2022 ANNUAL GROUNDWATER MONITORING REPORT
Big Sandy Plant – Fly Ash Pond
Louisa, Kentucky

Submitted to

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TABLE OF CONTENTS

LIST OF ATTACHMENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ACRONYMS AND ABBREVIATIONS

AEP	American Electric Power
amsl	above mean sea level
ASD	Alternative Source Demonstration
CCR	Coal Combustion Residuals
CFR	Code of Federal Regulations
EHS Support	EHS Support, LLC
FAP	Fly Ash Pond
GWPS	Groundwater Protection Standard
LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicate
MDL	Method Detection Limit
MS	Matrix Spike
MSD	Matrix Spike Duplicate
SSI	Statistically Significant Increase
SSL	Statistically Significant Level
TDS	Total Dissolved Solids
UPL	Upper Prediction Limit
USEPA	United States Environmental Protection Agency

SECTION 1

EXECUTIVE SUMMARY

In accordance with the United States Environmental Protection Agency's (USEPA's) regulations regarding the disposal of coal combustion residuals (CCR) in landfills and surface impoundments (40 Code of Federal Regulations [CFR] 257 Subpart D, "CCR rule"), Geosyntec Consultants, Inc. (Geosyntec) has produced this report to document the groundwater monitoring activities conducted at the Fly Ash Pond (FAP), a closed CCR unit at the Big Sandy Plant (the Site) located in Louisa, Kentucky, in 2022.

In general, the following activities were completed during 2022:

- The CCR unit was in assessment monitoring at both the beginning and end of 2022. Per the 2021 *Annual Groundwater Monitoring Report* (American Electric Power Service Corporation [AEP], 2022), the CCR unit remained in assessment monitoring at the end of 2021. Assessment monitoring was initiated at the site in April 2018.
- All monitoring wells that were installed and developed to establish a certified groundwater monitoring system around the CCR unit as documented in AEP's *Groundwater Monitoring Network Evaluation* (Geosyntec, 2016) were sampled pursuant to 40 CFR 257.95b on 22-24 March 2022 and pursuant to 40 CFR 257.95(d)(1) on 13-15 June 2022 and 10-12 October 2022. All samples collected during the March 2022 sampling event were analyzed for all constituents in Appendix IV of the CCR rules. Select samples were also analyzed for the Appendix III constituents. All samples collected during the June and October 2022 sampling event were analyzed for all Appendix III and Appendix IV constituents.
- Statistical evaluation was completed to support assessment monitoring at the unit. This report discusses the statistical analyses for three (3) assessment monitoring events which were performed in October 2021, March 2022, and June 2022.
    - Statistical evaluation of the October 2021 semiannual assessment monitoring event identified statistically significant levels (SSLs) for four (4) Appendix IV constituents at MW-1603: beryllium, cobalt, combined radium, and lithium. Statistically significant increases (SSIs) were observed for five (5) Appendix III constituents: boron (MW-1606), chloride (MW-1602 and -1606), fluoride (MW-1603), sulfate (MW-1602, -1603, and -1607) and total dissolved solids (TDS; MW-1603) (Geosyntec, 2022a). An alternative source demonstration (ASD) was successfully completed for the October 2021 event (EHS Support, LLC [EHS Support], 2022a); thus, the CCR unit remain in the assessment monitoring program at the beginning of 2022.

- Statistical evaluation of the March 2022 and June 2022 assessment monitoring event identified SSLs for four (4) Appendix IV constituents at MW-1603: beryllium, cobalt, combined radium, and lithium. SSIs were observed for five (5) Appendix III constituents: boron (MW-1606), chloride (MW-1602 and -1606), pH (MW-1601), sulfate (MW-1602 and -1603) and TDS (MW-1603). (Geosyntec, 2022b) An ASD was successfully completed for both events (EHS Support, 2022b); thus, the unit remained in the assessment monitoring program at the conclusion of 2022.

Because an ASD was successfully completed following the June 2022 sampling event, an assessment of corrective measures was not initiated for the FAP and a remedy was not selected for the FAP pursuant to 40 CFR 257.97 during the reporting period. No remedial activities were initiated or were ongoing pursuant to 40 CFR 257.98 during the reporting period.

SECTION 2

INTRODUCTION

This *Annual Groundwater Monitoring Report* has been prepared to report the status of activities for the preceding year for the Fly Ash Pond, an existing CCR unit at Kentucky Power Company's Big Sandy Plant. Kentucky Power Company is a wholly owned subsidiary of AEP. The USEPA's CCR rules require that the *Annual Groundwater Monitoring Report* shall be posted to the operating record for the preceding year no later than January 31.

The major components of this annual report, to the extent available at this time, are presented as follows:

- A figure showing the CCR unit, all groundwater monitoring wells, and monitoring well identification numbers (**Figure 1**);
- Identification of any monitoring wells that were installed or decommissioned during the preceding year, along with a statement regarding the rationale for the installation or decommissioning (as described in **Section 2.3**);
- All of the monitoring data collected, a summary showing the number of samples collected per monitoring well, the dates the samples were collected, and whether the sample was required by the detection monitoring or assessment monitoring programs (summarized in **Section 3.1** and attached as **Table 1**;
- Groundwater potentiometric maps illustrating the direction of groundwater flow and calculation of the rate of groundwater flow (provided as **Figures 2-4** and summarized in **Section 3.2** and **Table 2**).
- Results of the required statistical analysis of groundwater monitoring results (summarized in **Section 3.3** and attached as **Appendix 1**);
- Results of ASDs (summarized in **Section 3.4** and attached as **Appendix 2**);
- A summary of any transition between monitoring programs or an alternate monitoring frequency (as described in **Section 3.4**);
- A summary of key actions completed, and, where applicable, a description of any problems encountered and actions taken to resolve those problems (as described in **Section 3.5**); and
- A projection of key activities for the upcoming year (refer to **Section 4.2**).

