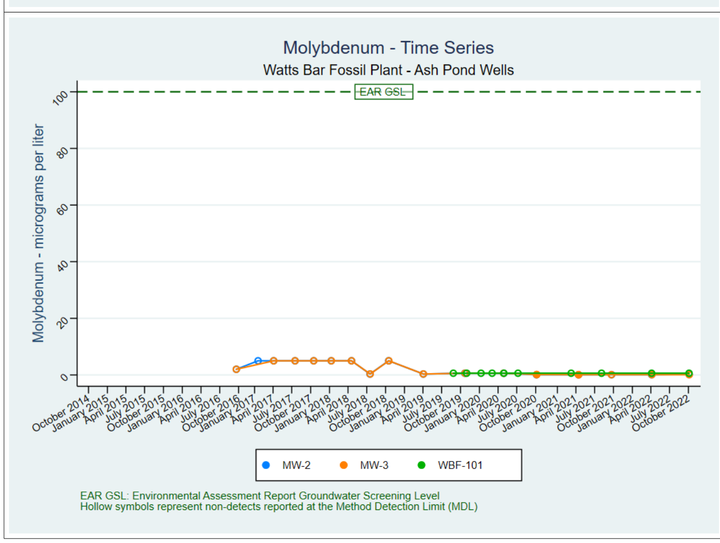


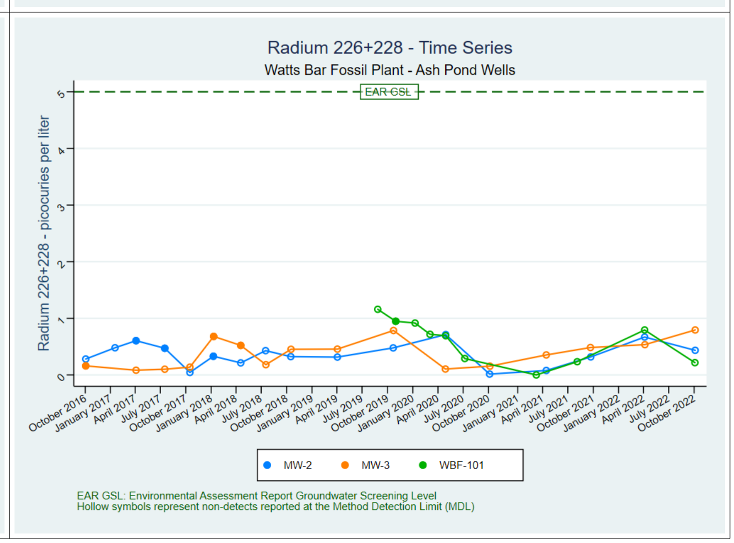

Cobalt - Time Series
Watts Bar Fossil Plant - Ash Pond Wells
Cobalt - micrograms per liter
0
100
200
300
EAR GSL
MW-2
MW-3
WBF-101
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)

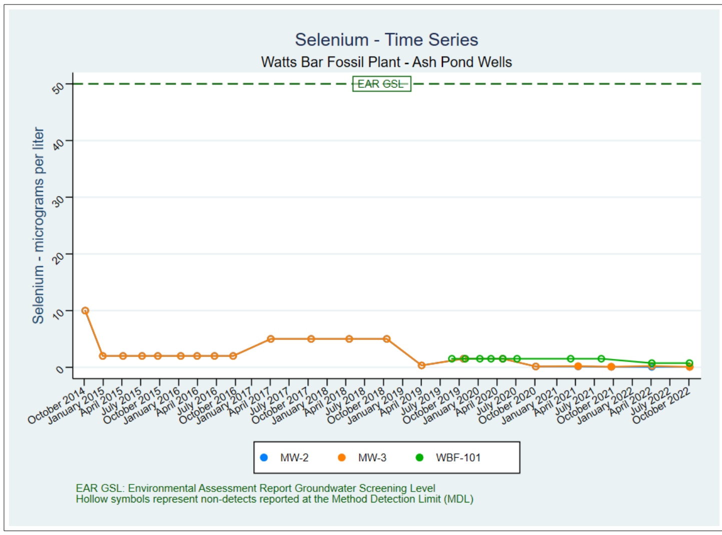

Lead - Time Series
Watts Bar Fossil Plant - Ash Pond Wells
Lead - micrograms per liter
0
3
6
9
12
15
EAR GSL
MW-2
MW-3
WBF-101
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)

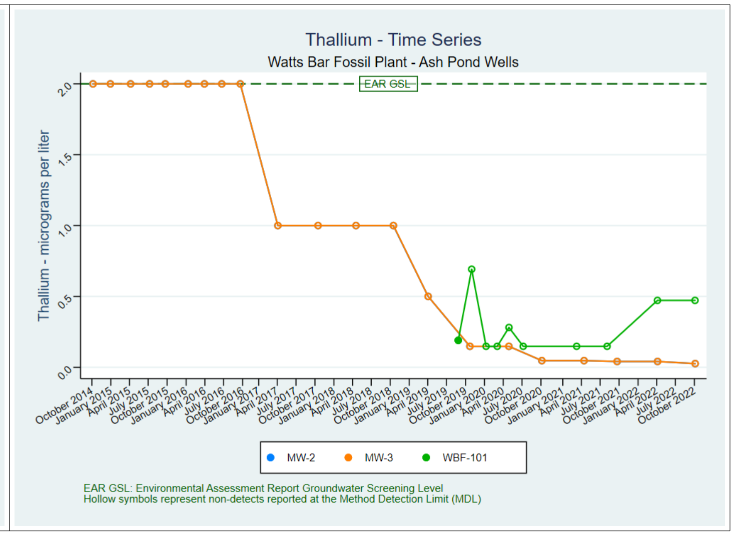

Lithium - Time Series
Watts Bar Fossil Plant - Ash Pond Wells
Lithium - micrograms per liter
0
10
20
30
40
50
EAR GSL
MW-2
MW-3
WBF-101
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)


Mercury - Time Series
Watts Bar Fossil Plant - Ash Pond Wells
Mercury - micrograms per liter
0.0
0.5
1.0
1.5
2.0
EAR GSL
MW-2
MW-3
WBF-101
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)

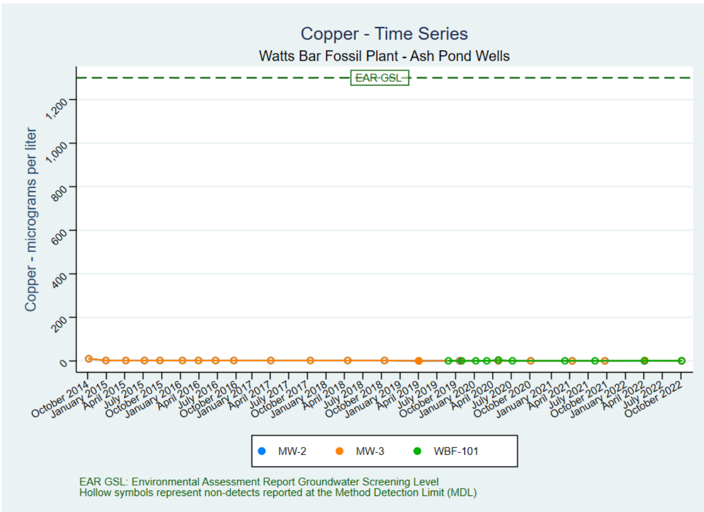

Molybdenum - Time Series
Watts Bar Fossil Plant - Ash Pond Wells
Molybdenum - micrograms per liter
0
20
40
60
80
100
EAR GSL
MW-2
MW-3
WBF-101
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)

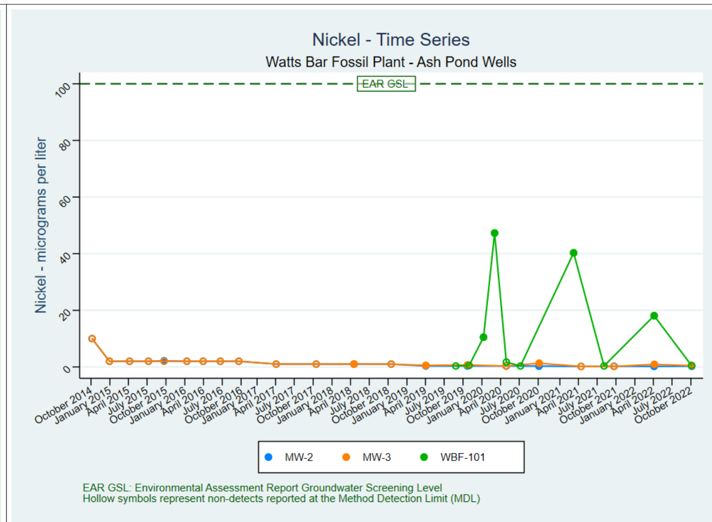

Radium 226+228 - Time Series
Watts Bar Fossil Plant - Ash Pond Wells
Radium 226+228 - picocuries per liter
0
1
2
3
4
5
EAR GSL
MW-2
MW-3
WBF-101
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)

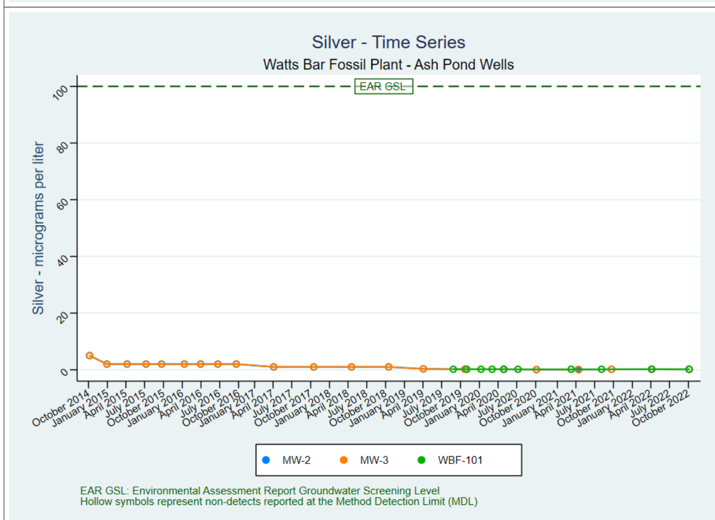

Selenium - Time Series
Watts Bar Fossil Plant - Ash Pond Wells
Selenium - micrograms per liter
EAR GSL
MW-2
MW-3
WBF-101
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)

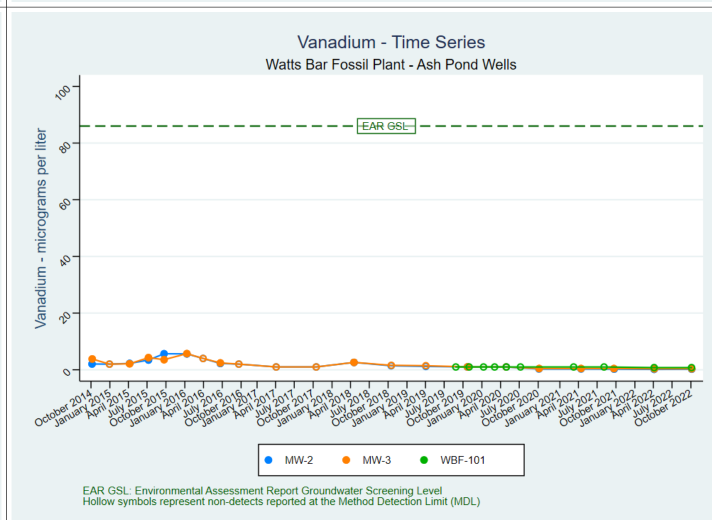

Thallium - Time Series
Watts Bar Fossil Plant - Ash Pond Wells
Thallium - micrograms per liter
EAR GSL
MW-2
MW-3
WBF-101
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)

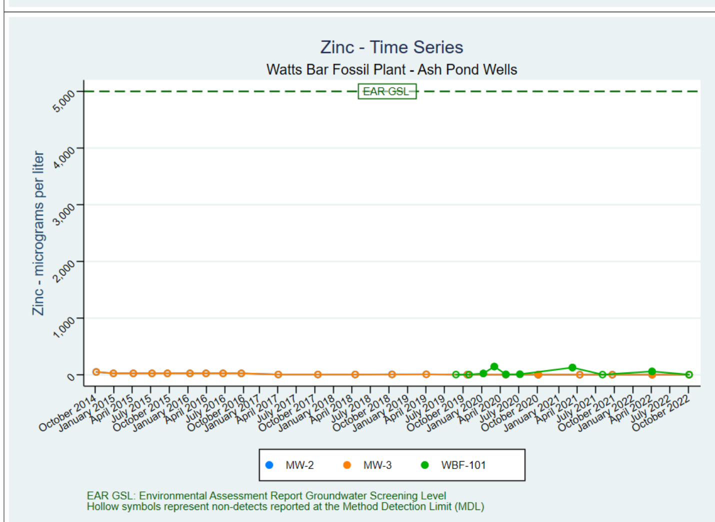
Time Series Plots
Ash Pond Wells
TDEC Appendix I Parameters
Watts Bar Fossil Plant - Spring City, Tennessee











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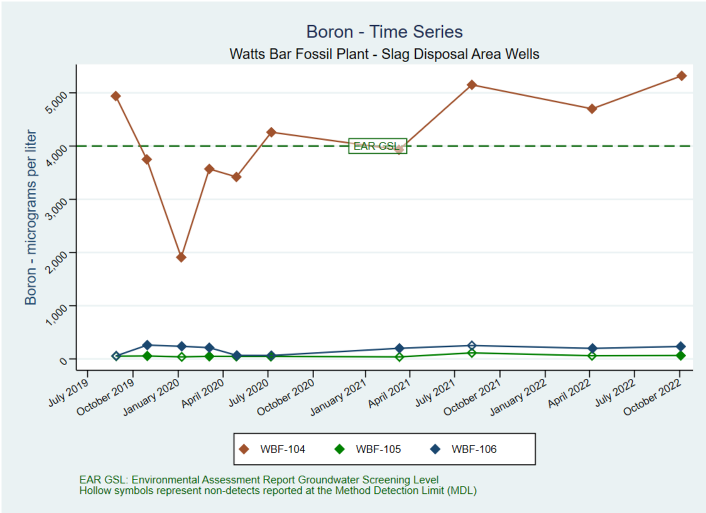
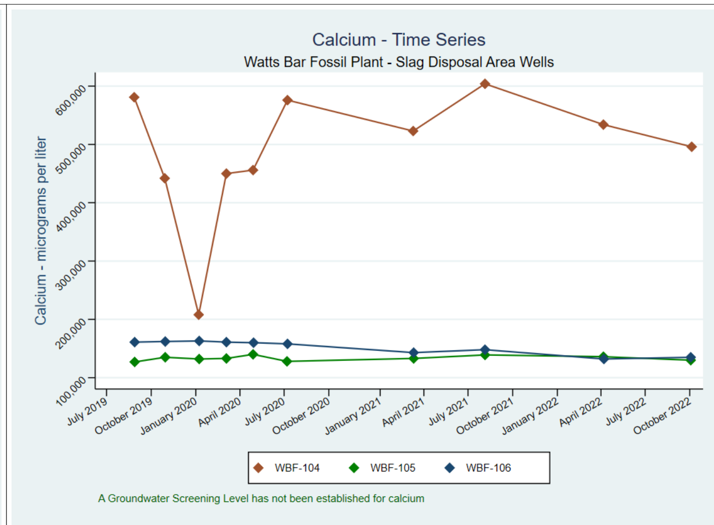
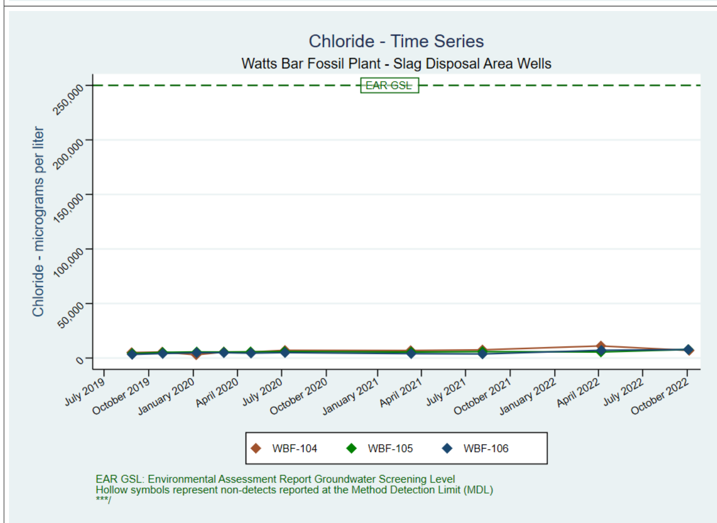
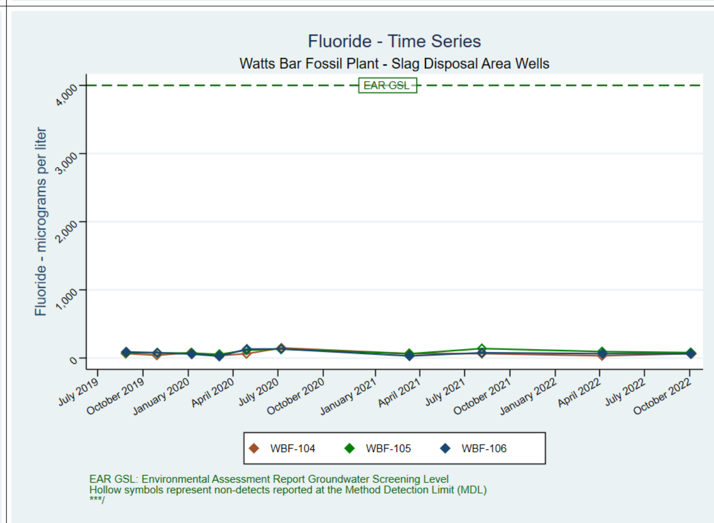
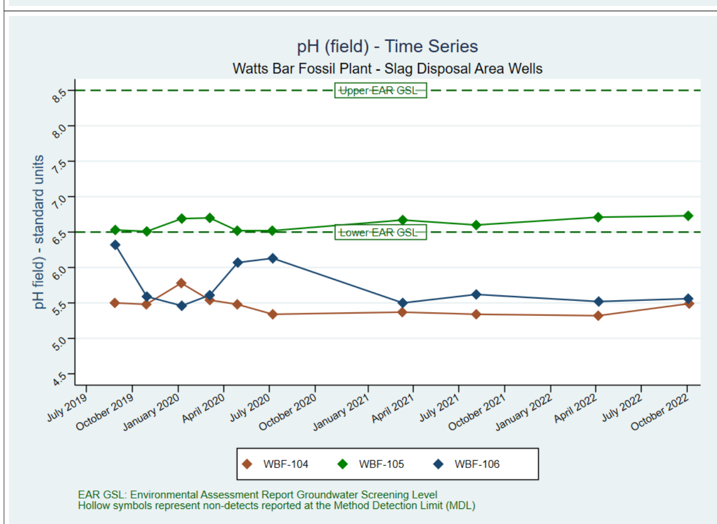
Time Series Plots
Slag Disposal Area Wells
CCR Rule Appendix III Parameters
Watts Bar Fossil Plant - Spring City, Tennessee

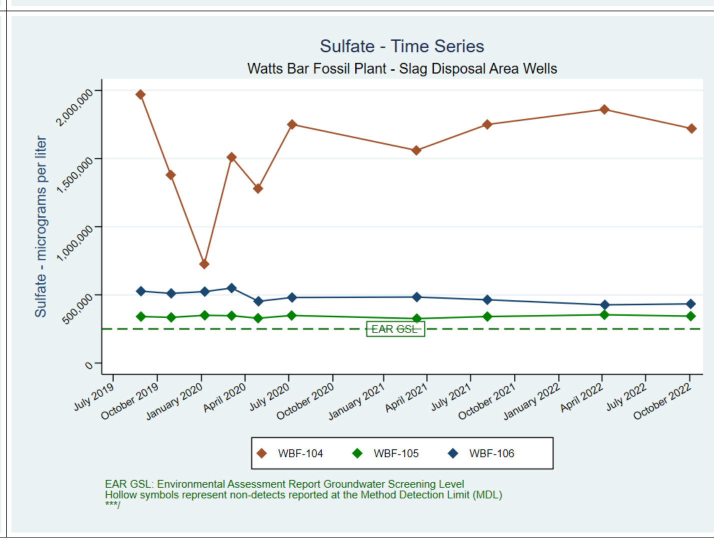


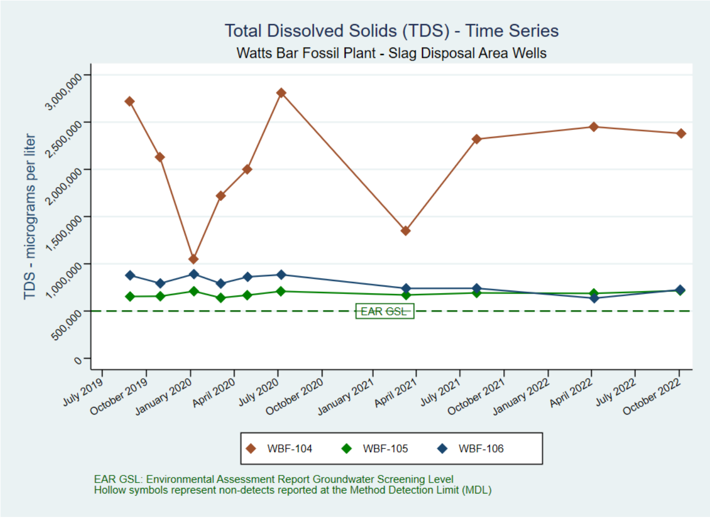












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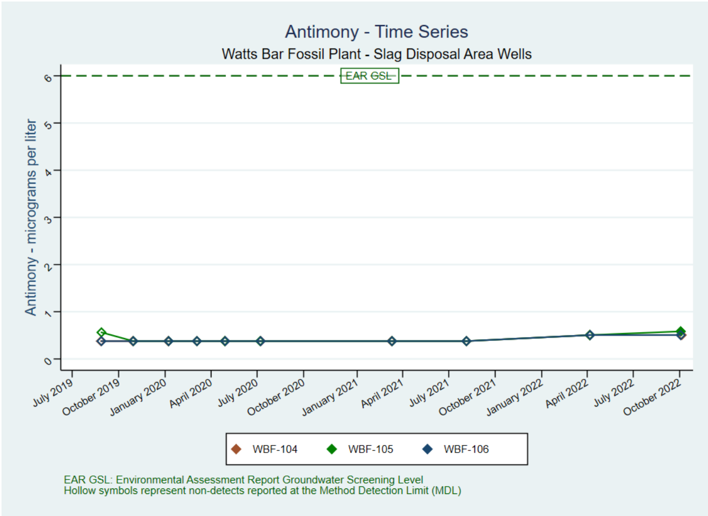
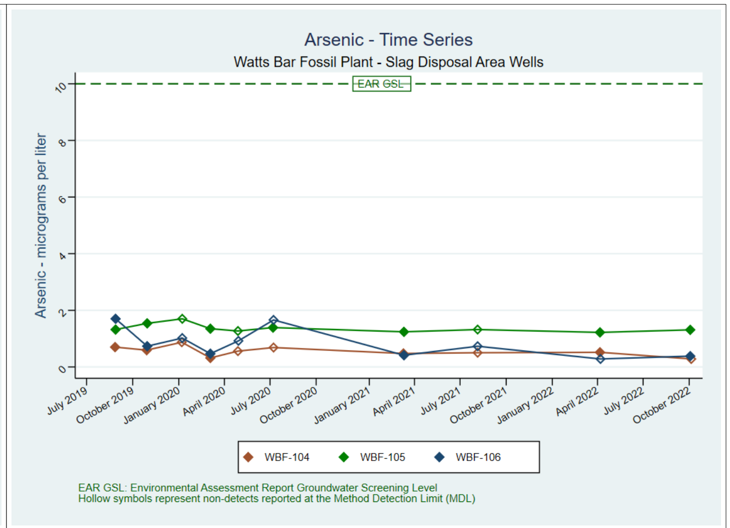
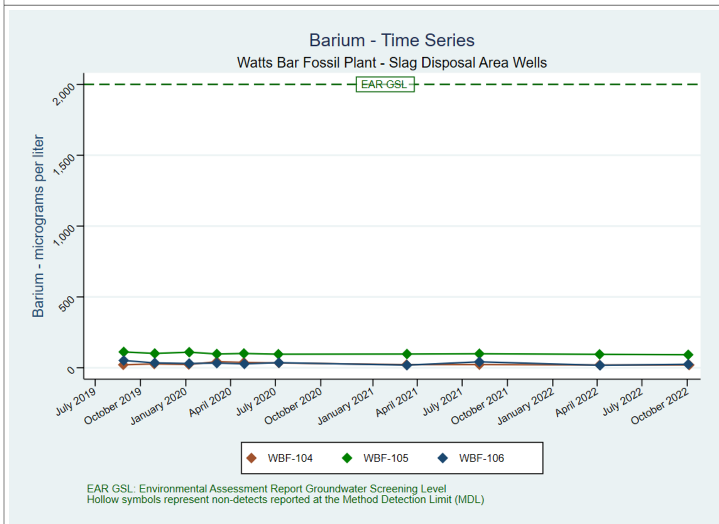
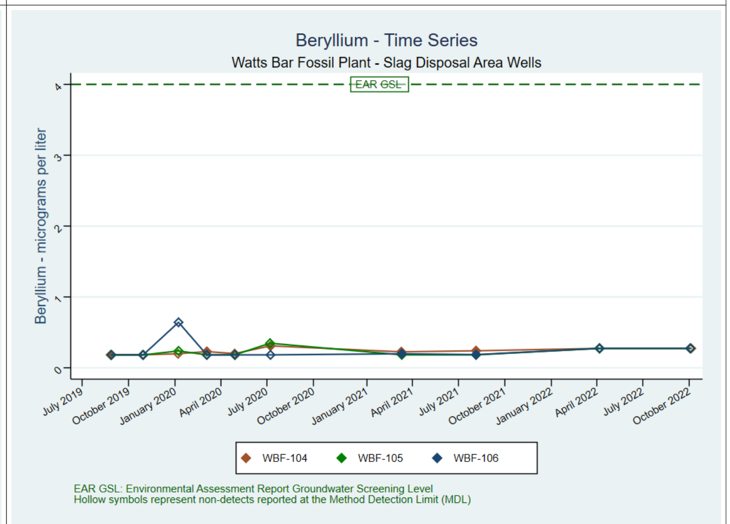
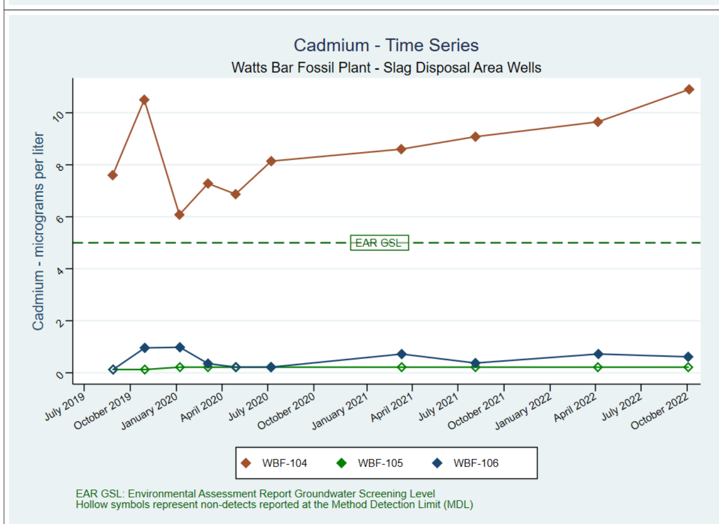
Time Series Plots
Slag Disposal Area Wells
CCR Rule Appendix IV Parameters
Watts Bar Fossil Plant - Spring City, Tennessee

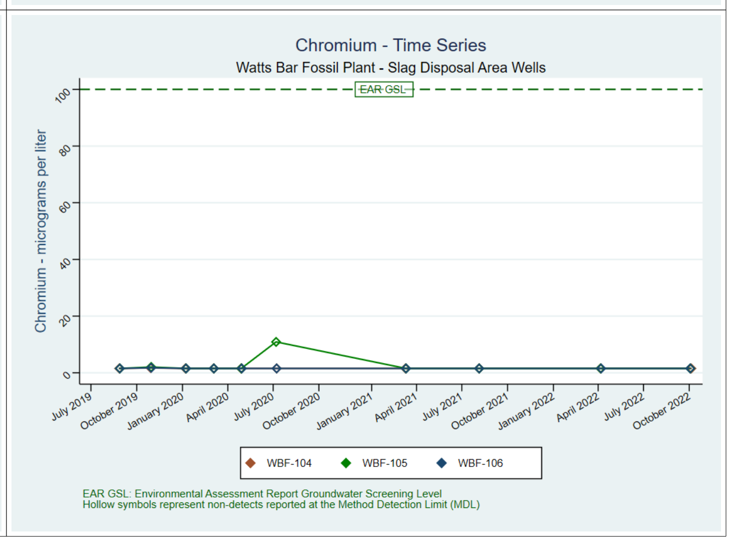


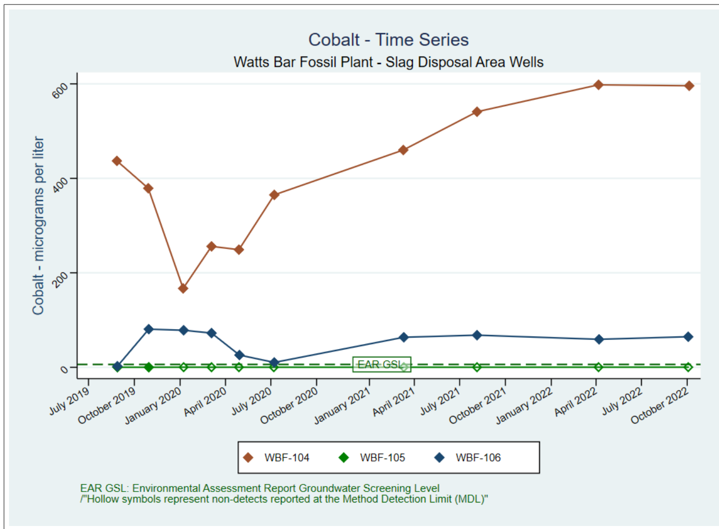


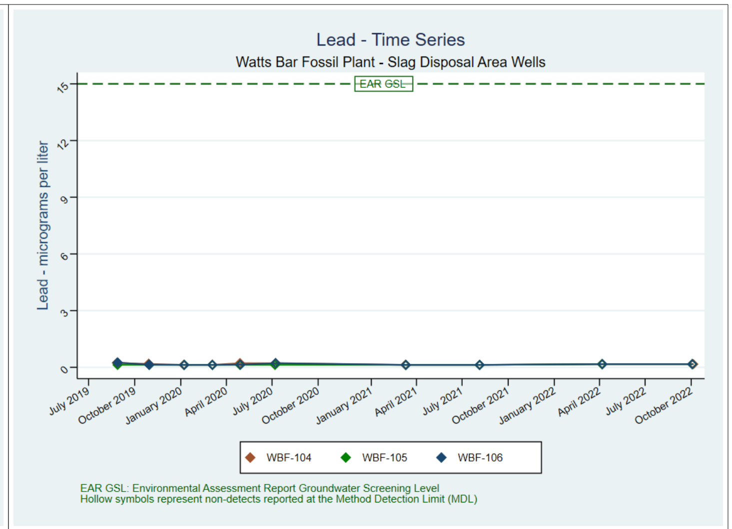


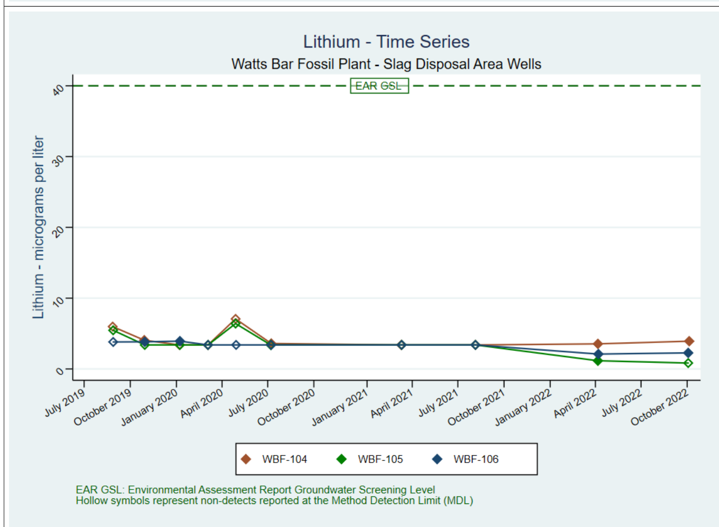







Cobalt - Time Series
Watts Bar Fossil Plant - Slag Disposal Area Wells
Cobalt - micrograms per liter
EAR GSL
WBF-104
WBF-105
WBF-106
EAR GSL: Environmental Assessment Report Groundwater Screening Level
/"Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)"


Lead - Time Series
Watts Bar Fossil Plant - Slag Disposal Area Wells
Lead - micrograms per liter
EAR GSL
WBF-104
WBF-105
WBF-106
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)


Lithium - Time Series
Watts Bar Fossil Plant - Slag Disposal Area Wells
Lithium - micrograms per liter
EAR GSL
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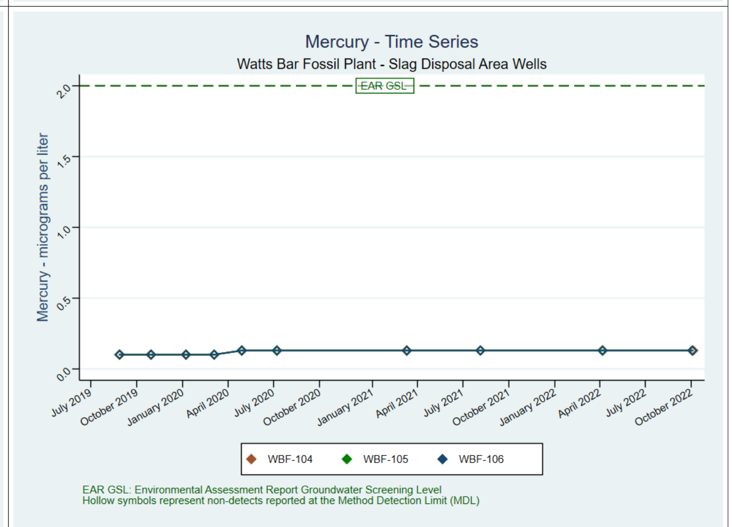
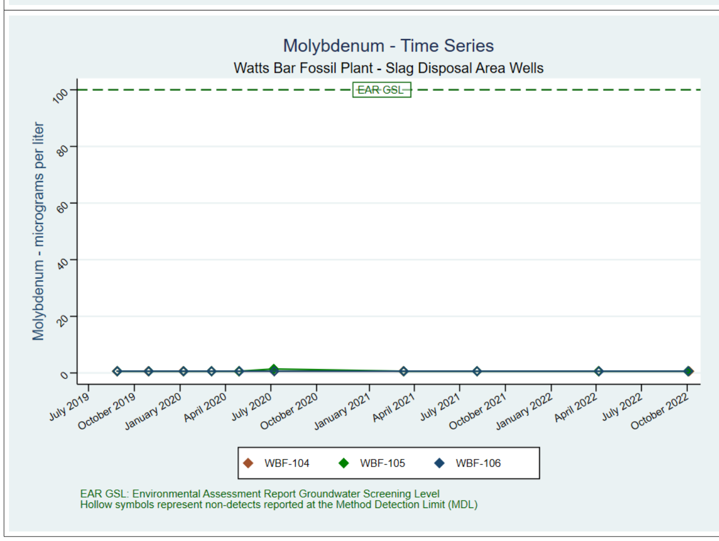
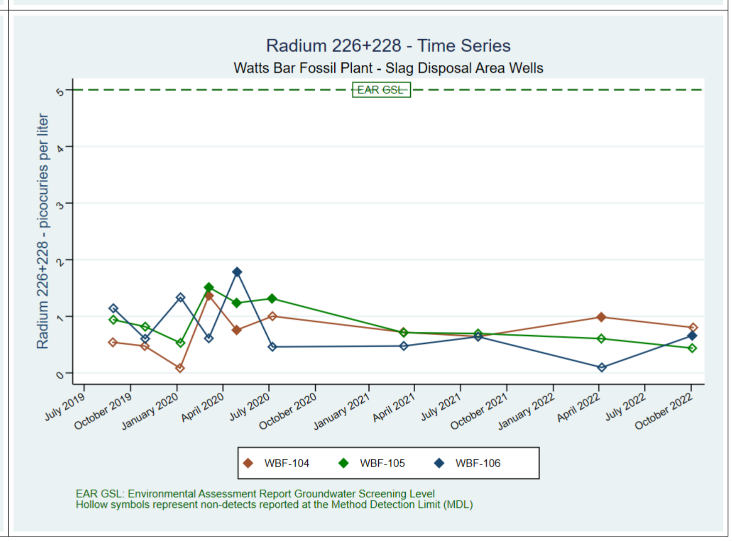
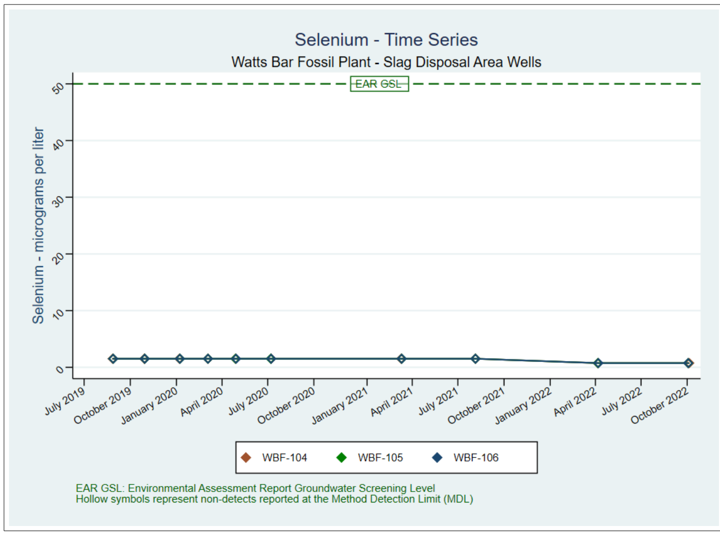
WBF-105
WBF-106
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)

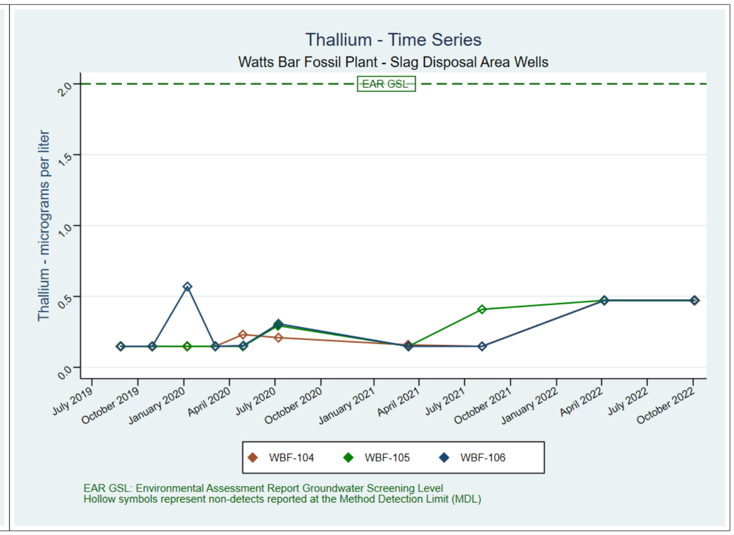

Mercury - Time Series
Watts Bar Fossil Plant - Slag Disposal Area Wells
Mercury - micrograms per liter
EAR GSL
WBF-104
WBF-105
WBF-106
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)


Molybdenum - Time Series
Watts Bar Fossil Plant - Slag Disposal Area Wells
Molybdenum - micrograms per liter
EAR GSL
WBF-104
WBF-105
WBF-106
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)


Radium 226+228 - Time Series
Watts Bar Fossil Plant - Slag Disposal Area Wells
Radium 226+228 - picocuries per liter
EAR GSL
WBF-104
WBF-105
WBF-106
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)

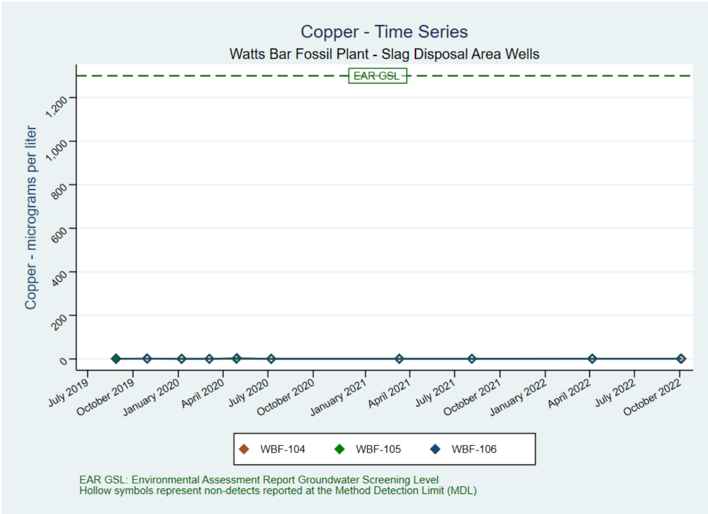


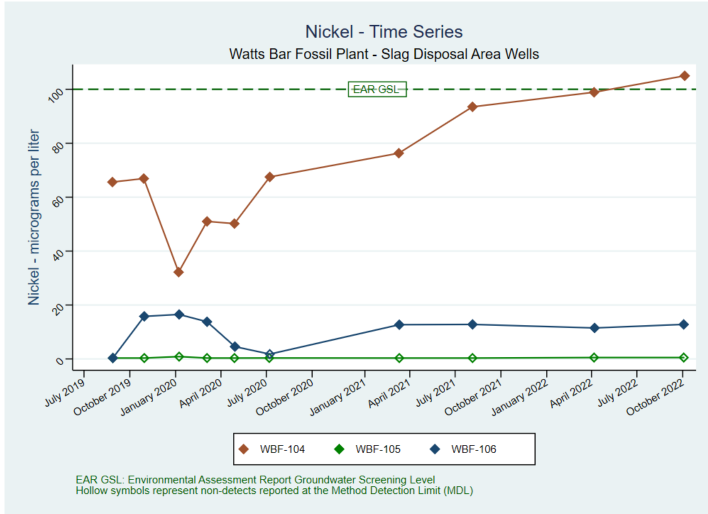
Selenium - Time Series
Watts Bar Fossil Plant - Slag Disposal Area Wells
Selenium - micrograms per liter
EAR GSL
0
10
20
30
40
50
July 2019
October 2019
January 2020
April 2020
July 2020
October 2020
January 2021
April 2021
July 2021
October 2021
January 2022
April 2022
July 2022
October 2022
WBF-104
WBF-105
WBF-106
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)

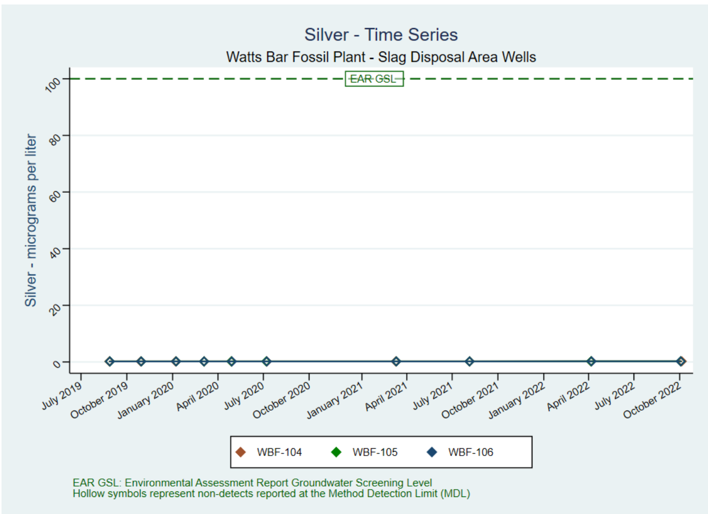


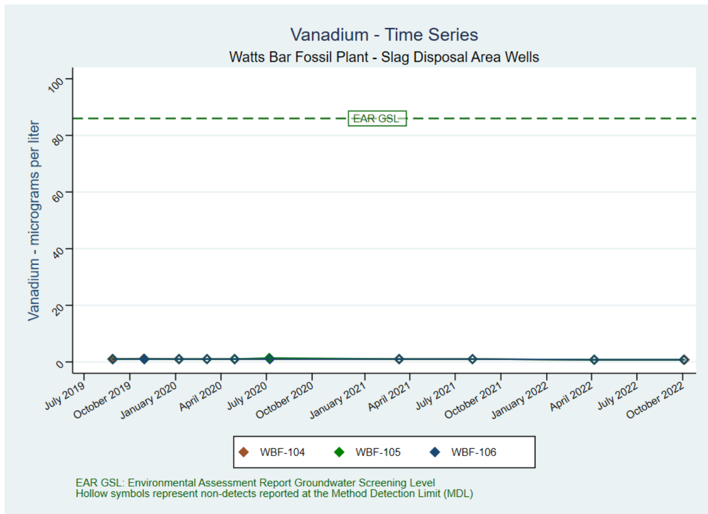
Thallium - Time Series
Watts Bar Fossil Plant - Slag Disposal Area Wells
Thallium - micrograms per liter
EAR GSL
0.0
0.5
1.0
1.5
2.0
July 2019
October 2019
January 2020
April 2020
July 2020
October 2020
January 2021
April 2021
July 2021
October 2021
January 2022
April 2022
July 2022
October 2022
WBF-104
WBF-105
WBF-106
EAR GSL: Environmental Assessment Report Groundwater Screening Level
Hollow symbols represent non-detects reported at the Method Detection Limit (MDL)