2.1 Site Description

The Big Sandy Plant is located approximately 4.5 miles north of the city of Louisa, Kentucky, along the Kentucky side of the Big Sandy River which forms the border with West Virginia. The facility operated two (2) surface impoundments for storing CCRs, both of which are now closed: the Bottom Ash Pond and the FAP. The FAP occupies approximately 130 acres and is located approximately 1.3 miles northwest of the Big Sandy Plant. The FAP currently receives wastewater from the Big Sandy Plant for discharge through a Kentucky Pollutant Discharge Elimination System permitted outfall.

The FAP was a valley impoundment with two (2) dams: the Main Dam (also historically referred to as the Horseford Creek Dam) in the northwest and Saddle Dam in the southeast. The FAP had a design capacity of approximately 12,000 acre-feet of storage at a maximum elevation of 705 feet above mean sea level (amsl). The FAP was constructed over three (3) phases. Stage I was completed between 1968 and 1970 and brought the crest elevation to 625 feet amsl. Stage II raised the crest elevation to 675 feet amsl between 1977 and 1978, which also included the construction of the Saddle Dam. Stage III was constructed incrementally between 1995 and 2010 to bring the final crest elevation to 711 feet amsl. (AEP, 2016a; Geosyntec, 2016)

Until 2015, when the Big Sandy Plant ceased burning coal and was refueled to burn natural gas, the FAP received sluiced fly ash and wastewater from the power plant via the Bottom Ash Pond. During its closure process, the contents of the Bottom Ash Pond were excavated and placed within the FAP. The Bottom Ash Pond was transitioned to closure status in accordance with 40 CFR 257.102 on 29 January 2020 (AEP, 2020). The FAP was transitioned to closure status in accordance with 40 CFR 257.102 on 07 October 2021 and the Notice of Closure Completion was issued on 05 November 2021 (AEP, 2021). The post-closure care period is 30 years.

The FAP was closed by closure-in-place in accordance with the Closure Plan for the unit (AEP, 2016b). The pond was incrementally dewatered and then capped with a low-permeability, flexible geomembrane and a 24-inch earthen layer to sustain vegetative growth and prevent erosion. The final cover is graded to prevent ponded water and to convey stormwater and discharged wastewater to the permitted outfall. (AEP, 2016b; AEP, 2016c)

2.2 Regional Physiographic Setting

The FAP is located in the Big Sandy Watershed (HUC 05070204), which comprises an area of approximately 400 square miles. Locally, the impoundment spans Horseford Creek and has a drainage area of approximately 675 acres (AEP, 2016a).

The near-surface hydrogeology of the region is generally categorized into two systems: an alluvial aquifer system of unconsolidated deposits, and an aquifer system in the fractures of the bedrock. The alluvial aquifer system typically consists of sand and gravel and occurs in present-day stream valleys. The bedrock mostly consists of repeated beds of fractured sandstone and limestone deposited during multiple sedimentary cycles. Groundwater elevations in the surrounding hills are generally higher than the former surface elevation of the FAP (Geosyntec, 2016).

2.3 Groundwater Monitoring System

There are five (5) background monitoring locations (MW-1011, -1012, -1203, -1604, and -1605) and five (5) compliance monitoring locations (MW-1601, -1602, -1603, -1606, and -1607), for a total of ten (10) monitoring wells in the network. Six (6) wells (MW-1011, -1012, -1203, -1601, -1602, and -1603) are screened in fractured sandstone and shale layers of the Breathitt formation. Four (4) wells (MW-1604 through -1607) are screened in the alluvium. The network meets the requirements of 40 CFR 257.91 (Geosyntec, 2016). A figure depicting the PE-certified

groundwater monitoring network, with the monitoring well locations and their corresponding identification numbers, is provided as **Figure 1**.

There were no monitoring wells installed or decommissioned in 2022. The network design, as summarized in the *Groundwater Monitoring Network Evaluation* (Geosyntec, 2016) and as posted to the CCR website for Big Sandy Plant, did not change.

2.4 History Under the Assessment Monitoring Program

Based on detection monitoring conducted in 2017 and 2018, SSIs over background were concluded for boron, calcium, chloride, fluoride, TDS, and sulfate at the FAP. An alternative source was not identified at the time, so the FAP initiated assessment monitoring in April 2018. Site-specific GWPS were set in accordance with 40 CFR 257.95(d)(2) and SSLs were identified for beryllium, cobalt, and lithium at MW-1603 (Geosyntec, 2019). The first ASD investigation was performed by EHS Support, which determined that SSLs identified for beryllium, cobalt, and lithium at MW-1603 were the result of the oxidation of coal seams that were intersected by the borehole and well screen for monitoring well MW-1603 (EHS Support, 2019a).

Additional ASD investigations were performed following the subsequent assessment monitoring statistical analyses. Each of these ASD reports concluded that the concentrations of Appendix IV constituents observed in the groundwater samples were the result of natural variations in groundwater (EHS Support, 2022b). Thus, the unit has remained in assessment monitoring through the end of 2022.