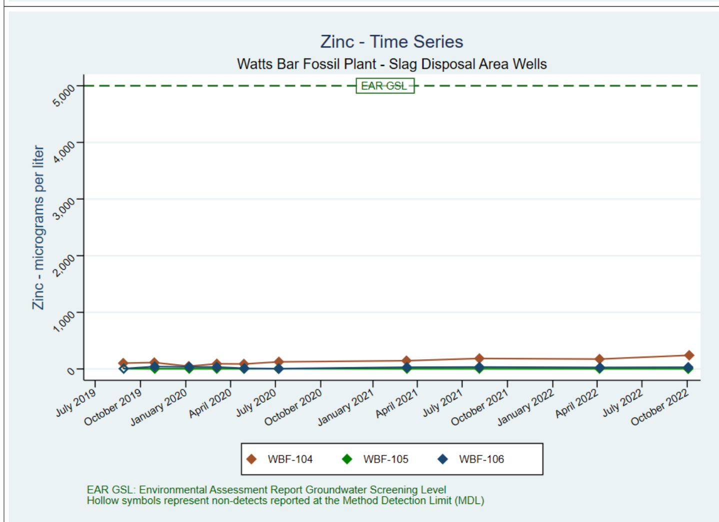
Time Series Plots
Slag Disposal Area Wells
TDEC Appendix I Parameters
Watts Bar Fossil Plant - Spring City, Tennessee











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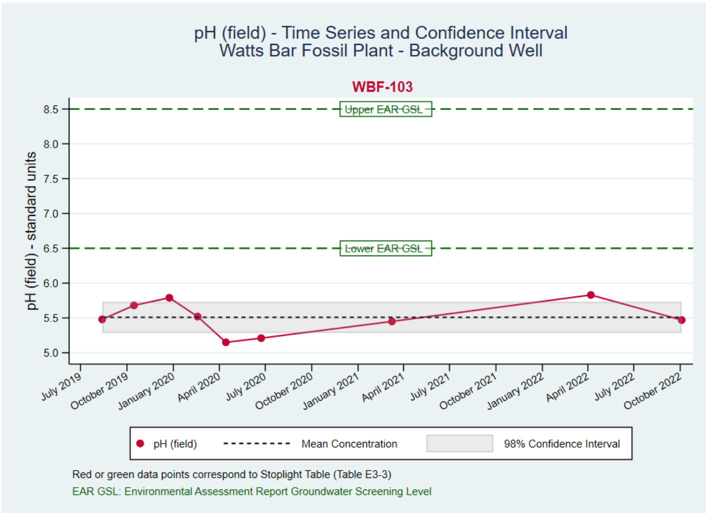
ATTACHMENT E.3-D
LINEAR REGRESSION PLOTS

Regression Plots
Background Well
CCR Rule Appendix III Parameters
Watts Bar Fossil Plant - Spring City, Tennessee



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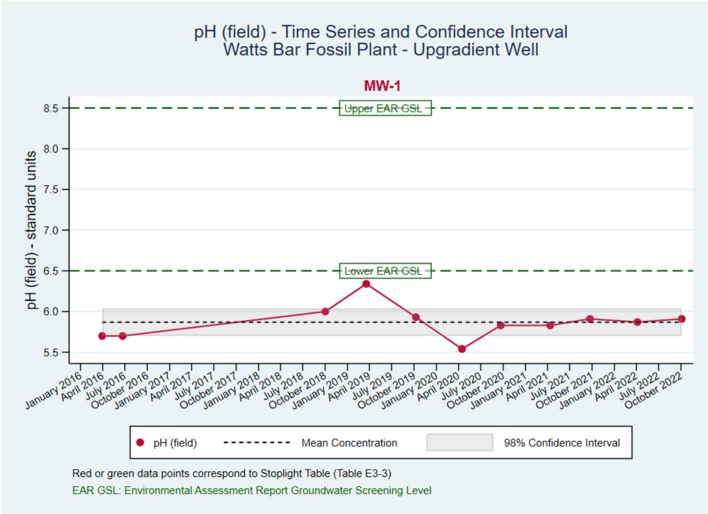
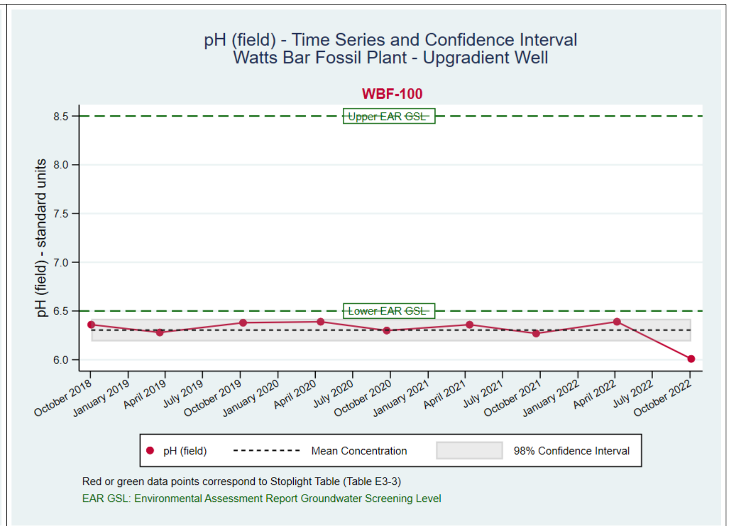
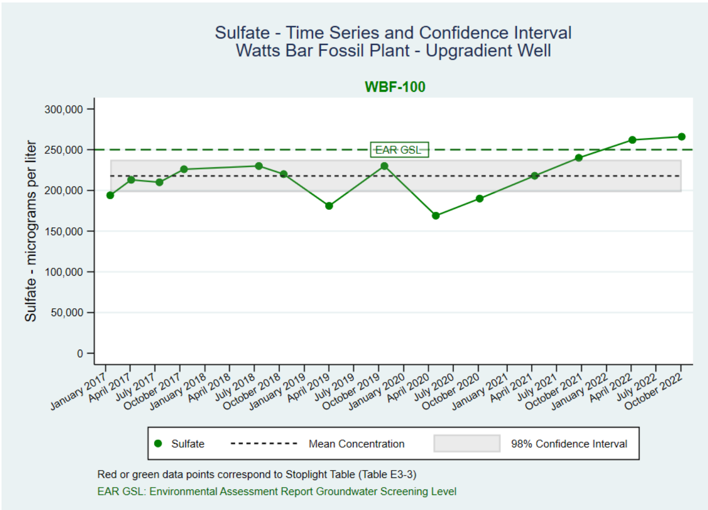
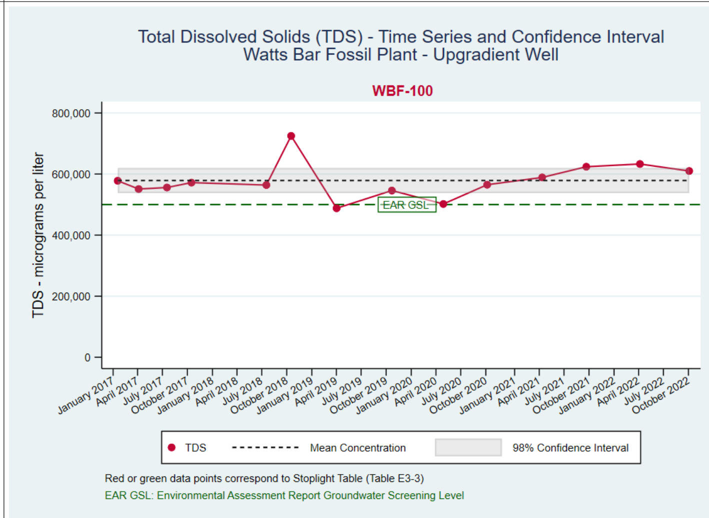
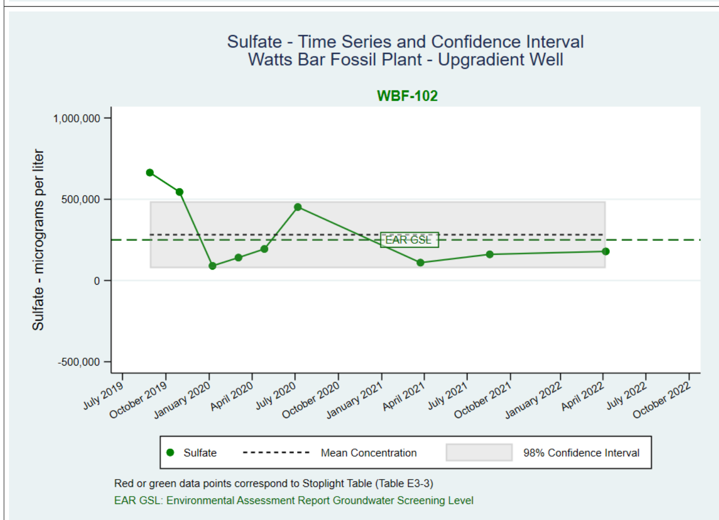
Regression Plots
Upgradient Wells
CCR Rule Appendix III Parameters
Watts Bar Fossil Plant - Spring City, Tennessee

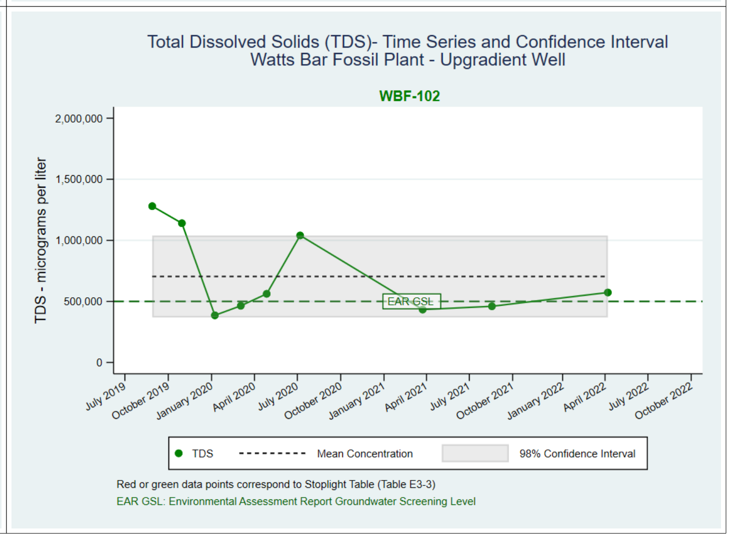




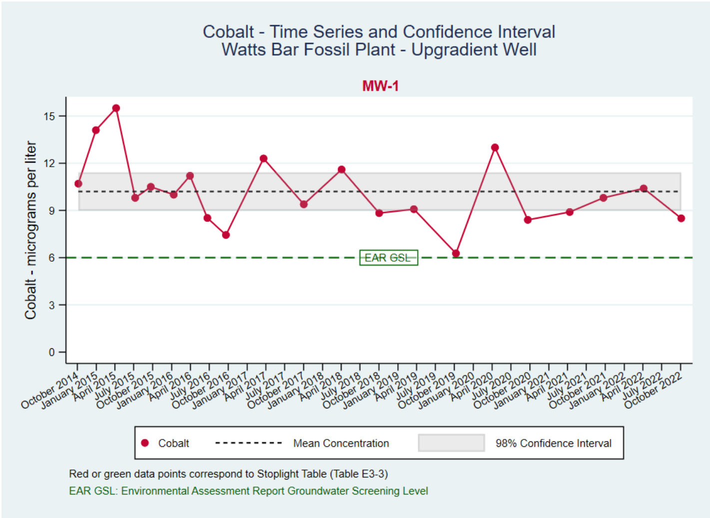


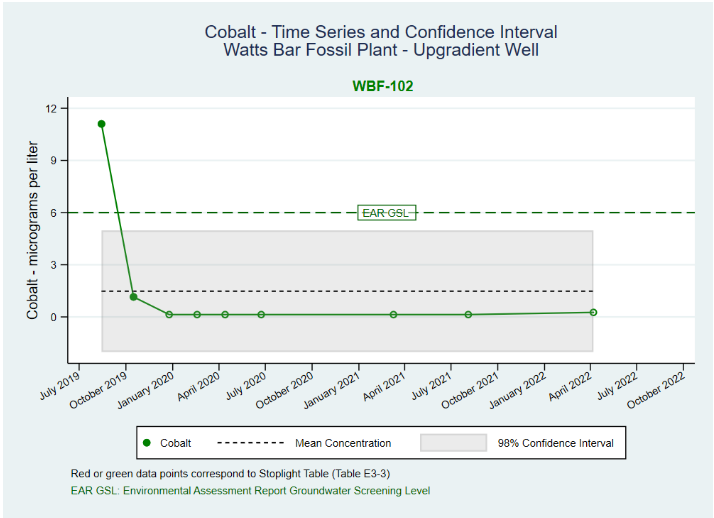




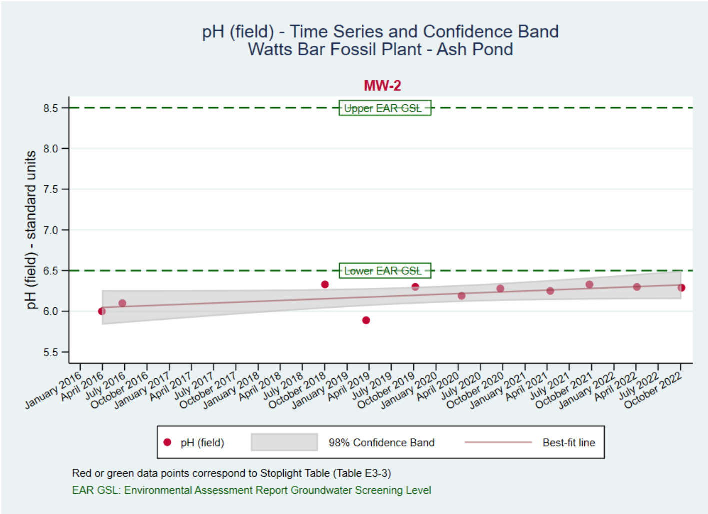


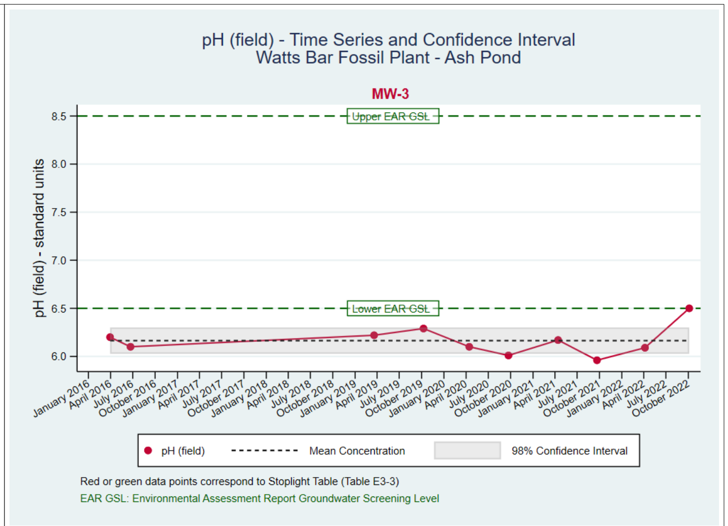
Regression Plots
Upgradient Wells
CCR Rule Appendix IV Parameters
Watts Bar Fossil Plant - Spring City, Tennessee

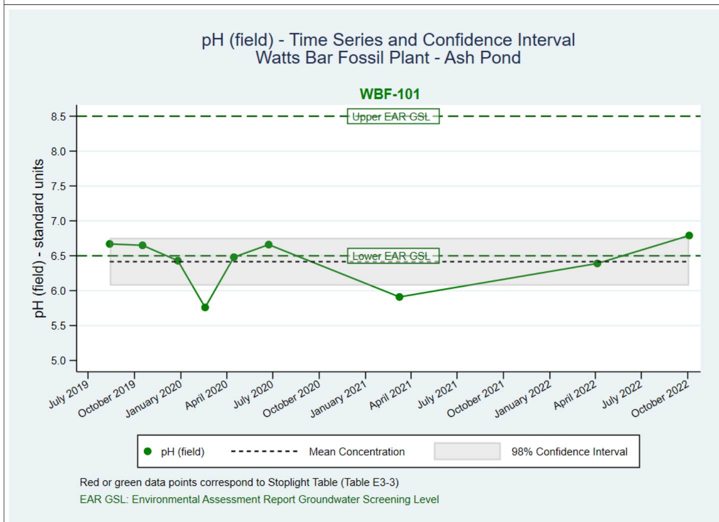


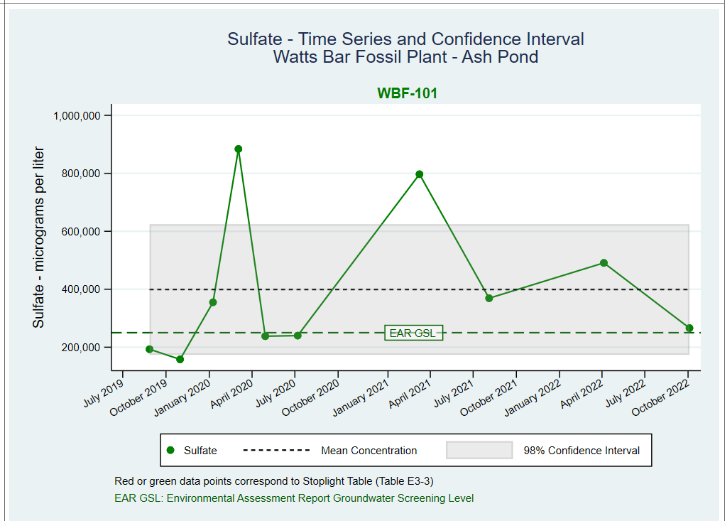


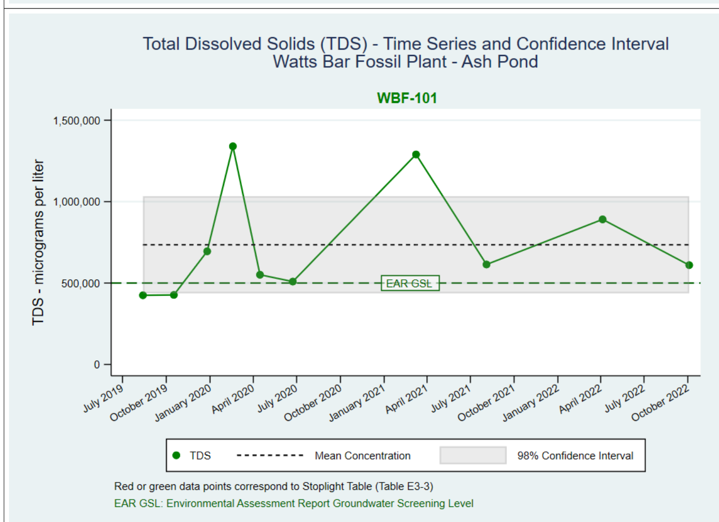
Regression Plots
Ash Pond
CCR Rule Appendix III Parameters
Watts Bar Fossil Plant - Spring City, Tennessee











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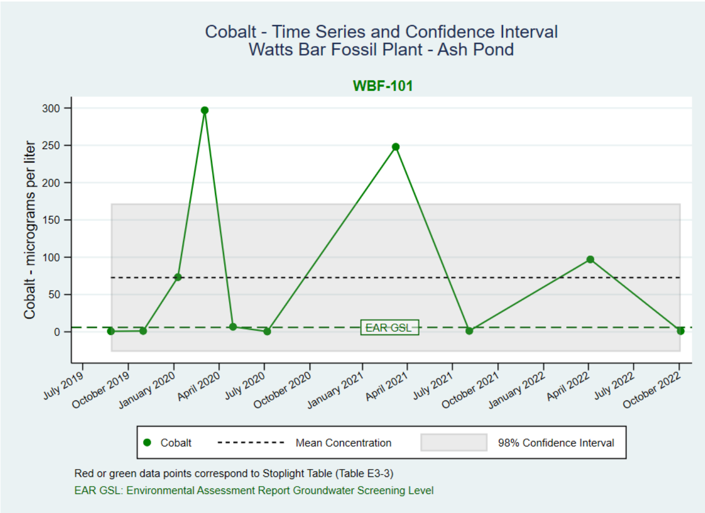
Regression Plots
Ash Pond
CCR Rule Appendix IV Parameters
Watts Bar Fossil Plant - Spring City, Tennessee



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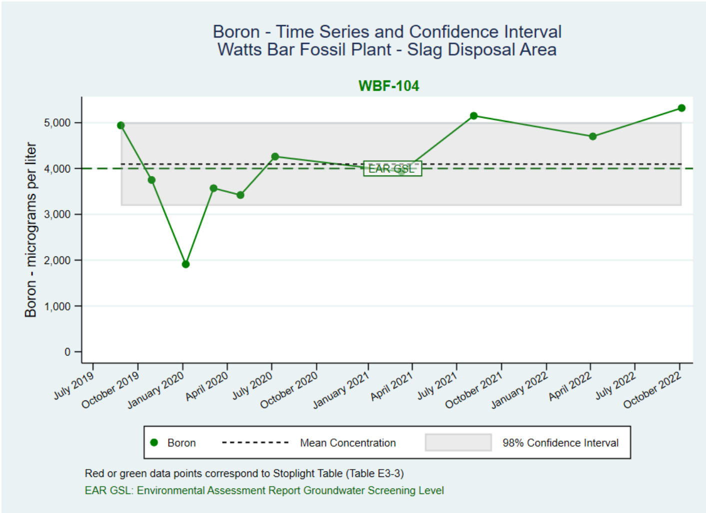
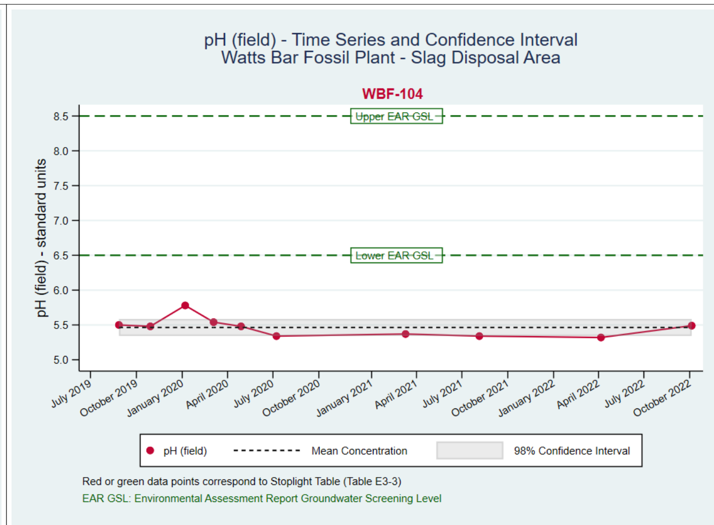
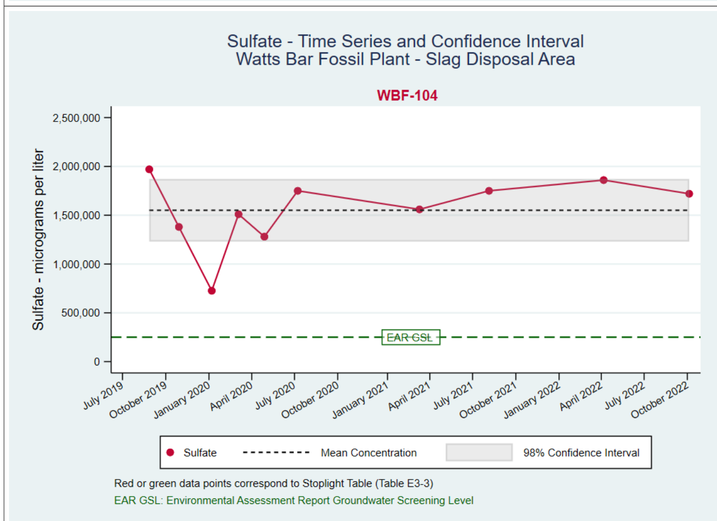
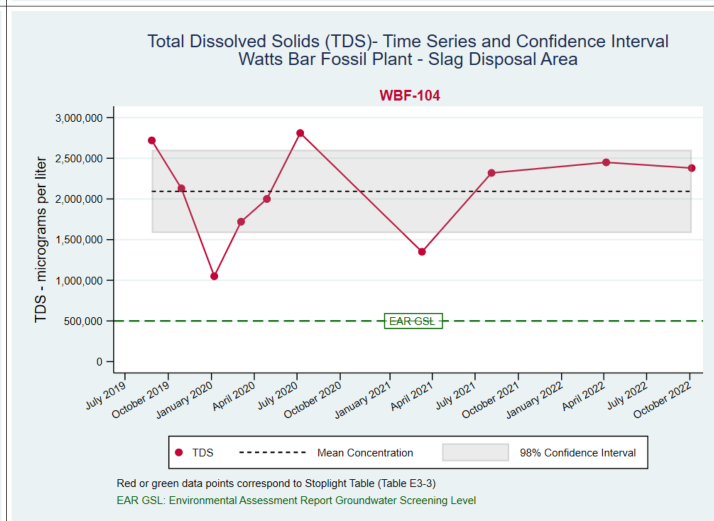
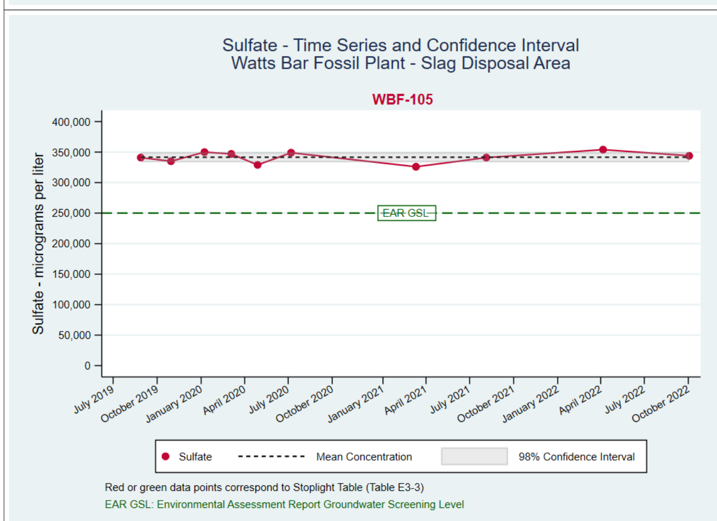
Regression Plots
Slag Disposal Area
CCR Rule Appendix III Parameters
Watts Bar Fossil Plant - Spring City, Tennessee

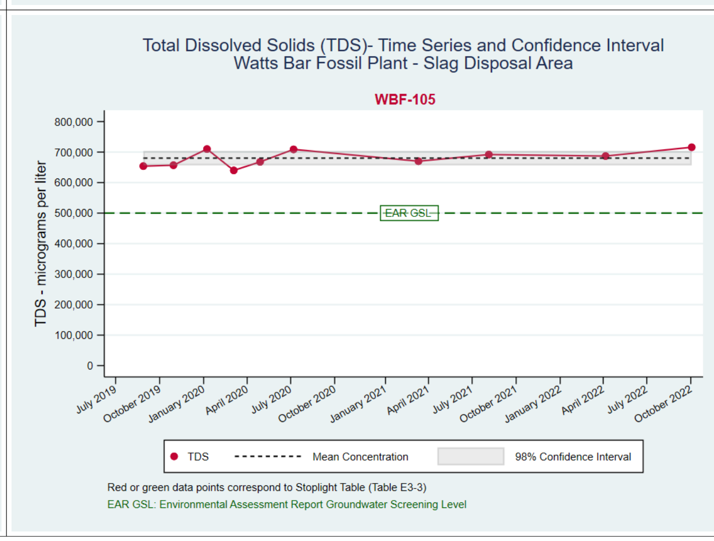


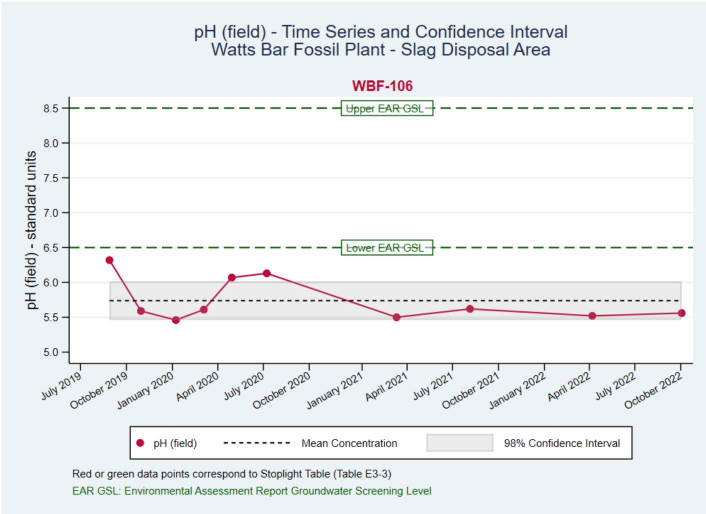


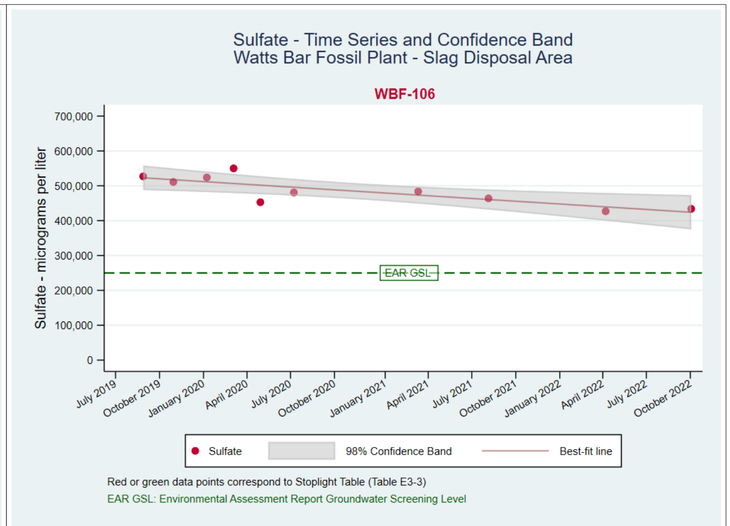


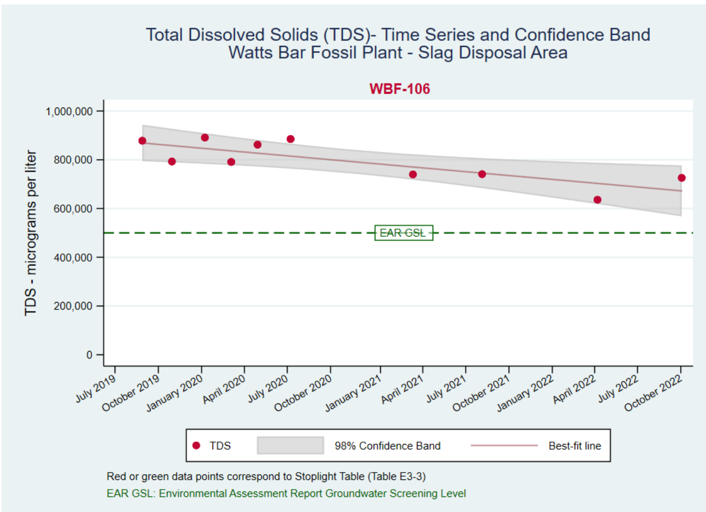












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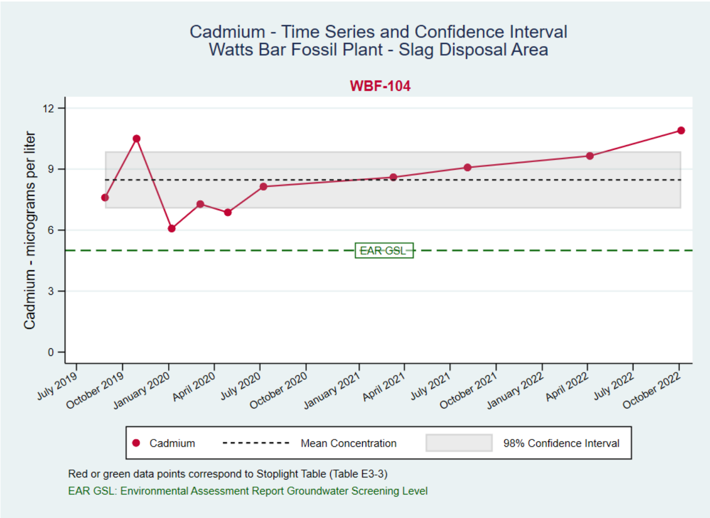
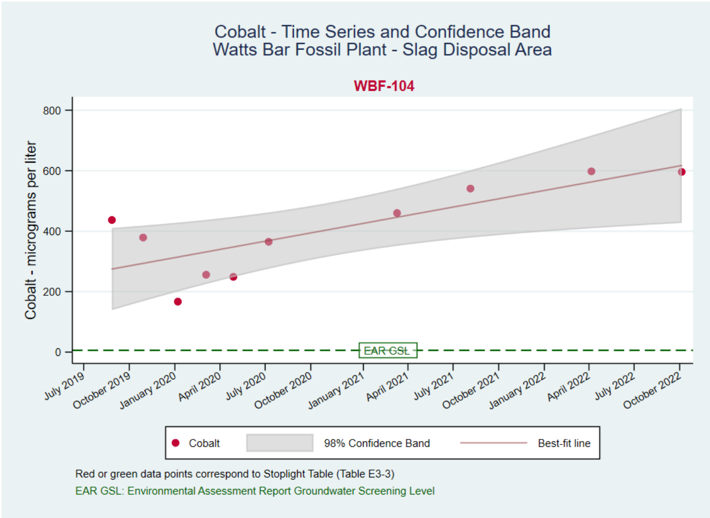
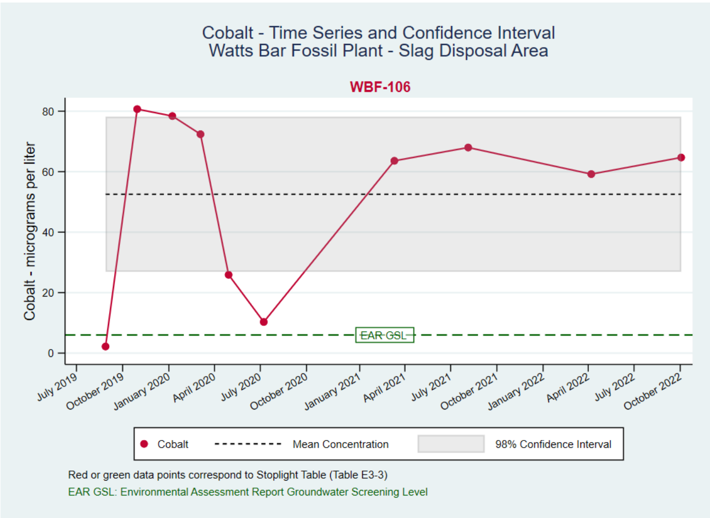
Regression Plots
Slag Disposal Area
CCR Rule Appendix IV Parameters
Watts Bar Fossil Plant - Spring City, Tennessee







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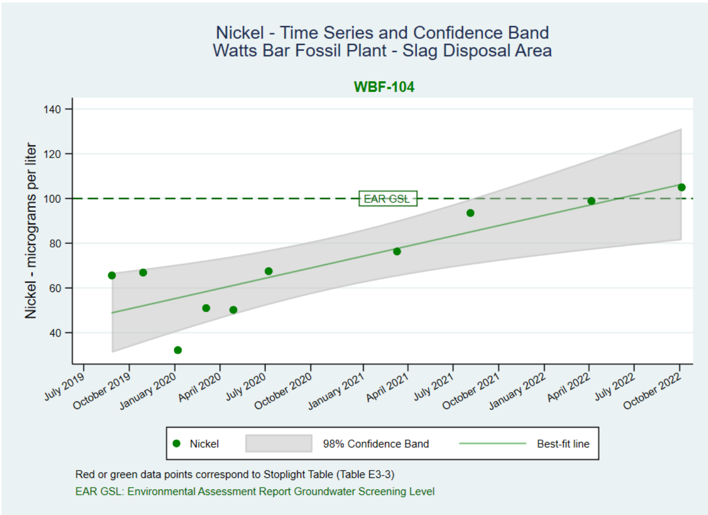
Regression Plots
Slag Disposal Area
TDEC Appendix I Parameters
Watts Bar Fossil Plant - Spring City, Tennessee



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ATTACHMENT E.3-E
LINEAR REGRESSION RESULTS

Attachment E.3-E - Linear Regression Results
Groundwater Investigation - Watts Bar Fossil Plant - Spring City, Tennessee

Well	Constituent Type	Constituent	p-value	Trend summary[1]
WBF-103	CCR Rule Appendix III Parameters	pH (field)	0.7349	No trend detected
MW-1	CCR Rule Appendix III Parameters	pH (field)	0.6425	No trend detected
	CCR Rule Appendix IV Parameters	Cobalt	0.0765	No trend detected
WBF-100	CCR Rule Appendix III Parameters	pH (field)	0.1745	No trend detected
		Sulfate	0.0941	No trend detected
		Total dissolved solids	0.4268	No trend detected
WBF-102	CCR Rule Appendix III Parameters	Sulfate	0.1548	No trend detected
		Total dissolved solids	0.1784	No trend detected
	CCR Rule Appendix IV Parameters	Cobalt	0.2431	No trend detected
MW-2	CCR Rule Appendix III Parameters	pH (field)	0.0405	Increasing
MW-3	CCR Rule Appendix III Parameters	pH (field)	0.7873	No trend detected
WBF-101	CCR Rule Appendix III Parameters	pH (field)	0.8232	No trend detected
		Sulfate	0.7076	No trend detected
		Total dissolved solids	0.6272	No trend detected
	CCR Rule Appendix IV Parameters	Cobalt	0.941	No trend detected
WBF-104	CCR Rule Appendix III Parameters	Boron	0.0757	No trend detected
		pH (field)	0.1694	No trend detected
		Sulfate	0.2552	No trend detected
		Total dissolved solids	0.5816	No trend detected
	CCR Rule Appendix IV Parameters	Cadmium	0.0525	No trend detected
		Cobalt	0.0063	Increasing
	TDEC Appendix I Paramters	Nickel	0.0016	Increasing
WBF-105	CCR Rule Appendix III Parameters	Sulfate	0.5959	No trend detected
		Total dissolved solids	0.1088	No trend detected
WBF-106	CCR Rule Appendix III Parameters	pH (field)	0.1891	No trend detected
		Sulfate	0.0035	Decreasing
		Total dissolved solids	0.005	Decreasing
	CCR Rule Appendix IV Parameters	Cobalt	0.4628	No trend detected

Notes
CCR Rule - Title 40, Code of Federal Regulations, Part 257
1. Trend evaluated using linear regression. Slope considered significant when $p<0.05$.
2. Fluoride is both a CCR Rule Appendix III and CCR Rule Appendix IV constituent. In this table, fluoride has been grouped with the Appendix III constituents only to avoid duplication of results.

APPENDIX E.4

STATISTICAL ANALYSIS OF SEEP INVESTIGATION

Originally Published as Appendix D of the Seep Sampling and Analysis Report

Appendix D – Statistical Analysis of Water Quality Parameters

Watts Bar Fossil Plant
Seep Investigation

May 21, 2021

Prepared for:

Tennessee Valley Authority
Chattanooga, Tennessee

Prepared by:

Stantec Consulting Services Inc.
Lexington, Kentucky

Revision Record

Revision	Description	Date
0	Submittal to TVA	May 21, 2021

Sign-off Sheet

This document entitled Appendix D – Statistical Analysis of Water Quality Parameters was prepared by Stantec Consulting Services Inc. ("Stantec") for the account of Tennessee Valley Authority (the "Client"). Any reliance on this document by any third party is strictly prohibited. The material in it reflects Stantec's professional judgment in light of the scope, schedule and other limitations stated in the document and in the contract between Stantec and the Client. 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 did not verify information supplied to it by others. Any use which a third party makes of this document is the responsibility of such third party. Such third party agrees that Stantec shall not be responsible for costs or damages of any kind, if any, suffered by it or any other third party as a result of decisions made or actions taken based on this document.

Prepared by ______________________________________
Chris LaLonde, Associate Senior Statistician/Risk Assessor

Reviewed by ______________________________________
Rebekah Brooks, Principal Hydrogeologist

Approved by ______________________________________
Carole M. Farr, Senior Principal Geologist

Table of Contents

LIST OF TABLES

LIST OF ATTACHMENTS

Abbreviations

α	alpha
AOC	Area of Concern
AOI	Area of Interest
CCR	Coal Combustion Residuals
DO	Dissolved Oxygen
H_a	Alternative hypothesis
H_o	Null hypothesis
µS/cm	MicroSiemens per Centimeter
mg/L	Milligrams per Liter
Q-Q Plot	Quantile-Quantile plot
SAP	Sampling and Analysis Plan
SAR	Sampling and Analysis Report
Stantec	Stantec Consulting Services Inc.
USEPA	United States Environmental Protection Agency
UTL	Upper Tolerance Level
WBF	Watts Bar Fossil Plant

May 21, 2021

1.0 INTRODUCTION

A statistical analysis of water quality parameter data collected in the Tennessee River adjacent to the Watts Bar Fossil Plant (WBF Plant) was conducted as part of the seep investigation. The statistical analysis was used to evaluate whether there are statistically significant differences between monitoring results collected “adjacent” to and “upstream” of the historical seep and identified AOI locations and between intermediate and upstream control areas for four water quality parameters (i.e., dissolved oxygen [DO], pH, specific conductance and temperature). This appendix to the WBF Plant Seep Sampling and Analysis Report (SAR) presents the statistical approach and methods used for this analysis and the analysis results.

2.0 OBJECTIVE

The objective of the statistical analysis is to identify statistically significant differences between four water quality parameter results (i.e., DO, pH, specific conductance, and temperature) measured “adjacent” to historical seep/AOI locations and results measured “upstream” of these location. As described in Section 3.2.1 of this SAR, six historical seep locations and the two identified AOIs adjacent to the Tennessee River were targeted for monitoring at the WBF Plant for the seep investigation. These locations were.combined (or clustered) for data analyses because of their close proximity (WBF-HSA1-5). The historical seep /AOI locations included in this statistical analysis are listed in Table D.1 and shown on Exhibits A.1, A.2, and A.3 (Appendix A).

Additional Areas of Interest (AOIs) will be identified only when statistically significant evidence indicates that: 1) water quality parameter results collected “adjacent” to the historical seep/AOI cluster are different than water quality parameter results collected “upstream” of these locations for all four parameters or 2) water quality parameter results collected adjacent to intermediate areas differ significantly from the upstream control area for all four parameters.

3.0 DATASETS

In accordance with the Seep Sampling and Analysis Plan (SAP), datasets were generated consisting of water quality parameter measurements for each of the four field parameters (i.e., DO, pH, specific conductance, and temperature) for the historical seep/AOI locations identified by Tennessee Valley Authority for evaluation. The data used in the statistical analysis were obtained in spreadsheet format from the "*Seep Investigation/ Surface Stream Field Parameter Measurement Forms"*, which were prepared in real time as the field investigation was being conducted. Statistical datasets for the water quality parameter results measured downstream, adjacent to, and upstream of the historical seep locations (Seeps A, #1-#5) and two AOIs identified during the accessible area inspection were aggregated (or "clustered") for the statistical analysis based on their close proximity (WBF-HSA1-5). A summary of the measurement location identifications and the number of measurements is provided in Table D.1.

Parameter measurements were also collected in intermediate areas, or inaccessible areas covered with riprap located upstream and downstream of WBF-HSA1-5. The distance between each measurement was typically 200 feet. Overall, this resulted in the collection of a total of eight measurements (four downstream and four upsteam of WBF-HSA1-5) in the intermediate areas .

Finally, data were also collected from an upstream control area. A total of 21 measurements were collected from the upstream control area. The distance between measurement locations was approximately five feet. The measurement locations are shown in Exhibit A.1 (Appendix A) and provided on Table B.1 (Appendix B).

4.0 STATISTICAL ANALYSIS METHODS

In accordance with the Seep SAP, the following statistical analysis methods were used to evaluate the water quality parameter measurement results:

- Formal hypothesis testing was used to identify statistically significant differences between adjacent and upstream monitoring data for clustered historical seep/AOI locations, WBF-HSA1-5, by comparison of mean/median parameter measurements between the datasets using parametric or non-parametric statistical methods
- Tolerance interval methods were utilized to assess significant differences between parameter measurements collected adjacent to the intermediate area and the upstream control area.
- Since statistically significant differences were identified for WBF-HSA1-5 for all four water quality parameters, tolerance interval methods were used to identify specific areas within WBF-HSA1-5 that may warrant additional investigation.

The statistical analysis was conducted in three phases: 1) exploratory data analysis/outlier screening, 2) testing of statistical assumptions, and 3) formal hypothesis testing. These phases are discussed below. Analyses were conducted using United States Environmental Protection Agency (USEPA) ProUCL (version 5.1.002) and STATA Statistics and Data Analysis (version 15.1).

4.1 EXPLORATORY DATA ANALYSIS/OUTLIER SCREENING

Initially, the monitoring data associated with historical seep/AOI locations were plotted on measurement result plots and in side-by-side box plots. Measurement result plots allow for the identification of trends, outliers, and to visually identify differences between water quality parameter measurements that were collected in a downstream to upstream direction. Box plots allow for the identification of outliers and provide a basic sense of the potential underlying statistical distributions. The measurement result and box plots are presented in Attachment D.1. In addition to graphical analysis, descriptive statistics were calculated for each water quality parameter for WBF-HSA1-5, intermediate areas, and the upstream control area. A summary of the descriptive statistics is presented in Attachment D.2.

Outliers are data points that are abnormally high or low as compared to the rest of the measurements and may represent anomalous data and/or data errors. Outliers may also represent natural variation of constituent concentrations in environmental systems. During the seep investigation, water quality parameters were measured at the intermediate areas, the upstream control area and downstream, adjacent and upstream of WBF-HSA1-5. Utilizing the complete set of data to screen for the presence of outliers allowed for evaluation of potential spatial variation in the natural ecosystem. Screening for outliers is a critical step as outliers can bias the statistical testing results.

Outliers were identified graphically using side by side box plots and measurement result plots (Attachment D.1). If suspect visual outliers were identified, then the data were analyzed to determine if they represent extreme outliers. The Tukey's procedure (Tukey 1977) as outlined in the USEPA document*: "Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities. Unified Guidance"* (USEPA 2009) – (Unified Guidance) can be used to identify extreme outliers. The Tukey's procedure is briefly outlined below:

***Lower extreme outlier*:** The value is less than: 25^{th} percentile – (3 x interquartile range)

or

Upper extreme outlier: The value is greater than: 75^{th} percentile + (3 x interquartile range)

where:

Interquartile Range = 75^{th} percentile value – 25^{th} percentile value

If an outlier was identified visually and considered extreme (Tukey's procedure), then formal statistical testing (Dixon's and/or Rosner tests) was conducted to determine if the data point(s) represents statistically significant outlier(s).

Utilizing the procedures outlined above, no outliers were identified and all water quality parameter measurements were used in the statistical analyses.

4.2 TEST OF STATISTICAL ASSUMPTIONS

In environmental applications, formal hypothesis testing is commonly used to compare mean/median values between two "populations". In the case of the investigation of the clustered historical seep/AOI locations, WBF-HSA1-5, at the WBF Plant, the populations can be defined as monitoring results collected ***adjacent*** to WBF-HSA1-5 and monitoring results collected immediately ***upstream*** of WBF-HSA1-5. In the case of the investigation of the intermediate areas, the population can be defined as monitoring results collected ***adjacent to the intermediate areas*** and monitoring results collected in the ***upstream control area***.

Parametric statistical tests must meet statistical assumptions of normality and equality of variance (homoscedasticity) between the populations. If the data fit or could be transformed to fit the normal distribution, two sample t-tests were used to identify statistically significant differences between monitoring data collected adjacent WBF-HSA1-5 and data collected immediately upstream. If the data set could not be transformed to a data set that was normally distributed, then non-parametric (distribution free) statistics were used to identify significant differences between adjacent and upstream measurements.

The assumption of normality was tested visually using Normal Quantile-Quantile (Q-Q) plots and statistically using the Shapiro-Wilks Test (alpha = 0.10). Normal Q-Q plots are presented in Attachment D.3. A data set that is not normally distributed can often be transformed to a data set that is normally distributed using simple mathematical transformations on the data. Ladder of power transformation techniques were used to try to normalize data sets that were originally identified as not-normally distributed. If a suitable transformation was identified, this transformation was applied to the data prior to proceeding with the two-sample t-test. No data sets could be normalized using the ladder of powers methods.

The assumption of homoscedasticity was tested using the F-Test for the Equality of Two-Variances. In instances where variances were not equal, the Satterthwaite's degrees of freedom were used to adjust for unequal variances. The results of the evaluation of normality and equality of variances between the upstream and adjacent measurement locations are presented in Table D.2.

4.3 FORMAL HYPOTHESIS TESTING

The objective of formal hypothesis testing is to determine whether mean/median water quality parameter measurement results for the "adjacent" datasets are statistically different than the results for the "upstream" datasets. Hypothesis tests are standard statistical methods used to decide between two competing alternatives based on available data. Uncertainties arise when sample statistics are used as estimates of "true" but unknown population parameters (mean, standard deviation). Hypothesis testing provides the framework for managing these uncertainties and controlling potential decision errors (Ofungwu 2014).

Hypothesis tests are set up based on two competing alternatives. The null hypothesis (H_o) represents baseline conditions or conditions of no effects/differences. The null hypothesis can be represented mathematically as:

H_o: Mean Adjacent – Mean Upstream = 0; or Mean Adjacent = Mean Upstream

The alternative hypothesis (H_a) is simply the opposite of the null hypothesis and can be written as:

H_a: Mean Adjacent – Mean Upstream ≠ 0

If there is an *a priori* knowledge that a parameter's mean may be greater than or less than the upstream mean, the alternative hypothesis can be written as:

H_a: Mean Adjacent – Mean Upstream < 0 or Mean Adjacent – Mean Upstream > 0

The former alternative hypothesis is considered a two-sided test (e.g., it is unknown if the difference will be higher or lower and therefore, need to account for both possibilities). The later alternative hypotheses are considered a one-sided test (e.g., there is *a priori* knowledge of the direction of change – the parameter measurement is expected to be higher or lower when comparing adjacent to upstream monitoring data).

Appropriate hypothesis tests were established prior to examining the data. Two-sided tests were used to evaluate pH and temperature as there is no *a priori* knowledge that these parameters are expected to be higher or lower when comparing adjacent to upstream monitoring data. However, one-sided tests were used to evaluate DO and specific conductance based on the following assumptions: 1) the DO would be expected to be lower adjacent to an active seep in a similar area as opposed to DO in a surface stream due to aeration of the moving water and 2) the specific conductance would be expected to be higher adjacent to an active seep as opposed to upstream due to expected higher concentrations of metals in water emanating from a Coal Combustion Residuals (CCR) unit.

The null and alternative hypotheses for the seep investigation are presented below:

- DO (milligrams/Liter)
  - H_o: Mean $DO_{Adjacent}$ – Mean $DO_{Upstream}$ = 0
  - H_a: Mean $DO_{Adjacent}$ – Mean $DO_{Upstream}$ < 0
- pH (Standard Units)
  - H_o: Mean $pH_{Adjacent}$ – Mean $pH_{Upstream}$ = 0
  - H_a: Mean $pH_{Adjacent}$ – Mean $pH_{Upstream}$ ≠ 0
- Specific Conductance (microSiemens/centimeter)
  - H_o: Mean Specific Conductance $_{Adjacent}$ - Mean Specific Conductance $_{Upstream}$ = 0
  - H_a: Mean Specific Conductance $_{Adjacent}$ – Mean Specific Conductance $_{Upstream}$ > 0
- Temperature (degrees Celsius)
  - H_o: Mean $Temperature_{Adjacent}$ – Mean $Temperature_{Upstream}$ = 0
  - H_a: Mean $Temperature_{Adjacent}$ – Mean $Temperature_{Upstream}$ ≠ 0.

Statistical hypothesis tests produce a p-value (probability value). The p-value represents the probability that the mean/median of the adjacent measurements is equal to the mean/median of the upstream measurements. If the p-value of a statistical test is ***small*** *(i.e., below the significance level)*, the normal procedure is to reject the H_o, accept the H_a, and conclude there is a ***statistically significant difference between adjacent and upstream monitoring results that is unlikely to have occurred by chance.***

The statistician establishes the "significance level" (alpha, α), which is typically set between 0.01 and 0.10. This can be thought of as an acceptable false positive rate (e.g., rejecting H_o when H_o is true, which is equivalent to finding a statistically significant difference between adjacent and upstream monitoring data, when in fact one does not exist).

The significance level for a single test needs to be adjusted in situations where multiple hypothesis tests are going to be conducted at a site. Conducting multiple statistical tests on a site increases the chances of getting a significant result simply by chance (e.g. false positive statistical test result). For example, four statistical tests were conducted at the WBF Plant to identify differences in adjacent and upstream water quality parameter monitoring data for the seep investigation; if alpha is set at 0.1 and the multiple testing is ignored, then the cumulative error rate can be calculated:

Cumulative error rate = $1-(1-0.1)^4$ = 34% chance of making false positive error

The Bonferroni correction was utilized to adjust the significance level to control the site-wide false positive rate described above. This method simply divides the desired overall significance level ($\alpha = 0.10$) by the number of hypothesis tests conducted site-wide (4 parameters x 1 clustered historical seep/AOI location = 4 tests). For the WBF Plant, the adjustment yields an individual test significance level of 0.1/4 tests = 0.025. Therefore, to reject H_o and determine that there is a statistically significant difference between adjacent and upstream monitoring results that is unlikely to have occurred by chance, the p-value of the test needs to be less than 0.025.

4.4 TOLERANCE INTERVALS

Tolerance limits consist of two values expected to contain a pre-specified proportion of the underlying data population with a specified level of confidence. For example, for a 95% tolerance interval with a 95% confidence level, there is 95% confidence that, on average, 95% of the data population is contained within the interval. The one-sided Upper Tolerance Level (UTL) is commonly used in environmental monitoring and is constructed using background data (Ofungwu 2014).

The calculation of the UTL is straightforward:

$$UTL = \overline{x} \pm \tau s$$

Where:

$\overline{x}$ = mean constituent concentration in background/control dataset

s = standard deviation of constituent in background/control dataset

τ = tau multiplier - based on size of dataset, confidence (95%) and desired coverage (95%).

Tolerance intervals were calculated in two cases: 1) for comparison of data collected from the upstream control area against data collected adjacent to the intermediate areas, and 2) for comparison of measurements from individual adjacent locations within the HSA1-4 cluster with measurements directly upstream of this area, as described in Section 4.5.

Prior to calculating tolerance intervals, the data were tested for normality and for outliers using methods described previously. If the data set could not be transformed to a data set that was normally distributed, then non-parametric (distribution free) statistics were used to calculate tolerance intervals.

The statistical null hypothesis (H_o) is that mean parameter measurements collected from the intermediate areas lie within the tolerance interval, and the alternate hypothesis (H_a) is that the mean parameter measurements are outside of the tolerance interval. In order to test these hypotheses, 95% confidence intervals around the mean parameter measurements from the intermediate areas were estimated and compared to the upstream control area tolerance intervals.

Prior to calculating confidence intervals, the monitoring data collected adjacent to the intermediate area were tested for normality and for outliers using methods described previously. If the data set could not be transformed to a data set that was normally distributed, then non-parametric (distribution free) statistics were used to calculate confidence intervals.

Confidence intervals were calculated based on the following equation:

$$Confidence\ Interval = \overline{x} \pm t_{1-\propto/2,n-1} * s/\sqrt{n}$$

Where:

$\overline{x}$ = mean parameter measurement in intermediate area

s = standard deviation of parameter measurement in intermediate area

n = number of measurements in Intermediate area dataset

$t_{(1-\propto/2,n-1)}$ = two tailed t value, with n-1 degrees of freedom (where α = 0.05)

Statistically significant differences were identified if the confidence interval calculated using the intermediate area dataset fell outside of the tolerance interval based on the upstream control area data set.

4.5 ADDITIONAL STATISTICAL ANALYSIS TO IDENTIFY POTENTIAL AOIS

Based on the findings of the analyses described above, statistically significant differences were identified for all four water quality parameters when comparing measurements collected adjacent to and upstream of WBF-HSA1-5. An additional statistical analysis was conducted to limit specific areas where statistically significant differences in water quality measurements may occur and to identify potential additional AOIs within the area covered by WBF-HSA1-5 that may warrant additional investigation.

The analysis was designed to answer the question: *Do individual water quality parameter measurements collected at locations adjacent to WBF-HSA1-5 look different (e.g. either higher or lower) than measurements collected immediately upstream of WBF-HSA1-5?* To answer this question, tolerance limits were calculated for all four water quality parameters using measurements collected immediately upstream of historical seep locations WBF-HSA1-5. These tolerance limits represent upstream conditions where impacts from a potential inaccessible seep location (i.e. riprap covered) are unlikely. Individual measurement results collected adjacent to WBF-HSA1-5 were then compared to the upstream tolerance limits to identify individual measurement locations where tolerance limits were exceeded.

The measurement result plots (Attachment D.1) provide evidence that there are individual measurement locations adjacent to the WBF-HSA1-5 area with lower measurements for DO and pH as compared to the other individual measurements collected adjacent to WBF-HSA1-5. Also, there are groupings of higher measurements for specific conductance and temperature as compared to other measurements collected adjacent to WBF-HSA1-5.

The distribution of the data for each water quality parameter collected adjacent to WBF-HSA1-5 was also evaluated using side-by-side box plots (Attachment D.1). Based on visual evidence from the side-by-side box plots, the distributions for DO and pH appeared negatively skewed relative to other water quality parameter measurement locations, suggesting lower measurements for DO and pH were predominant in these data distributions. Lower tolerance limits were estimated for DO and pH. Conversely, the data distributions for specific conductance and temperature appeared positively skewed, suggesting that higher measurements for specific conductance and temperature were predominate in the data distribution. Upper tolerance limits were estimated for SC and temperature.

Additional potential AOI(s) were identified when all four water quality parameters measurements at individual locations collected adjacent to WBF-HSA1-5 exceeded their respective tolerance limits.

5.0 STATISTICAL ANALYSIS RESULTS

The following sections describe the results of 1) the hypothesis testing comparing the water quality parameter results between the adjacent and upstream measurements at WBF-HSA1-5, 2) the interval testing comparing the water quality parameter results from the intermediate area to the upstream control area, and 3) the tolerance limit testing comparing water quality parameter results from individual adjacent locations within the WBF-HSA1-5 area to water quality measurement data collected immediately upstream of WBF-HSA1-5.

5.1 HYPOTHESIS TESTING RESULTS: ADJACENT AND UPSTREAM MEASUREMENT COMPARISONS AT WBF-HSA1-5

A historical seep is considered an AOI when the mean/median values of all four water quality parameters (DO, pH, specific conductance, and temperature) are found to be statistically different when comparing adjacent to upstream monitoring data. For pH and temperature, the difference between upstream and adjacent measurements may be either positive or negative. Specific conductance would be expected to increase in proximity to an active seep due to higher concentrations of metals in water emanating from a CCR unit, and DO would be expected to decrease as seep water from a similar area would show decreased DO relative to a surface stream. Therefore, only significant increases in specific conductance and significant decreases in DO in the adjacent areas, relative to the upstream areas were evaluated. Table D.3 provides a summary of the hypothesis testing results, including the p-values obtained using procedures described in preceding sections to identify significant differences between adjacent and upstream water quality parameter monitoring data at WBF-HSA1-5. Statistically significant differences were identified for all four parameters at WBF-HSA1-5; therefore, additional AOIs were identified for possible further investigation.

5.2 INTERVAL TESTING RESULTS: INTERMEDIATE AREA COMPARISON TO UPSTREAM CONTROL AREAS

Water quality parameter measurement results collected from the intermediate areas in the Tennesee River were evaluated against monitoring data collected from the upstream control area to identify any potential AOI.

For the intermediate areas to be considered an AOI, the mean values of all four water quality parameters were required to be statistically different when monitoring data collected adjacent to the intermediate areas were compared to data collected in the upstream control area. Table D.4 presents a summary of the interval testing results used to identify significant differences between the intermediate areas and the upstream control area monitoring data. Statistically significant differences were not identified for all four parameters comparing intermediate areas to the upstream control area; therefore, this analysis did not identify any additional AOIs for further investigation.

5.3 ADDITIONAL INTERVAL TESTING RESULTS: INDIVIDUAL LOCATION COMPARISON TO UPSTREAM LOCATIONS WITHIN WBF-HSA1-5

An additional statistical analysis was conducted to limit specific areas where statistically significant differences in water quality measurements may occur and to identify potential additional AOIs within the area covered by WBF-HSA1-5 that may warrant additional investigation. Individual water quality parameter measurement results collected adjacent to WBF-HSA1-5 were evaluated against tolerance limits calculated from data collected immediately upstream of WBF-HSA1-5 to identify additional potential AOIs.

Potential additional AOI(s) within the WBF-HSA1-5 cluster area were identified when all four water quality parameters measured at individual locations adjacent to WBF-HSA1-5 exceeded their respective tolerance limits. Based on this analysis, one previously identified AOI (AOI02) was confirmed, and two additional AOIs (AOI03 and AOI04) were identified within the WBF-HSA1-5 cluster area.

A total of nine individual measurement locations where all four water quality parameters were either above or below their respective tolerance limits were identified. These locations were observed in three distinct areas within the WBF-HSA1-5 cluster area , as listed below:

- AOI02 bracketed by measurement location 35 to measurement location 43
- AOI03 bracketed by measurement location 68 to measurement location 74
- AOI04 bracketed by measurement location 90 to measurement location 92.

Exhibit A.3 provides a map showing these three areas and the individual locations where the water quality parameter measurements exceeded the tolerance limits and the identified AOIs. Attachment D.4 provides measurement result plots, tolerance intervals, with shading indicating the measurement locations that bound the individual AOIs that warrant additional investigation. Table D.5 provides a summary of the statistical testing used to identify AOIs.

6.0 REFERENCES

Ofungwu, J., 2014. *Statistical Applications for Environmental Analysis and Risk Assessment*. Hoboken, New Jersey: John Wiley and Sons, Inc.

Tukey, J.W., 1977. *Exploratory Data Analysis*. Reading, Massachusetts: Addison-Wesely, 1977

U.S. Environmental Protection Agency, 2009. *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance*.

TABLES

TABLE D.1 – Summary of Water Quality Parameter Measurement Locations
Watts Bar Fossil Plant
April 2019

Historical Seep/AOI Cluster	Measurement Location IDs	Number of Measurements		
		Downstream	Adjacent	Upstream
Tennessee River				
WBF-HSA1-5	WBF-HSA1-5-D-5 to WBF-HSA1-5-U-111	10	85	12

Notes:

1. Historical Seep (HS) location and measurement location identications (IDs) are shown on Exhibits A.1 through A.3 in Appendix A.

TABLE D.2 – Tests of Normality and Equality of Variances between Adjacent and Upstream Monitoring Results
Watts Bar Fossil Plant
April 2019

	Historical Seep/AOI Cluster
	Tennessee River
Monitoring Parameters	**WBF-HSA1-5**
Number of Samples (Adjacent / Upstream)	85/12
Dissolved Oxygen	Not Normal
pH	Not Normal
Specific Conductance	Not Normal
Temperature	Not Normal

Notes:

HS — Historical Seep

Not Normal — Data Sets (adjacent and upstream) are not normally distributed (alpha=0.01)

TABLE D.3 – Summary of Statistical Hypothesis Testing
Watts Bar Fossil Plant
April 2019

Historical Seep/AOI Cluster	Number of Samples	p-value			
		DO	pH	Specific Conductance	Temperature
Tennessee River					
	Adjacent / Upstream	mg/L	SU	uS/cm	DEG C
WBF-HSA1-5	85/12	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**

Notes:

DEG C	degrees Celsius
DO	Dissolved Oxygen
HS	Historical Seep
mg/L	milligrams per Liter
SU	Standard Units
SWFPR	site wide false positive rate
uS/cm	microSiemens per centimeter

1. The p-value represents the probability that the mean of the adjacent measurements is equal to the mean of the upstream measurements. If a p-value is small (i.e., below the significance level), it is indicative that there is a statistically significant difference between adjacent and upstream monitoring results that is unlikely to have occurred by chance.

2. Bonferroni method used to adjust significance level (SWFPR/No. of statistical tests). Adjusted to 0.10/4=0.025 (4 parameters x 1 HS)

3. Shaded values indicate a statistically significant difference between measurements collected adjacent and upstream of historical seep/AOI cluster WBF-HSA1-5 (p-value is below adjusted significance level).

TABLE D.4 – Summary of Intermediate Area Statistical Testing
Watts Bar Fossil Plant
April 2019

Parameter	95 % Confidence Interval - Intermediate Area	Tolerance Interval	
		WBF-UC	Significant?
Dissolved Oxygen	(11.1 - 11.6)	(11.1 - 11.6)	NO
pH	(8.10 - 8.29)	(8.19 - 8.41)	NO
Specific Conductance	(154 - 166)	(152 - 156)[a]	NO
Temperature	(16.8 - 17.9)	(17.0 - 17.4)[a]	NO

Notes:

% percent

WBF-UC Upstream Control collected on 4/17/2019 in Tennessee River

[a] Data not normally distributed; reported values are non-parametric upper tolerance limits, reported as the minimum and maximum measurement. Level of confidence (65.9%)

1. Tolerance Interval: 95% tolerance interval with 95% coverage.

2. Shaded values are statistically significant differences if the confidence interval calculated using the intermediate area data set falls outside of the tolerance interval.

TABLE D.5: Summary of Statistical Testing to Identify Areas of Interest (AOI) Watts Bar Fossil Plant

Area of Interest	Measurement ID	Dissolved Oxygen	pH (field)	Specific Conductance (field)	Temperature Water (C)
	Tolerance Limit	LTL < 10.71	LTL < 8.142	UTL > 158.4	UTL > 16.9
AOI02	WBF-HSA1-5-A-35	**10.52**	**7.99**	**177.2**	**18.9**
	WBF-HSA1-5-A-36	**10.63**	**7.91**	**181.4**	16.9
	WBF-HSA1-5-A-37	**10.64**	**7.15**	**265.9**	**17.1**
	WBF-HSA1-5-A-38	**10.65**	**7.86**	**177.1**	16.9
	WBF-HSA1-5-A-39	**9.61**	**7.78**	**196.9**	16.9
	WBF-HSA1-5-A-40	**10.14**	**7.55**	**217.9**	**17.1**
	WBF-HSA1-5-A-41	10.93	**7.99**	**165.6**	16.8
	WBF-HSA1-5-A-42	**10.42**	**8.04**	**171.9**	16.9
	WBF-HSA1-5-A-43	**9.77**	**7.96**	**186.9**	**17**
AOI03	WBF-HSA1-5-A-68	**10.06**	**7.97**	**162.6**	**17**
	WBF-HSA1-5-A-69	11.16	**8.06**	**167.9**	**17**
	WBF-HSA1-5-A-70	11.09	**8.11**	**189.9**	**17.2**
	WBF-HSA1-5-A-71	**10.44**	8.17	**179.1**	**17**
	WBF-HSA1-5-A-72	11	8.22	**168.9**	**17.1**
	WBF-HSA1-5-A-73	**9.61**	**7.97**	**257.9**	**17**
	WBF-HSA1-5-A-74	**10.61**	**7.97**	**215.2**	**17.5**
AOI04	WBF-HSA1-5-A-90	**10.14**	**7.4**	**231**	**17.1**
	WBF-HSA1-5-A-91	10.88	**7.8**	**178**	**17**
	WBF-HSA1-5-A-92	**10.55**	**7.94**	**172.9**	**17.1**

Notes:

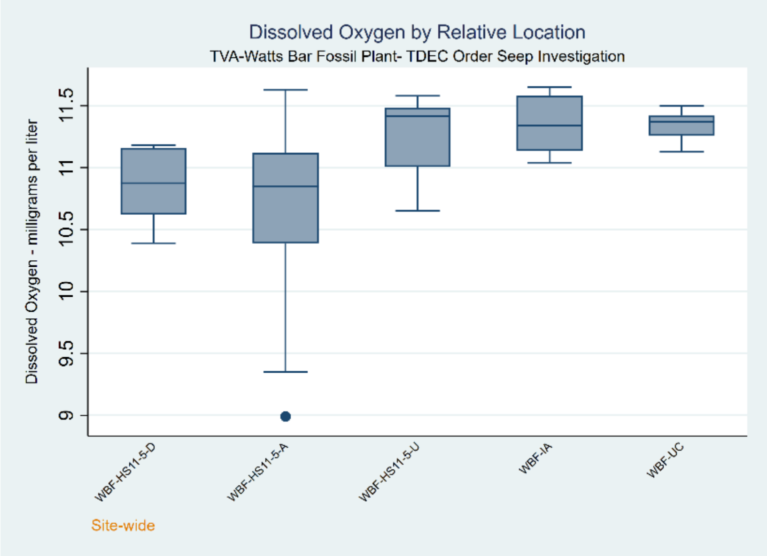
LTL: Lower Tolerance Limit
UTL: Upper Tolerance Limit
Bold and underlined indicates that individual parameter measurement exceeds its respective LTL or UTL
Bold, underlined and shaded indicates that all 4 parameters exceed their respective LTL or UTL

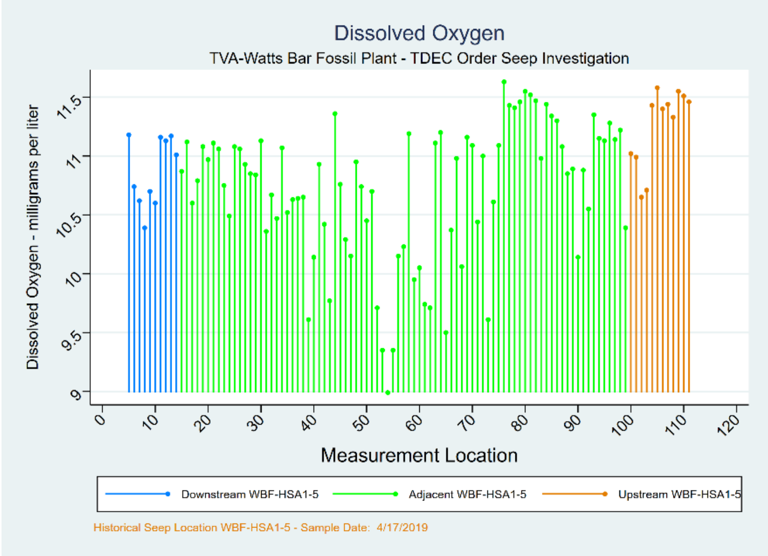
ATTACHMENTS

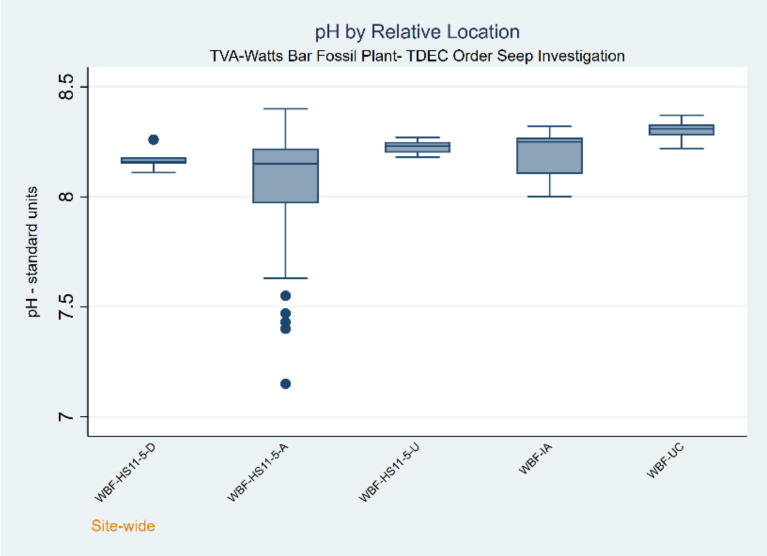
ATTACHMENT D.1

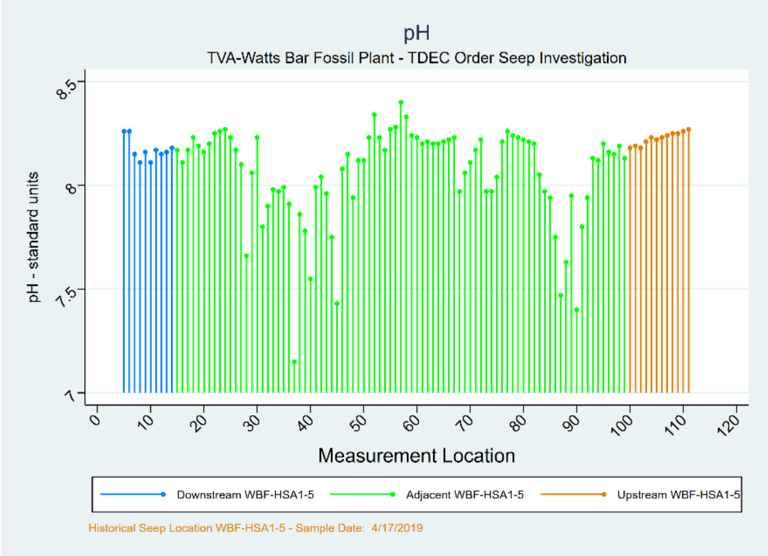
Measurement Results and Box Plots

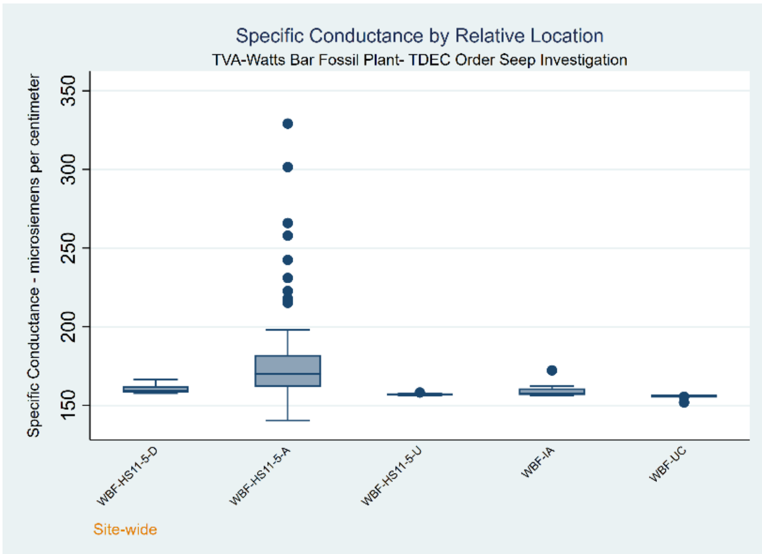
Measurement Results and Box Plots

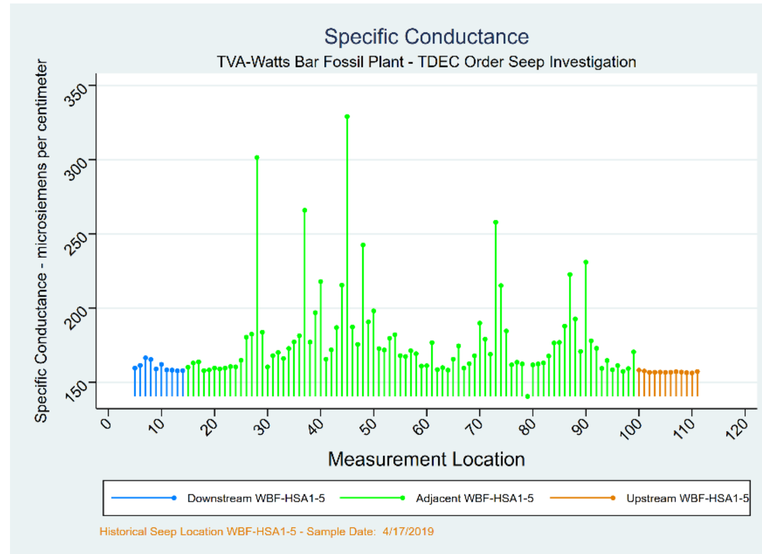


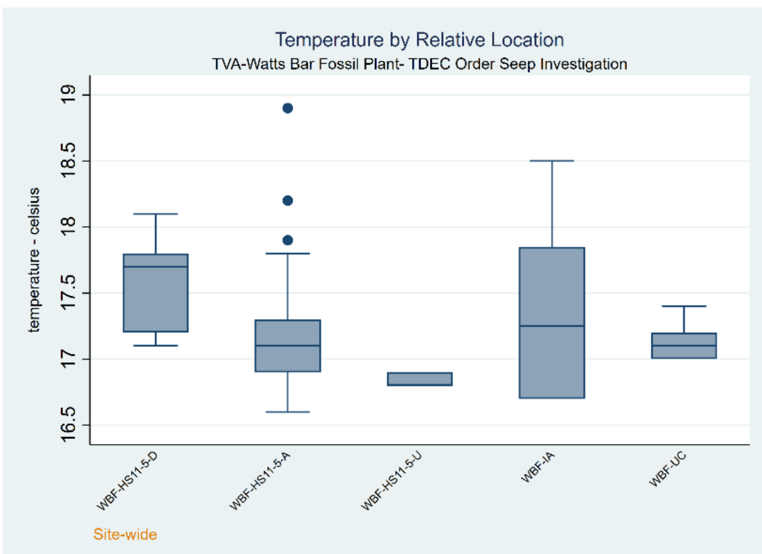


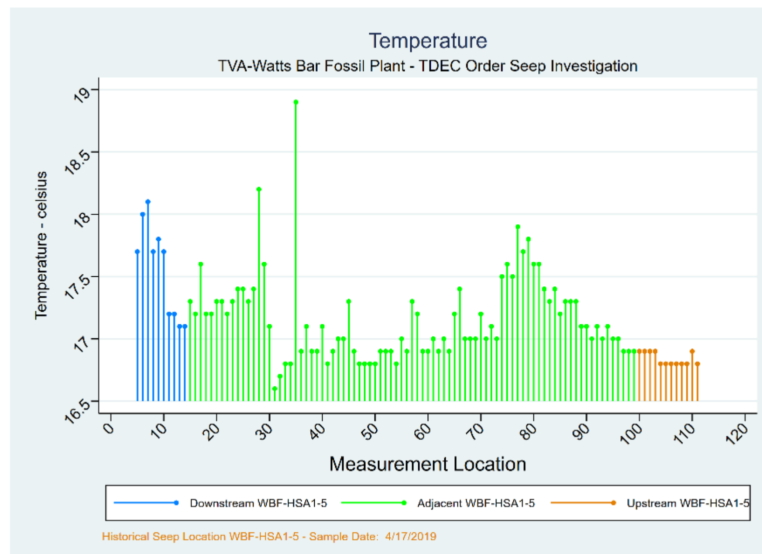





Specific Conductance by Relative Location
TVA-Watts Bar Fossil Plant- TDEC Order Seep Investigation
Specific Conductance - microsiemens per centimeter
150
200
250
300
350
WBF-HS11-5-D
WBF-HS11-5-A
WBF-HS11-5-U
WBF-IA
WBF-UC
Site-wide


Specific Conductance
TVA-Watts Bar Fossil Plant - TDEC Order Seep Investigation
Specific Conductance - microsiemens per centimeter
150
200
250
300
350
0
10
20
30
40
50
60
70
80
90
100
110
120
Measurement Location
Downstream WBF-HSA1-5
Adjacent WBF-HSA1-5
Upstream WBF-HSA1-5
Historical Seep Location WBF-HSA1-5 - Sample Date: 4/17/2019


Temperature by Relative Location
TVA-Watts Bar Fossil Plant- TDEC Order Seep Investigation
temperature - celsius
16.5
17
17.5
18
18.5
19
WBF-HS11-5-D
WBF-HS11-5-A
WBF-HS11-5-U
WBF-IA
WBF-UC
Site-wide


Temperature
TVA-Watts Bar Fossil Plant - TDEC Order Seep Investigation
Temperature - celsius
16.5
17
17.5
18
18.5
19
0
10
20
30
40
50
60
70
80
90
100
110
120
Measurement Location
Downstream WBF-HSA1-5
Adjacent WBF-HSA1-5
Upstream WBF-HSA1-5
Historical Seep Location WBF-HSA1-5 - Sample Date: 4/17/2019

ATTACHMENT D.2

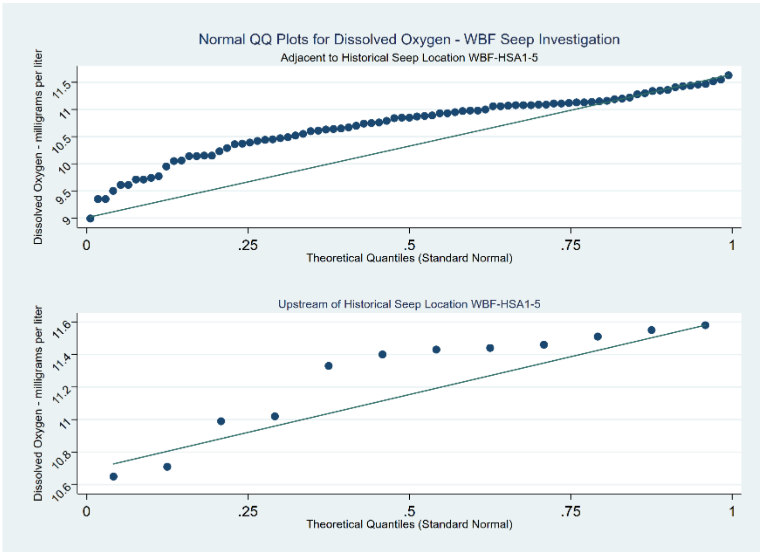
Summary of Descriptive Statistics

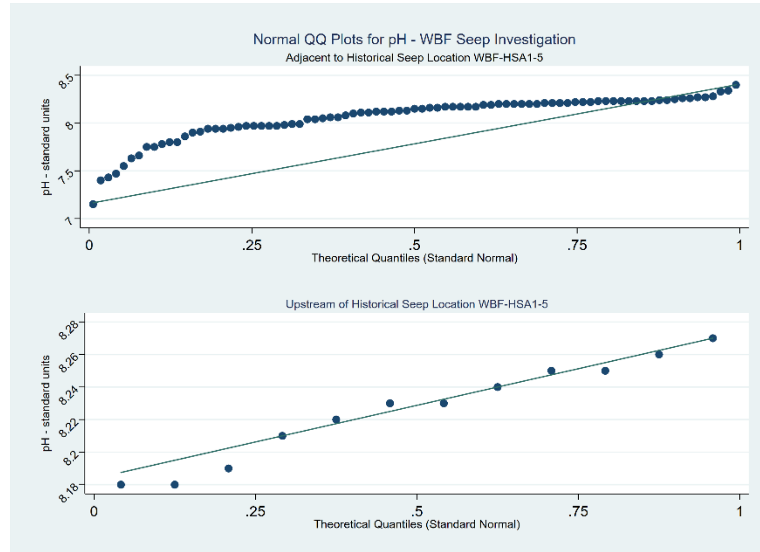
Summary of Descriptive Statistics Watts Bar Fossil Plant - Seep Investigation								
Historical Seep	**Relative Location to Historical Seep**	**Number of Samples**	**Minimum**	**Maximum**	**Mean**	**Standard Deviation**	**Median**	**95th Percentile**
Tennessee River								
Dissolved Oxygen (milligrams per Liter)								
WBF-HSA1-5	Downstream	10	10.39	11.18	10.87	0.29	10.875	11.18
	Adjacent	85	8.99	11.63	10.71	0.59	10.85	11.46
	Upstream	12	10.65	11.58	11.26	0.33	11.415	11.58
Upstream Control		21	11.13	11.5	11.35	0.11	11.37	11.49
Intermediate Areas		8	11.04	11.65	11.35	0.24	11.34	11.65
pH (Standard Units)								
WBF-HSA1-5	Downstream	10	8.11	8.26	8.17	0.05	8.16	8.26
	Adjacent	85	7.15	8.4	8.06	0.23	8.15	8.27
	Upstream	12	8.18	8.27	8.23	0.03	8.23	8.27
Upstream Control		21	8.22	8.37	8.30	0.04	8.31	8.36
Intermediate Areas		8	8	8.32	8.20	0.12	8.25	8.32
Specific Conductivity (microsiemens per centimeter)								
WBF-HSA1-5	Downstream	10	157.8	166.5	160.63	3.16	159.3	166.5
	Adjacent	85	140.5	329.1	179.29	30.73	170.1	242.5
	Upstream	12	156.3	158.2	156.99	0.52	156.85	158.2
Upstream Control		21	151.9	156.2	155.70	0.89	155.9	156.1
Intermediate Areas		8	156.4	172.3	159.85	5.40	157.6	172.3
Temperature (Celsius)								
WBF-HSA1-5	Downstream	10	17.1	18.1	17.56	0.38	17.7	18.1
	Adjacent	85	16.6	18.9	17.16	0.35	17.1	17.7
	Upstream	12	16.8	16.9	16.84	0.05	16.8	16.9
Upstream Control		21	17	17.4	17.11	0.12	17.1	17.3
Intermediate Areas		8	16.7	18.5	17.35	0.71	17.25	18.5