SECTION 3

2022 GROUNDWATER MONITORING

In general, the following key activities related to groundwater monitoring were completed in 2022:

- All monitoring wells that were installed and developed to establish a certified groundwater monitoring system around the CCR unit, in accordance with the requirements of 40 CFR 257.91 and documented in AEP's *Groundwater Monitoring Network Evaluation* (Geosyntec, 2016) were sampled pursuant to 40 CFR 257.95(b) in March 2022, pursuant to 40 CFR 257.95(d)(1) in June 2022, and pursuant to 40 CFR 257.95(d)(1) in October 2022. Further information on these sampling events is provided in **Section 3.1**.
- Groundwater monitoring data underwent various validation tests, including tests for completeness, valid values, transcription errors, and consistent units;
- Statistical analysis of the assessment monitoring data was conducted in accordance with AEP's *Statistical Analysis Plan* (Geosyntec, 2017) to establish GWPSs and to determine whether one or more Appendix IV constituents were detected at SSLs above the corresponding GWPSs in assessment monitoring samples collected during the October 2021 and the March and June 2022 sampling events. The corresponding statistical analyses were completed on 10 February 2022 and 03 October 2022, respectively. These statistical evaluations are discussed further in **Section 3.3** of this report. Statistical analyses of samples collected during the October 2022 sampling event will be completed in 2023;
- The statistical evaluation of data collected during the October 2021, March 2022, and June 2022 sampling events concluded that four (4) Appendix IV constituents were detected at SSLs above the corresponding GWPSs at MW-1603;
- Because Appendix IV constituents were found to be detected at SSLs above the corresponding GWPSs during the statistical evaluations for the October 2021 and the March and June 2022 sampling events, ASD studies were conducted. These ASD studies are discussed further in **Section 3.4** of this report.

3.1 Groundwater Quality Data

The sampling events in 2022 took place over the periods of 22-24 March 2022, 13-15 June 2022, and 10-12 October 2022. All samples collected during the March 2022 sampling event were analyzed for all constituents in Appendix IV of the CCR rules. Select samples were also analyzed for the Appendix III constituents. All samples collected during the June and October 2022 sampling event were analyzed for all Appendix III and Appendix IV constituents. All sampling and analyses were in accordance with the CCR rule*s,* AEP's *Groundwater Sampling and Analysis Plan* (AEP and EHS Support, 2016), and AEP's *Statistical Analysis Plan* (Geosyntec, 2017). The statistical process was guided by USEPA's *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance* ("Unified Guidance"; USEPA, 2009)

Table 1 contains the data analyzed from the samples collected during the assessment monitoring events in 2022, including the number of samples collected per well, and the sample collection date. **Table 1** also includes background data collected during eight background sampling events and previous detection and assessment monitoring data.

3.2 Groundwater Flow Rate and Direction

Groundwater flow conditions at the Site are generally consistent with site topography, with groundwater flowing from the hillsides surrounding the FAP and discharging into the Horseford Creek Valley. North of the Main Dam, it appears that groundwater from the Horseford Creek alluvium would flow into the Blaine Creek valley alluvium and eventually make its way into the surface water of the creek. (Geosyntec, 2016)

Static water elevation data and groundwater flow directions, in the form of potentiometric surface maps, from each monitoring event in the reporting period are shown in **Figures 2**, **3**, and **4**, respectively.

The groundwater velocity and monitoring well production rates are high enough at this facility that no modification to the semiannual assessment monitoring frequency is needed at this time. **Table 2** contains groundwater velocity data for each sampling event.

3.3 Statistical Analysis

Statistical analyses of data collected during the October 2021 sampling events for determination of SSLs or SSIs detected above (or outside of, for pH) the corresponding GWPS statistical limits were completed and documented in the 10 February 2022 *Statistical Analysis Summary* (Geosyntec, 2022a). Statistical analyses of data collected during the March and June 2022 sampling events for determination of SSLs or SSIs detected above (or outside, for pH) the corresponding GWPS statistical limits were completed and documented in the 13 October 2022 *Statistical Analysis Summary* (Geosyntec, 2022b). Both statistical analysis summary reports are provided in **Appendix 1** of this report. Statistical analyses of samples collected during the October 2022 sampling event will be completed in 2023.

The statistical evaluation of data collected during the October 2021 sampling event concluded that four (4) Appendix IV constituents were detected at SSLs above the corresponding GWPSs at monitoring well MW-1603 (i.e., beryllium, cobalt, combined radium, and lithium). The statistical evaluation of data collected during the March and June 2022 sampling events concluded that four (4) Appendix IV constituents were detected at SSLs above the corresponding GWPSs at the same well (i.e., beryllium, cobalt, combined radium, and lithium at monitoring well MW-1603).

Notices of Appendix IV constituents detected at SSLs above the GWPS were issued on 20 May 2022 and 11 November 2022 for the October 2021 and March and June 2022 sampling events, respectively. The notices were posted to the Big Sandy Plant's operating record as required by 40 CFR 257.95(g) and 40 CFR 257.105(h)(8).

3.4 Alternative Source Demonstration

EHS Support prepared the *Alternative Source Demonstration Addendum Report for the October 2021 Monitoring Data* (EHS Support, 2022a) to demonstrate that a source other than the CCR unit caused the SSLs detected in samples collected during the October 2021 sampling event, or that the SSLs resulted from errors in sampling, analysis, statistical evaluation, or natural variations in groundwater quality. The evaluation to support the ASD included an assessment of site and regional geochemistry along with historical data for the FAP.

EHS Support prepared the *Alternative Source Demonstration Addendum Report for the March and June 2022 Monitoring Data* (EHS Support, 2022b) to demonstrate that a source other than the CCR unit caused the SSLs detected in samples collected during the March and June 2022 sampling events, or that the SSLs resulted from errors in sampling, analysis, statistical evaluation, or natural variations in groundwater quality. The evaluation to support the ASD included an assessment of site and regional geochemistry along with historical data for the FAP.