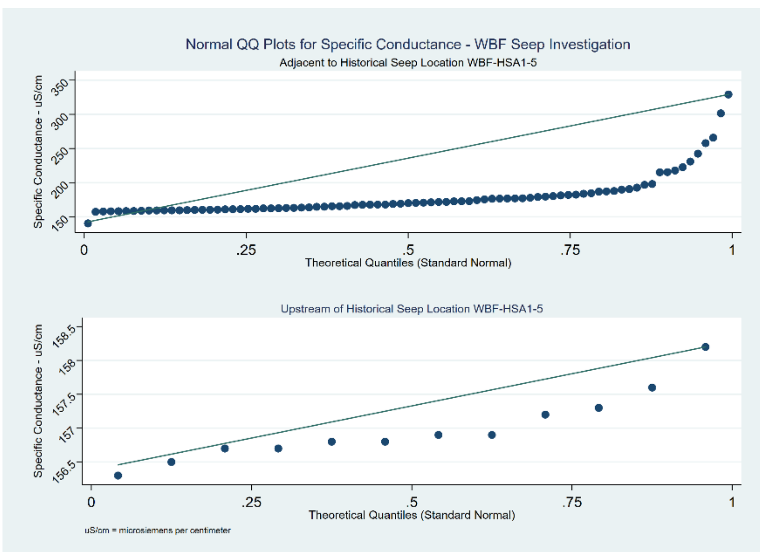
ATTACHMENT D.3

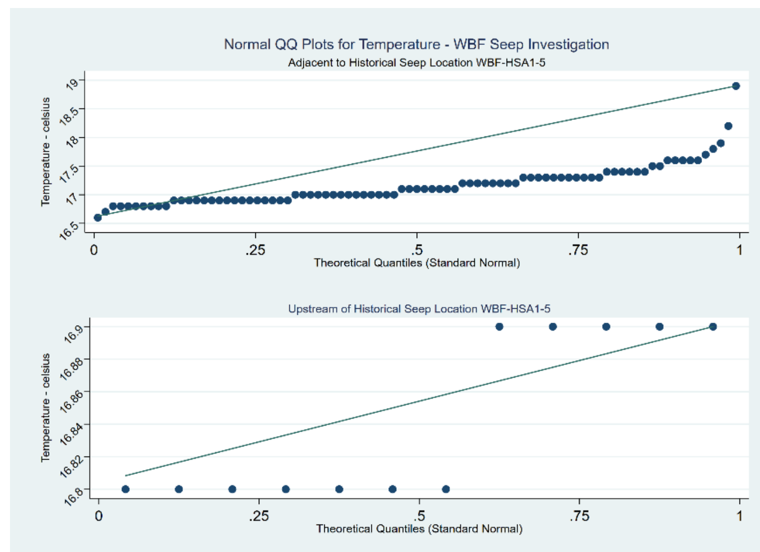
Normal Q-Q Plots

Normal Q-Q Plots





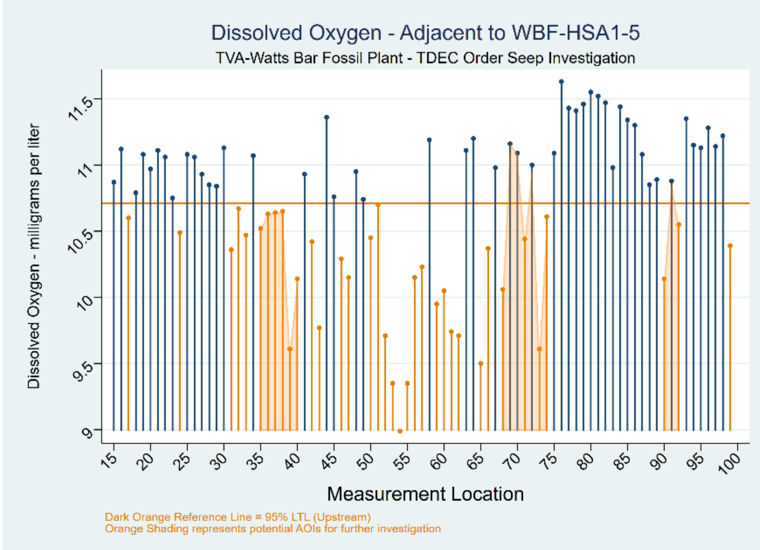


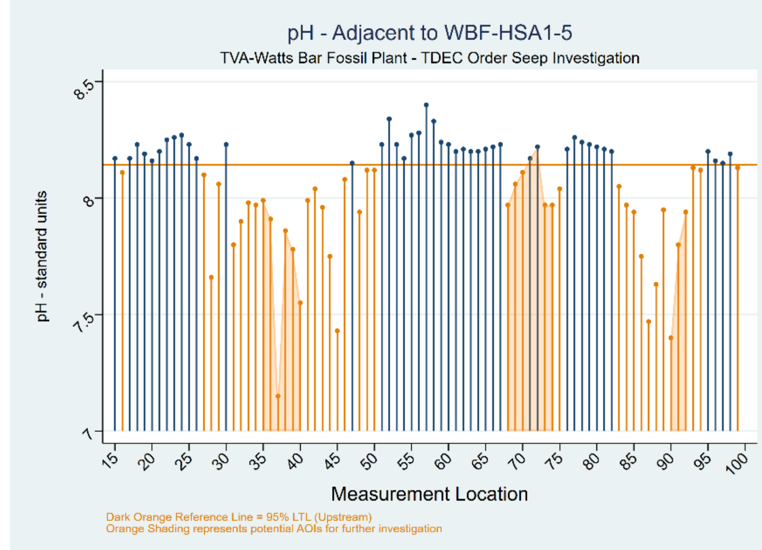


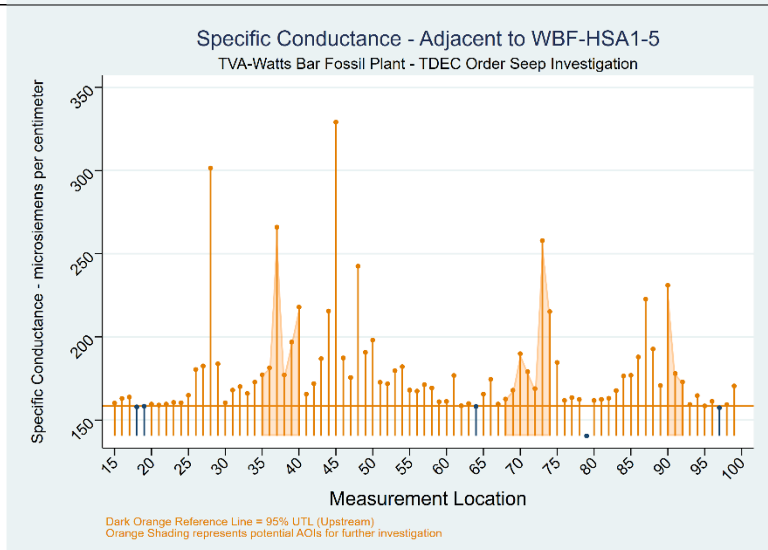
ATTACHMENT D.4

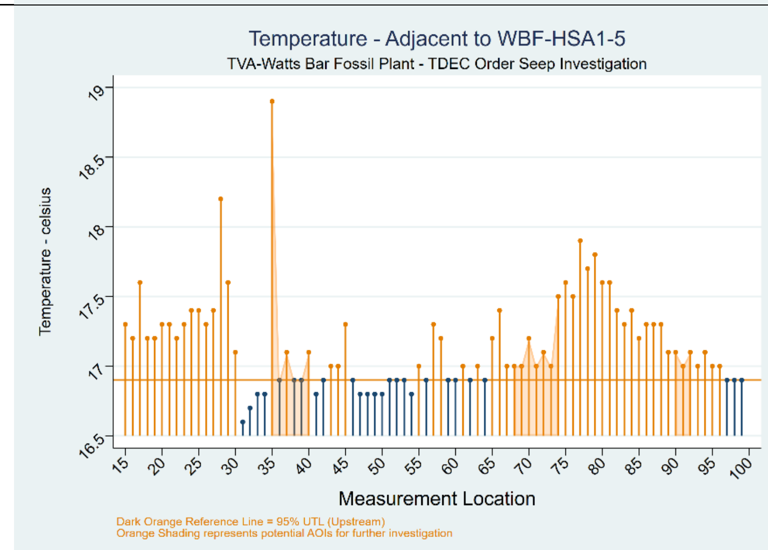
Measurement Results Plots, Tolerance Limits, and Areas of Interest

Measurement Results Plots, Tolerance Limits, and Areas of Interest









APPENDIX E.5

STATISTICAL ANALYSIS OF SURFACE STREAM DATA

Appendix E.5 - Statistical Analysis of Surface Stream Data

TDEC Commissioner's Order:
Environmental Assessment Report
Watts Bar Fossil Plant
Spring City, Tennessee

March 31, 2024

Prepared for:

Tennessee Valley Authority
Chattanooga, Tennessee

Prepared by:

Stantec Consulting Services Inc.
Lexington, Kentucky

REVISION LOG

Revision	Description	Date
0	Submittal to TDEC	November 7, 2023
1	Addresses January 31, 2024 TDEC Review Comments and Issued for TDEC	March 31, 2024

Sign-off Sheet

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Reviewed by ______________________

Matt Pontier, Engineering Staff

Approved by ______________________

Carole M. Farr, Senior Principal Geologist

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LIST OF TABLES

LIST OF ATTACHMENTS

Abbreviations

CASRN	Chemical Abstracts Service Registry Number
CCR	Coal Combustion Residuals
CCR Parameters	Constituents listed in Appendices III and IV of 40 CFR 257 and five inorganic constituents included in Appendix I of Tennessee Rule 0400-11-01-.04
CCR Rule	Title 40, Code of Federal Regulations, Part 257
EAR	Environmental Assessment Report
EI	Environmental Investigation
ESV	Ecological Screening Value
ID	Identification
IQR	Interquartile Range
MDL	Method Detection Limit
NA	Not Available
PCA	Principal Component Analysis
SSL_{HH}	Site-specific Human Health Screening Levels
Stantec	Stantec Consulting Services Inc.
TDEC	Tennessee Department of Environment and Conservation
TVA	Tennessee Valley Authority
µg/L	micrograms per Liter
WBF Plant	Watts Bar Fossil Plant

March 31, 2024

1.0 INTRODUCTION

Stantec Consulting Services Inc. (Stantec) prepared this appendix on behalf of the Tennessee Valley Authority (TVA) to summarize the statistical analyses performed on surface stream data to support evaluations conducted for the Environmental Assessment Report (EAR) at the Watts Bar Fossil Plant (WBF Plant) located in Spring City, Tennessee. The surface stream samples were collected between July 2019 and November 2019 in one river body in proximity to the WBF Plant. Further details regarding the surface stream sampling and a summary of the analytical data are presented in Appendix J.1 and the *WBF Plant Surface Stream Sampling and Analysis Report* (Appendix J.2).

For the Environmental Investigation (EI), surface stream samples were collected from locations along sample transects from the Tennessee River in proximity to the WBF Plant coal combustion residual (CCR) management units. Sample transects/location names, locations relative to WBF Plant CCR management units, and the numbers of samples collected from each water body are presented in Table E.5-1. Fourteen samples were collected from the Discharge Channel; however, these samples were not included in the statistical analysis because conditions in the Discharge Channel are not representative of natural surface stream conditions and the Discharge Channel is regulated under a National Pollutant Discharge Elimination System permit (#TN0005789). The constituents listed in Appendices III and IV of 40 CFR 257 and five inorganic constituents included in Appendix I of Tennessee Rule 0400-11-01-.04 (CCR Parameters) included in the statistical analysis are presented in Table E.5-2.

Table E.5-1 – Surface Stream Sample Transect/Locations, WBF Plant

Water Body	Transect/Location Name	Location Relative to CCR Management Units	Number of Samples
Tennessee River	TR01, TR02	Upstream	34
	TR03, TR04, TR05	Adjacent	46
	TR06, TR07	Downstream	33

Table E.5-2 – CCR Parameters Evaluated in Statistical Analysis

CCR Parameter	CASRN
CCR Rule Appendix III Parameters	
Boron	7440-42-8
Calcium	7440-70-2
Chloride	16887-00-6
Fluoride[1] (also Appendix IV)	16984-48-8
pH	Not Available (NA)
Sulfate	14808-79-8
Total Dissolved Solids	NA
CCR Rule Appendix IV Parameters	
Antimony	7440-36-0
Arsenic	7440-38-2
Barium	7440-39-3
Beryllium	7440-41-7
Cadmium	7440-43-9
Chromium	7440-47-3
Cobalt	7440-48-4
Lead	7439-92-1
Lithium	7439-93-2
Mercury	7439-97-6
Molybdenum	7439-98-7
Radium-226+228	13982-63-3/ 15262-20-1
Selenium	7782-49-2
Thallium	7440-28-0
TDEC Appendix I Parameters	
Copper	7440-50-8
Nickel	7440-02-0
Silver	7440-22-4
Vanadium	7440-62-2
Zinc	7440-66-6
Other	
Hardness	NA
Iron	7439-89-6
Magnesium	7439-95-4
Manganese	7439-96-5
Total Suspended Solids	NA

Notes:
CASRN: Chemical Abstracts Service Registry Number
CCR Rule - Title 40, Code of Federal Regulations, Part 257
NA – Not available
TDEC - Tennessee Department of Environment and Conservation
[1]Fluoride is both a CCR Rule Appendix III and CCR Rule Appendix IV CCR Parameter. In this table, and in the results figures and tables for this report, fluoride has been grouped with the Appendix III CCR Parameters only to avoid duplication.

The following sections present the methods and results from the general exploratory data analysis using summary statistics, data plots, and outlier screening, and a comparison of surface stream results to Site-specific Ecological Screening Values (ESVs) and Human Health Screening Levels (SSL_{HH}) that were developed for the EAR. The site specific ESVs and SSL_{HH} for surface stream data are provided in Table 1-2 and Appendix A.2.

Additional statistical analyses (principal component analysis [PCA] and hypothesis testing) were performed if the following conditions were satisfied: 1) CCR parameter concentrations were above ESVs or SSL_{HH} and 2) data were collected from transects/locations adjacent and from transects/locations either upstream or downstream to the WBF Plant CCR management units. Since CCR parameter concentrations were not above ESVs or SSL_{HH} in the surface stream datasets, no additional statistical analyses were conducted.

2.0 METHODS

The statistical evaluation for the surface stream data collected at the WBF Plant for the EI was conducted in three parts: 1) exploratory data analysis, 2) comparison of results to site-specific ESVs and to generic SSL_{HH}, and 3) additional statistical analysis, when warranted.

2.1 EXPLORATORY DATA ANALYSIS

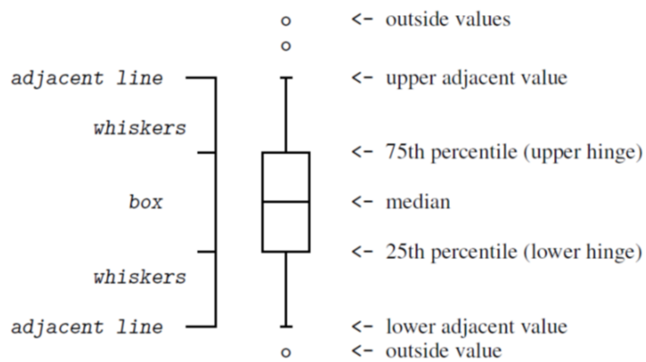
Exploratory data analysis is the initial step of statistical analysis. It utilizes simple summary statistics (e.g. mean, median, standard deviation and percentiles) and graphical representations to identify characteristics of an analytical dataset, such as the center of the data (mean, median), variation, distribution, spatial or temporal patterns, presence of outliers, and randomness.

2.1.1 Summary Statistics

Summary statistics were calculated for each CCR Parameter and aggregated by the transect’s position relative to the WBF Plant CCR management units (upstream, adjacent and downstream). Summary statistics also were calculated for the following additional water quality parameters: hardness, iron, magnesium, manganese, and total suspended solids. Summary statistics include information such as the total numbers of available samples, the frequencies of detection, ranges of reporting limits, minimum and maximum detected concentrations, mean concentrations, standard deviations, median concentrations and the 95th percentile concentrations. Where applicable, summary statistics were calculated for the results for both total and dissolved metal results. Summary statistics tables are presented in Attachment E.5-A.

2.1.2 Exploratory Data Plots

Exploratory data plots (box plots and transect plots) were constructed using the surface stream results for total metals to support a visual review of the data. Box plots were used to identify the center of the data, distribution, and variability, and to visually identify potential outliers. The diagram below graphically depicts the basics of the construction of the box plots (StataCorp LLC 2017).



The box portion of the plot is the interquartile range (IQR), which represents the middle 50 percent of data, with the bottom of the box being the 25th percentile and the top of the box being the 75th percentile. The line inside the box is the median concentration. The top of the upper "whisker" represents the first observed concentration above the 75th percentile, whereas the bottom of the lower "whisker" represents the first observed concentration below the 25th percentile (upper adjacent value and lower adjacent value, respectively). Values that lie outside of the adjacent values represent outside (or outlier) concentrations (i.e. concentrations at the upper and lower ends of the distribution of the data). The method detection limit (MDL) was used as the reported value in order to construct the box plot when analytical results were reported as non-detects.

Box plots were prepared that compared results by transect in the Tennessee River. Transects, ordered by relative location to the WBF Plant CCR management units (upstream, adjacent, downstream), were useful in assessing upstream to downstream patterns within the water body, as well as data distribution, variability, and potential outliers. Box plots for CCR Rule Appendix III, CCR Rule Appendix IV, and TDEC Appendix I CCR Parameters are presented in Attachment E.5-B.

Transect plots were constructed that showed individual sample results aggregated by transect, position relative to the WBF Plant CCR management units (upstream, adjacent, or downstream), and relative position within the water body (right bank, center channel, or left bank).

- Tennessee River: Right Bank = Fossil Plant Bank; Left Bank = Opposite Bank

The symbols used in the transect plots indicate whether the reported result is a detected concentration (solid symbol) or a non-detect reported at the MDL (hollow symbol).

Multiple transect plots were constructed for each CCR Parameter. Individual plots were constructed with a reference line for the SSL_{HH} using analytical results collected in the Tennessee River, because the Tennessee River is a potable water source, as described in Appendix J.1. Transect plots with a reference line for the site-specific ESVs were constructed using analytical results collected in the Tennessee River. In many cases, the sample results were much lower than either SSL_{HH} or ESVs, so including the reference lines induced a scaling effect which obscured patterns in the data. A third plot was produced for each CCR Parameter without a reference line in order to better identify patterns.

Transect plots provide more detailed information than side-by-side box plots and allow a more rigorous evaluation of the data. These plots are particularly useful in identifying potential patterns in the dataset (trends), frequency of detection, outliers, spatial differences relative to the WBF Plant CCR management units (upstream, adjacent, and downstream), and differences relative to the position in the water body (plant-side bank versus opposite-side bank or center channel). The transect plots are presented in Attachment E.5-C.

2.1.3 Outlier Screening

Outliers are data points that are abnormally high or low as compared to other measurements and may represent anomalous data or data errors. Outliers may also represent natural variations of CCR Parameter concentrations in environmental systems. Screening for outliers is an important step because outliers can bias statistical estimates, statistical testing results, and inferences.

Outlier values were initially screened visually using the side-by-side box plots. If suspected visual outliers were identified, then Tukey's procedure was used to identify extreme outliers (Tukey 1977). This method relies on the IQR, which is defined as the 75^{th} percentile value minus the 25^{th} percentile value. Values were identified as potential outliers as follows:

- **Lower extreme outliers** are less than the 25^{th} percentile minus 3 x IQR
- **Upper extreme outliers** are greater than the 75^{th} percentile plus 3 x IQR.

Finally, when the potential outliers were identified visually and by Tukey's procedure, then statistical testing for outliers (Rosner's Test) was conducted to determine if those data points were statistically significant outliers.

Following confirmation of the outliers as statistically significant, a desktop evaluation was conducted to verify that the data points were not errors (e.g., laboratory or transcriptional errors). Field forms, data validation reports and other variables in the dataset that could influence analytical results also were evaluated at this point. If a verifiable error was discovered, the outlier was removed and, if possible, replaced with a corrected value.

In the absence of a verifiable error, additional lines of evidence were reviewed to determine final outlier disposition (e.g., frequency of detection, spatial and temporal variability). If an outlier was identified as suitable for removal from further statistical analysis, a clear and defensible rationale based on multiple lines of evidence was provided. In addition, values that were identified as outliers and removed from further evaluation in the present statistical analysis were retained in the historical database and will be reevaluated for inclusion or exclusion in future statistical analyses of this dataset. The results of the outlier screening for the WBF Plant surface stream dataset are provided in Section 3.1.

2.2 COMPARISON OF SURFACE STREAM RESULTS TO ESVs AND SSL_{HH}

The analytical results for total metals in the surface stream dataset for all sampled water bodies were compared to water body specific ESVs, as provided in Table 1-2 and Appendix A.2. In addition, surface stream data from the Tennessee River were compared to generic SSL_{HH} values (also provided in Appendix A.2) because it is used as a potable water source. Results were summarized graphically using transect plots and in tabular format in Tables in Appendix J.1.

When an analytical sample result for a CCR Parameter was above the ESV and data were collected from transects/locations adjacent and from transect/locations upstream and/or downstream to the WBF Plant CCR management units, additional statistical evaluation of that CCR parameter was applied in the EAR. This additional evaluation included:

- Formal hypothesis testing to identify differences between upstream, adjacent, and downstream results, and
- PCA to identify the variables and individual samples that explain the greatest proportion of variability (provide the greatest amount of information) in the datasets.

No additional statistical analyses were conducted (PCA and hypothesis testing) for the surface stream datasets as described in Section 3.2.

3.0 RESULTS AND DISCUSSION

3.1 SUMMARY STATISTICS, EXPLORATORY DATA PLOTS, AND OUTLIER SCREENING

Summary statistics tables are presented in Attachment E.5-A, box plots are presented in Attachment E.5-B, and transect plots are presented in Attachment E.5-C. Box plots and transect plots that were used to identify the potential statistical outliers are presented in Attachment E.5-D. The summary statistics and exploratory data plots were aggregated by transect location relative to the WBF Plant CCR management units (upstream, adjacent, downstream) and sample position in the water body (plant-side bank, center channel, and opposite-side bank).

The outlier screening method described in Section 2.1.3 identified one outlier that was determined to be suitable for removal from further statistical analysis (Table E.5-3). This outlier was initially identified using exploratory data plots (see Attachment E.5-D) and confirmed as a statistical outlier using Rosner's Outlier Test ($p\text{-value}<0.01$) and the Tukey's Extreme Outlier Test. Subsequently, additional lines of evidence were reviewed to determine final outlier disposition (e.g., frequency of detection, spatial and temporal variability).

For the outlier identified for exclusion from further statistical analysis in Table E.5-3, this exclusion was supported by a spatial review that compared the magnitude of the outlier result to the distribution of concentrations for that parameter in surface water at the sampled locations in the Tennessee River. This spatial comparison was supported by a visual review of the box-plots and transect plots for these parameters in surface stream samples as presented in Appendix E.5-D. The results of this spatial review indicated that the outlier in Table E.5-3 represents a value that is considerably separated from all other surface stream concentrations for that parameter for samples collected in the vicinity of the WBF Plant from Tennessee River. As such, this result was an outlier not only for the individual sampling location where it was collected, but it was also an outlier in the context of a much larger dataset. Inclusion of outliers that are well-separated from the dominant data in statistical analysis can distort calculated decision statistics, which may in turn lead to incorrect remediation decisions (USEPA 2022). It is preferable to compute environmental statistics based on datasets that represent the main population (USEPA 2022). Therefore, it was determined that inclusion of the outlier in Table E.5-3 in further statistical analysis would obscure statistical interpretation of the available surface stream data and this value was removed from further statistical analysis in the EAR (i.e., excluded from the summary statistics, box-plots, and transect plots presented in Attachments E.5-A, E.5-B, and E.5-C, respectively). However, this outlier remains in the historical dataset and will require reevaluation for inclusion/exclusion if these data are analyzed in future reports.

Furthermore, since the outlier identified in Table E.5-3 was identified in the dissolved fraction of the sample, an additional comparison was done to the total results from the same sample. This comparison revealed that the dissolved fraction result was an order of magnitude higher than the total fraction result (Table E.5-3). This indicates a data error, since the dissolved fraction of a substance cannot, by definition, exceed the total concentration of that substance. Therefore, the outlier result identified in Table E.5-3 was removed from further statistical analysis in the EAR (i.e., excluded from the summary statistics, box-plots, and transect plots presented in Attachments E.5-A, E.5-B, and E.5-C, respectively). However, this outlier remains in the historical dataset and will require reevaluation for inclusion/exclusion if these data are analyzed in future reports.

Table E.5-3 - Statistically Significant Outliers – WBF Plant, Surface Stream

CCR Parameter	Water body	Sample Location	Sample ID	Lowest Applicable Ecological Screening Value (ESV) or Human Health Screening Level (SSL_{HH})	Does Outlier Exceed Lowest Applicable ESV or SSL_{HH}?	Outlier Value (Dissolved)	Total Value
Copper	Tennessee River	TR02 (Upstream of CUF Plant)	WBF-STR-TR02-LB-MID-20190709	7.0 µg/L	Yes	23.7 µg/L	1.12 µg/L

Notes:
ID - identification
µg/L – micrograms per Liter

3.2 COMPARISON OF SURFACE STREAM RESULTS TO ESVS AND SSL_{HH}

There were no sample results above chronic ESVs, acute ESVs, or SSL_{HH} from surface stream sampling in the Tennessee River.

4.0 REFERENCES

StataCorp. (2017). Stata Graphics Reference Manual Stata: Release 15. Statistical Software. College Station, TX: StataCorp LLC.

Tukey, J.W. (1977). *Exploratory Data Analysis*. Reading, Massachusetts: Addison-Wesley. 1977.

United States Environmental Protection Agency (USEPA) (2022). ProUCL Version 5.2.0 Technical Guide: Statistical Software for Environmental Applications for Data Sets with and without Nondetect Observations. Washington DC. USEPA Office of Research and Development.

ATTACHMENT E.5-A - SUMMARY STATISTICS BY WATER BODY

Summary Statistics - Tennessee River
Surface Stream Investigation
Watts Bar Fossil Plant - Spring City, Tennessee

Parameter	Gradient	Fraction	Frequency of Detection	Range of Reporting Limits	% Non Detect	Statistics using Detected Data Only		Statistics using Detects & Non-Detects			
						Minimum Detect	Maximum Detect	Mean	Standard Deviation	50th Percentile	95th Percentile
CCR Rule Appendix III Parameters											
Boron	Upstream	D	3/34	(30.3 - 38.6)	91.2%	33.4	41	31.1	2.24	34.7	38.6
		T	2/34	(30.3 - 38.6)	94.1%	31.7	42.4	30.7	2.06	31	38.6
	Adjacent	D	8/46	(30.3 - 38.6)	82.6%	31.9	81.2	33.9	9.67	38.6	50.4
		T	10/46	(30.3 - 38.6)	78.3%	34.5	168	39.9	27	38.6	104
	Downstream	D	1/33	(30.3 - 54.9)	97.0%	45.4	45.4	30.8	2.63	38.6	41.3
		T	2/33	(30.3 - 39.5)	93.9%	38.8	51	31.2	3.8	36.3	39.1
Calcium	Upstream	D	34/34	--	0.0%	20,900	24,100	22,400	760	22,200	23,600
		T	34/34	--	0.0%	20,900	24,000	22,300	885	22,400	23,900
	Adjacent	D	46/46	--	0.0%	20,500	24,800	22,500	1,090	22,900	24,100
		T	46/46	--	0.0%	20,600	24,500	22,600	921	22,900	24,100
	Downstream	D	33/33	--	0.0%	20,600	24,700	22,400	1,300	22,400	24,300
		T	33/33	--	0.0%	20,700	24,700	22,600	1,320	22,500	24,600
Chloride	Upstream	N	34/34	--	0.0%	3,990	30,400	6,500	6,130	4,540	14,800
	Adjacent	N	46/46	--	0.0%	3,980	6,620	5,190	1,160	4,240	6,590
	Downstream	N	33/33	--	0.0%	4,040	6,410	5,160	919	4,740	6,310
Sulfate	Upstream	N	34/34	--	0.0%	8,170	56,400	12,300	11,100	9,380	28,000
	Adjacent	N	46/46	--	0.0%	8,160	11,800	9,690	1,420	8,780	11,500
	Downstream	N	33/33	--	0.0%	8,310	11,200	9,780	1,090	9,860	11,000
TDS	Upstream	N	34/34	--	0.0%	82,000	129,000	95,100	9,450	93,000	108,000
	Adjacent	N	46/46	--	0.0%	86,000	137,000	101,000	10,600	98,500	121,000
	Downstream	N	33/33	--	0.0%	79,000	115,000	94,500	9,420	92,000	110,000
CCR Rule Appendix IV Parameters											
Antimony	Upstream	D	0/34	(0.378 - 0.408)	100.0%	--	--	--	--	0.378	0.378
		T	0/34	(0.378 - 0.378)	100.0%	--	--	--	--	0.378	0.378
	Adjacent	D	0/46	(0.378 - 0.378)	100.0%	--	--	--	--	0.378	0.378
		T	0/46	(0.378 - 0.378)	100.0%	--	--	--	--	0.378	0.378
	Downstream	D	2/33	(0.378 - 0.633)	93.9%	0.378	0.467	0.381	0.0155	0.378	0.414
		T	4/33	(0.378 - 0.378)	87.9%	0.394	0.585	0.392	0.0467	0.378	0.479
Arsenic	Upstream	D	25/34	(0.498 - 0.648)	26.5%	0.418	0.907	0.544	0.107	0.563	0.718
		T	34/34	--	0.0%	0.462	0.921	0.625	0.107	0.608	0.78
	Adjacent	D	37/46	(0.512 - 0.768)	19.6%	0.376	0.844	0.565	0.112	0.578	0.776
		T	46/46	--	0.0%	0.491	0.927	0.654	0.102	0.623	0.788
	Downstream	D	33/33	--	0.0%	0.384	0.668	0.525	0.0693	0.521	0.658
		T	33/33	--	0.0%	0.445	0.888	0.589	0.0889	0.583	0.717
Barium	Upstream	D	34/34	--	0.0%	25	28.6	26.8	0.812	26.9	28
		T	34/34	--	0.0%	25.6	30.6	28.5	1.16	28.6	30.3
	Adjacent	D	46/46	--	0.0%	23.8	29.6	26.1	1.34	26	28.4
		T	46/46	--	0.0%	24.8	46.6	28.6	2.98	28.4	30
	Downstream	D	33/33	--	0.0%	21.6	28.7	25.9	1.7	26.2	28.1
		T	33/33	--	0.0%	24.3	31.1	28.1	1.89	28.4	30.6
Beryllium	Upstream	D	13/34	(0.155 - 0.182)	61.8%	0.182	0.504	0.193	0.0691	0.169	0.286
		T	13/34	(0.155 - 0.182)	61.8%	0.195	0.431	0.208	0.0758	0.155	0.333
	Adjacent	D	7/46	(0.155 - 0.327)	84.8%	0.229	0.321	0.174	0.0447	0.176	0.3
		T	9/46	(0.155 - 0.32)	80.4%	0.17	0.368	0.176	0.0472	0.182	0.295
	Downstream	D	3/33	(0.155 - 0.244)	90.9%	0.169	0.216	0.159	0.0131	0.169	0.217
		T	7/33	(0.155 - 0.907)	78.8%	0.359	0.846	0.25	0.181	0.155	0.773
Cadmium	Upstream	D	1/34	(0.125 - 0.125)	97.1%	0.17	0.17	0.126	0.0076	0.125	0.125
		T	1/34	(0.125 - 0.125)	97.1%	0.141	0.141	0.125	0.0027	0.125	0.125
	Adjacent	D	1/46	(0.125 - 0.125)	97.8%	0.13	0.13	0.125	0.000729	0.125	0.125
		T	0/46	(0.125 - 0.125)	100.0%	--	--	--	--	0.125	0.125
	Downstream	D	0/33	(0.125 - 0.125)	100.0%	--	--	--	--	0.125	0.125
		T	2/33	(0.125 - 0.125)	93.9%	0.152	0.153	0.127	0.00656	0.125	0.136
Chromium	Upstream	D	0/34	(1.53 - 3.1)	100.0%	--	--	--	--	1.53	2.1
		T	0/34	(1.53 - 2.74)	100.0%	--	--	--	--	1.53	2.35
	Adjacent	D	10/46	(1.53 - 5.2)	78.3%	1.67	2.14	1.63	0.19	1.54	2.39
		T	10/46	(1.53 - 2.98)	78.3%	1.84	11.9	1.89	1.52	1.53	2.63
	Downstream	D	0/33	(1.53 - 2.71)	100.0%	--	--	--	--	1.53	2.39
		T	0/33	(1.53 - 6.61)	100.0%	--	--	--	--	1.53	3.96

Summary Statistics - Tennessee River
Surface Stream Investigation
Watts Bar Fossil Plant - Spring City, Tennessee

Parameter	Gradient	Fraction	Frequency of Detection	Range of Reporting Limits	% Non Detect	Statistics using Detected Data Only		Statistics using Detects & Non-Detects			
						Minimum Detect	Maximum Detect	Mean	Standard Deviation	50th Percentile	95th Percentile
Cobalt	Upstream	D	13/34	(0.075 - 0.075)	61.8%	0.075	0.169	0.0837	0.0182	0.075	0.111
		T	34/34	--	0.0%	0.099	0.233	0.149	0.0336	0.142	0.213
	Adjacent	D	15/46	(0.075 - 0.075)	67.4%	0.085	0.143	0.0849	0.0181	0.075	0.132
		T	43/46	(0.139 - 0.151)	6.5%	0.1	0.224	0.15	0.0283	0.145	0.212
	Downstream	D	5/33	(0.075 - 0.075)	84.9%	0.085	0.106	0.0782	0.00818	0.075	0.1
		T	33/33	--	0.0%	0.087	0.272	0.134	0.0359	0.13	0.183
Fluoride	Upstream	N	34/34	--	0.0%	51.6	326	74.1	62.4	56.8	161
	Adjacent	N	46/46	--	0.0%	52.4	82.4	60.4	6.17	59.2	73.7
	Downstream	N	25/33	(51.5 - 62.2)	24.2%	52.3	81.9	60.3	8.44	58	75.7
Lead	Upstream	D	3/34	(0.128 - 0.131)	91.2%	0.203	1.03	0.161	0.154	0.128	0.233
		T	28/34	(0.128 - 0.128)	17.7%	0.133	0.31	0.16	0.0331	0.154	0.2
	Adjacent	D	2/46	(0.128 - 0.128)	95.7%	0.155	0.184	0.13	0.00899	0.128	0.128
		T	41/46	(0.128 - 0.218)	10.9%	0.132	0.375	0.185	0.0525	0.178	0.301
	Downstream	D	1/33	(0.128 - 0.128)	97.0%	0.138	0.138	0.128	0.00171	0.128	0.128
		T	21/33	(0.128 - 0.128)	36.4%	0.128	0.244	0.159	0.0347	0.148	0.231
Lithium	Upstream	D	7/34	(3.14 - 3.39)	79.4%	3.38	6.64	3.41	0.739	3.39	4.74
		T	8/34	(3.14 - 3.39)	76.5%	3.57	5.82	3.43	0.651	3.39	4.97
	Adjacent	D	8/46	(3.14 - 3.39)	82.6%	3.15	5.2	3.29	0.433	3.39	4.25
		T	10/46	(3.14 - 3.39)	78.3%	3.18	4.89	3.31	0.411	3.39	4.32
	Downstream	D	2/33	(3.14 - 3.39)	93.9%	3.34	3.46	3.16	0.0703	3.34	3.39
		T	3/33	(3.14 - 3.39)	90.9%	3.51	4.22	3.2	0.206	3.39	3.54
Mercury	Upstream	D	0/34	(0.101 - 0.101)	100.0%	--	--	--	--	0.101	0.101
		T	0/34	(0.101 - 0.101)	100.0%	--	--	--	--	0.101	0.101
	Adjacent	D	0/46	(0.101 - 0.101)	100.0%	--	--	--	--	0.101	0.101
		T	0/46	(0.101 - 0.101)	100.0%	--	--	--	--	0.101	0.101
	Downstream	D	0/33	(0.101 - 0.101)	100.0%	--	--	--	--	0.101	0.101
		T	0/33	(0.101 - 0.101)	100.0%	--	--	--	--	0.101	0.101
Molybdenum	Upstream	D	0/34	(0.61 - 0.61)	100.0%	--	--	--	--	0.61	0.61
		T	2/34	(0.61 - 0.61)	94.1%	0.613	0.659	0.612	0.00828	0.61	0.611
	Adjacent	D	1/46	(0.61 - 0.61)	97.8%	0.703	0.703	0.612	0.0136	0.61	0.61
		T	0/46	(0.61 - 0.61)	100.0%	--	--	--	--	0.61	0.61
	Downstream	D	0/33	(0.61 - 0.61)	100.0%	--	--	--	--	0.61	0.61
		T	0/33	(0.61 - 0.61)	100.0%	--	--	--	--	0.61	0.61
Radium-226+228	Upstream	T	2/34	(0.498 - 1.089)	94.1%	0.497	0.746	0.506	0.0454	0.599	0.79
	Adjacent	T	2/46	(0.451 - 1.291)	95.7%	0.589	0.666	0.466	0.0489	0.637	0.998
	Downstream	T	3/33	(0.492 - 0.923)	90.9%	0.725	0.755	0.527	0.0856	0.715	0.921
Selenium	Upstream	D	0/34	(1.51 - 2.62)	100.0%	--	--	--	--	2.62	2.62
		T	0/34	(1.51 - 2.62)	100.0%	--	--	--	--	2.62	2.62
	Adjacent	D	0/46	(1.51 - 2.62)	100.0%	--	--	--	--	2.62	2.62
		T	0/46	(1.51 - 2.62)	100.0%	--	--	--	--	2.62	2.62
	Downstream	D	0/33	(1.51 - 2.62)	100.0%	--	--	--	--	2.62	2.62
		T	0/33	(1.51 - 2.62)	100.0%	--	--	--	--	2.62	2.62
Thallium	Upstream	D	5/34	(0.128 - 0.148)	85.3%	0.163	0.319	0.141	0.0375	0.138	0.21
		T	3/34	(0.128 - 0.148)	91.2%	0.381	0.505	0.156	0.0914	0.128	0.406
	Adjacent	D	1/46	(0.128 - 0.28)	97.8%	0.457	0.457	0.135	0.048	0.128	0.148
		T	2/46	(0.128 - 0.148)	95.7%	0.16	0.221	0.131	0.0142	0.138	0.148
	Downstream	D	2/33	(0.128 - 0.148)	93.9%	0.151	0.226	0.132	0.0171	0.148	0.149
		T	4/33	(0.128 - 0.148)	87.9%	0.152	0.437	0.145	0.0579	0.128	0.229
TDEC Appendix I Parameters											
Copper	Upstream	D	20/34	(0.627 - 1.27)	41.2%	0.699	23.7	1.65	3.87	0.911	2.31
		T	34/34	--	0.0%	0.741	1.48	1.05	0.188	1.06	1.43
	Adjacent	D	21/46	(0.627 - 1.46)	54.4%	0.706	2.2	0.832	0.253	0.904	1.43
		T	43/46	(1.15 - 1.48)	6.5%	0.657	2.45	1.15	0.277	1.14	1.53
	Downstream	D	25/33	(0.774 - 1.03)	24.2%	0.7	1.83	1.01	0.299	0.898	1.59
		T	33/33	--	0.0%	0.807	1.44	1.05	0.166	1.02	1.32
Nickel	Upstream	D	4/34	(0.312 - 1.42)	88.2%	0.325	0.341	0.316	0.00869	0.335	1.16
		T	7/34	(0.312 - 1.56)	79.4%	0.317	0.453	0.339	0.0408	0.416	1.35
	Adjacent	D	7/46	(0.312 - 1.75)	84.8%	0.339	0.431	0.326	0.0298	0.336	1.46
		T	23/46	(0.312 - 1.86)	50.0%	0.323	0.62	0.395	0.0884	0.417	1.72
	Downstream	D	7/33	(0.312 - 1)	78.8%	0.342	0.441	0.325	0.0293	0.336	0.416
		T	20/33	(0.312 - 1.48)	39.4%	0.369	0.506	0.398	0.058	0.429	0.807

Summary Statistics - Tennessee River Surface Stream Investigation Watts Bar Fossil Plant - Spring City, Tennessee											
Parameter	Gradient	Fraction	Frequency of Detection	Range of Reporting Limits	% Non Detect	Statistics using Detected Data Only		Statistics using Detects & Non-Detects			
						Minimum Detect	Maximum Detect	Mean	Standard Deviation	50th Percentile	95th Percentile
Silver	Upstream	D	2/34	(0.121 - 0.177)	94.1%	0.211	0.268	0.128	0.0287	0.121	0.189
		T	0/34	(0.121 - 0.177)	100.0%	--	--	--	--	0.121	0.177
	Adjacent	D	0/46	(0.121 - 0.177)	100.0%	--	--	--	--	0.121	0.177
		T	1/46	(0.121 - 0.177)	97.8%	0.27	0.27	0.124	0.0217	0.121	0.177
	Downstream	D	0/33	(0.121 - 0.177)	100.0%	--	--	--	--	0.121	0.177
		T	0/33	(0.121 - 0.177)	100.0%	--	--	--	--	0.121	0.177
Vanadium	Upstream	D	14/34	(0.899 - 1.8)	58.8%	1.02	2.09	1.07	0.265	1.07	1.77
		T	16/34	(0.995 - 2.04)	52.9%	1	1.4	1.13	0.137	1.26	1.86
	Adjacent	D	36/46	(0.899 - 1.88)	21.7%	0.917	1.92	1.25	0.219	1.31	1.81
		T	30/46	(0.955 - 2.24)	34.8%	1.06	2.4	1.42	0.288	1.56	1.83
	Downstream	D	18/33	(0.899 - 0.991)	45.5%	0.899	2.16	1.12	0.282	1.02	1.48
		T	22/33	(0.991 - 2.09)	33.3%	1.05	2.26	1.28	0.292	1.26	2.02
Zinc	Upstream	D	2/34	(3.22 - 3.22)	94.1%	4.9	14.8	3.61	1.97	3.22	3.81
		T	3/34	(3.22 - 3.22)	91.2%	3.48	3.68	3.25	0.111	3.22	3.54
	Adjacent	D	5/46	(3.22 - 3.22)	89.1%	3.59	5.65	3.37	0.478	3.22	4.5
		T	18/46	(3.22 - 3.22)	60.9%	3.33	9.55	4.01	1.52	3.22	7.34
	Downstream	D	0/33	(3.22 - 3.22)	100.0%	--	--	--	--	3.22	3.22
		T	6/33	(3.22 - 3.22)	81.8%	3.56	6.57	3.43	0.62	3.22	4.2
Other Analyzed Constituents											
Hardness	Upstream	N	34/34	--	0.0%	76,200	86,100	81,400	2,930	81,700	85,300
	Adjacent	N	46/46	--	0.0%	75,500	90,500	81,800	3,790	81,700	87,900
	Downstream	N	33/33	--	0.0%	72,400	86,900	79,400	3,150	78,500	84,300
Iron	Upstream	D	5/34	(14.1 - 19.5)	85.3%	15.9	119	19.1	18.5	19.5	35.1
		T	34/34	--	0.0%	73.8	203	128	38.5	129	187
	Adjacent	D	8/46	(14.1 - 19.5)	82.6%	18.4	77.1	18.5	11.9	19.5	45.2
		T	46/46	--	0.0%	69.1	221	139	40.9	142	198
	Downstream	D	5/33	(14.1 - 19.5)	84.9%	22.1	87.1	20.6	17.4	19.5	60.4
		T	33/33	--	0.0%	75.6	323	174	57.9	165	286
Magnesium	Upstream	D	34/34	--	0.0%	5,670	7,070	6,270	426	6,110	6,900
		T	34/34	--	0.0%	5,760	7,030	6,260	436	6,090	6,950
	Adjacent	D	46/46	--	0.0%	4,970	7,390	6,140	687	6,040	7,170
		T	46/46	--	0.0%	4,880	7,310	6,160	669	6,010	7,240
	Downstream	D	33/33	--	0.0%	4,460	6,840	5,510	509	5,740	5,990
		T	33/33	--	0.0%	4,600	7,090	5,590	582	5,790	6,490
Manganese	Upstream	D	34/34	--	0.0%	1.72	54.3	9.57	11.5	5.6	32.6
		T	34/34	--	0.0%	42.4	103	71.6	23.8	83.2	102
	Adjacent	D	44/46	(1.35 - 1.35)	4.4%	1.42	55.3	8.2	10.5	4.9	34.4
		T	46/46	--	0.0%	41.3	99.7	68.8	21.8	77.4	96.1
	Downstream	D	30/33	(1.35 - 1.35)	9.1%	1.46	58.6	7.48	13.1	3.19	40
		T	33/33	--	0.0%	41.3	98.1	68.7	20.1	67.2	96.1
TSS	Upstream	N	34/34	--	0.0%	2,800	5,500	4,490	523	4,500	5,110
	Adjacent	N	46/46	--	0.0%	3,500	5,900	4,570	471	4,500	5,580
	Downstream	N	33/33	--	0.0%	2,700	8,200	5,050	1,370	4,700	7,600

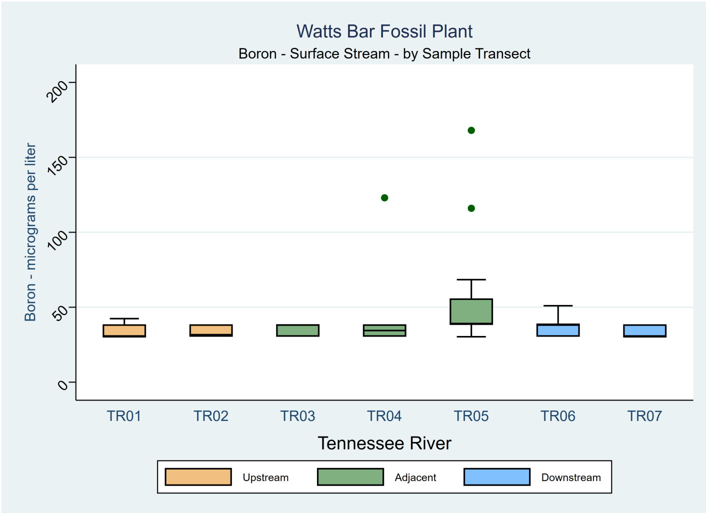
Notes:

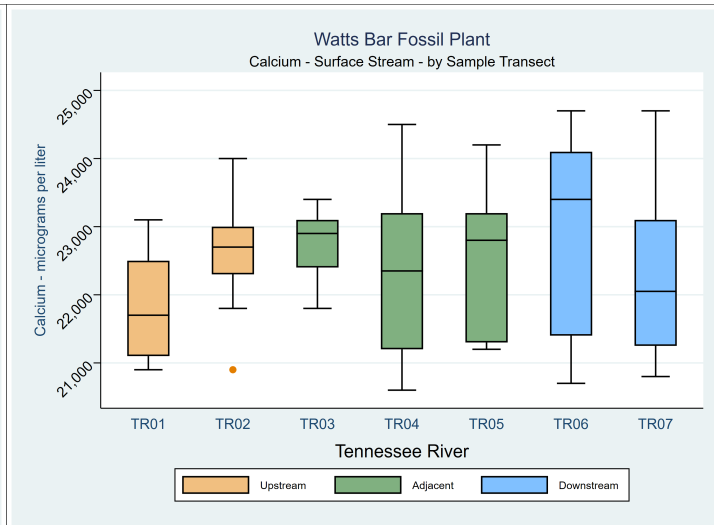
CCR Rule - Title 40, Code of Federal Regulations, Part 257
TDEC - Tennessee Department of Environment and Conservation
% - percent
"--" - Not Applicable
TDS - Total Dissolved Solids
TSS - Total Suspended Solids

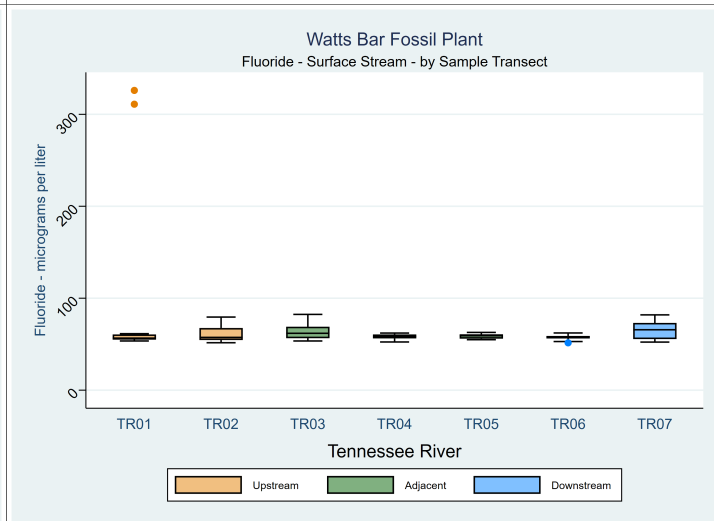
Statistical data sets were aggregated by location of transect relative to the CCR management units (upstream, adjacent downstream) and sample fraction (total, dissolved, or normal)
Except for Radium 226 + 228, all units micrograms per liter (µg/L)
Units for Radium 226+228 are picocuries per liter (pCi/L)
Fractions reported include dissolved (D), total (T), and normal (N)
All non-detects reported at the laboratory reporting limit
For Parameters with non-detects reported at the method detection limit, the mean and standard deviation were calculated using Kaplan-Meier methods (KM).