The ASD reports concluded that the elevated concentrations of beryllium, cobalt, combined radium, and lithium in MW-1603 are due to the well being screened across highly organic layers of rock with a coal-like texture that results in groundwater samples with a much lower pH than any other compliance well in the groundwater monitoring network. Because the ASDs were successful in demonstrating that the Appendix IV SSLs detected in samples collected from monitoring well MW-1603 were not derived from the CCR constituents within the FAP, the assessment monitoring program was continued, and no transition between monitoring requirements occurred in 2022. The FAP would return to a detection monitoring program if all Appendix III and IV constituents were below background values for two consecutive monitoring events. The ASD reports are included in **Appendix 2**.

3.5 Problems Encountered and Resolutions

No significant problems were encountered during the 2022 reporting period.

SECTION 4

CURRENT STATUS AND 2023 KEY ACTIVITIES

4.1 Current Status

The FAP CCR unit at the Big Sandy Plant remained in assessment monitoring during the 2022 reporting period and is anticipated to remain in assessment monitoring for the 2023 reporting period.

4.2 Planned Key Activities for 2023

Key activities for 2023 will include the following:

- Continue assessment monitoring sampling of CCR wells for all Appendix IV constituents annually pursuant to 40 CFR 257.95(b) and semiannually, pursuant to 40 CFR 257.95(d)(1) for all Appendix III constituents and those Appendix IV constituents detected during the previous sampling performed pursuant to 40 CFR 257.95(b);
- Continue establishment of GWPS statistical limits for all Appendix IV constituents and statistical comparison of Appendix IV concentrations in downgradient monitoring wells to those standards;
- If an SSL is identified at a downgradient well that is not demonstrated to be due to a source other than the CCR unit or resulting from errors in sampling, analysis, statistical evaluation, or natural variations in groundwater quality by a successful ASD, undertake all activities as required pursuant to 40 CFR 257.95(g).

SECTION 5

REFERENCES

AEP. 2016a. *History of Construction, CFR 257.73(c)(1), Fly Ash Pond, Big Sandy Plant, Louisa, Kentucky.* October.

AEP. 2016b. *Closure Plan, CFR 257.102(b), Fly Ash Pond, Big Sandy Plant, Louisa, Kentucky.* October.

AEP. 2016c. *Post Closure Plan, CFR 257.104(d), Fly Ash Pond, Big Sandy Plant, Louisa, Kentucky.* October. Revised January 2022.

AEP. 2020. *Notice of Completion of Closure, Big Sandy Plant, Bottom Ash Pond.* February 28. Revision 1.

AEP. 2021. *Closure Completion Notice, Big Sandy Plant, Fly Ash Pond.* November 4.

AEP. 2022. *Annual Groundwater Monitoring Report, Kentucky Power Company Big Sandy Plant, Fly Ash Pond CCR Management Unit, Louisa, Kentucky.* January.

AEP and EHS Support. 2016. *Groundwater Sampling and Analysis Plan*. October.

EHS Support. 2019. *Alternative Source Demonstration Report for Beryllium, Cobalt, and Lithium, Big Sandy Fly Ash Pond, Louisa, Kentucky*. February.

EHS Support. 2022a. *Alternative Source Demonstration Addendum Report for the March and June 2022 Monitoring Data, Big Sandy Fly Ash Pond, Louisa, Kentucky.* March.

EHS Support. 2022b. *Alternative Source Demonstration Addendum Report for the October 2021 Monitoring Data, Big Sandy Fly Ash Pond, Louisa, Kentucky.* December.

Geosyntec. 2016. *Groundwater Monitoring Network Evaluation*. December.

Geosyntec. 2017. *Statistical Analysis Plan.* January.

Geosyntec. 2019. *Statistical Analysis Summary, Fly Ash Pond, Big Sandy Plant, Louisa, Kentucky.* February 10.

Geosyntec. 2022a. *Statistical Analysis Summary, Fly Ash Pond, Big Sandy Plant, Louisa, Kentucky.* January 8.

Geosyntec. 2022b. *Statistical Analysis Summary, Fly Ash Pond, Big Sandy Plant, Louisa, Kentucky.* October 13.

USEPA. 2009. *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance* ("Unified Guidance"). March.

TABLES

Table 1 - Groundwater Data Summary: MW-1011
Big Sandy - FAP
Appendix III Constituents

Collection Date	Monitoring Program	Boron	Calcium	Chloride	Fluoride	pH	Sulfate	Total Dissolved Solids
		mg/L	mg/L	mg/L	mg/L	SU	mg/L	mg/L
9/27/2016	Background	0.071	79.1	3.39	0.19	7.0	79.5	388
11/9/2016	Background	0.081	74.6	3.43	0.21	7.0	74.4	360
1/12/2017	Background	0.103	75.4	2.83	0.25	6.9	72.8	363
2/21/2017	Background	0.098	75.8	2.68	0.21	7.1	72.5	371
4/25/2017	Background	0.148	78.0	2.71	0.23	6.7	74.7	358
5/24/2017	Background	0.156	85.2	2.86	0.20	6.7	73.8	370
6/21/2017	Background	0.129	72.6	2.19	0.22	6.7	69.4	338
7/13/2017	Background	0.111	78.1	2.31	0.21	7.1	78.2	371
9/18/2017	Detection	0.146	80.1	2.85	0.18	6.9	78.0	372
4/26/2018	Assessment	0.139	105	4.71	0.20	6.3	106	456
9/20/2018	Assessment	0.165	72.7	3.43	0.28	7.0	76.3	386
3/13/2019	Assessment	0.101	80.5	5.22	0.24	6.5	84.2	411
6/27/2019	Assessment	0.119	75.3	4.20	0.27	7.0	75.2	386
8/21/2019	Assessment	0.117	86.2	4.41	0.26	7.1	76.2	385
3/17/2020	Assessment	--	--	--	0.24	7.5	--	--
6/29/2020	Assessment	0.111	82.8	5.10	0.24	6.9	82.8	--
8/26/2020	Assessment	--	--	--	--	4.3	--	443
10/5/2020	Assessment	0.105	82.7	4.86	0.26	7.2	81.5	388
3/9/2021	Assessment	--	--	--	0.29	6.9	--	--
6/9/2021	Assessment	0.092	81.2	5.02	0.28	6.8	82.0	380
10/5/2021	Assessment	0.118	79.0	3.74	0.28	6.9	78.1	380
3/23/2022	Assessment	0.052	123 M1, P3	6.11	0.23	8.1	80.8	380
6/13/2022	Assessment	0.105	82.4	4.02	0.26	7.6	85.1	390
10/10/2022	Assessment	0.117	80.4	3.17	0.26	6.8	81.4	390

Notes:
mg/L: milligrams per liter
SU: standard unit
<: Non-detect value. Analytes which were not detected are shown as less than the method detection limit (MDL) followed by a 'U1' flag.
In analytical data prior to 5/18/2021, U1 flags were reported as U in the analytical report.
- -: Not analyzed
J1: Concentration estimated. Analyte was detected between the method detection limit and the reporting limit.
In analytical data prior to 5/18/2021, J1 flags were reported as J in the analytical report.
M1: The associated matrix spike (MS) or matrix spike duplicate (MSD) was above acceptance limits.
L1: The associated laboratory control sample (LSC) or laboratory control sample duplicate (LCSD) recovery was outside acceptance limits.
P3: The precision on the matrix spike duplicate (MSD) was above acceptance limits.
S7: Sample did not achieve constant weight.
S12: Residue weight is below the method criteria but was already analyzed with 100mL.

Table 1 - Groundwater Data Summary: MW-1011
Big Sandy - FAP
Appendix IV Constituents

Geosyntec Consultants, Inc.

Collection Date	Monitoring Program	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Combined Radium	Fluoride	Lead	Lithium	Mercury	Molybdenum	Selenium	Thallium
		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	pCi/L	mg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L
9/27/2016	Background	1.01	17.8	52.0	< 0.005 U1	0.02	0.5	2.85	2.56	0.19	0.214	0.011	< 0.002 U1	1.80	0.09 J1	0.229
11/9/2016	Background	0.75	9.93	48.1	< 0.005 U1	0.02 J1	0.744	1.12	3.56	0.21	0.297	0.017	< 0.002 U1	1.51	0.07 J1	0.162
1/12/2017	Background	0.36	10.5	47.7	< 0.005 U1	0.01 J1	0.369	1.47	5.24	0.25	0.026	0.009	< 0.002 U1	1.39	0.03 J1	0.160
2/21/2017	Background	0.28	11.1	49.5	< 0.005 U1	0.008 J1	0.189	1.09	3.43	0.21	0.024	0.016	< 0.002 U1	1.21	< 0.03 U1	0.153
4/25/2017	Background	0.26	11.9	53.0	< 0.004 U1	0.01 J1	0.223	1.23	2.65	0.23	0.035	0.003	< 0.002 U1	1.23	< 0.03 U1	0.102
5/24/2017	Background	0.22	9.46	54.7	< 0.004 U1	0.008 J1	0.318	1.15	2.566	0.20	0.020	0.005	< 0.002 U1	0.99	< 0.03 U1	0.134
6/21/2017	Background	0.24	5.57	45.7	< 0.004 U1	0.006 J1	0.294	0.413	2.576	0.22	0.01 J1	0.014	0.004 J1	1.34	0.05 J1	0.098
7/13/2017	Background	0.24	5.92	46.0	< 0.004 U1	0.01 J1	0.223	0.444	2.353	0.21	0.054	0.010	< 0.002 U1	1.39	0.03 J1	0.091
4/26/2018	Assessment	0.16	13.5	63.1	< 0.004 U1	< 0.005 U1	0.207	3.25	5.69	0.20	0.095	0.010	< 0.002 U1	0.82	< 0.03 U1	0.121
9/20/2018	Assessment	0.18	7.25	44.8	< 0.02 U1	< 0.01 U1	0.588	0.683	2.56	0.28	0.08	0.009	--	0.8	< 0.03 U1	< 0.1 U1
10/23/2018	Assessment	--	--	--	--	--	--	--	--	--	--	--	< 0.002 U1	--	--	--
3/13/2019	Assessment	0.15	7.53	49.2	< 0.02 U1	< 0.01 U1	0.576	0.709	2.425	0.24	0.217	0.02 J1	< 0.002 U1	0.9 J1	< 0.03 U1	< 0.1 U1
6/27/2019	Assessment	0.15	5.17	47.5	< 0.02 U1	< 0.01 U1	0.304	0.438	2.582	0.27	0.181	< 0.009 U1	< 0.002 U1	0.7 J1	< 0.03 U1	< 0.1 U1
8/21/2019	Assessment	0.18	5.31	49.2	< 0.02 U1	0.01 J1	0.341	0.421	2.54	0.26	0.1 J1	0.00973	< 0.002 U1	0.7 J1	< 0.03 U1	< 0.1 U1
3/17/2020	Assessment	0.14	6.96	51.5	< 0.02 U1	< 0.01 U1	0.253	0.724	4.44	0.24	< 0.05 U1	0.00871	< 0.002 U1	0.7 J1	< 0.03 U1	< 0.1 U1
6/29/2020	Assessment	0.18	6.72	49.2	< 0.02 U1	0.01 J1	0.203	0.339	3.02	0.24	0.05 J1	0.00993	< 0.002 U1	0.8 J1	0.06 J1	< 0.1 U1
10/5/2020	Assessment	0.18	5.31	46.3	< 0.02 U1	< 0.01 U1	0.09 J1	0.321	2.57	0.26	< 0.05 U1	0.00926	< 0.002 U1	0.8 J1	0.04 J1	< 0.1 U1
3/9/2021	Assessment	0.14	7.71	50.0	< 0.007 U1	< 0.004 U1	0.481	0.438	2.81	0.29	0.06 J1	0.00977	< 0.002 U1	0.7 J1	< 0.09 U1	0.06 J1
6/9/2021	Assessment	0.17	4.84	46.4	< 0.007 U1	0.012 J1	0.35	0.452	4.09	0.28	0.10 J1	0.00852	< 0.002 U1	0.8	< 0.09 U1	0.06 J1
10/5/2021	Assessment	0.19	4.42	46.1	< 0.007 U1	0.012 J1	0.22	0.305	3.19	0.28	0.10 J1	0.00987	< 0.002 U1	0.9	< 0.09 U1	0.06 J1
3/23/2022	Assessment	0.37	19.3	57.5	0.007 J1	0.007 J1	0.36	1.12	3.69	0.23	0.15 J1	0.0106	< 0.002 U1	0.7	< 0.09 U1	0.06 J1
6/13/2022	Assessment	0.16	3.55	47.2	< 0.007 U1	< 0.004 U1	0.21	0.284	3.29	0.26	< 0.05 U1	0.00948	< 0.002 U1	0.9	< 0.09 U1	0.06 J1
10/10/2022	Assessment	0.13	3.68	44.0	< 0.007 U1	< 0.004 U1	0.30	0.223	2.73	0.26	< 0.05 U1	0.0111	< 0.004 U1	0.8	< 0.09 U1	0.04 J1