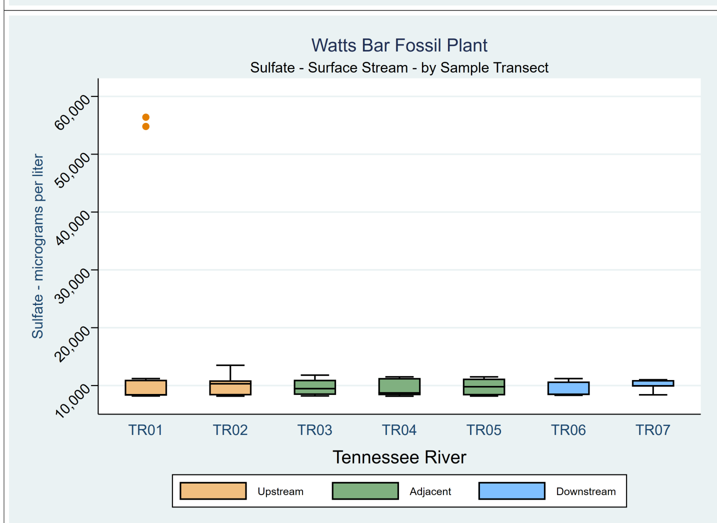
ATTACHMENT E.5-B - BOX PLOTS

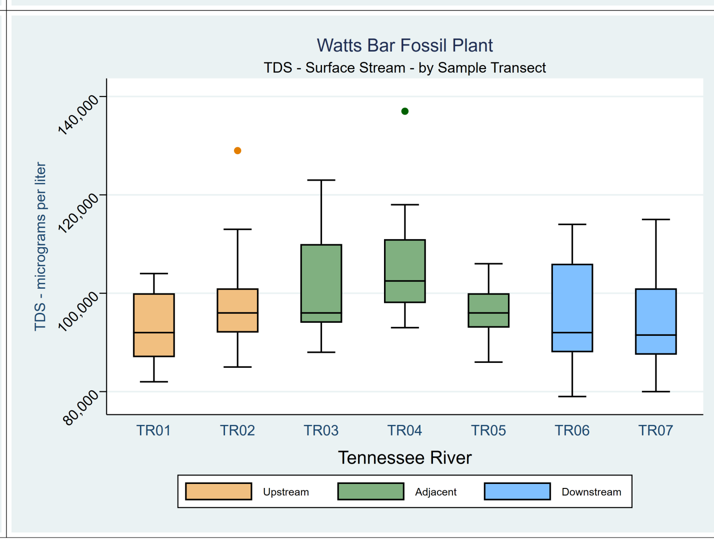
Box Plots
CCR Rule Appendix III Parameters
Surface Stream Investigation
Watts Bar Fossil Plant - Spring City, Tennessee



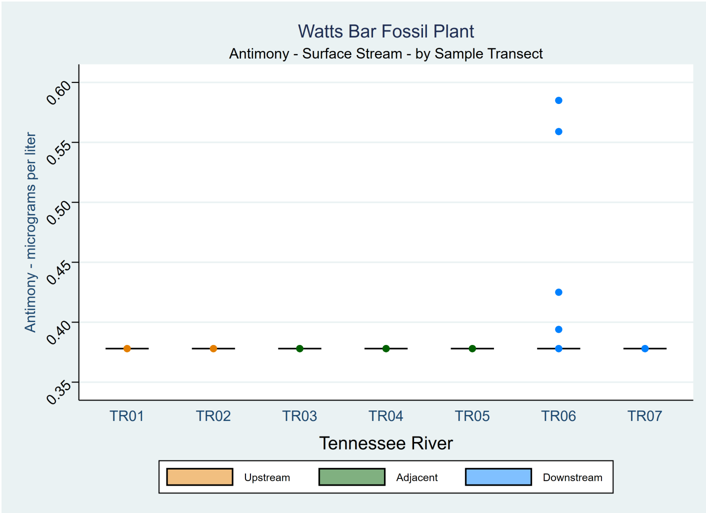


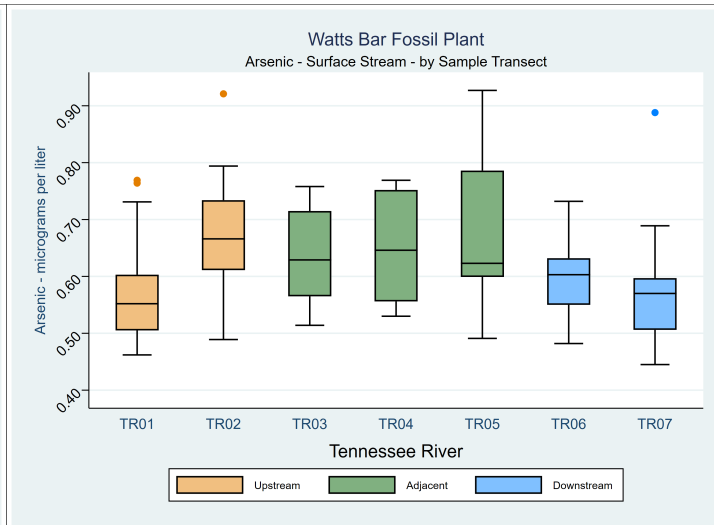


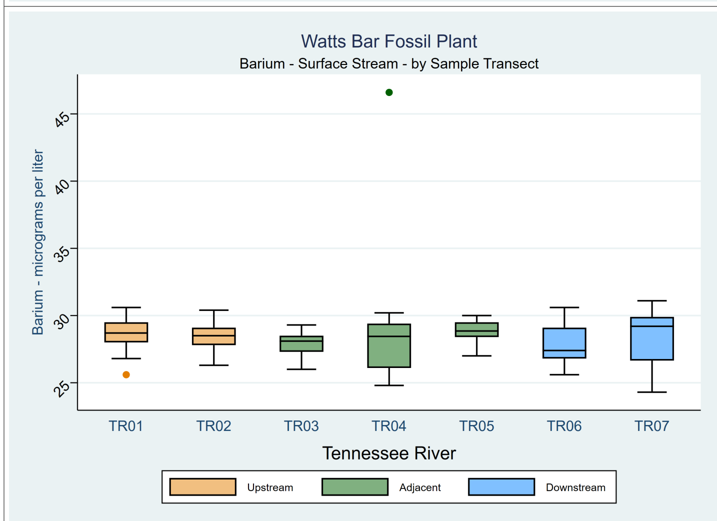


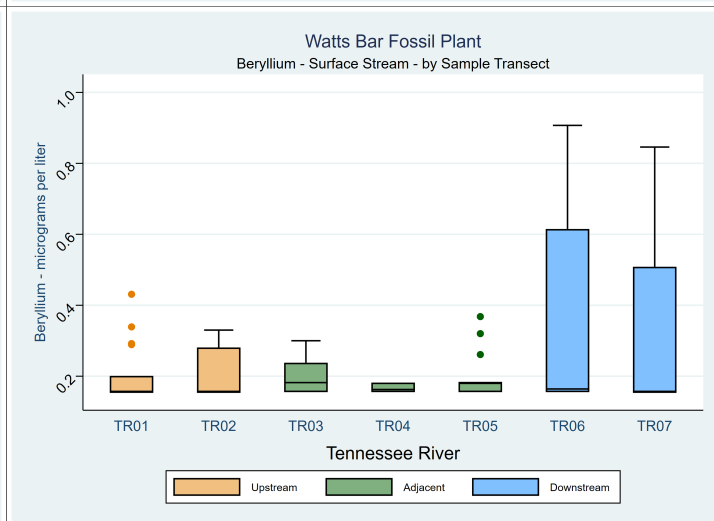


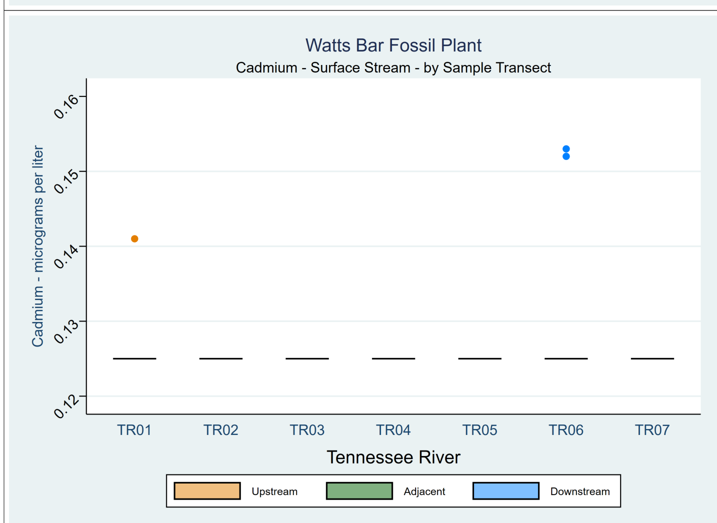
Box Plots
CCR Rule Appendix IV Parameters
Surface Stream Investigation
Watts Bar Fossil Plant - Spring City, Tennessee

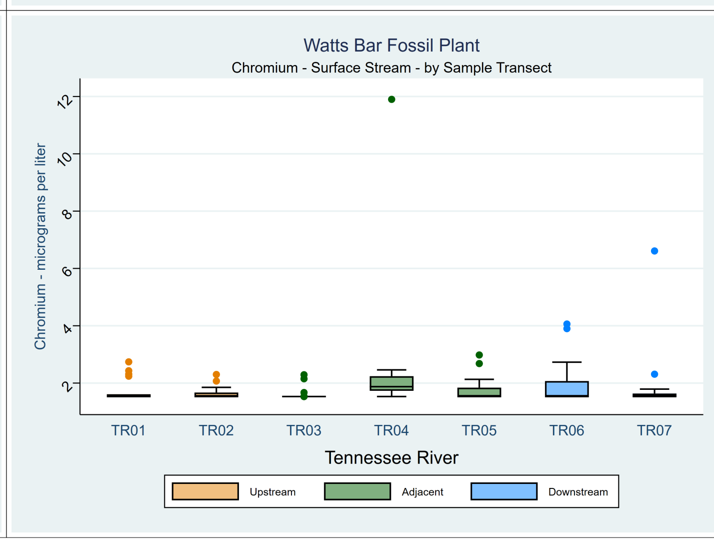


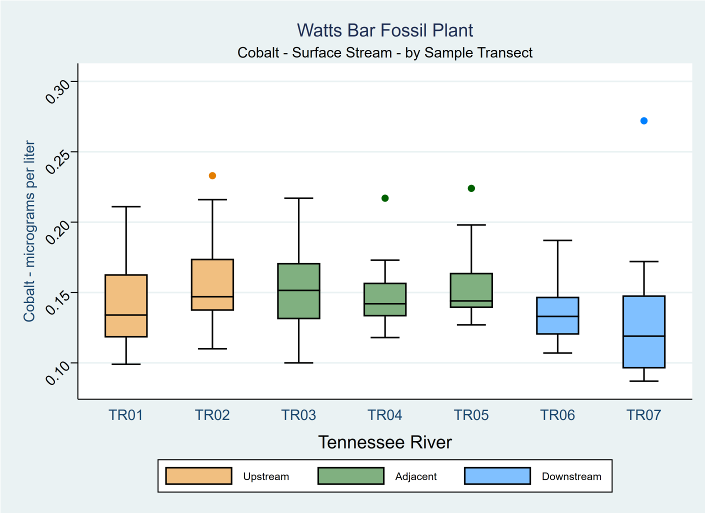


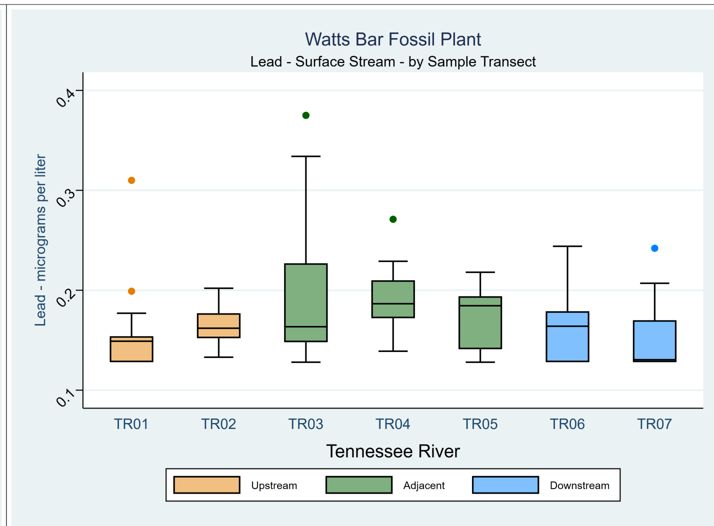


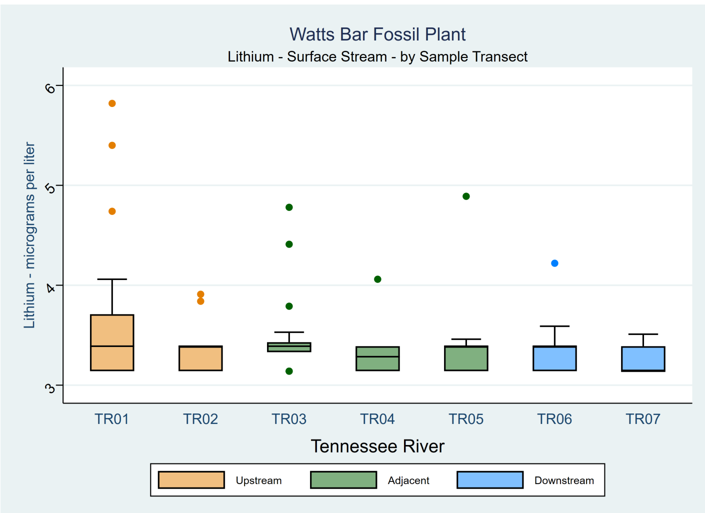


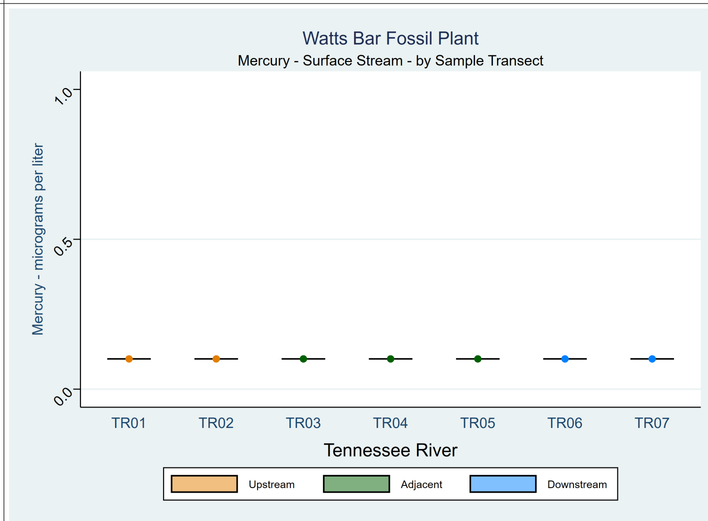


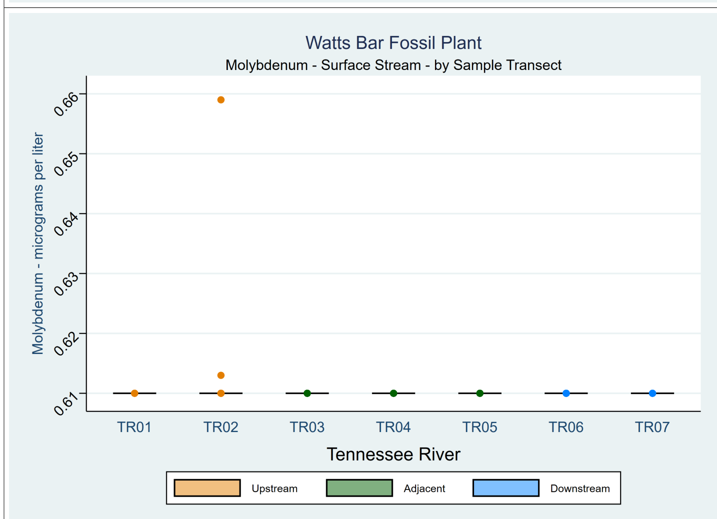


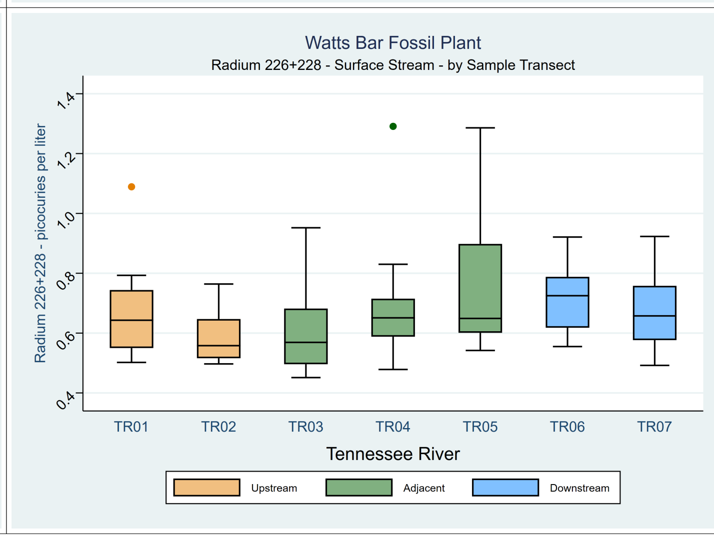

Watts Bar Fossil Plant
Cobalt - Surface Stream - by Sample Transect
Cobalt - micrograms per liter
0.10
0.15
0.20
0.25
0.30
TR01
TR02
TR03
TR04
TR05
TR06
TR07
Tennessee River
Upstream
Adjacent
Downstream

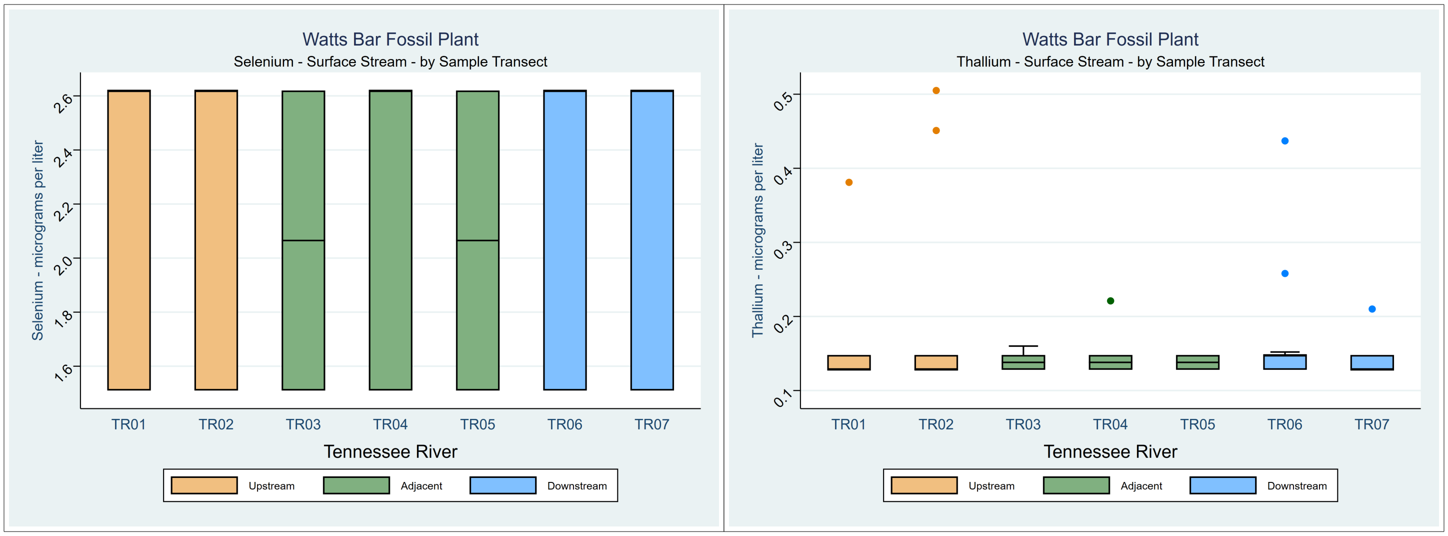

Watts Bar Fossil Plant
Lead - Surface Stream - by Sample Transect
Lead - micrograms per liter
0.1
0.2
0.3
0.4
TR01
TR02
TR03
TR04
TR05
TR06
TR07
Tennessee River
Upstream
Adjacent
Downstream


Watts Bar Fossil Plant
Lithium - Surface Stream - by Sample Transect
Lithium - micrograms per liter
3
4
5
6
TR01
TR02
TR03
TR04
TR05
TR06
TR07
Tennessee River
Upstream
Adjacent
Downstream


Watts Bar Fossil Plant
Mercury - Surface Stream - by Sample Transect
Mercury - micrograms per liter
0.0
0.5
1.0
TR01
TR02
TR03
TR04
TR05
TR06
TR07
Tennessee River
Upstream
Adjacent
Downstream

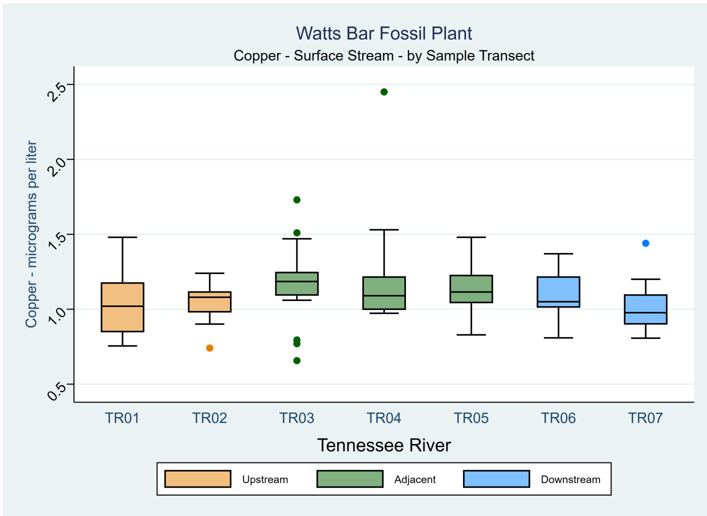

Watts Bar Fossil Plant
Molybdenum - Surface Stream - by Sample Transect
Molybdenum - micrograms per liter
0.61
0.62
0.63
0.64
0.65
0.66
TR01
TR02
TR03
TR04
TR05
TR06
TR07
Tennessee River
Upstream
Adjacent
Downstream

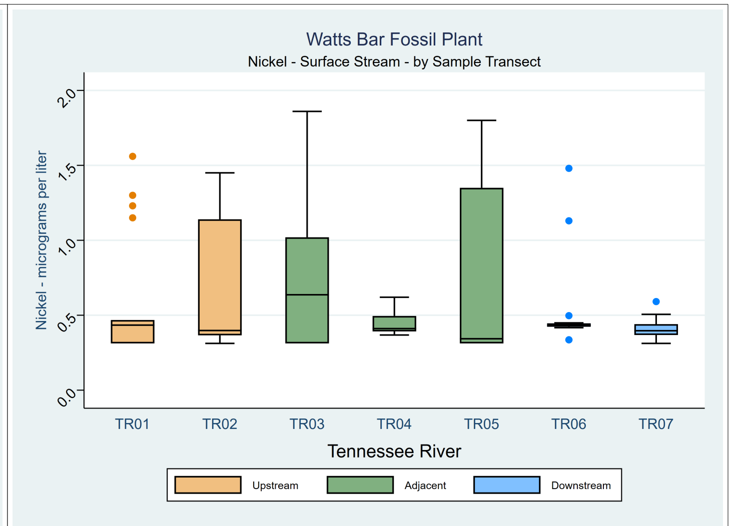

Watts Bar Fossil Plant
Radium 226+228 - Surface Stream - by Sample Transect
Radium 226+228 - picocuries per liter
0.4
0.6
0.8
1.0
1.2
1.4
TR01
TR02
TR03
TR04
TR05
TR06
TR07
Tennessee River
Upstream
Adjacent
Downstream

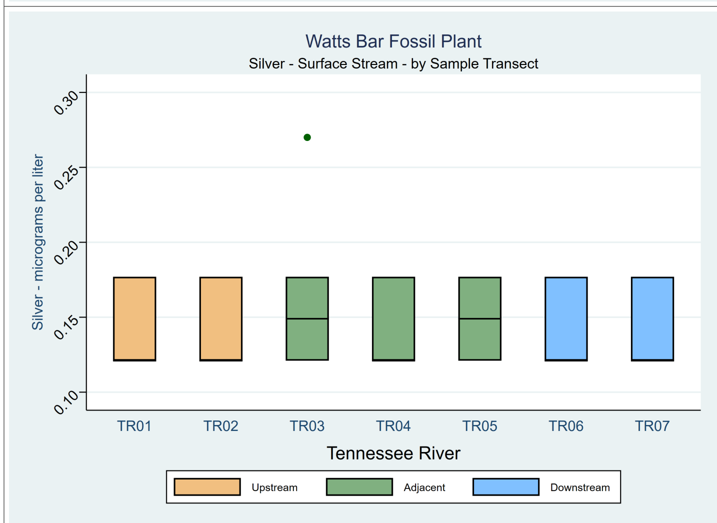


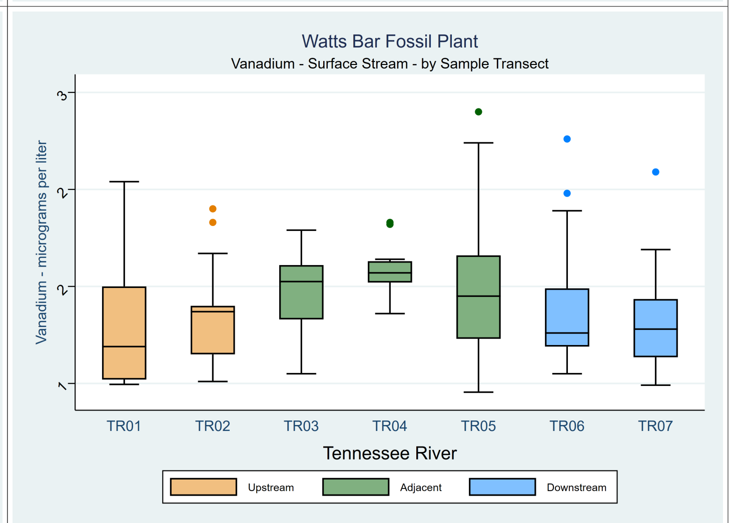
Watts Bar Fossil Plant
Selenium - Surface Stream - by Sample Transect
Selenium - micrograms per liter
1.6
1.8
2.0
2.2
2.4
2.6
TR01
TR02
TR03
TR04
TR05
TR06
TR07
Tennessee River
Upstream
Adjacent
Downstream
Watts Bar Fossil Plant
Thallium - Surface Stream - by Sample Transect
Thallium - micrograms per liter
0.1
0.2
0.3
0.4
0.5
TR01
TR02
TR03
TR04
TR05
TR06
TR07
Tennessee River
Upstream
Adjacent
Downstream

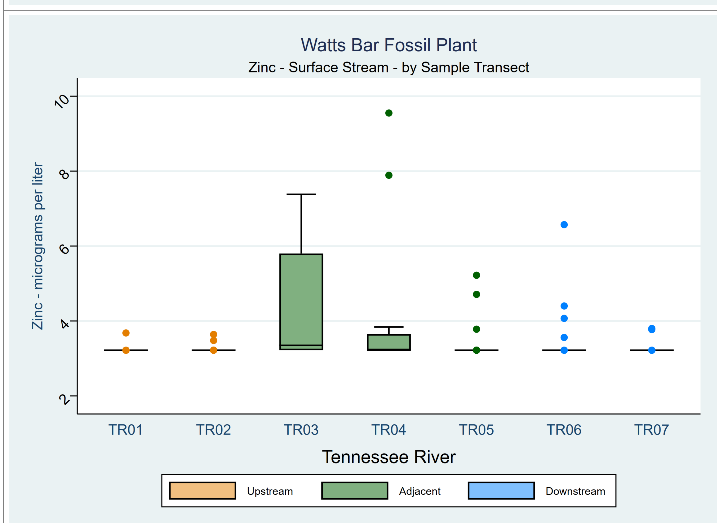
Box Plots
TDEC Appendix I Parameters
Surface Stream Investigation
Watts Bar Fossil Plant - Spring City, Tennessee











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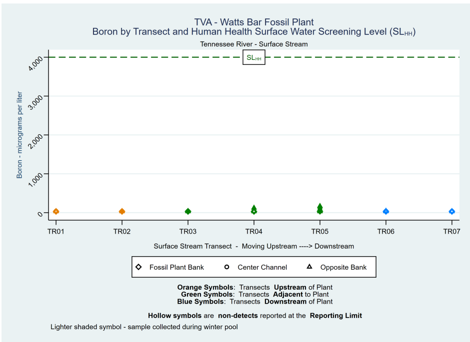
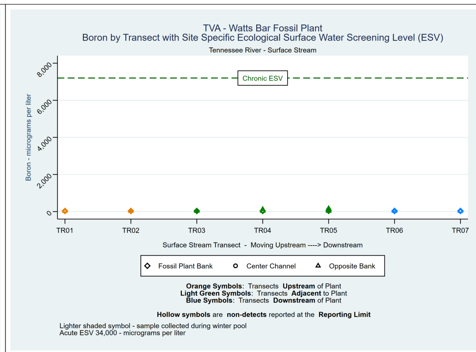
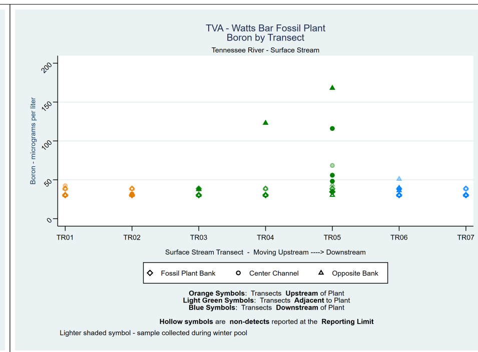
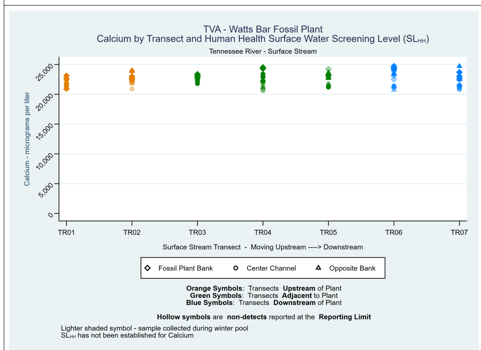
ATTACHMENT E.5-C - TRANSECT PLOTS

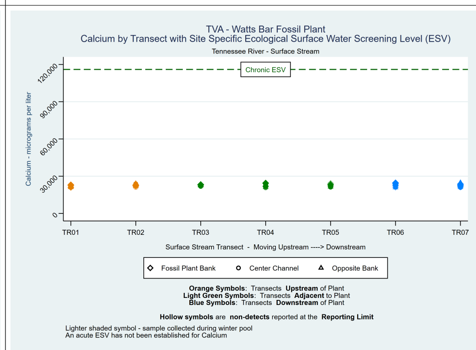
Transect Plots
CCR Rule Appendix III Parameters
Surface Stream Investigation
Watts Bar Fossil Plant - Spring City, Tennessee

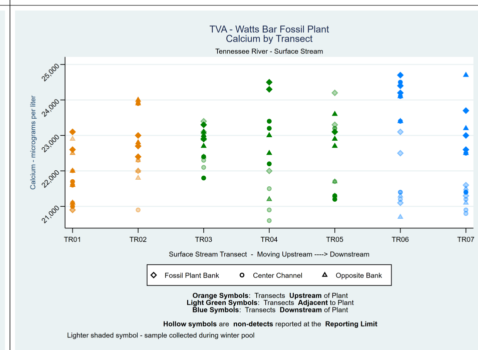


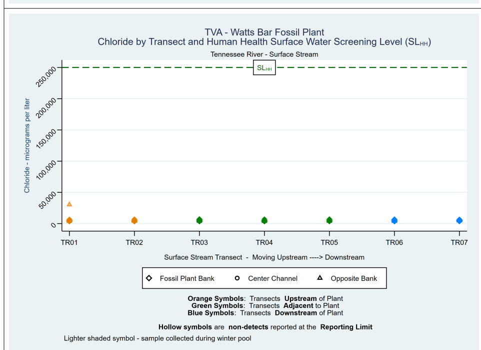


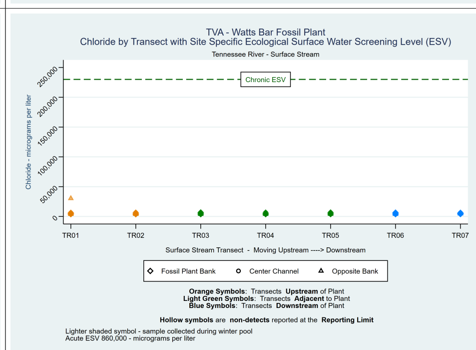


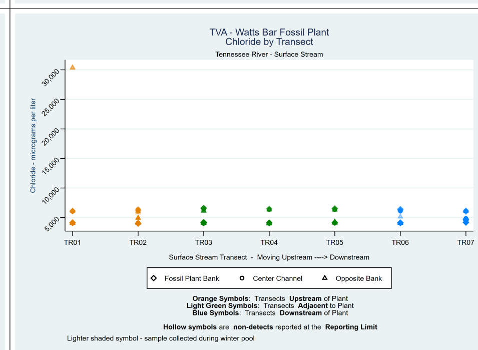


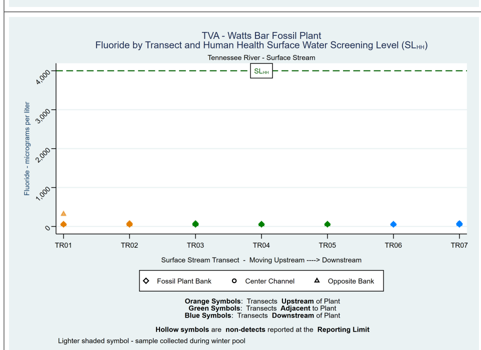


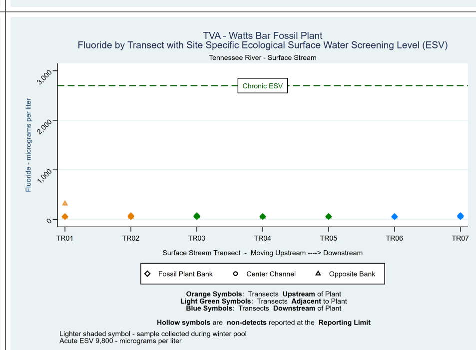


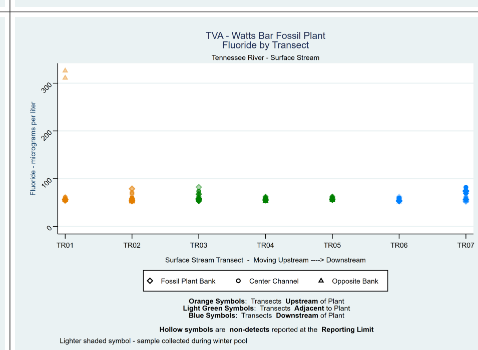




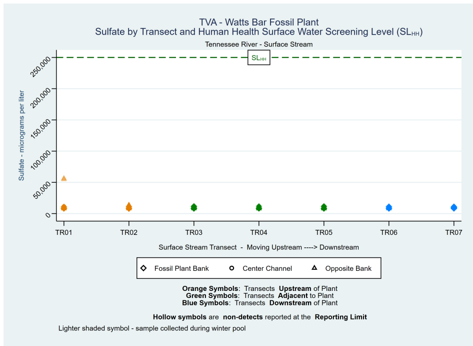


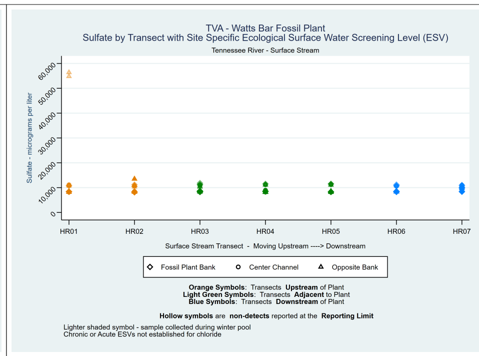


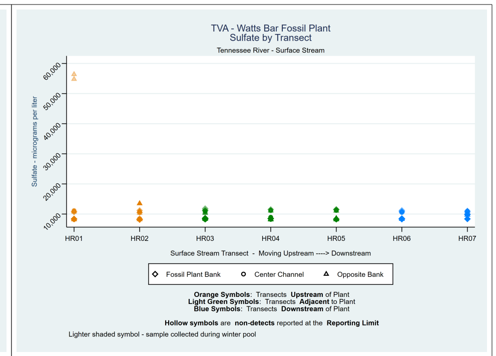


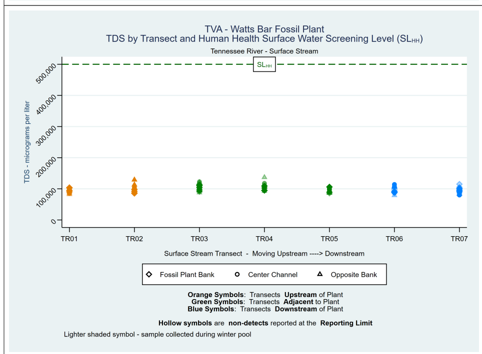


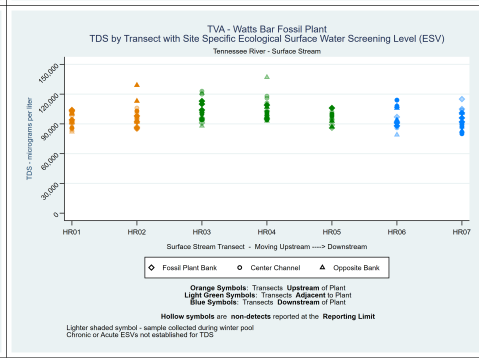
Place-holder for pH Field	Place-holder for pH Field	Place-holder for pH Field

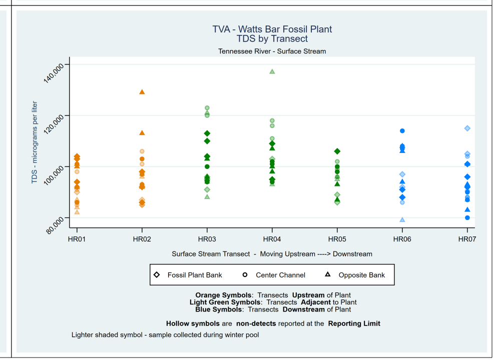

TVA - Watts Bar Fossil Plant
Sulfate by Transect and Human Health Surface Water Screening Level (SLHH)
Tennessee River - Surface Stream
SLHH
Sulfate - micrograms per liter
0
50,000
100,000
150,000
200,000
250,000
TR01 TR02 TR03 TR04 TR05 TR06 TR07
Surface Stream Transect - Moving Upstream ----> Downstream
Fossil Plant Bank
Center Channel
Opposite Bank
Orange Symbols: Transects Upstream of Plant
Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Hollow symbols are non-detects reported at the Reporting Limit
Lighter shaded symbol - sample collected during winter pool


TVA - Watts Bar Fossil Plant
Sulfate by Transect with Site Specific Ecological Surface Water Screening Level (ESV)
Tennessee River - Surface Stream
Sulfate - micrograms per liter
0
10,000
20,000
30,000
40,000
50,000
60,000
HR01 HR02 HR03 HR04 HR05 HR06 HR07
Surface Stream Transect - Moving Upstream ----> Downstream
Fossil Plant Bank
Center Channel
Opposite Bank
Orange Symbols: Transects Upstream of Plant
Light Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Hollow symbols are non-detects reported at the Reporting Limit
Lighter shaded symbol - sample collected during winter pool
Chronic or Acute ESVs not established for chloride

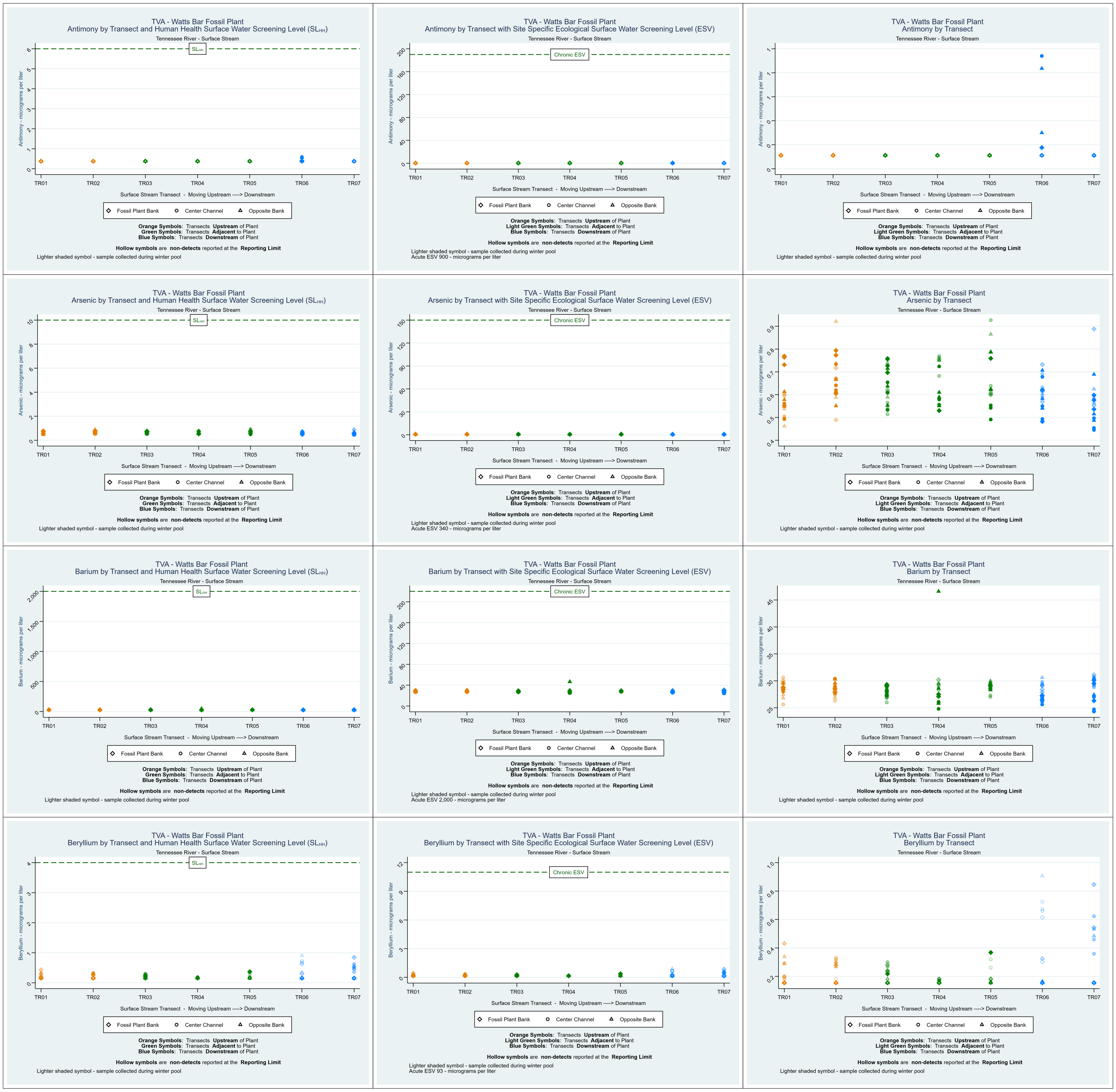

TVA - Watts Bar Fossil Plant
Sulfate by Transect
Tennessee River - Surface Stream
Sulfate - micrograms per liter
10,000
20,000
30,000
40,000
50,000
60,000
HR01 HR02 HR03 HR04 HR05 HR06 HR07
Surface Stream Transect - Moving Upstream ----> Downstream
Fossil Plant Bank
Center Channel
Opposite Bank
Orange Symbols: Transects Upstream of Plant
Light Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Hollow symbols are non-detects reported at the Reporting Limit
Lighter shaded symbol - sample collected during winter pool