Notes:
µg/L: micrograms per liter
mg/L: milligrams per liter
pCi/L: picocuries per liter
<: Non-detect value. Analytes which were not detected are shown as less than the method detection limit (MDL) followed by a 'U1' flag. In analytical data prior to 5/18/2021, U1 flags were reported as U in the analytical report.
- -: Not analyzed
J1: Concentration estimated. Analyte was detected between the method detection limit and the reporting limit. In analytical data prior to 5/18/2021, J1 flags were reported as J in the analytical report.
M1: The associated matrix spike (MS) or matrix spike duplicate (MSD) was above acceptance limits.
L1: The associated laboratory control sample (LSC) or laboratory control sample duplicate (LCSD) recovery was outside acceptance limits.
P3: The precision on the matrix spike duplicate (MSD) was above acceptance limits.
S7: Sample did not achieve constant weight.
S12: Residue weight is below the method criteria but was already analyzed with 100mL.

Table 1 - Groundwater Data Summary: MW-1012
Big Sandy - FAP
Appendix III Constituents

Collection Date	Monitoring Program	Boron	Calcium	Chloride	Fluoride	pH	Sulfate	Total Dissolved Solids
		mg/L	mg/L	mg/L	mg/L	SU	mg/L	mg/L
9/27/2016	Background	0.176	1.48	1.19	0.71	8.9	35.2	547
11/9/2016	Background	0.159	1.21	1.15	0.70	9.1	35.6	535
1/12/2017	Background	0.182	1.19	1.24	0.73	9.1	40.1	553
2/22/2017	Background	0.171	1.45	1.14	0.68	9.4	36.8	554
4/26/2017	Background	0.183	1.20	1.17	0.71	8.7	37.4	546
5/24/2017	Background	0.244	1.20	1.24	0.71	8.8	36.8	540
6/22/2017	Background	0.174	1.07	1.14	0.64	8.9	38.1	547
7/13/2017	Background	0.172	1.16	1.12	0.66	9.0	38.0	558
9/19/2017	Detection	0.205	1.11	1.10	0.67	9.1	38.5	546
4/26/2018	Assessment	0.227	1.13	1.34	0.82	9.0	36.6	541
9/20/2018	Assessment	0.236	1.11	1.27	0.75	9.1	36.6	561
3/13/2019	Assessment	0.189	1.15	1.26	0.73	8.8	35.6	572
6/25/2019	Assessment	0.169	1.10	1.19	0.74	9.3	35.9	559
8/21/2019	Assessment	0.176	1.38	1.26	0.79	9.4	36.8	583
3/18/2020	Assessment	--	--	--	0.76	10.9	--	--
6/30/2020	Assessment	0.181	1.72	5.21	0.72	9.2	36.7	--
8/27/2020	Assessment	--	--	--	--	9.3	--	582
10/6/2020	Assessment	0.175	1.37	1.32	0.68	9.2	37.0	577
3/10/2021	Assessment	--	--	--	0.85	9.0	--	--
6/9/2021	Assessment	0.174	1.2	1.32	0.80	9.3	35.4	550
10/6/2021	Assessment	0.192	1.2	1.40	0.80	9.2	33.5	570
3/24/2022	Assessment	--	--	--	0.82	8.7	--	--
6/15/2022	Assessment	0.237	1.46	1.41	0.77	10.3	38.6	570
10/12/2022	Assessment	0.196	1.53	1.35	0.76	8.7	38.7	550

Notes:
mg/L: milligrams per liter
SU: standard unit
<: Non-detect value. Analytes which were not detected are shown as less than the method detection limit (MDL) followed by a 'U1' flag.
In analytical data prior to 5/18/2021, U1 flags were reported as U in the analytical report.
- -: Not analyzed
J1: Concentration estimated. Analyte was detected between the method detection limit and the reporting limit.
In analytical data prior to 5/18/2021, J1 flags were reported as J in the analytical report.
M1: The associated matrix spike (MS) or matrix spike duplicate (MSD) was above acceptance limits.
L1: The associated laboratory control sample (LSC) or laboratory control sample duplicate (LCSD) recovery was outside acceptance limits.
P3: The precision on the matrix spike duplicate (MSD) was above acceptance limits.
S7: Sample did not achieve constant weight.
S12: Residue weight is below the method criteria but was already analyzed with 100mL.