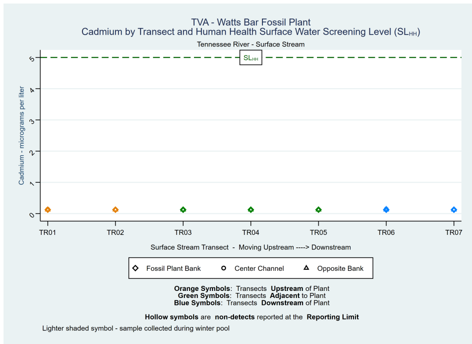

TVA - Watts Bar Fossil Plant
TDS by Transect and Human Health Surface Water Screening Level (SLHH)
Tennessee River - Surface Stream
SLHH
TDS - micrograms per liter
0
100,000
200,000
300,000
400,000
500,000
TR01 TR02 TR03 TR04 TR05 TR06 TR07
Surface Stream Transect - Moving Upstream ----> Downstream
Fossil Plant Bank
Center Channel
Opposite Bank
Orange Symbols: Transects Upstream of Plant
Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Hollow symbols are non-detects reported at the Reporting Limit
Lighter shaded symbol - sample collected during winter pool

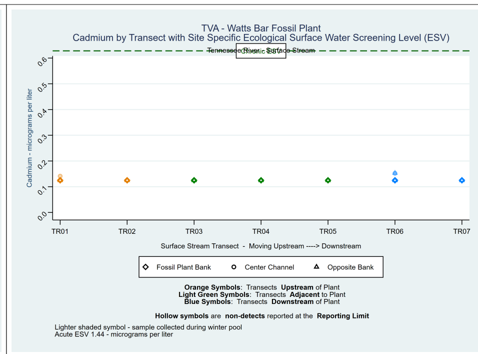

TVA - Watts Bar Fossil Plant
TDS by Transect with Site Specific Ecological Surface Water Screening Level (ESV)
Tennessee River - Surface Stream
TDS - micrograms per liter
0
30,000
60,000
90,000
120,000
150,000
HR01 HR02 HR03 HR04 HR05 HR06 HR07
Surface Stream Transect - Moving Upstream ----> Downstream
Fossil Plant Bank
Center Channel
Opposite Bank
Orange Symbols: Transects Upstream of Plant
Light Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Hollow symbols are non-detects reported at the Reporting Limit
Lighter shaded symbol - sample collected during winter pool
Chronic or Acute ESVs not established for TDS

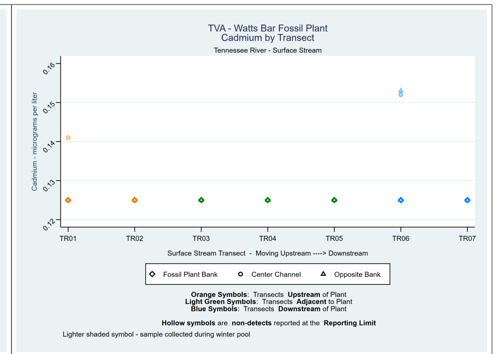

TVA - Watts Bar Fossil Plant
TDS by Transect
Tennessee River - Surface Stream
TDS - micrograms per liter
80,000
100,000
120,000
140,000
HR01 HR02 HR03 HR04 HR05 HR06 HR07
Surface Stream Transect - Moving Upstream ----> Downstream
Fossil Plant Bank
Center Channel
Opposite Bank
Orange Symbols: Transects Upstream of Plant
Light Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Hollow symbols are non-detects reported at the Reporting Limit
Lighter shaded symbol - sample collected during winter pool

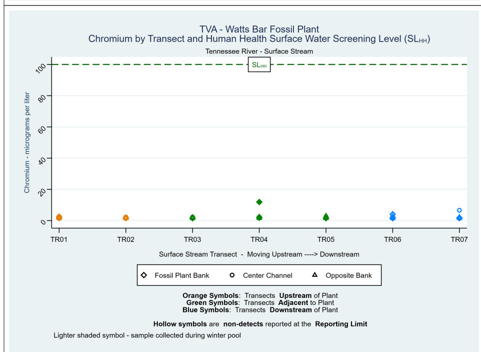
Transect Plots
CCR Rule Appendix IV Parameters
Surface Stream Investigation
Watts Bar Fossil Plant - Spring City, Tennessee

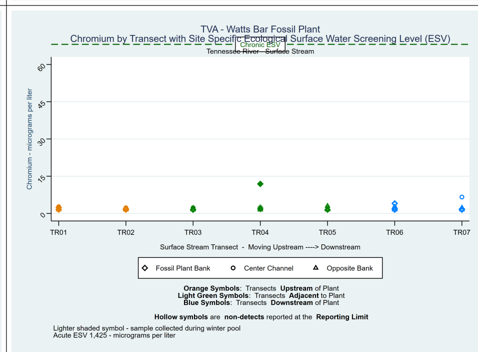


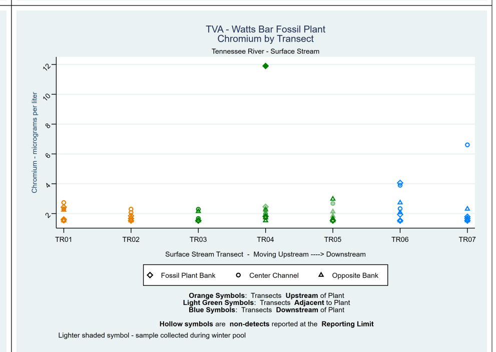

TVA - Watts Bar Fossil Plant
Cadmium by Transect and Human Health Surface Water Screening Level (SL_HH)
Tennessee River - Surface Stream
SL_HH
Cadmium - micrograms per liter
TR01 TR02 TR03 TR04 TR05 TR06 TR07
Surface Stream Transect - Moving Upstream ----> Downstream
Fossil Plant Bank Center Channel Opposite Bank
Orange Symbols: Transects Upstream of Plant
Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Hollow symbols are non-detects reported at the Reporting Limit
Lighter shaded symbol - sample collected during winter pool

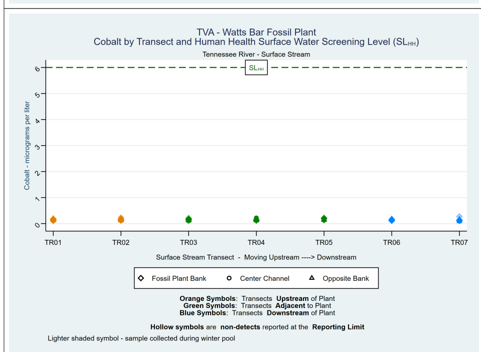

TVA - Watts Bar Fossil Plant
Cadmium by Transect with Site Specific Ecological Surface Water Screening Level (ESV)
Tennessee River - Surface Stream
Cadmium - micrograms per liter
TR01 TR02 TR03 TR04 TR05 TR06 TR07
Surface Stream Transect - Moving Upstream ----> Downstream
Fossil Plant Bank Center Channel Opposite Bank
Orange Symbols: Transects Upstream of Plant
Light Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Hollow symbols are non-detects reported at the Reporting Limit
Lighter shaded symbol - sample collected during winter pool
Acute ESV 1.44 - micrograms per liter

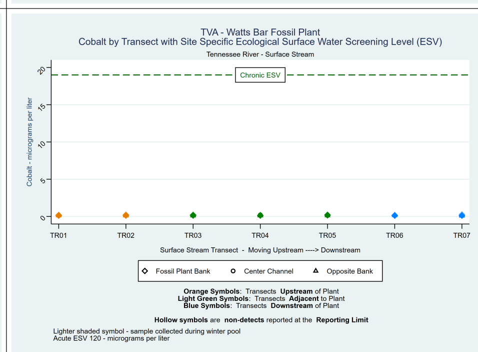

TVA - Watts Bar Fossil Plant
Cadmium by Transect
Tennessee River - Surface Stream
Cadmium - micrograms per liter
TR01 TR02 TR03 TR04 TR05 TR06 TR07
Surface Stream Transect - Moving Upstream ----> Downstream
Fossil Plant Bank Center Channel Opposite Bank
Orange Symbols: Transects Upstream of Plant
Light Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Hollow symbols are non-detects reported at the Reporting Limit
Lighter shaded symbol - sample collected during winter pool

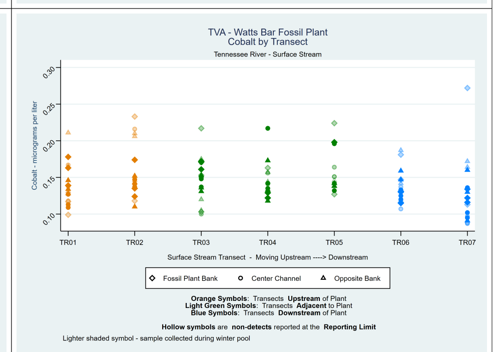

TVA - Watts Bar Fossil Plant
Chromium by Transect and Human Health Surface Water Screening Level (SL_HH)
Tennessee River - Surface Stream
SL_HH
Chromium - micrograms per liter
TR01 TR02 TR03 TR04 TR05 TR06 TR07
Surface Stream Transect - Moving Upstream ----> Downstream
Fossil Plant Bank Center Channel Opposite Bank
Orange Symbols: Transects Upstream of Plant
Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Hollow symbols are non-detects reported at the Reporting Limit
Lighter shaded symbol - sample collected during winter pool

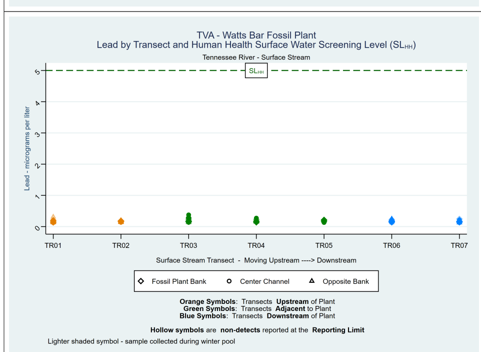

TVA - Watts Bar Fossil Plant
Chromium by Transect with Site Specific Ecological Surface Water Screening Level (ESV)
Chronic ESV
Tennessee River - Surface Stream
Chromium - micrograms per liter
TR01 TR02 TR03 TR04 TR05 TR06 TR07
Surface Stream Transect - Moving Upstream ----> Downstream
Fossil Plant Bank Center Channel Opposite Bank
Orange Symbols: Transects Upstream of Plant
Light Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Hollow symbols are non-detects reported at the Reporting Limit
Lighter shaded symbol - sample collected during winter pool
Acute ESV 1,425 - micrograms per liter

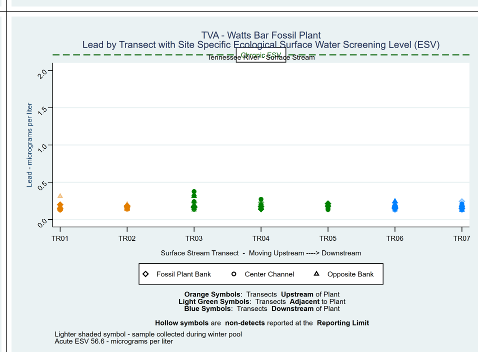

TVA - Watts Bar Fossil Plant
Chromium by Transect
Tennessee River - Surface Stream
Chromium - micrograms per liter
TR01 TR02 TR03 TR04 TR05 TR06 TR07
Surface Stream Transect - Moving Upstream ----> Downstream
Fossil Plant Bank Center Channel Opposite Bank
Orange Symbols: Transects Upstream of Plant
Light Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Hollow symbols are non-detects reported at the Reporting Limit
Lighter shaded symbol - sample collected during winter pool

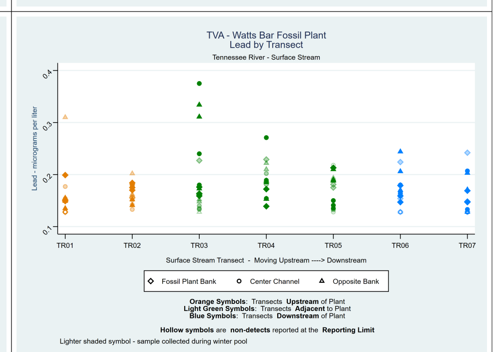

TVA - Watts Bar Fossil Plant
Cobalt by Transect and Human Health Surface Water Screening Level (SL_HH)
Tennessee River - Surface Stream
SL_HH
Cobalt - micrograms per liter
TR01 TR02 TR03 TR04 TR05 TR06 TR07
Surface Stream Transect - Moving Upstream ----> Downstream
Fossil Plant Bank Center Channel Opposite Bank
Orange Symbols: Transects Upstream of Plant
Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Hollow symbols are non-detects reported at the Reporting Limit
Lighter shaded symbol - sample collected during winter pool

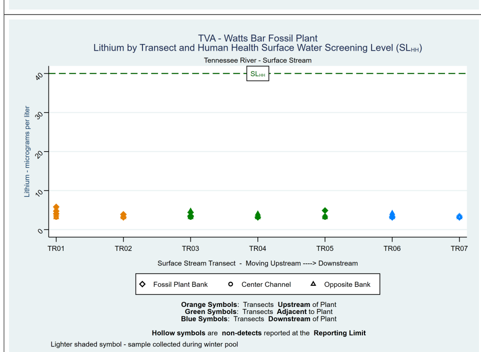

TVA - Watts Bar Fossil Plant
Cobalt by Transect with Site Specific Ecological Surface Water Screening Level (ESV)
Tennessee River - Surface Stream
Chronic ESV
Cobalt - micrograms per liter
TR01 TR02 TR03 TR04 TR05 TR06 TR07
Surface Stream Transect - Moving Upstream ----> Downstream
Fossil Plant Bank Center Channel Opposite Bank
Orange Symbols: Transects Upstream of Plant
Light Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Hollow symbols are non-detects reported at the Reporting Limit
Lighter shaded symbol - sample collected during winter pool
Acute ESV 120 - micrograms per liter

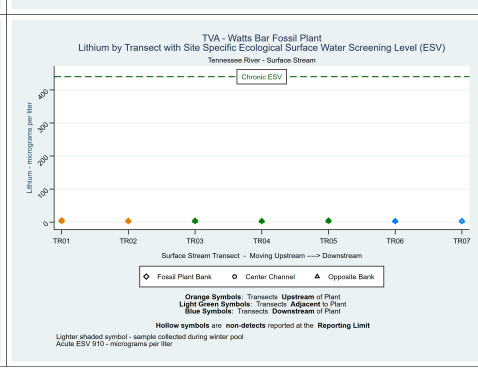

TVA - Watts Bar Fossil Plant
Cobalt by Transect
Tennessee River - Surface Stream
Cobalt - micrograms per liter
TR01 TR02 TR03 TR04 TR05 TR06 TR07
Surface Stream Transect - Moving Upstream ----> Downstream
Fossil Plant Bank Center Channel Opposite Bank
Orange Symbols: Transects Upstream of Plant
Light Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Hollow symbols are non-detects reported at the Reporting Limit
Lighter shaded symbol - sample collected during winter pool

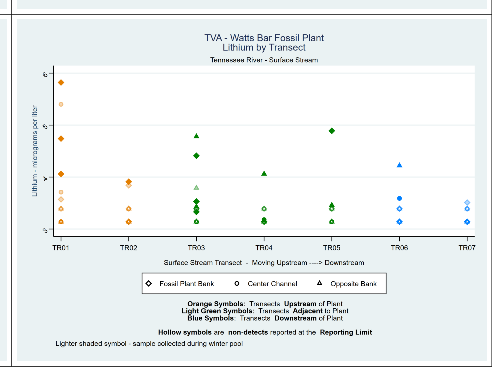

TVA - Watts Bar Fossil Plant
Lead by Transect and Human Health Surface Water Screening Level (SL_HH)
Tennessee River - Surface Stream
SL_HH
Lead - micrograms per liter
TR01 TR02 TR03 TR04 TR05 TR06 TR07
Surface Stream Transect - Moving Upstream ----> Downstream
Fossil Plant Bank Center Channel Opposite Bank
Orange Symbols: Transects Upstream of Plant
Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Hollow symbols are non-detects reported at the Reporting Limit
Lighter shaded symbol - sample collected during winter pool

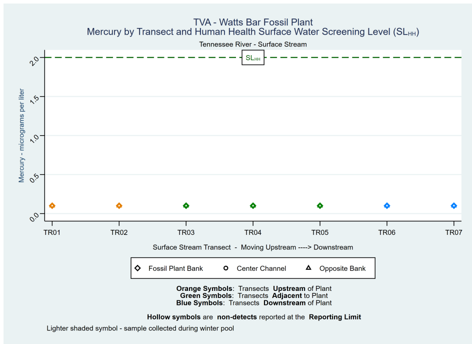

TVA - Watts Bar Fossil Plant
Lead by Transect with Site Specific Ecological Surface Water Screening Level (ESV)
Chronic ESV
Tennessee River - Surface Stream
Lead - micrograms per liter
TR01 TR02 TR03 TR04 TR05 TR06 TR07
Surface Stream Transect - Moving Upstream ----> Downstream
Fossil Plant Bank Center Channel Opposite Bank
Orange Symbols: Transects Upstream of Plant
Light Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Hollow symbols are non-detects reported at the Reporting Limit
Lighter shaded symbol - sample collected during winter pool
Acute ESV 56.6 - micrograms per liter

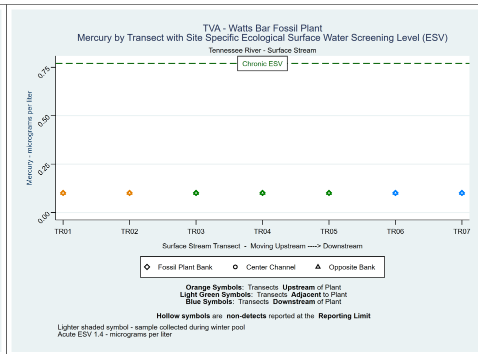

TVA - Watts Bar Fossil Plant
Lead by Transect
Tennessee River - Surface Stream
Lead - micrograms per liter
TR01 TR02 TR03 TR04 TR05 TR06 TR07
Surface Stream Transect - Moving Upstream ----> Downstream
Fossil Plant Bank Center Channel Opposite Bank
Orange Symbols: Transects Upstream of Plant
Light Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Hollow symbols are non-detects reported at the Reporting Limit
Lighter shaded symbol - sample collected during winter pool

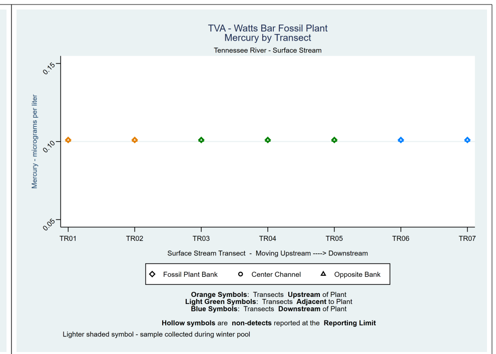

TVA - Watts Bar Fossil Plant
Lithium by Transect and Human Health Surface Water Screening Level (SL_HH)
Tennessee River - Surface Stream
SL_HH
Lithium - micrograms per liter
TR01 TR02 TR03 TR04 TR05 TR06 TR07
Surface Stream Transect - Moving Upstream ----> Downstream
Fossil Plant Bank Center Channel Opposite Bank
Orange Symbols: Transects Upstream of Plant
Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Hollow symbols are non-detects reported at the Reporting Limit
Lighter shaded symbol - sample collected during winter pool

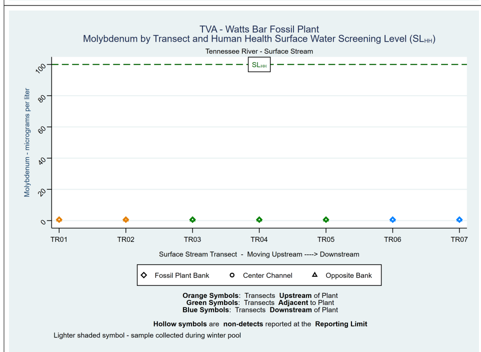

TVA - Watts Bar Fossil Plant
Lithium by Transect with Site Specific Ecological Surface Water Screening Level (ESV)
Tennessee River - Surface Stream
Chronic ESV
Lithium - micrograms per liter
TR01 TR02 TR03 TR04 TR05 TR06 TR07
Surface Stream Transect - Moving Upstream ----> Downstream
Fossil Plant Bank Center Channel Opposite Bank
Orange Symbols: Transects Upstream of Plant
Light Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Hollow symbols are non-detects reported at the Reporting Limit
Lighter shaded symbol - sample collected during winter pool
Acute ESV 910 - micrograms per liter

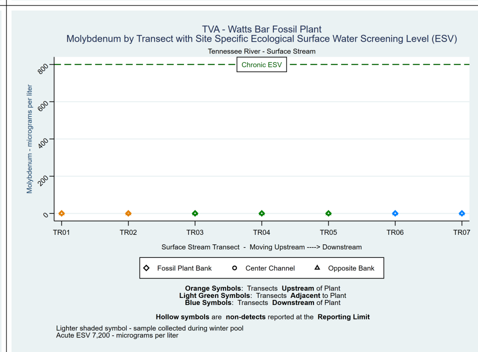

TVA - Watts Bar Fossil Plant
Lithium by Transect
Tennessee River - Surface Stream
Lithium - micrograms per liter
TR01 TR02 TR03 TR04 TR05 TR06 TR07
Surface Stream Transect - Moving Upstream ----> Downstream
Fossil Plant Bank Center Channel Opposite Bank
Orange Symbols: Transects Upstream of Plant
Light Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Hollow symbols are non-detects reported at the Reporting Limit
Lighter shaded symbol - sample collected during winter pool


TVA - Watts Bar Fossil Plant
Mercury by Transect and Human Health Surface Water Screening Level (SLHH)
Tennessee River - Surface Stream
SLHH
Mercury - micrograms per liter
TR01 TR02 TR03 TR04 TR05 TR06 TR07
Surface Stream Transect - Moving Upstream ----> Downstream
Fossil Plant Bank
Center Channel
Opposite Bank
Orange Symbols: Transects Upstream of Plant
Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Hollow symbols are non-detects reported at the Reporting Limit
Lighter shaded symbol - sample collected during winter pool

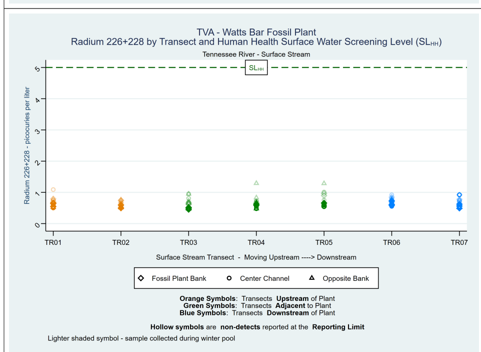

TVA - Watts Bar Fossil Plant
Mercury by Transect with Site Specific Ecological Surface Water Screening Level (ESV)
Tennessee River - Surface Stream
Chronic ESV
Mercury - micrograms per liter
TR01 TR02 TR03 TR04 TR05 TR06 TR07
Surface Stream Transect - Moving Upstream ----> Downstream
Fossil Plant Bank
Center Channel
Opposite Bank
Orange Symbols: Transects Upstream of Plant
Light Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Hollow symbols are non-detects reported at the Reporting Limit
Lighter shaded symbol - sample collected during winter pool
Acute ESV 1.4 - micrograms per liter

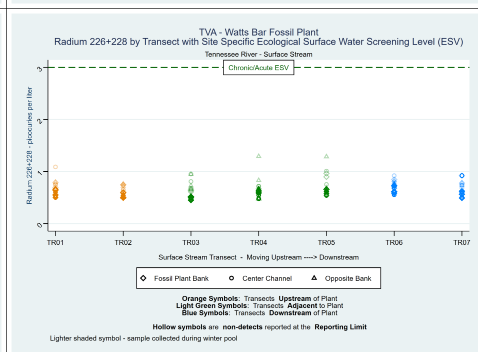

TVA - Watts Bar Fossil Plant
Mercury by Transect
Tennessee River - Surface Stream
Mercury - micrograms per liter
TR01 TR02 TR03 TR04 TR05 TR06 TR07
Surface Stream Transect - Moving Upstream ----> Downstream
Fossil Plant Bank
Center Channel
Opposite Bank
Orange Symbols: Transects Upstream of Plant
Light Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Hollow symbols are non-detects reported at the Reporting Limit
Lighter shaded symbol - sample collected during winter pool

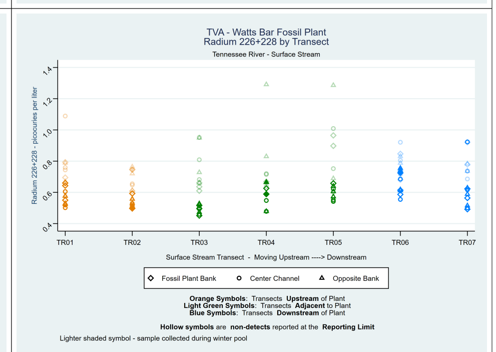

TVA - Watts Bar Fossil Plant
Molybdenum by Transect and Human Health Surface Water Screening Level (SLHH)
Tennessee River - Surface Stream
SLHH
Molybdenum - micrograms per liter
TR01 TR02 TR03 TR04 TR05 TR06 TR07
Surface Stream Transect - Moving Upstream ----> Downstream
Fossil Plant Bank
Center Channel
Opposite Bank
Orange Symbols: Transects Upstream of Plant
Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Hollow symbols are non-detects reported at the Reporting Limit
Lighter shaded symbol - sample collected during winter pool

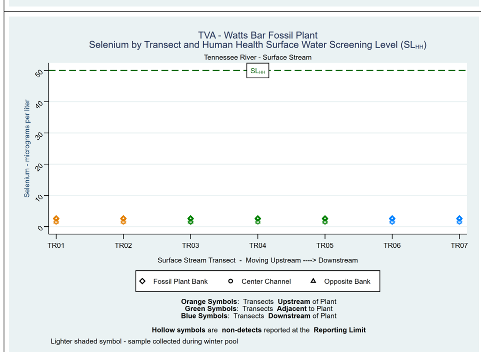

TVA - Watts Bar Fossil Plant
Molybdenum by Transect with Site Specific Ecological Surface Water Screening Level (ESV)
Tennessee River - Surface Stream
Chronic ESV
Molybdenum - micrograms per liter
TR01 TR02 TR03 TR04 TR05 TR06 TR07
Surface Stream Transect - Moving Upstream ----> Downstream
Fossil Plant Bank
Center Channel
Opposite Bank
Orange Symbols: Transects Upstream of Plant
Light Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Hollow symbols are non-detects reported at the Reporting Limit
Lighter shaded symbol - sample collected during winter pool
Acute ESV 7,200 - micrograms per liter

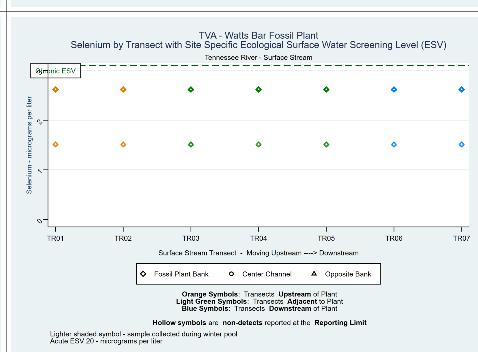

TVA - Watts Bar Fossil Plant
Molybdenum by Transect
Tennessee River - Surface Stream
Molybdenum - micrograms per liter
TR01 TR02 TR03 TR04 TR05 TR06 TR07
Surface Stream Transect - Moving Upstream ----> Downstream
Fossil Plant Bank
Center Channel
Opposite Bank
Orange Symbols: Transects Upstream of Plant
Light Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Hollow symbols are non-detects reported at the Reporting Limit
Lighter shaded symbol - sample collected during winter pool

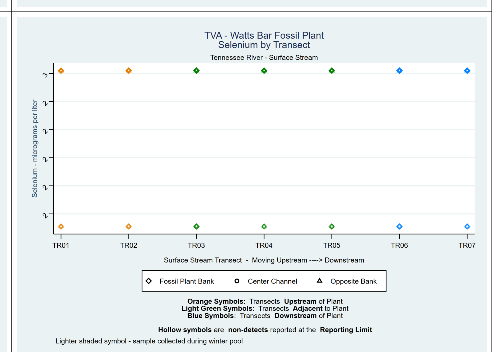

TVA - Watts Bar Fossil Plant
Radium 226+228 by Transect and Human Health Surface Water Screening Level (SLHH)
Tennessee River - Surface Stream
SLHH
Radium 226+228 - picocuries per liter
TR01 TR02 TR03 TR04 TR05 TR06 TR07
Surface Stream Transect - Moving Upstream ----> Downstream
Fossil Plant Bank
Center Channel
Opposite Bank
Orange Symbols: Transects Upstream of Plant
Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Hollow symbols are non-detects reported at the Reporting Limit
Lighter shaded symbol - sample collected during winter pool

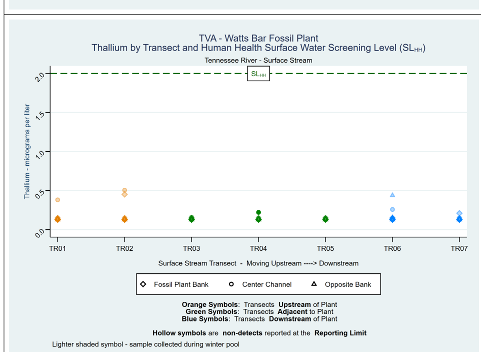

TVA - Watts Bar Fossil Plant
Radium 226+228 by Transect with Site Specific Ecological Surface Water Screening Level (ESV)
Tennessee River - Surface Stream
Chronic/Acute ESV
Radium 226+228 - picocuries per liter
TR01 TR02 TR03 TR04 TR05 TR06 TR07
Surface Stream Transect - Moving Upstream ----> Downstream
Fossil Plant Bank
Center Channel
Opposite Bank
Orange Symbols: Transects Upstream of Plant
Light Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Hollow symbols are non-detects reported at the Reporting Limit
Lighter shaded symbol - sample collected during winter pool

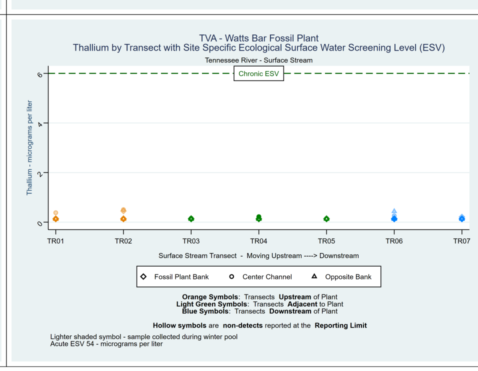

TVA - Watts Bar Fossil Plant
Radium 226+228 by Transect
Tennessee River - Surface Stream
Radium 226+228 - picocuries per liter
TR01 TR02 TR03 TR04 TR05 TR06 TR07
Surface Stream Transect - Moving Upstream ----> Downstream
Fossil Plant Bank
Center Channel
Opposite Bank
Orange Symbols: Transects Upstream of Plant
Light Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Hollow symbols are non-detects reported at the Reporting Limit
Lighter shaded symbol - sample collected during winter pool

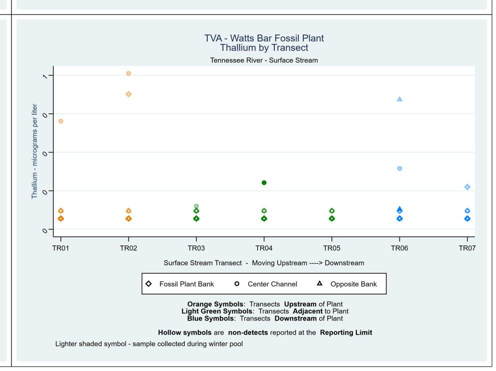

TVA - Watts Bar Fossil Plant
Selenium by Transect and Human Health Surface Water Screening Level (SLHH)
Tennessee River - Surface Stream
SLHH
Selenium - micrograms per liter
TR01 TR02 TR03 TR04 TR05 TR06 TR07
Surface Stream Transect - Moving Upstream ----> Downstream
Fossil Plant Bank
Center Channel
Opposite Bank
Orange Symbols: Transects Upstream of Plant
Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Hollow symbols are non-detects reported at the Reporting Limit
Lighter shaded symbol - sample collected during winter pool


TVA - Watts Bar Fossil Plant
Selenium by Transect with Site Specific Ecological Surface Water Screening Level (ESV)
Tennessee River - Surface Stream
Selenium - micrograms per liter
TR01 TR02 TR03 TR04 TR05 TR06 TR07
Surface Stream Transect - Moving Upstream ----> Downstream
Fossil Plant Bank
Center Channel
Opposite Bank
Orange Symbols: Transects Upstream of Plant
Light Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Hollow symbols are non-detects reported at the Reporting Limit
Lighter shaded symbol - sample collected during winter pool
Acute ESV 20 - micrograms per liter

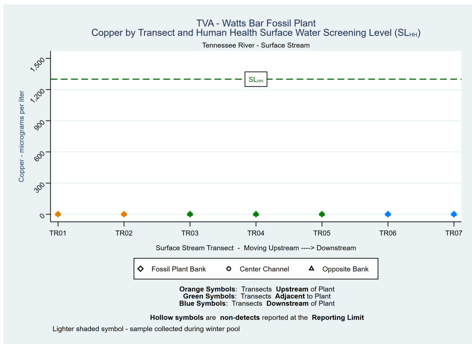

TVA - Watts Bar Fossil Plant
Selenium by Transect
Tennessee River - Surface Stream
Selenium - micrograms per liter
TR01 TR02 TR03 TR04 TR05 TR06 TR07
Surface Stream Transect - Moving Upstream ----> Downstream
Fossil Plant Bank
Center Channel
Opposite Bank
Orange Symbols: Transects Upstream of Plant
Light Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Hollow symbols are non-detects reported at the Reporting Limit
Lighter shaded symbol - sample collected during winter pool

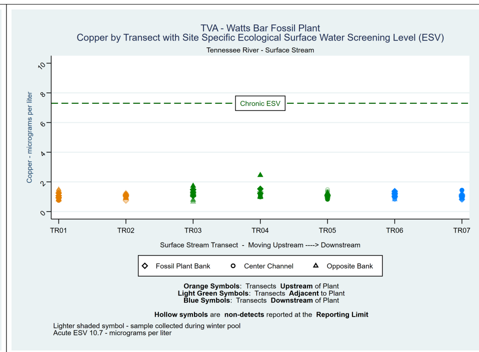

TVA - Watts Bar Fossil Plant
Thallium by Transect and Human Health Surface Water Screening Level (SLHH)
Tennessee River - Surface Stream
SLHH
Thallium - micrograms per liter
TR01 TR02 TR03 TR04 TR05 TR06 TR07
Surface Stream Transect - Moving Upstream ----> Downstream
Fossil Plant Bank
Center Channel
Opposite Bank
Orange Symbols: Transects Upstream of Plant
Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Hollow symbols are non-detects reported at the Reporting Limit
Lighter shaded symbol - sample collected during winter pool

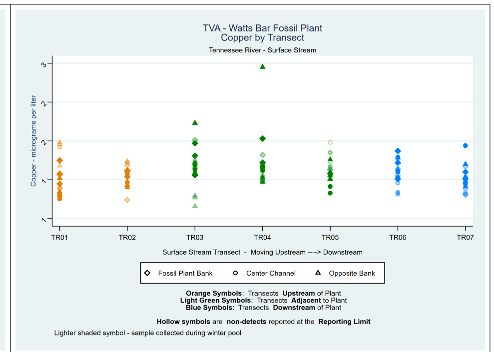

TVA - Watts Bar Fossil Plant
Thallium by Transect with Site Specific Ecological Surface Water Screening Level (ESV)
Tennessee River - Surface Stream
Chronic ESV
Thallium - micrograms per liter
TR01 TR02 TR03 TR04 TR05 TR06 TR07
Surface Stream Transect - Moving Upstream ----> Downstream
Fossil Plant Bank
Center Channel
Opposite Bank
Orange Symbols: Transects Upstream of Plant
Light Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Hollow symbols are non-detects reported at the Reporting Limit
Lighter shaded symbol - sample collected during winter pool
Acute ESV 54 - micrograms per liter

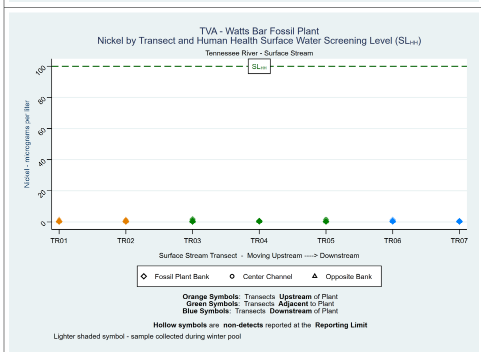

TVA - Watts Bar Fossil Plant
Thallium by Transect
Tennessee River - Surface Stream
Thallium - micrograms per liter
TR01 TR02 TR03 TR04 TR05 TR06 TR07
Surface Stream Transect - Moving Upstream ----> Downstream
Fossil Plant Bank
Center Channel
Opposite Bank
Orange Symbols: Transects Upstream of Plant
Light Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Hollow symbols are non-detects reported at the Reporting Limit
Lighter shaded symbol - sample collected during winter pool

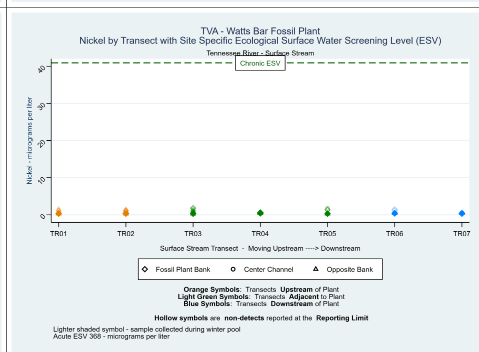
Transect Plots
TDEC Appendix I Parameters
Surface Stream Investigation
Watts Bar Fossil Plant - Spring City, Tennessee

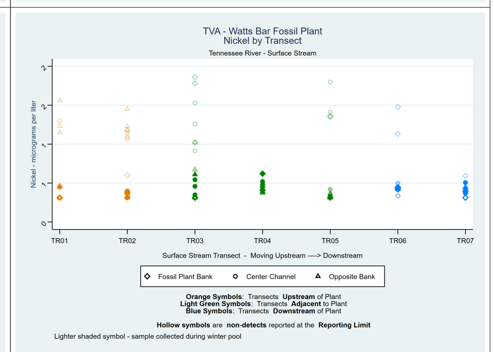


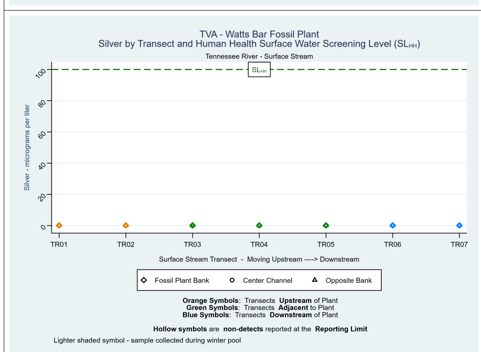


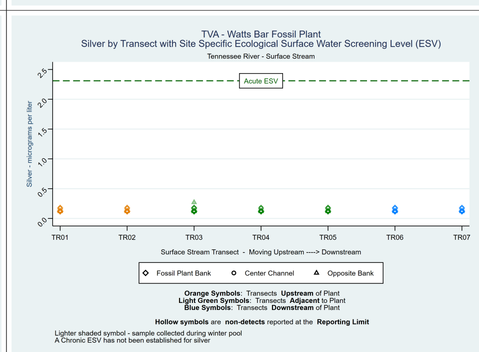


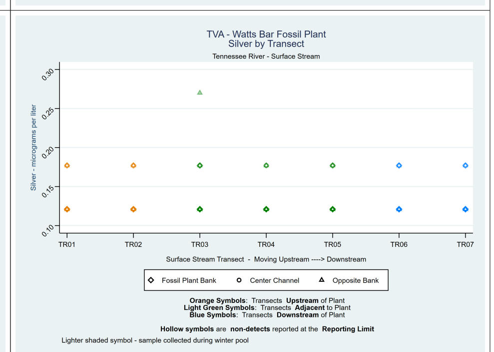


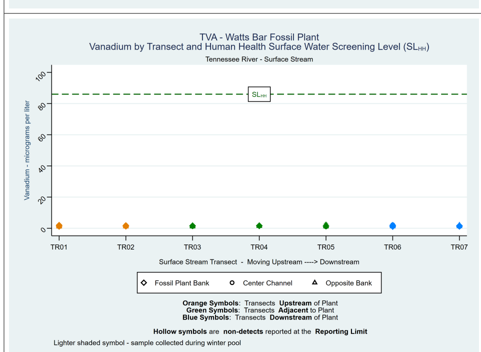


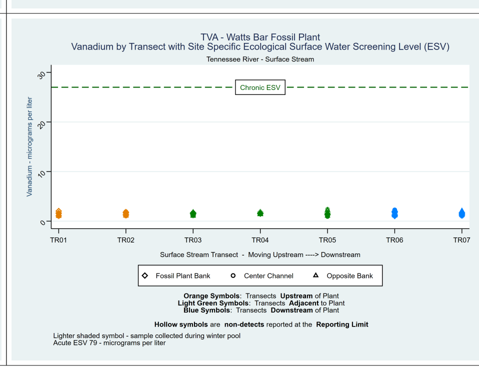


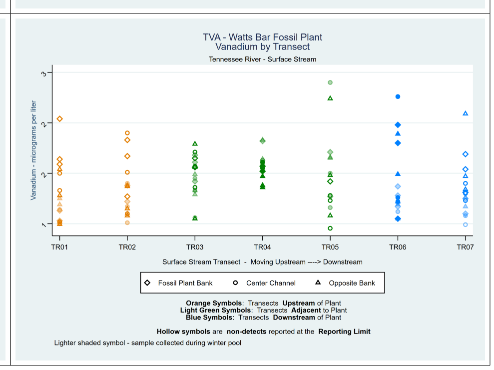


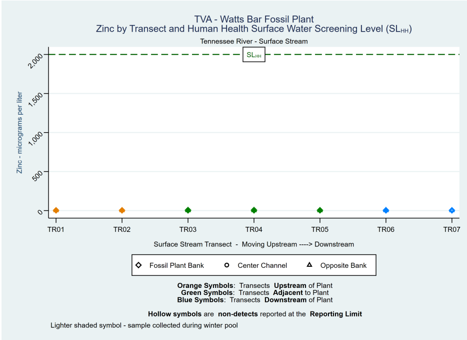


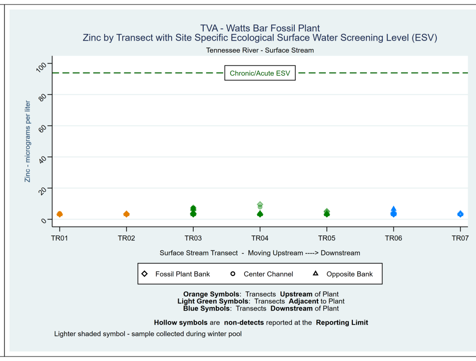


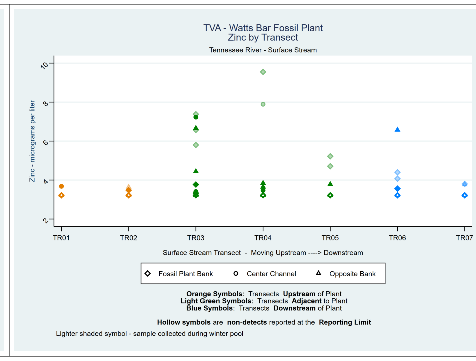






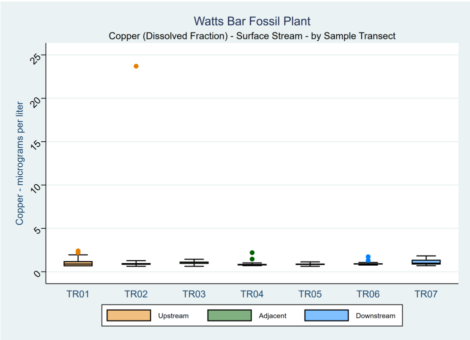

TVA - Watts Bar Fossil Plant
Zinc by Transect and Human Health Surface Water Screening Level (SLHH)
Tennessee River - Surface Stream
SLHH
Zinc - micrograms per liter
2,000
1,500
1,000
500
0
TR01
TR02
TR03
TR04
TR05
TR06
TR07
Surface Stream Transect - Moving Upstream ----> Downstream
Fossil Plant Bank
Center Channel
Opposite Bank
Orange Symbols: Transects Upstream of Plant
Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Hollow symbols are non-detects reported at the Reporting Limit
Lighter shaded symbol - sample collected during winter pool

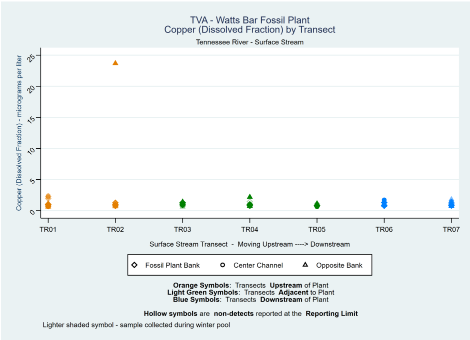

TVA - Watts Bar Fossil Plant
Zinc by Transect with Site Specific Ecological Surface Water Screening Level (ESV)
Tennessee River - Surface Stream
Chronic/Acute ESV
Zinc - micrograms per liter
100
80
60
40
20
0
TR01
TR02
TR03
TR04
TR05
TR06
TR07
Surface Stream Transect - Moving Upstream ----> Downstream
Fossil Plant Bank
Center Channel
Opposite Bank
Orange Symbols: Transects Upstream of Plant
Light Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Hollow symbols are non-detects reported at the Reporting Limit
Lighter shaded symbol - sample collected during winter pool


TVA - Watts Bar Fossil Plant
Zinc by Transect
Tennessee River - Surface Stream
Zinc - micrograms per liter
10
8
6
4
2
TR01
TR02
TR03
TR04
TR05
TR06
TR07
Surface Stream Transect - Moving Upstream ----> Downstream
Fossil Plant Bank
Center Channel
Opposite Bank
Orange Symbols: Transects Upstream of Plant
Light Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Hollow symbols are non-detects reported at the Reporting Limit
Lighter shaded symbol - sample collected during winter pool

ATTACHMENT E.5-D - BOX AND TRANSECT PLOTS – STATISTICAL OUTLIER

Box and Transect Plots
Tennessee River
Surface Stream Investigation
Watts Bar Fossil Plant - Spring City, Tennessee





APPENDIX E.6

STATISTICAL ANALYSIS OF SEDIMENT DATA

Appendix E.6 - Statistical Analysis of Sediment Data

TDEC Commissioner's Order:
Environmental Assessment Report
Watts Bar Fossil Plant
Spring City, Tennessee

March 31, 2024

Prepared for:

Tennessee Valley Authority
Chattanooga, Tennessee

Prepared by:

Stantec Consulting Services Inc.
Lexington, Kentucky

Revision Log

Revision	Description	Date
0	Submittal to TDEC	November 7, 2023
1	Addresses January 31, 2024 TDEC Review Comments and Issued for TDEC	March 31, 2024

Sign-off Sheet

This document entitled Appendix E.6 - Statistical Analysis of Sediment Data was prepared by Stantec Consulting Services Inc. ("Stantec") for the account of Tennessee Valley Authority (the "Client"). Any reliance on this document by any third party is strictly prohibited. The material in it reflects Stantec's professional judgment in light of the scope, schedule and other limitations stated in the document and in the contract between Stantec and the Client. The opinions in the document are based on conditions and information existing at the time the document was published and do not consider any subsequent changes. In preparing the document, Stantec did not verify information supplied to it by others. Any use which a third party makes of this document is the responsibility of such third party. Such third party agrees that Stantec shall not be responsible for costs or damages of any kind, if any, suffered by it or any other third party as a result of decisions made or actions taken based on this document.