Table 1 - Groundwater Data Summary: MW-1012
Big Sandy - FAP
Appendix IV Constituents

Geosyntec Consultants, Inc.

Collection Date	Monitoring Program	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Combined Radium	Fluoride	Lead	Lithium	Mercury	Molybdenum	Selenium	Thallium
		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	pCi/L	mg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L
9/27/2016	Background	0.79	24.0	37.6	0.044	0.05	1.1	0.346	1.592	0.71	1.84	0.006	< 0.002 U1	3.25	0.2	0.03 J1
11/9/2016	Background	1.20	28.9	24.4	0.027	0.04	0.903	0.113	0.548	0.70	0.872	0.014	0.002 J1	1.68	0.05 J1	0.02 J1
1/12/2017	Background	0.79	24.7	23.8	0.01 J1	0.04	0.395	0.066	0.542	0.73	0.439	0.008	< 0.002 U1	1.12	0.04 J1	0.02 J1
2/22/2017	Background	0.99	28.8	29.5	0.026	0.14	0.578	0.184	0.452	0.68	1.17	0.009	0.002 J1	1.52	0.07 J1	0.04 J1
4/26/2017	Background	0.89	22.9	29.9	0.025	0.02	0.512	0.131	0.148	0.71	0.632	0.004	0.003 J1	1.25	0.04 J1	0.02 J1
5/24/2017	Background	0.97	23.2	23.7	0.01 J1	0.01 J1	7.84	0.078	1.72	0.71	0.334	< 0.0002 U1	0.004 J1	1.41	0.07 J1	0.01 J1
6/22/2017	Background	0.91	21.6	21.1	0.008 J1	0.007 J1	0.293	0.046	0.3575	0.64	0.261	0.018	< 0.002 U1	1.18	0.04 J1	0.02 J1
7/13/2017	Background	0.96	22.1	25.7	0.022	0.008 J1	0.449	0.102	1.301	0.66	0.546	0.004	< 0.002 U1	1.43	0.09 J1	0.02 J1
4/26/2018	Assessment	0.65	15.8	24.1	0.01 J1	0.006 J1	0.262	0.062	1.135	0.82	0.287	0.006	0.003 J1	0.89	0.05 J1	0.02 J1
9/20/2018	Assessment	0.62	14.0	24.2	0.02	< 0.01 U1	0.442	0.079	0.291	0.75	0.346	< 0.009 U1	0.013	0.8	0.08 J1	< 0.1 U1
3/13/2019	Assessment	0.60	15.2	27.2	0.03 J1	< 0.01 U1	0.459	0.106	0.3959	0.73	0.354	0.01 J1	< 0.004 U1	0.9 J1	0.09 J1	< 0.1 U1
6/25/2019	Assessment	0.67	13.4	28.0	0.03 J1	< 0.01 U1	0.252	0.097	0.506	0.74	0.352	< 0.009 U1	< 0.002 U1	0.8 J1	0.08 J1	< 0.1 U1
8/21/2019	Assessment	0.77	19.0	41.9	0.06 J1	< 0.01 U1	0.625	0.260	0.354	0.79	0.924	0.00536	< 0.002 U1	1 J1	0.3	< 0.1 U1
3/18/2020	Assessment	0.60	19.6	61.7	0.130	0.01 J1	0.850	0.519	3.47	0.76	1.97	0.00588	0.002 J1	1 J1	0.3	< 0.1 U1
6/30/2020	Assessment	0.58	19.1	68.2	0.116	0.01 J1	0.912	0.527	2.62	0.72	1.86	0.00593	0.002 J1	1 J1	0.4	< 0.1 U1
10/6/2020	Assessment	0.89	23.0	34.7	0.06 J1	0.02 J1	0.468	0.229	1.04	0.68	0.851	0.00531	< 0.002 U1	1 J1	0.2 J1	< 0.1 U1
3/10/2021	Assessment	0.76	21.2	30.5	0.03 J1	0.01 J1	0.489	0.159	0.815	0.85	0.629	0.00552	0.002 J1	2.87	0.1 J1	< 0.04 U1
6/9/2021	Assessment	0.74	18.6	30.6	0.024 J1	0.014 J1	0.44	0.117	0.58	0.80	0.47	0.00540	< 0.002 U1	1.6	< 0.09 U1	< 0.04 U1
10/6/2021	Assessment	0.77	17.8	30.5	0.026 J1	0.010 J1	0.25	0.113	0.98	0.80	0.48	0.00564	< 0.002 U1	1.8	< 0.09 U1	0.05 J1
3/24/2022	Assessment	1.52	49.9	32.6	0.018 J1	0.012 J1	0.24	0.124	1.31	0.82	0.41	0.00552	< 0.002 U1	5.5	< 0.09 U1	< 0.04 U1
6/15/2022	Assessment	1.14	45.4	28.2	0.013 J1	0.012 J1	0.52	0.084	0.50	0.77	2.4	0.00493	< 0.002 U1	4.0	0.12 J1	0.05 J1
10/12/2022	Assessment	1.08	38.6	31.2	0.016 J1	0.018 J1	0.43	0.102	2.37	0.76	0.54	0.00534	< 0.002 U1	2.9	< 0.09 U1	< 0.04 U1