Prepared by ____________________

Chris La Londe, Senior Risk Assessor

Reviewed by ____________________

Matt Pontier, Staff Engineer

Approved by ____________________

Carole M. Farr, PG, Senior Principal Geologist

Table of Contents

LIST OF TABLES

LIST OF ATTACHMENTS

Abbreviations

CASRN	Chemical Abstracts Service Registry Number
CCR	Coal Combustion Residuals
CCR Parameters	The Constituents listed in Appendices III and IV of 40 CFR 257 and five inorganic constituents included in Appendix I of Tennessee Rule 0400-11-01-.04
CCR Rule	Title 40, Code of Federal Regulations, Part 257
EAR	Environmental Assessment Report
EI	Environmental Investigation
ESV	Ecological Screening Level
IQR	Interquartile Range
NA	Not Available
%	Percent
PCA	Principal Component Analysis
Stantec	Stantec Consulting Services Inc.
TDEC	Tennessee Department of Environment and Conservation
TVA	Tennessee Valley Authority
WBF Plant	Watts Bar Fossil Plant

1.0 INTRODUCTION

Stantec Consulting Services Inc. (Stantec) prepared this appendix on behalf of the Tennessee Valley Authority (TVA) to summarize the statistical analyses performed on sediment data to support evaluations conducted for the Environmental Assessment Report (EAR) at the Watts Bar Fossil Plant (WBF Plant) located in Spring City, Tennessee. The sediment samples were collected between March and April 2019 from the Tennessee River in proximity to the WBF Plant. Further details regarding the sediment sampling, and laboratory data results are presented in Appendix J.3 and the WBF Plant *Benthic Investigation Sampling and Analysis Report* (Appendix J.4)**.**

For the Environmental Investigation (EI), sediment samples were collected from locations along sample transects or individual locations from the Tennessee River in proximity to the WBF Plant coal combustion residual (CCR) management units. Sample transects/location names and locations relative to WBF Plant CCR management units and the numbers of samples collected are presented in Table E.6-1. The constituents listed in Appendices III and IV of 40 CFR 257 and five inorganic constituents included in Appendix I of Tennessee Rule 0400-11-01-.04 (CCR Parameters) included in the statistical analysis are presented in Table E.6-2.

Table E.6-1 – Sediment Sample Transect/Locations

Water body	Transect/Location Name	Location Relative to WBF Plant CCR Management Units	Number of Samples
Tennessee River	TR04, TR05, TR05.5	Adjacent	3
	TR06, TR06.75, TR07	Downstream	4

Table E.6-2 – CCR Parameters Evaluated in Statistical Analysis

CCR Parameter	CASRN
CCR Rule Appendix III Parameters	
Boron	7440-42-8
Calcium	7440-70-2
Chloride	16887-00-6
Fluoride[1] (also Appendix IV)	16984-48-8
pH	NA
Sulfate	14808-79-8
CCR Rule Appendix IV Parameters	
Antimony	7440-36-0
Arsenic	7440-38-2
Barium	7440-39-3
Beryllium	7440-41-7
Cadmium	7440-43-9
Chromium	7440-47-3
Cobalt	7440-48-4
Lead	7439-92-1
Lithium	7439-93-2
Mercury	7439-97-6
Molybdenum	7439-98-7
Radium-226+228	13982-63-3/ 15262-20-1
Selenium	7782-49-2
Thallium	7440-28-0
TDEC Appendix I Parameters	
Copper	7440-50-8
Nickel	7440-02-0
Silver	7440-22-4
Vanadium	7440-62-2
Zinc	7440-66-6
Other	
% Ash	NA
Strontium	7440-24-6

Notes: CASRN - Chemical Abstracts Service Registry Number; CCR Rule - Title 40, Code of Federal Regulations, Part 257; NA – Not available; TDEC - Tennessee Department of Environment and Conservation

[1]Fluoride is both a CCR Rule Appendix III and CCR Rule Appendix IV CCR parameter. In this table, and in the results figures and tables for this report, fluoride has been grouped with the Appendix III CCR parameters only to avoid duplication.

The following sections present the methods and results from the general exploratory data analysis using summary statistics, data plots, and outlier screening, and a comparison of sediment results to Ecological Screening Levels (ESVs) that were developed for the EAR. The ESVs for the sediment data are provided in Table 1-3 and Appendix A.2.

Additional statistical analyses (principal component analysis [PCA] and hypothesis testing) may be warranted if the following conditions were met: 1) CCR Parameter concentrations were above ESVs, and 2) data were collected from transects/locations adjacent, and from transects/locations either upstream or downstream to the WBF Plant CCR management units.

2.0 METHODS

The statistical evaluation for the EI sediment data collected at the WBF Plant was conducted in three parts: 1) exploratory data analysis, 2) comparison of results to EAR screening levels, and 3) additional statistical analysis, when warranted.

2.1 EXPLORATORY DATA ANALYSIS

Exploratory data analysis is the initial step of statistical analysis. It utilizes simple summary statistics (e.g. mean, median, standard deviation, and percentiles) and graphical representations to identify important characteristics of an analytical dataset, such as the center of the data (mean, median), variation, distribution, spatial or temporal patterns, presence of outliers, and randomness.

2.1.1 Summary Statistics

Summary statistics were calculated for each CCR parameter grouped by water body and aggregated by the transect position relative to the WBF Plant CCR management units (adjacent and downstream). Summary statistics also were calculated for percent (%) ash and strontium. Summary statistics include information such as the total numbers of available samples, the frequencies of detection, ranges of reporting limits, minimum and maximum detected concentrations, mean concentrations, standard deviations, median concentrations and the 95^{th} percentile concentrations. Summary statistics tables are presented in Attachment E.6-A.

2.1.2 Exploratory Data Plots

Exploratory data plots (transect plots) were constructed using the sediment results to support a visual review of the data. Box plots are commonly used to identify the center of the data, distribution, and variability, and to visually identify potential outliers. Except for TR07, only one sample was collected for each transect or individual location, therefore, box plots were not constructed for the sediment results.

Transect plots were constructed for sediment data collected in the Tennessee River and show individual sample results aggregated by transect position relative to the WBF Plant CCR management units (adjacent and downstream) and relative position within the water body (plant side bank or opposite-side bank). The symbols used in the transect plots indicate whether the reported result is a detected concentration (solid symbol) or a non-detect reported at the Method Detection Limit (hollow symbol).

Two transect plots were constructed for each CCR Parameter. One was a plot that included a reference line for the ESV for that parameter. In many cases, the sample results were much lower than the ESVs, so including the reference line induced a scaling effect that obscured patterns in the data. A second plot was produced for each CCR Parameter without a reference line in order to better identify patterns.

These plots are particularly useful in identifying potential patterns in the dataset (trends), frequency of detection, outliers, spatial differences relative to the WBF Plant CCR management units (adjacent and downstream), and differences relative to the position in the water body (right bank [plant-side bank] versus left bank [opposite-side bank]). The transect plots are presented in Attachment E.6-B.

2.1.3 Outlier Screening

Outliers are data points that are abnormally high or low as compared to other measurements and may represent anomalous data or data errors. Outliers may also represent natural variations of CCR Parameter concentrations in environmental systems. Screening for outliers is a critical step because outliers can bias statistical estimates, statistical testing results, and inferences.

Outlier values were initially screened visually using the transect plots. If suspected visual outliers were identified, then Tukey's procedure was used to identify extreme outliers (Tukey 1977). This method relies on the Interquartile Range (IQR), which is defined as the 75th percentile value minus the 25th percentile value. Values were identified as potential outliers as follows:

- **Lower extreme outliers** are less than the 25th percentile minus 3 x IQR
- **Upper extreme outliers** are greater than the 75th percentile plus 3 x IQR.

Finally, when the potential outliers were identified visually and by Tukey's procedure, then statistical testing for outliers (Rosner's Test) was conducted to determine if those data points were statistically significant outliers.

Following confirmation of the outliers as statistically significant, a desktop evaluation was conducted to verify that the data points were not errors, (e.g., laboratory or transcriptional errors). Field forms, data validation reports, and other variables in the dataset that could influence analytical results also were evaluated at this point. If a verifiable error was discovered, the outlier was removed and, if possible, replaced with a corrected value.

In the absence of a verifiable error, additional lines of evidence were reviewed to determine final outlier disposition (e.g., frequency of detection, spatial and temporal variability). If an outlier was identified as suitable for removal from further statistical analysis, a clear and defensible rationale based on multiple lines of evidence was provided. In addition, values that were identified as outliers and removed from further evaluation in the present statistical analysis were retained in the historical database and will be reevaluated for inclusion or exclusion in future statistical analyses of this dataset. The results of the outlier screening for the WBF Plant sediment dataset are provided in Section 3.1.

2.2 COMPARISON OF SEDIMENT RESULTS TO ESVs

The analytical results for the sediment dataset were compared to ESVs, as provided in Table 1-3 and Appendix A.2. Comparisons were done graphically using transect plots for sample results from the Tennessee River (Attachment E.6-B). Analytical results were also compared to ESVs in tabular format and are presented in Tables in Appendix J.3.

Additional statistical analyses may be warranted if the following conditions were met: 1) CCR Parameter concentrations were above ESVs and 2) data were collected from transects/locations adjacent, and from transects/locations either upstream or downstream to the WBF Plant CCR management units.

These additional statistical evaluations may include:

- Formal hypothesis testing to identify differences between adjacent and downstream results, and
- PCA to identify the variables and individual samples that explain the greatest proportion of variability (provide the greatest amount of information) in the datasets.

The results are presented in Section 3.2.

3.0 RESULTS AND DISCUSSION

3.1 SUMMARY STATISTICS, EXPLORATORY DATA PLOTS, AND OUTLIER SCREENING

Summary statistics tables are presented in Attachment E.6-A and transect plots are presented in Attachment E.6-B. The summary statistics were aggregated by transect or individual sample location relative to the WBF Plant CCR management units (adjacent and downstream). The transect data plots were aggregated by transect location relative to the WBF Plant CCR management units (adjacent and downstream) and sample position in the water body (plant-side bank and opposite-side bank).

No outliers were identified in the WBF Plant sediment data set.

3.2 COMPARISON OF SEDIMENT RESULTS TO ESVS

No sediment results collected from the Tennessee River in proximity to the WBF Plant CCR management units exceeded either acute or chronic ESVs.

No additional statistical evaluation (PCA or Hypothesis testing) were warranted since no CCR parameter concentrations were identified above acute or chronic ESVs.

4.0 REFERENCES

StataCorp. (2017). Stata Graphics Reference Manual Stata: Release 15. Statistical Software. College Station, Texas: StataCorp LLC.

Tukey, J.W. (1977). *Exploratory Data Analysis*. Reading, Massachusetts: Addison-Wesley. 1977.

ATTACHMENT E.6-A
SUMMARY STATISTICS

Summary Statistics - Tennessee River Sediment Investigation Watts Bar Fossil Plant - Spring City, Tennessee										
Parameter	**Location Relative to CCR Management Units**	**Frequency of Detection**	**Range of Reporting Limits**	**% Non Detect**	**Statistics using Detected Data Only**		**Statistics using Detects & Non-Detects**			
					Minimum Detect	**Maximum Detect**	**Mean**	**Standard Deviation**	**50th Percentile**	**95th Percentile**
Percent Ash										
Ash	Adjacent	4/4	--	0.0%	1	5	3.8	1.9	4.5	5
	Downstream	4/4	--	0.0%	1	5	3.3	2.1	3.5	5
CCR Rule Appendix III Parameters										
Boron	Adjacent	3/3	--	0.0%	1.16	2.89	1.96	0.872	1.83	2.78
	Downstream	4/4	--	0.0%	1.03	2.36	1.72	0.62	1.75	2.32
Calcium	Adjacent	3/3	--	0.0%	1,420	9,500	5,000	4,120	4,080	8,960
	Downstream	4/4	--	0.0%	1,090	2,360	1,640	529	1,550	2,250
Chloride	Adjacent	0/3	(5.42 - 5.88)	100.0%	--	--	--	--	5.59	5.85
	Downstream	0/4	(5.43 - 6.19)	100.0%	--	--	--	--	5.77	6.14
pH(Lab)	Adjacent	3/3	--	0.0%	7.2	7.5	7.33	0.153	7.3	7.48
	Downstream	4/4	--	0.0%	7.3	7.6	7.38	0.15	7.3	7.56
Sulfate	Adjacent	3/3	--	0.0%	40.1	65.1	50.9	12.8	47.6	63.4
	Downstream	4/4	--	0.0%	25.4	48.3	39.3	10.1	41.7	47.8
CCR Rule Appendix IV Parameters										
Antimony	Adjacent	3/3	--	0.0%	0.0865	0.159	0.112	0.0405	0.0916	0.152
	Downstream	3/4	(0.0465 - 0.0465)	25.0%	0.0498	0.101	0.0673	0.0218	0.0609	0.0966
Arsenic	Adjacent	3/3	--	0.0%	2.41	4.59	3.55	1.09	3.64	4.5
	Downstream	4/4	--	0.0%	1.34	2.29	1.72	0.427	1.62	2.22
Barium	Adjacent	3/3	--	0.0%	75.7	106	91.9	15.3	94	105
	Downstream	4/4	--	0.0%	43.3	108	72.7	28.3	69.8	104
Beryllium	Adjacent	3/3	--	0.0%	0.608	0.884	0.771	0.145	0.821	0.878
	Downstream	4/4	--	0.0%	0.309	1.09	0.672	0.346	0.644	1.05
Cadmium	Adjacent	3/3	--	0.0%	0.0959	0.423	0.289	0.171	0.348	0.416
	Downstream	4/4	--	0.0%	0.0743	0.127	0.0923	0.0238	0.0839	0.121
Chromium	Adjacent	3/3	--	0.0%	13.8	17.9	15.3	2.26	14.2	17.5
	Downstream	4/4	--	0.0%	7.43	16.5	11.7	4.06	11.5	16.1
Cobalt	Adjacent	3/3	--	0.0%	8.45	11.3	9.56	1.53	8.92	11.1
	Downstream	4/4	--	0.0%	4.63	9.79	6.97	2.32	6.73	9.5
Fluoride	Adjacent	3/3	--	0.0%	0.95	1.32	1.17	0.195	1.24	1.31
	Downstream	2/4	(0.952 - 1)	50.0%	1.22	1.47	1.15	0.215	1.11	1.43
Lead	Adjacent	3/3	--	0.0%	9.41	21.2	15.6	5.91	16.1	20.7
	Downstream	4/4	--	0.0%	5.82	12	7.81	2.91	6.71	11.3
Lithium	Adjacent	3/3	--	0.0%	6.94	11.4	9.68	2.4	10.7	11.3
	Downstream	4/4	--	0.0%	5.52	16.9	10.7	5.15	10.1	16.3

Summary Statistics - Tennessee River Sediment Investigation Watts Bar Fossil Plant - Spring City, Tennessee										
Parameter	Location Relative to CCR Management Units	Frequency of Detection	Range of Reporting Limits	% Non Detect	Statistics using Detected Data Only		Statistics using Detects & Non-Detects			
					Minimum Detect	Maximum Detect	Mean	Standard Deviation	50th Percentile	95th Percentile
Mercury	Adjacent	3/3	--	0.0%	0.0185	0.079	0.0492	0.0303	0.0501	0.0761
	Downstream	3/4	(0.0102 - 0.0102)	25.0%	0.0116	0.0298	0.0165	0.00783	0.013	0.0275
Molybdenum	Adjacent	3/3	--	0.0%	0.401	0.572	0.464	0.0942	0.418	0.557
	Downstream	4/4	--	0.0%	0.163	0.418	0.293	0.111	0.296	0.406
Radium-226+228	Adjacent	3/3	--	0.0%	2.04	2.96	2.49	0.46	2.46	2.91
	Downstream	4/4	--	0.0%	1.66	2.91	2.44	0.575	2.6	2.9
Selenium	Adjacent	3/3	--	0.0%	0.638	1.02	0.87	0.204	0.953	1.01
	Downstream	4/4	--	0.0%	0.43	1.12	0.781	0.375	0.788	1.12
Thallium	Adjacent	3/3	--	0.0%	0.151	0.215	0.174	0.0359	0.155	0.209
	Downstream	4/4	--	0.0%	0.0887	0.189	0.135	0.0449	0.131	0.184
TDEC Appendix I Parameters										
Copper	Adjacent	3/3	--	0.0%	9.35	30.3	17.5	11.2	12.8	28.6
	Downstream	4/4	--	0.0%	4.52	10.3	7.24	2.58	7.06	10
Nickel	Adjacent	3/3	--	0.0%	9.63	13.5	11.7	1.96	12.1	13.4
	Downstream	4/4	--	0.0%	5.8	14.3	9.78	3.84	9.51	13.9
Silver	Adjacent	3/3	--	0.0%	0.0263	0.0409	0.0313	0.00829	0.0268	0.0395
	Downstream	1/4	(0.0195 - 0.0216)	75.0%	0.0232	0.0232	0.0204	0.0016	0.0213	0.023
Vanadium	Adjacent	3/3	--	0.0%	17.7	26.1	20.9	4.52	19	25.4
	Downstream	4/4	--	0.0%	8.54	19	13.5	4.66	13.2	18.5
Zinc	Adjacent	3/3	--	0.0%	40.8	98.6	74	29.8	82.6	97
	Downstream	4/4	--	0.0%	33.9	58.9	45.9	10.5	45.4	57.3
Other Constituents										
Strontium	Adjacent	3/3	--	0.0%	5.63	13.6	10	4.05	10.9	13.3
	Downstream	4/4	--	0.0%	5.08	8.88	6.74	1.62	6.5	8.59

Notes:

CCR Rule - Title 40, Code of Federal Regulations, Part 257

TDEC - Tennessee Department of Environment and Conservation

% - percent

"--" - Not Applicable

Statistical datasets were aggregated by location of transect relative to the CCR management units (upstream, adjacent, downstream)

Except for Ash, pH & Radium 226 + 228, all units are milligrams per kilogram (mg/kg)

Units for Ash are percent (%)

Units for pH are Standard Units (S.U.)

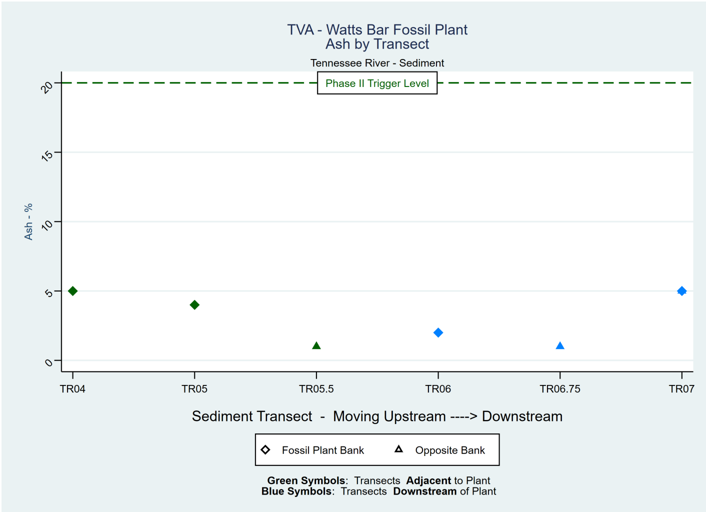
Units for Radium 226+228 are picocuries per gram (pCi/g)

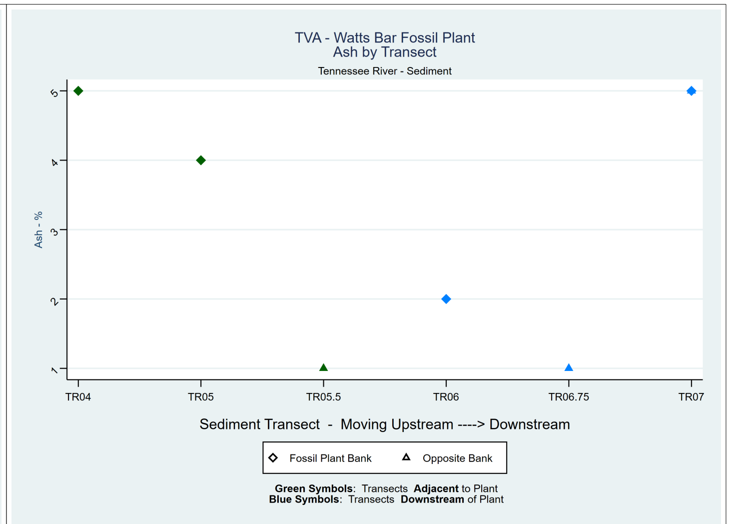
All non-detects reported at the laboratory reporting limit

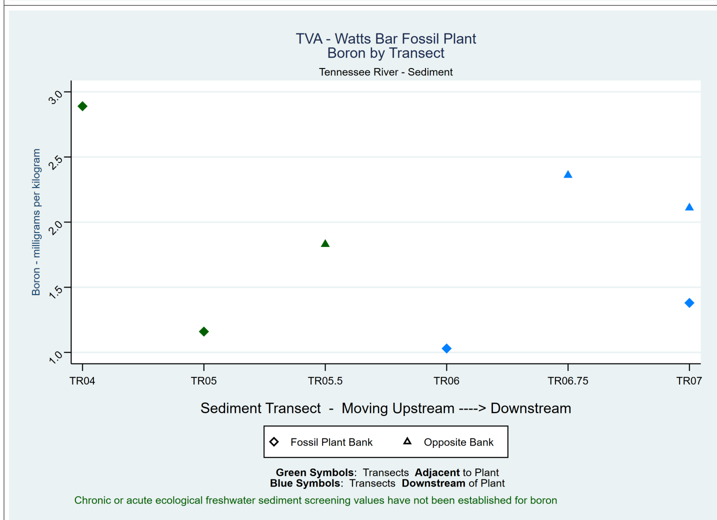
For Parameters with non-detects reported at the method detection limit, the mean and standard deviation were calculated using Kaplan-Meier methods (KM).

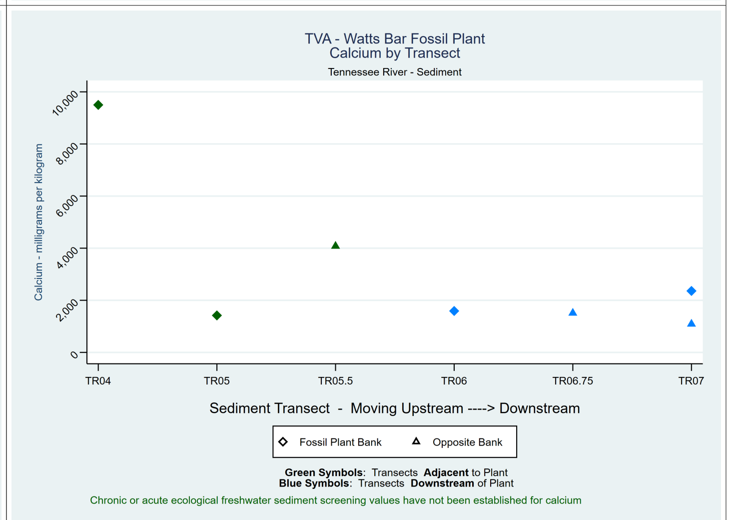
ATTCHMENT E.6-B
TRANSECT PLOTS

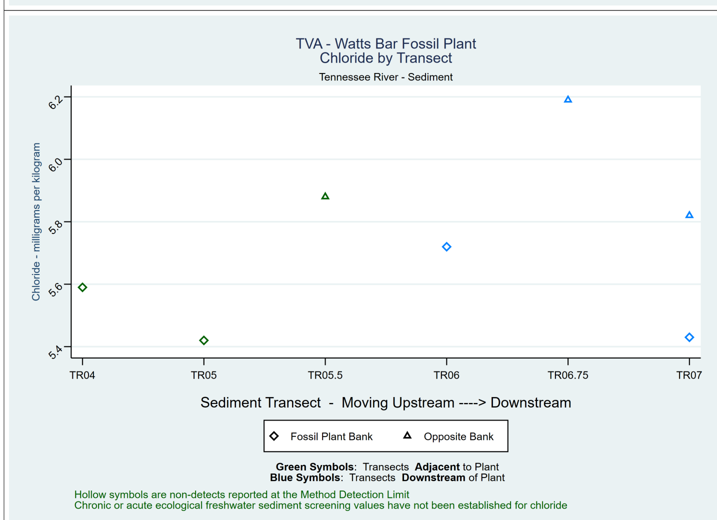
Transect Plots
CCR Rule Appendix III Parameters
Sediment Investigation - Tennessee River
Watts Bar Fossil Plant, Spring City, Tennessee

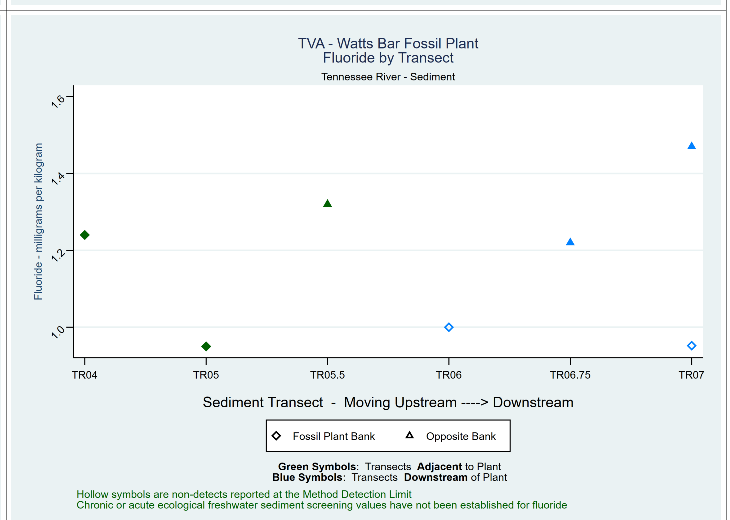


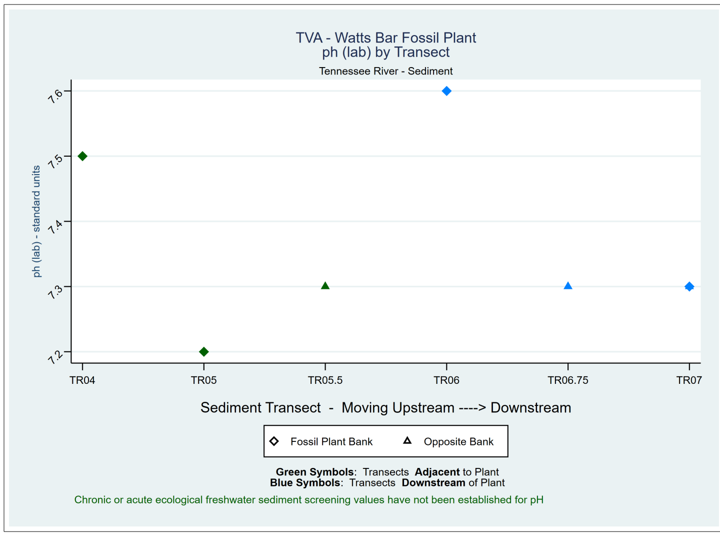




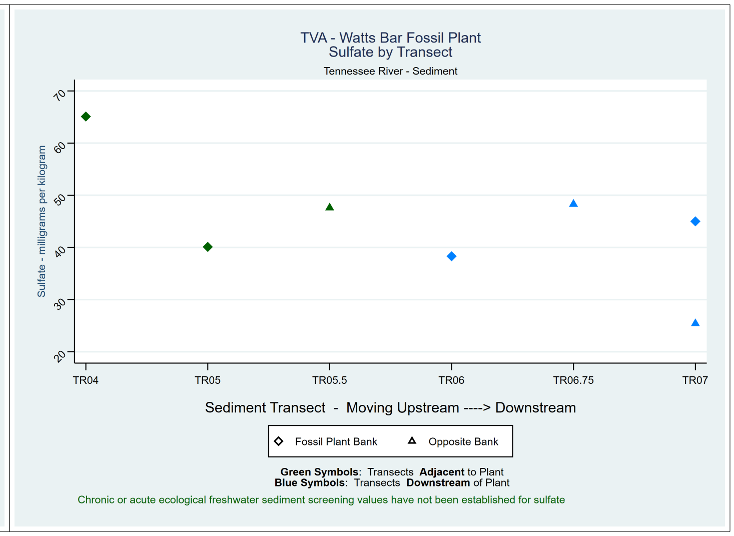






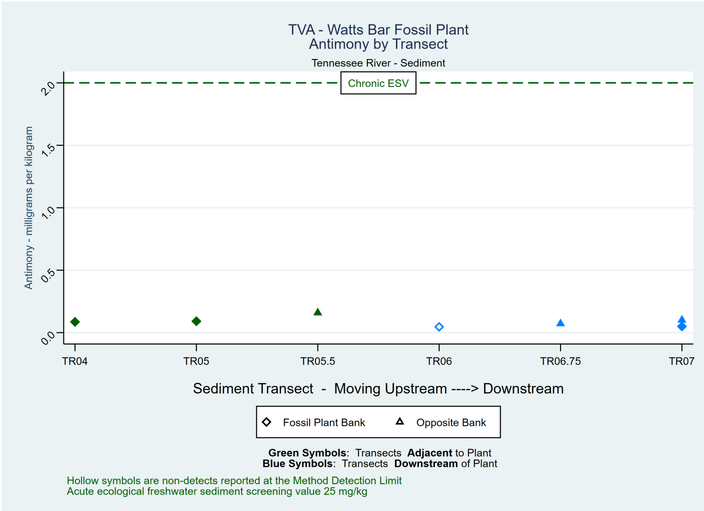


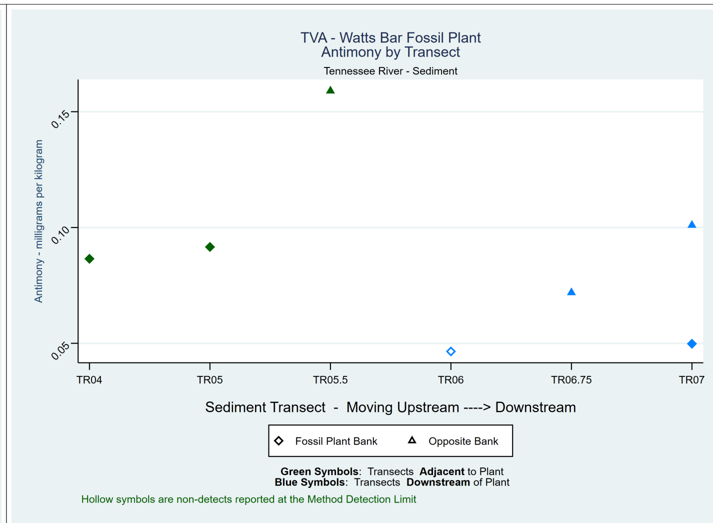
TVA - Watts Bar Fossil Plant
ph (lab) by Transect
Tennessee River - Sediment
ph (lab) - standard units
7.2
7.3
7.4
7.5
7.6
TR04
TR05
TR05.5
TR06
TR06.75
TR07
Sediment Transect - Moving Upstream ----> Downstream
Fossil Plant Bank
Opposite Bank
Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Chronic or acute ecological freshwater sediment screening values have not been established for pH

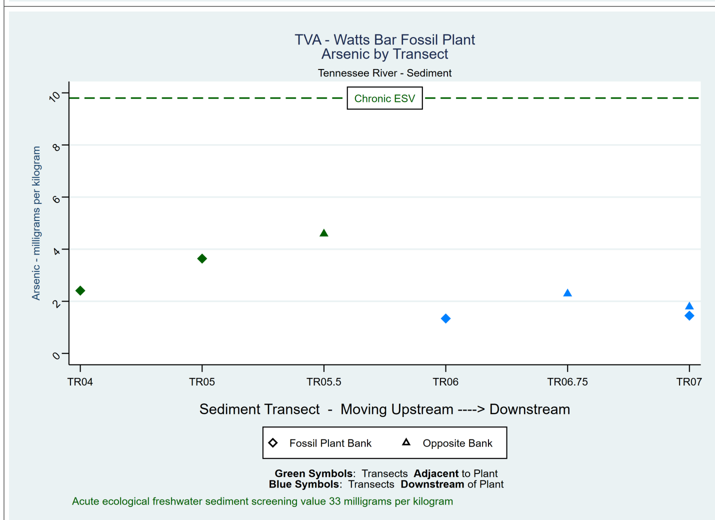


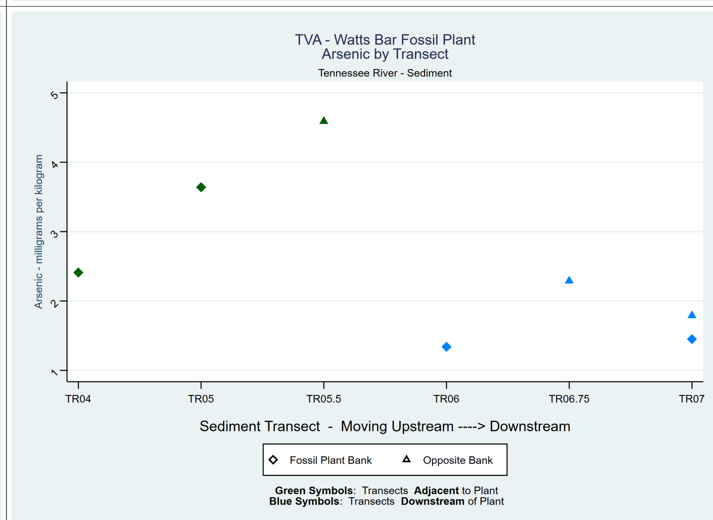
TVA - Watts Bar Fossil Plant
Sulfate by Transect
Tennessee River - Sediment
Sulfate - milligrams per kilogram
20
30
40
50
60
70
TR04
TR05
TR05.5
TR06
TR06.75
TR07
Sediment Transect - Moving Upstream ----> Downstream
Fossil Plant Bank
Opposite Bank
Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Chronic or acute ecological freshwater sediment screening values have not been established for sulfate

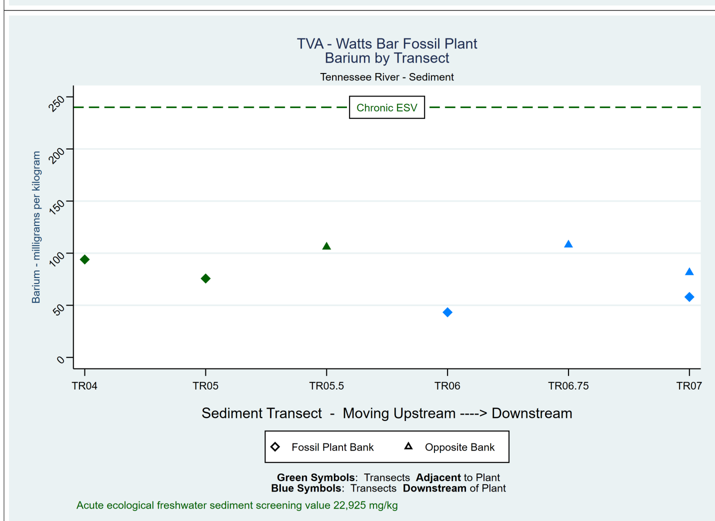
Transect Plots
CCR Rule Appendix IV Parameters
Sediment Investigation - Tennessee River
Watts Bar Fossil Plant, Spring City, Tennessee



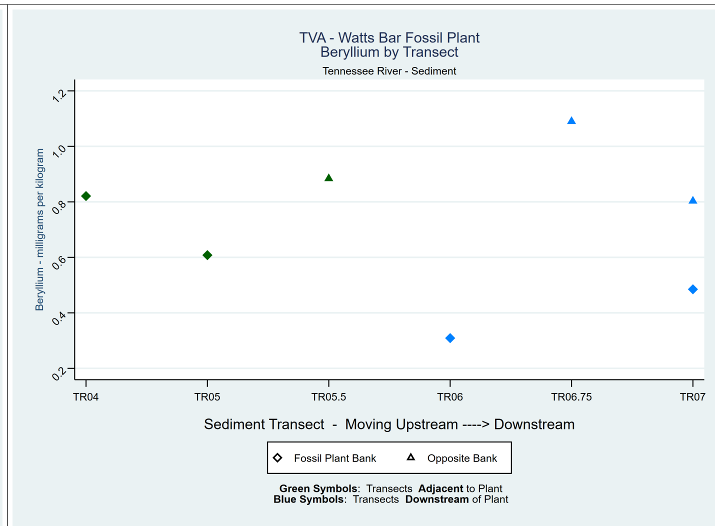


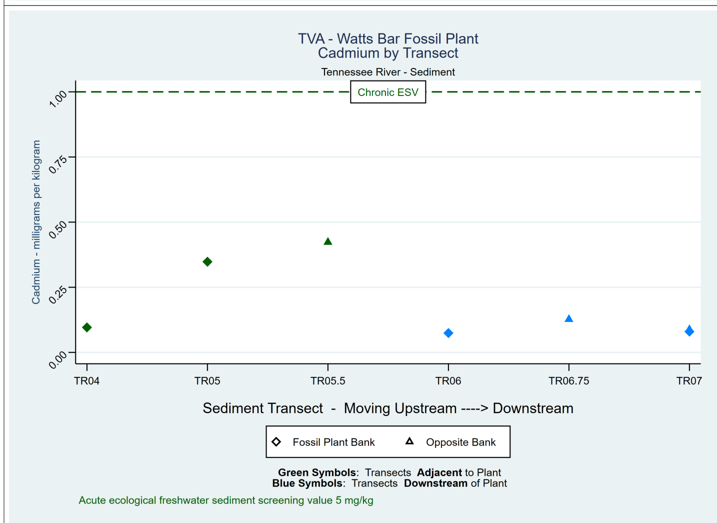


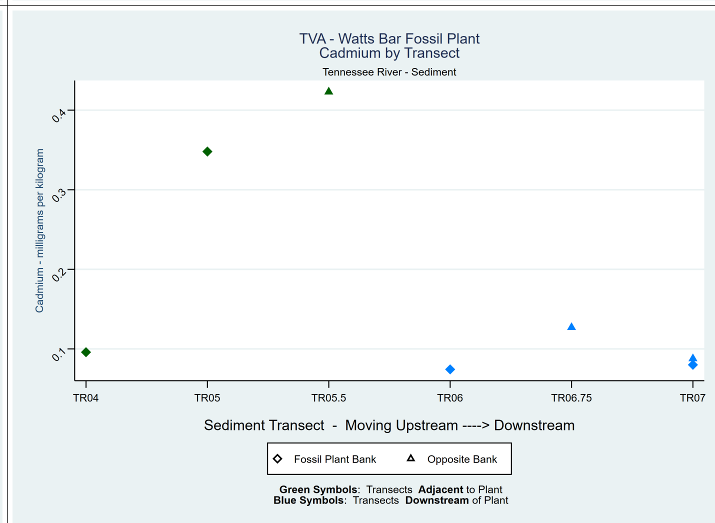


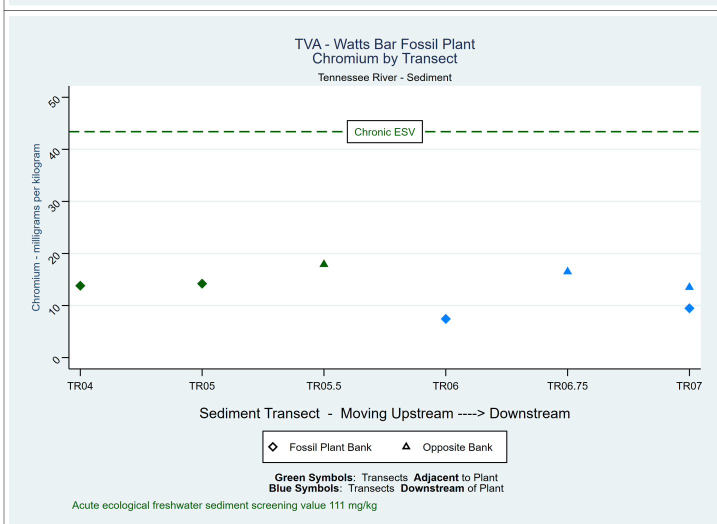


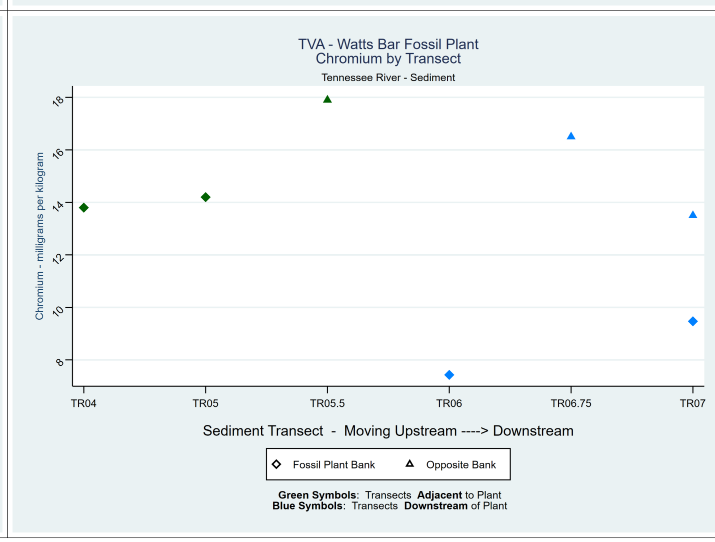

TVA - Watts Bar Fossil Plant
Beryllium by Transect
Tennessee River - Sediment
Beryllium - milligrams per kilogram
0.0
0.5
1.0
1.5
Chronic ESV
TR04
TR05
TR05.5
TR06
TR06.75
TR07
Sediment Transect - Moving Upstream ----> Downstream
Fossil Plant Bank
Opposite Bank
Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Acute ecological freshwater sediment screening value 42 mg/kg

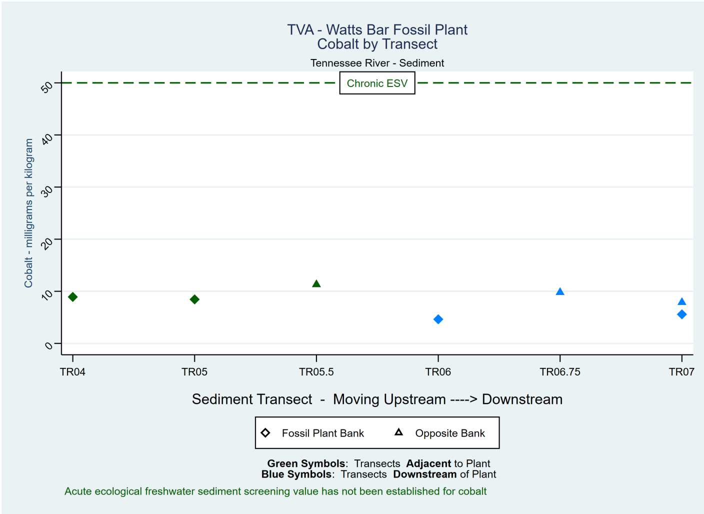

TVA - Watts Bar Fossil Plant
Beryllium by Transect
Tennessee River - Sediment
Beryllium - milligrams per kilogram
0.2
0.4
0.6
0.8
1.0
1.2
TR04
TR05
TR05.5
TR06
TR06.75
TR07
Sediment Transect - Moving Upstream ----> Downstream
Fossil Plant Bank
Opposite Bank
Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant

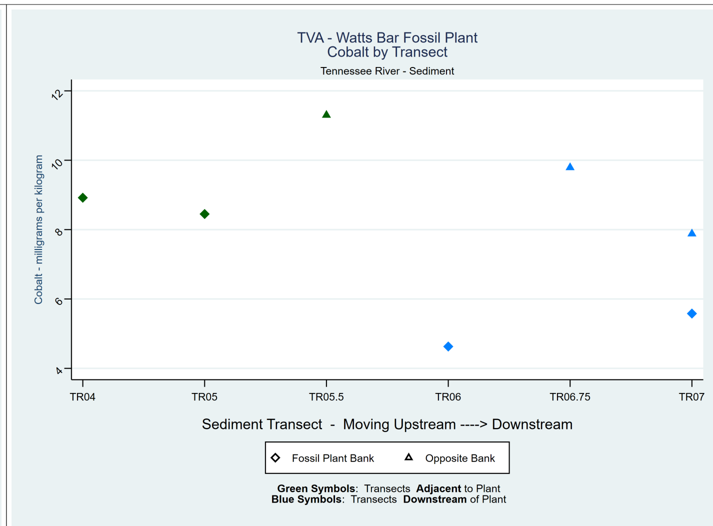

TVA - Watts Bar Fossil Plant
Cadmium by Transect
Tennessee River - Sediment
Cadmium - milligrams per kilogram
0.00
0.25
0.50
0.75
1.00
Chronic ESV
TR04
TR05
TR05.5
TR06
TR06.75
TR07
Sediment Transect - Moving Upstream ----> Downstream
Fossil Plant Bank
Opposite Bank
Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Acute ecological freshwater sediment screening value 5 mg/kg

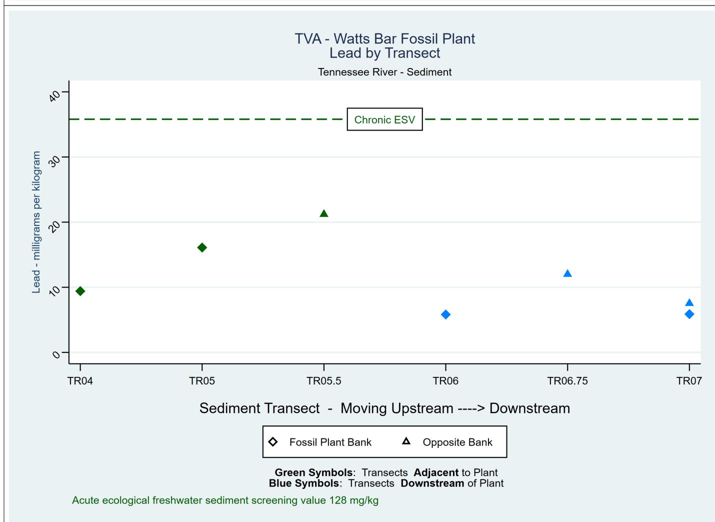

TVA - Watts Bar Fossil Plant
Cadmium by Transect
Tennessee River - Sediment
Cadmium - milligrams per kilogram
0.1
0.2
0.3
0.4
TR04
TR05
TR05.5
TR06
TR06.75
TR07
Sediment Transect - Moving Upstream ----> Downstream
Fossil Plant Bank
Opposite Bank
Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant

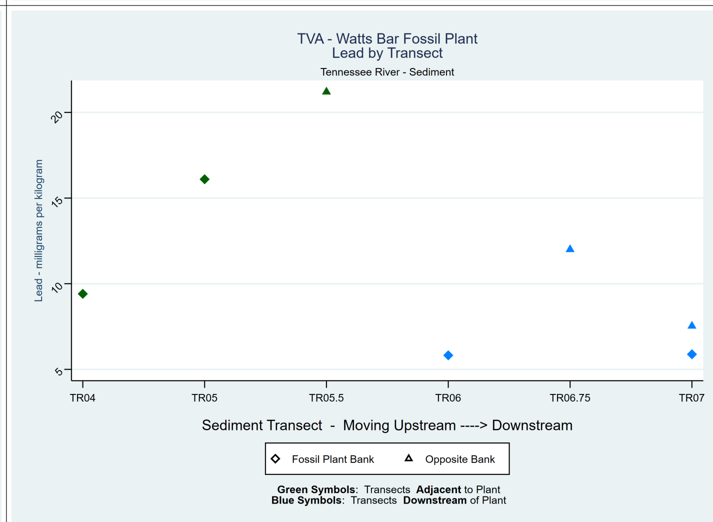

TVA - Watts Bar Fossil Plant
Chromium by Transect
Tennessee River - Sediment
Chromium - milligrams per kilogram
0
10
20
30
40
50
Chronic ESV
TR04
TR05
TR05.5
TR06
TR06.75
TR07
Sediment Transect - Moving Upstream ----> Downstream
Fossil Plant Bank
Opposite Bank
Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Acute ecological freshwater sediment screening value 111 mg/kg


TVA - Watts Bar Fossil Plant
Chromium by Transect
Tennessee River - Sediment
Chromium - milligrams per kilogram
8
10
12
14
16
18
TR04
TR05
TR05.5
TR06
TR06.75
TR07
Sediment Transect - Moving Upstream ----> Downstream
Fossil Plant Bank
Opposite Bank
Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant

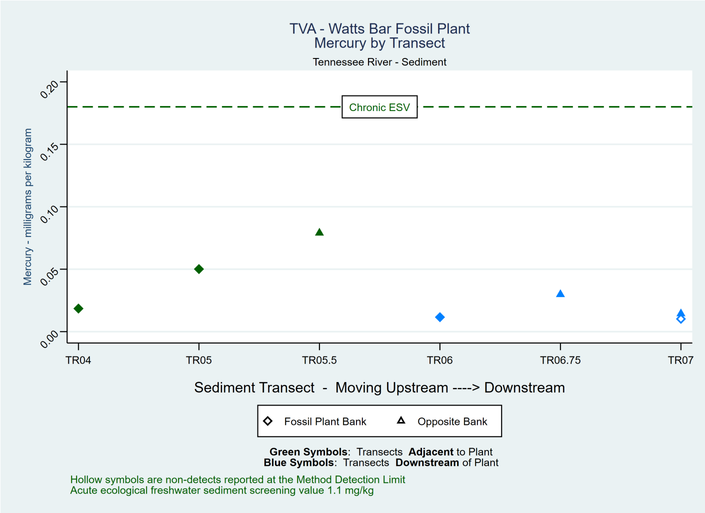


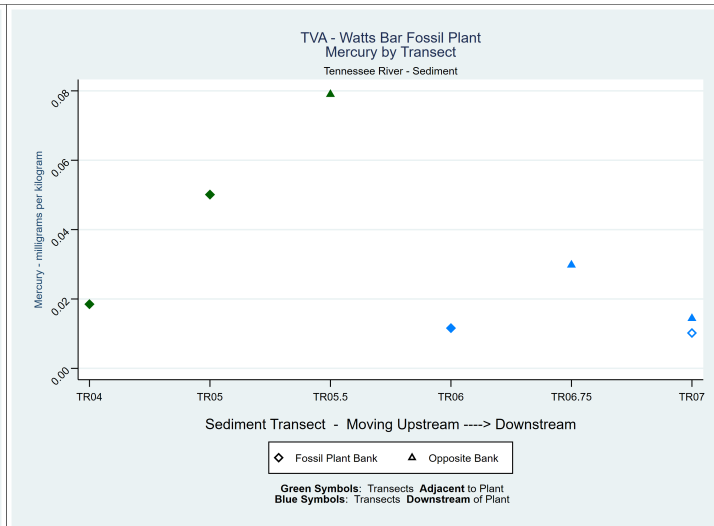


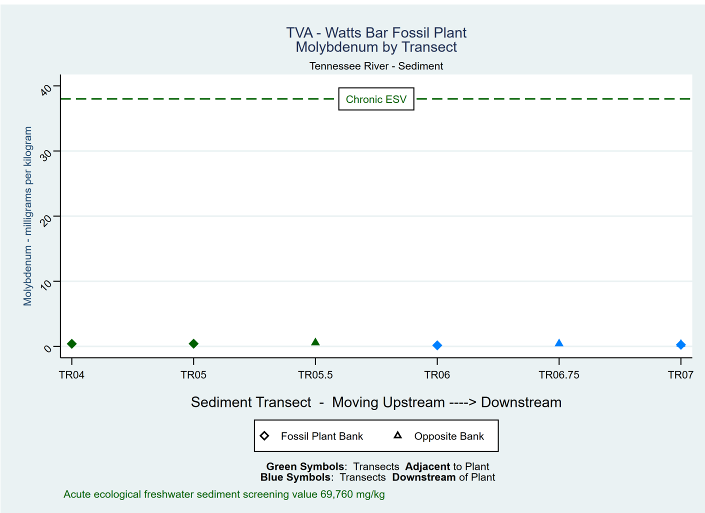


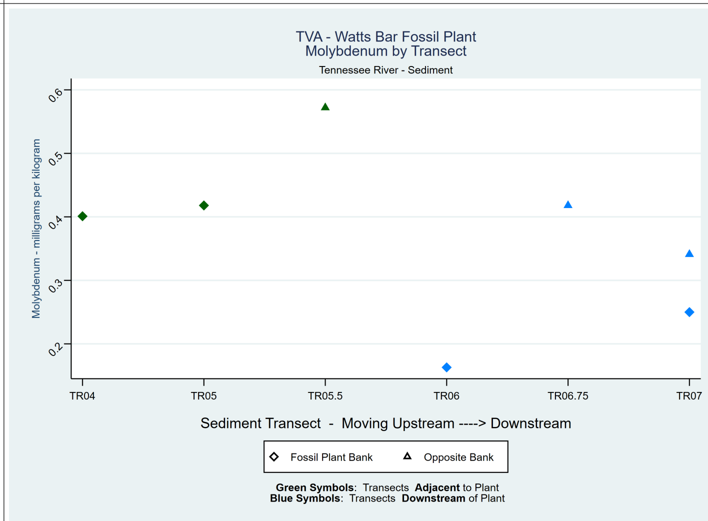


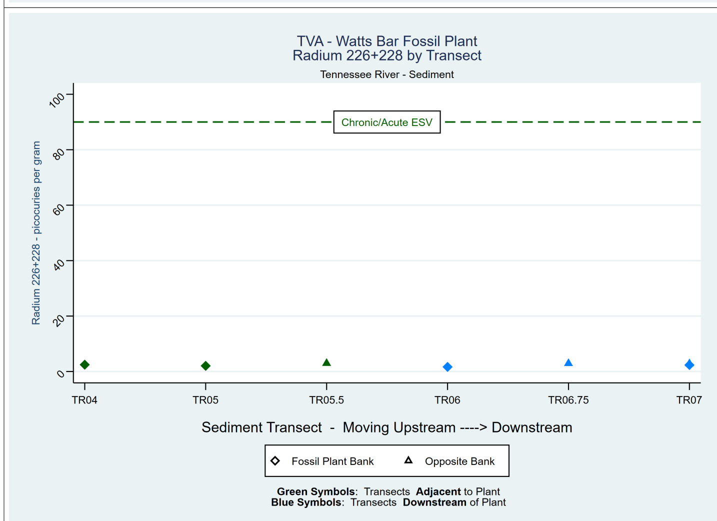
Chronic or Acute Ecological Screening Values have not been established for Lithium

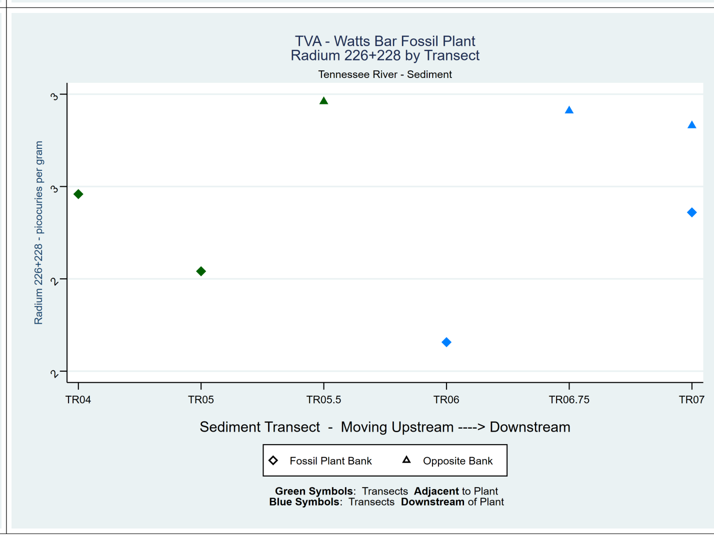

TVA - Watts Bar Fossil Plant
Mercury by Transect
Tennessee River - Sediment
Mercury - milligrams per kilogram
Chronic ESV
0.00
0.05
0.10
0.15
0.20
TR04
TR05
TR05.5
TR06
TR06.75
TR07
Sediment Transect - Moving Upstream ----> Downstream
Fossil Plant Bank
Opposite Bank
Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Hollow symbols are non-detects reported at the Method Detection Limit
Acute ecological freshwater sediment screening value 1.1 mg/kg

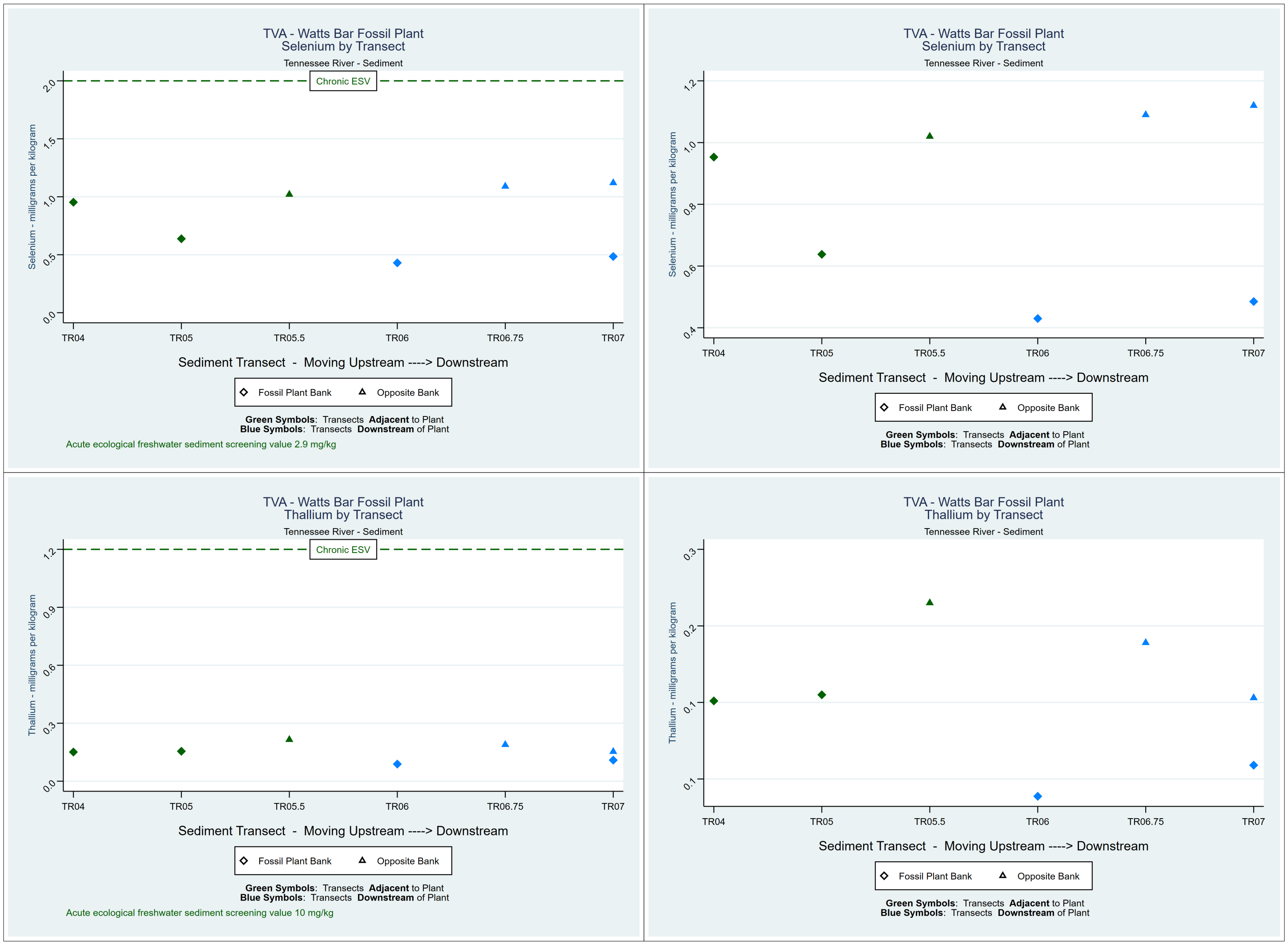

TVA - Watts Bar Fossil Plant
Mercury by Transect
Tennessee River - Sediment
Mercury - milligrams per kilogram
0.00
0.02
0.04
0.06
0.08
TR04
TR05
TR05.5
TR06
TR06.75
TR07
Sediment Transect - Moving Upstream ----> Downstream
Fossil Plant Bank
Opposite Bank
Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant


TVA - Watts Bar Fossil Plant
Molybdenum by Transect
Tennessee River - Sediment
Molybdenum - milligrams per kilogram
Chronic ESV
0
10
20
30
40
TR04
TR05
TR05.5
TR06
TR06.75
TR07
Sediment Transect - Moving Upstream ----> Downstream
Fossil Plant Bank
Opposite Bank
Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Acute ecological freshwater sediment screening value 69,760 mg/kg

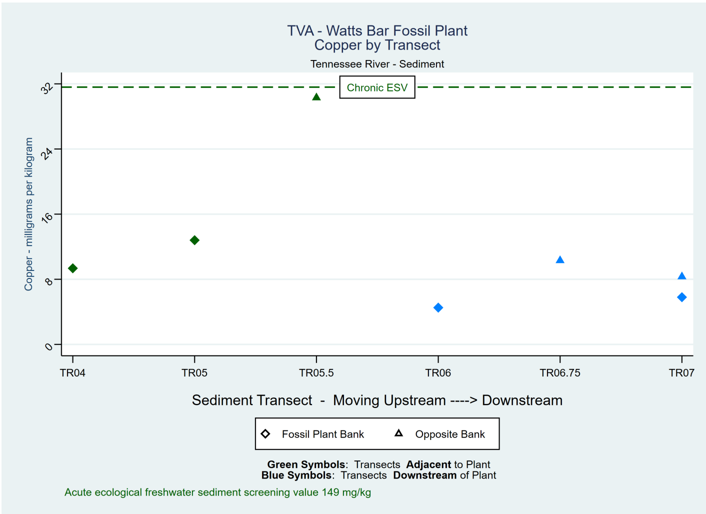

TVA - Watts Bar Fossil Plant
Molybdenum by Transect
Tennessee River - Sediment
Molybdenum - milligrams per kilogram
0.2
0.3
0.4
0.5
0.6
TR04
TR05
TR05.5
TR06
TR06.75
TR07
Sediment Transect - Moving Upstream ----> Downstream
Fossil Plant Bank
Opposite Bank
Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant

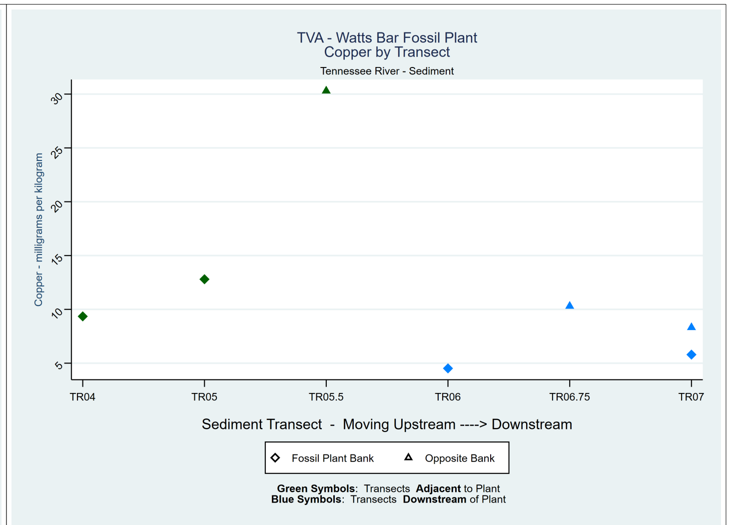

TVA - Watts Bar Fossil Plant
Radium 226+228 by Transect
Tennessee River - Sediment
Radium 226+228 - picocuries per gram
Chronic/Acute ESV
0
20
40
60
80
100
TR04
TR05
TR05.5
TR06
TR06.75
TR07
Sediment Transect - Moving Upstream ----> Downstream
Fossil Plant Bank
Opposite Bank
Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant

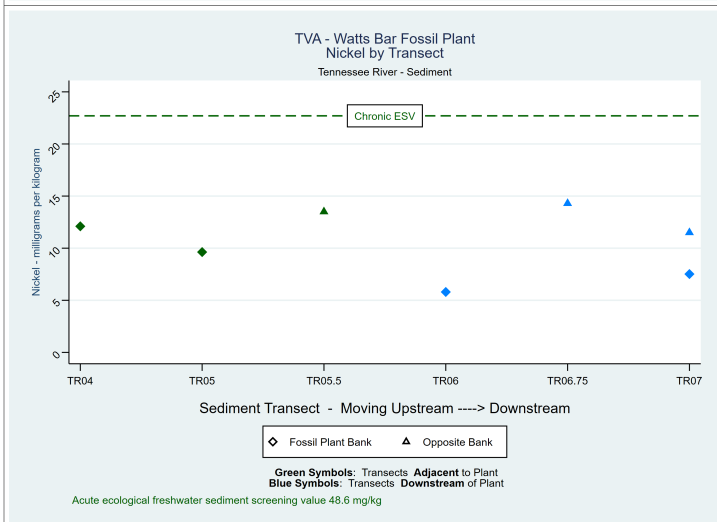

TVA - Watts Bar Fossil Plant
Radium 226+228 by Transect
Tennessee River - Sediment
Radium 226+228 - picocuries per gram
2
2
3
3
TR04
TR05
TR05.5
TR06
TR06.75
TR07
Sediment Transect - Moving Upstream ----> Downstream
Fossil Plant Bank
Opposite Bank
Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant

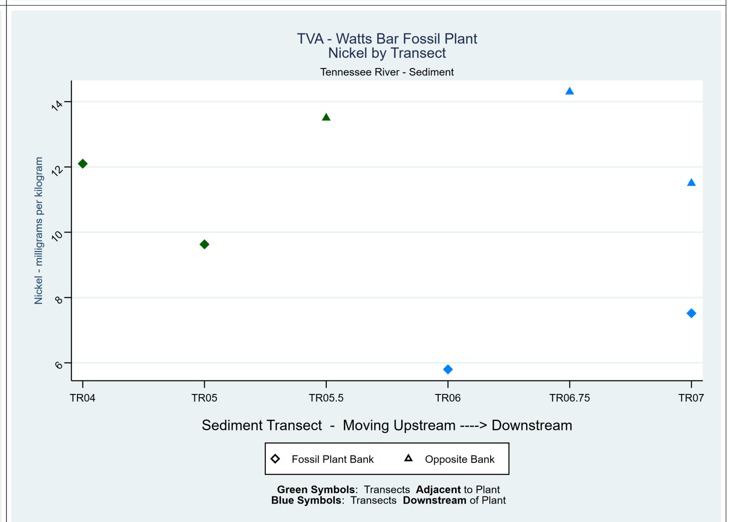

TVA - Watts Bar Fossil Plant
Selenium by Transect
Tennessee River - Sediment
Chronic ESV
Selenium - milligrams per kilogram
0.0
0.5
1.0
1.5
2.0
TR04
TR05
TR05.5
TR06
TR06.75
TR07
Sediment Transect - Moving Upstream ----> Downstream
Fossil Plant Bank
Opposite Bank
Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Acute ecological freshwater sediment screening value 2.9 mg/kg
TVA - Watts Bar Fossil Plant
Selenium by Transect
Tennessee River - Sediment
Selenium - milligrams per kilogram
0.4
0.6
0.8
1.0
1.2
TR04
TR05
TR05.5
TR06
TR06.75
TR07
Sediment Transect - Moving Upstream ----> Downstream
Fossil Plant Bank
Opposite Bank
Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
TVA - Watts Bar Fossil Plant
Thallium by Transect
Tennessee River - Sediment
Chronic ESV
Thallium - milligrams per kilogram
0.0
0.3
0.6
0.9
1.2
TR04
TR05
TR05.5
TR06
TR06.75
TR07
Sediment Transect - Moving Upstream ----> Downstream
Fossil Plant Bank
Opposite Bank
Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Acute ecological freshwater sediment screening value 10 mg/kg
TVA - Watts Bar Fossil Plant
Thallium by Transect
Tennessee River - Sediment
Thallium - milligrams per kilogram
0.1
0.1
0.2
0.3
TR04
TR05
TR05.5
TR06
TR06.75
TR07
Sediment Transect - Moving Upstream ----> Downstream
Fossil Plant Bank
Opposite Bank
Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant

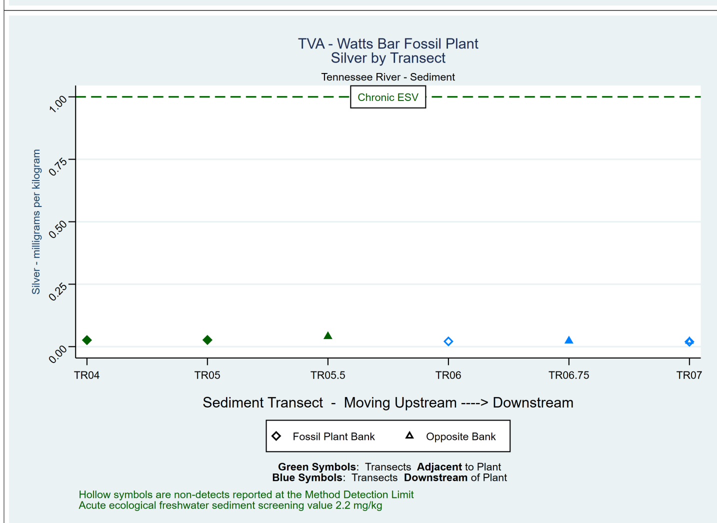
Transect Plots
TDEC Appendix I Parameters
Sediment Investigation - Tennessee River
Watts Bar Fossil Plant, Spring City, Tennessee

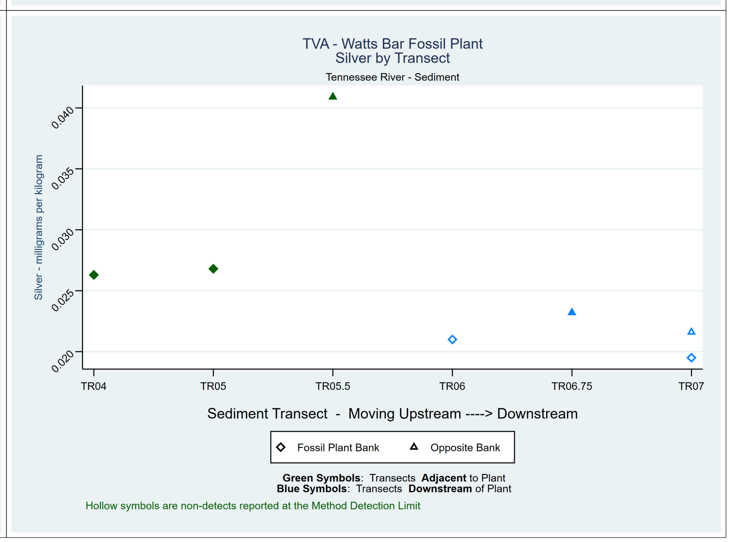


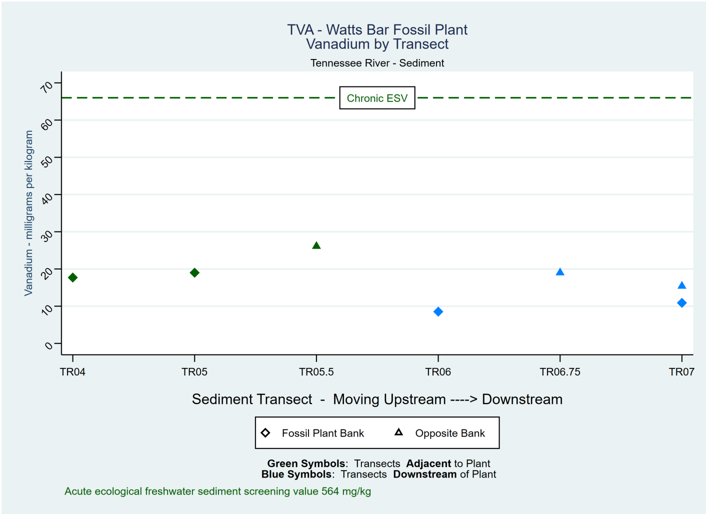


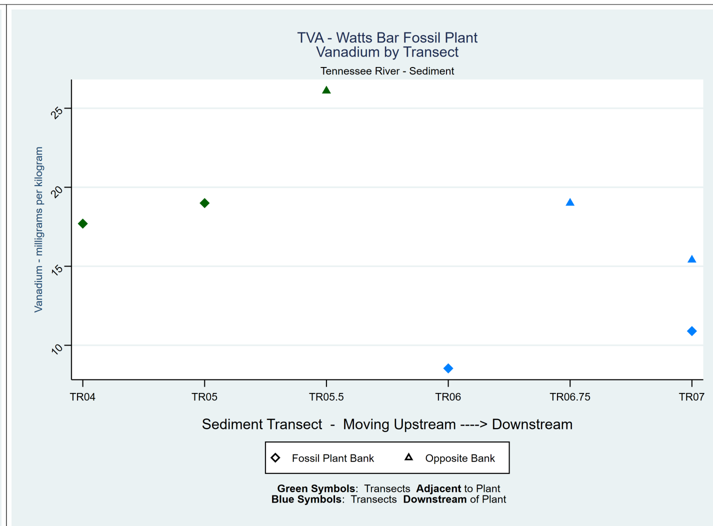


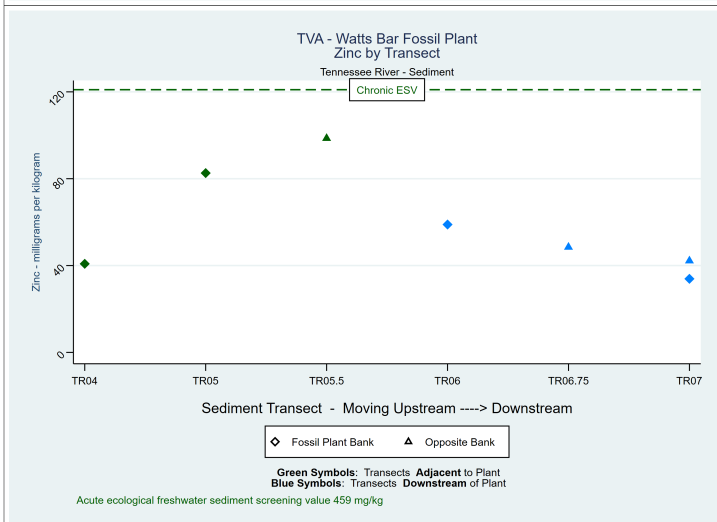


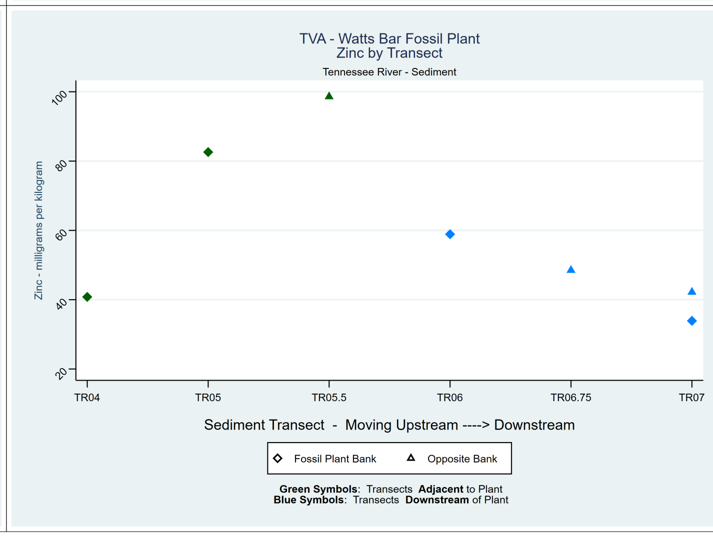





TVA - Watts Bar Fossil Plant
Vanadium by Transect
Tennessee River - Sediment
Chronic ESV
Vanadium - milligrams per kilogram
TR04
TR05
TR05.5
TR06
TR06.75
TR07
Sediment Transect - Moving Upstream ----> Downstream
Fossil Plant Bank
Opposite Bank
Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Acute ecological freshwater sediment screening value 564 mg/kg


TVA - Watts Bar Fossil Plant
Vanadium by Transect
Tennessee River - Sediment
Vanadium - milligrams per kilogram
TR04
TR05
TR05.5
TR06
TR06.75
TR07
Sediment Transect - Moving Upstream ----> Downstream
Fossil Plant Bank
Opposite Bank
Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant


TVA - Watts Bar Fossil Plant
Zinc by Transect
Tennessee River - Sediment
Chronic ESV
Zinc - milligrams per kilogram
TR04
TR05
TR05.5
TR06
TR06.75
TR07
Sediment Transect - Moving Upstream ----> Downstream
Fossil Plant Bank
Opposite Bank
Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant
Acute ecological freshwater sediment screening value 459 mg/kg


TVA - Watts Bar Fossil Plant
Zinc by Transect
Tennessee River - Sediment
Zinc - milligrams per kilogram
TR04
TR05
TR05.5
TR06
TR06.75
TR07
Sediment Transect - Moving Upstream ----> Downstream
Fossil Plant Bank
Opposite Bank
Green Symbols: Transects Adjacent to Plant
Blue Symbols: Transects Downstream of Plant

APPENDIX E.7

DATA EVALUATION OF FISH TISSUE SAMPLE DATA

Stantec

Appendix E.7 - Data Evaluation of Fish Tissue Sample Data

TDEC Commissioner's Order:
Environmental Assessment Report
Watts Bar Fossil Plant
Spring City, Tennessee

March 31, 2024

Prepared for:

Tennessee Valley Authority
Chattanooga, Tennessee

TVA TENNESSEE VALLEY AUTHORITY

Prepared by:

Stantec Consulting Services Inc.
Lexington, Kentucky

Revision Log

Revision	Description	Date
0	Submittal to TDEC	November 7, 2023
1	Addresses January 31, 2024 TDEC Review Comments and Issued for TDEC	March 31, 2024

Sign-off Sheet

This document entitled Appendix E.7 - Data Evaluation of Fish Tissue Sample Data was prepared by Stantec Consulting Services Inc. ("Stantec") for the account of Tennessee Valley Authority (the "Client"). Any reliance on this document by any third party is strictly prohibited. The material in it reflects Stantec's professional judgment in light of the scope, schedule and other limitations stated in the document and in the contract between Stantec and the Client. The opinions in the document are based on conditions and information existing at the time the document was published and do not consider any subsequent changes. In preparing the document, Stantec did not verify information supplied to it by others. Any use which a third party makes of this document is the responsibility of such third party. Such third party agrees that Stantec shall not be responsible for costs or damages of any kind, if any, suffered by it or any other third party as a result of decisions made or actions taken based on this document.

Prepared by ______________________

Melissa Whitfield Aslund, PhD, Environmental Scientist

Reviewed by ______________________

Chris La Londe, Risk Assessor

Approved by ______________________

Carole M. Farr, Senior Principal Geologist

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LIST OF TABLES

Abbreviations

BG	Bluegill
CBR	Critical Body Residue
CC	Channel Catfish
CCR	Coal Combustion Residuals
CCR Rule	Title 40, Code of Federal Regulations, Part 257
EAR	Environmental Assessment Report
EI	Environmental Investigation
ESVs	Ecological Screening Values
LB	Largemouth Bass
LOAEL	Lowest Observed Adverse Effect Level
mg/kg	Milligrams per Kilogram
NOAEL	No Observed Adverse Effect Level
RS	Redear Sunfish
SH	Shad
Stantec	Stantec Consulting Services Inc.
TDEC	Tennessee Department of Environment and Conservation
TRA	Tennessee River Adjacent
TRD	Tennessee River Downstream
TRU	Tennessee River Upstream
TVA	Tennessee Valley Authority
USEPA	United States Environmental Protection Agency
WBF Plant	Watts Bar Fossil Plant
WW	Wet Weight

March 31, 2024

1.0 INTRODUCTION

Stantec Consulting Services Inc. (Stantec) prepared this appendix on behalf of the Tennessee Valley Authority (TVA) to summarize the data evaluation performed on fish tissue data to support the Environmental Assessment Report (EAR) at the Watts Bar Fossil Plant (WBF Plant) located in Spring City, Tennessee. Fish tissue samples were collected as part of the Tennessee Department of Environment and Conservation (TDEC) Order Environmental Investigation (EI) between April and May 2019 in the Tennessee River in proximity to the WBF Plant. Further details regarding the fish tissue sampling program and results are available in Appendix J.5 and the *Fish Tissue Sampling and Analysis Report* (Appendix J.6).

The water bodies, sampling locations, fish species, and tissue types included in this evaluation are summarized in Table E.7-1.

Table E.7-1 – Summary of Samples Collected and Included in Data Evaluation for Each Sampling Location, Fish Species, and Tissue Type

Water Body	Sample Location	Locations Relative to WBF CCR Units	Bluegill (BG)			Channel Catfish (CC)			Largemouth Bass (LB)			Redear Sunfish (RS)			Shad (SH)
			Muscle	Liver	Ovary	Muscle	Liver	Ovary	Muscle	Liver	Ovary	Muscle	Liver	Ovary	Whole Fish
Tennessee River	TRU	Upstream	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	TRA	Adjacent	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	TRD	Downstream	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Notes: CCR - Coal Combustion Residuals, TRU – Tennessee River Upstream, TRA – Tennessee River Adjacent, TRD – Tennessee River Downstream

For each sampled waterbody, this data evaluation focused on constituents from one of the following two categories:

1. Constituents for which potential risks to aquatic life have been identified based on observations of concentrations greater than applicable EAR ecological screening values (ESVs, see Appendix A.2) in sediment or surface stream (excluding statistical outliers). Detailed comparisons of constituent concentrations in surface stream and sediment to the applicable ESVs are provided in Appendices E.5 and E.6, respectively.

2. Constituents with potential to bioaccumulate in fish tissues as identified by the United States Environmental Protection Agency (USEPA 2018).

The constituents identified for review in fish tissue for each sampled waterbody based on these criteria are summarized in Table E.7-2.

Table E.7-2 - Constituents Identified for Review in Fish Tissue for the Tennessee River

Water Body	Constituent	Rationale for Review in Fish Tissue
Tennessee River	Mercury	Bioaccumlative per USEPA (2018)
	Selenium	Bioaccumlative per USEPA (2018)

For the constituents identified in Table E.7-2 for the Tennessee River, the following sections present the methods and results from the data evaluation and comparison of fish tissue data to established screening levels for fish tissue critical body residue (CBR) No Observed Adverse Effect Levels (NOAELs) and Lowest Observed Adverse Effect Levels (LOAELs), where available, (see Table 1-5 and Appendix A.2 for list of CBRs identified as EAR screening levels for fish tissue concentrations).

2.0 METHODS

2.1 COMPARISON OF CONSTITUENT CONCENTRATIONS IN FISH TISSUES TO FISH TISSUE CRITICAL BODY RESIDUES

For the constituents identified in Table E.7-2 as requiring further review in the assessed water bodies in proximity to the WBF Plant, measured constituent concentrations (or reported detection limits, for samples where the constituent was not detected) for each analyzed fish species and tissue type were compared directly to the applicable CBRs presented in Appendix A.2.

3.0 RESULTS

Fish tissue samples taken in the three Tennessee River reaches were compared to CBR NOAELs and LOAELs for mercury and selenium. The reported fish tissue concentrations for these constituents are summarized and compared to their applicable CBRs in Table E.7-3 below. Additional information on the fish tissue results comparison to CBRs in the Tennessee River is included in Appendix J.5.

Table E.7-3 – Fish Tissue Concentrations for Mercury and Selenium in the Tennessee River

Constituent Type	Constituent	Sample Location	Gradient	Sample Concentration (mg/kg ww)*												
				Muscle				Liver				Ovary				Whole Fish
				BG	CC	LB	RS	BG	CC	LB	RS	BG	CC	LB	RS	SH
CCR Rule Appendix IV Constituents	Mercury	TRU	Upstream	0.07	0.11	0.2	0.06	0.033	0.27	0.081	0.045	<0.0076	<0.0071	0.011	<0.0071	0.02
		TRA	Adjacent	<0.0072	0.12	0.28	0.029	0.026	0.25	0.17	0.081	<0.0072	<0.0076	0.026	<0.0075	0.013
		TRD	Downstream	0.054	0.072	0.2	0.083	0.029	0.11	0.07	0.14	<0.0072	<0.0074	0.014	0.008	0.014
	Selenium	TRU	Upstream	1.4	0.78	1.5	2.1	1.3	1.2	1.1	1.1	2.3	2.2	2.4	2.6	1.7
		TRA	Adjacent	1.3	0.7	1.4	1.9	1.6	1.3	1.1	2.1	2.8	2.1	2.7	3.2	1.2
		TRD	Downstream	1.3	0.67	1.3	2	1.1	1.3	1	1.9	2.2	2.3	2.6	3.6	1.4

Notes: CCR Rule - Title 40, Code of Federal Regulations, Part 257; BG – Bluegill; CBR - Critical Body Residue; CC - Channel Catfish; LB - Largemouth Bass; RS - Redear Sunfish; SH – Shad; TRA – Tennessee River Adjacent; TRD – Tennessee River Downstream; TRU – Tennessee River Upstream; LOAEL – Lowest Observed Adverse Effect Level; mg/kg – milligram per kilogram, ww – wet weight; NOAEL - No Observed Adverse Effect Level;
*Selenium concentrations reported as mg/kg ww for liver tissue and mg/kg dry weight for whole body, muscle, and ovary to permit direct comparison to the selenium critical body residues (CBRs) for these tissues.

Legend
No applicable CBR
Concentration < CBR NOAEL
Concentration > CBR NOAEL
Concentration > CBR LOAEL

4.0 DISCUSSION

For the reviewed constituents, where fish tissue concentrations were higher than CBR NOAELs, there was generally minimal variability in constituent concentrations between the upstream, adjacent, and downstream sampling reaches in proximity to the WBF Plant. However, because of the former WBF Plant's proximity to the Watts Bar Dam, there was insufficient space to establish a sampling control area immediately upstream of the WBF Plant. Therefore, the upstream control sampling reach was established in the forebay area of the Watts Bar Dam, resulting in the downstream and adjacent sampling reaches being located in the Chickamauga Reservoir inflow zone and the upstream sampling reach being established in the Watts Bar Reservoir forebay zone. Because these two reservoir zone types have much different flow regimes and ecologies, any direct comparisons between the upstream and downstream reaches are inappropriate.

Further interpretation of the ecological implications of these tissue concentrations will be completed in the context of the Corrective Action/Risk Assessment Plan.

5.0 REFERENCES

United State Environmental Protection Agency. (2018). *Region 4 Ecological Risk Assessment Supplemental Guidance. March 2018 Update, Screening Values.*