Notes:
µg/L: micrograms per liter
mg/L: milligrams per liter
pCi/L: picocuries per liter
<: Non-detect value. Analytes which were not detected are shown as less than the method detection limit (MDL) followed by a 'U1' flag. In analytical data prior to 5/18/2021, U1 flags were reported as U in the analytical report.
- -: Not analyzed
J1: Concentration estimated. Analyte was detected between the method detection limit and the reporting limit. In analytical data prior to 5/18/2021, J1 flags were reported as J in the analytical report.
M1: The associated matrix spike (MS) or matrix spike duplicate (MSD) was above acceptance limits.
L1: The associated laboratory control sample (LSC) or laboratory control sample duplicate (LCSD) recovery was outside acceptance limits.
P3: The precision on the matrix spike duplicate (MSD) was above acceptance limits.
S7: Sample did not achieve constant weight.
S12: Residue weight is below the method criteria but was already analyzed with 100mL.

Table 1 - Groundwater Data Summary: MW-1203
Big Sandy - FAP
Appendix III Constituents

Collection Date	Monitoring Program	Boron	Calcium	Chloride	Fluoride	pH	Sulfate	Total Dissolved Solids
		mg/L	mg/L	mg/L	mg/L	SU	mg/L	mg/L
9/26/2016	Background	0.097	60.5	5.72	0.15	7.8	28.4	261
11/9/2016	Background	0.088	56.8	5.35	0.13	6.9	26.5	273
1/12/2017	Background	0.110	59.9	5.69	0.13	7.0	33.4	278
2/21/2017	Background	0.092	55.8	5.23	0.12	7.0	30.2	248
4/26/2017	Background	0.122	55.6	5.18	0.12	6.6	29.0	265
5/23/2017	Background	0.160	55.6	5.08	0.12	6.5	29.6	279
6/21/2017	Background	0.137	62.3	4.74	0.11	6.7	28.0	264
7/13/2017	Background	0.089	56.7	5.05	0.10	6.7	33.0	261
9/18/2017	Detection	0.116	57.0	4.92	0.13	6.8	29.3	255
4/26/2018	Assessment	0.147	57.4	5.66	0.14	6.0	37.5	253
9/20/2018	Assessment	0.125	53.4	5.37	0.12	6.7	32.3	253
3/14/2019	Assessment	0.09 J1	54.9	5.53	0.11	6.2	38.7	259
6/27/2019	Assessment	0.1 J1	54.3	5.28	0.12	6.8	39.0	273
8/21/2019	Assessment	0.097	60.8	5.14	0.13	7.0	32.4	283
3/17/2020	Assessment	--	--	--	0.12	7.4	--	--
6/30/2020	Assessment	0.104	64.9	5.17	0.12	6.7	30.6	--
8/27/2020	Assessment	--	--	--	--	6.9	--	263
10/5/2020	Assessment	0.100	64.2	5.24	0.14	7.1	30.4	266
3/9/2021	Assessment	--	--	--	0.15	6.7	--	--
6/9/2021	Assessment	0.096	57.8	5.32	0.15	6.6	29.4	260
10/6/2021	Assessment	0.099	59.1	5.13	0.14	6.9	27.8	270
3/23/2022	Assessment	0.098	60.2	5.40	0.12	8.9	42.9	260
6/13/2022	Assessment	0.10	59.4	4.95	0.13	7.6	28.4	290 S7
10/10/2022	Assessment	0.099	59.4	4.91	0.12	6.0	28.7	260

Notes:
mg/L: milligrams per liter
SU: standard unit
<: Non-detect value. Analytes which were not detected are shown as less than the method detection limit (MDL) followed by a 'U1' flag.
In analytical data prior to 5/18/2021, U1 flags were reported as U in the analytical report.
- -: Not analyzed
J1: Concentration estimated. Analyte was detected between the method detection limit and the reporting limit.
In analytical data prior to 5/18/2021, J1 flags were reported as J in the analytical report.
M1: The associated matrix spike (MS) or matrix spike duplicate (MSD) was above acceptance limits.
L1: The associated laboratory control sample (LSC) or laboratory control sample duplicate (LCSD) recovery was outside acceptance limits.
P3: The precision on the matrix spike duplicate (MSD) was above acceptance limits.
S7: Sample did not achieve constant weight.
S12: Residue weight is below the method criteria but was already analyzed with 100mL.

Table 1 - Groundwater Data Summary: MW-1203
Big Sandy - FAP
Appendix IV Constituents

Geosyntec Consultants, Inc.

Collection Date	Monitoring Program	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Combined Radium	Fluoride	Lead	Lithium	Mercury	Molybdenum	Selenium	Thallium
		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	pCi/L	mg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L
9/26/2016	Background	0.02 J1	0.26	95.3	0.022	< 0.004 U1	0.4	1.04	1.334	0.15	0.103	0.011	< 0.002 U1	0.21	0.04 J1	0.01 J1
11/9/2016	Background	0.03 J1	0.43	110	0.126	0.009 J1	1.50	1.04	1.473	0.13	1.28	0.017	< 0.002 U1	0.28	0.2	0.02 J1
1/12/2017	Background	0.03 J1	0.42	102	0.089	< 0.004 U1	0.718	1.15	1.657	0.13	0.748	0.014	< 0.002 U1	0.15	0.2	0.03 J1
2/21/2017	Background	0.02 J1	0.39	94.8	0.077	< 0.004 U1	0.365	0.989	2.509	0.12	0.509	0.017	< 0.002 U1	0.20	0.1	0.063
4/26/2017	Background	0.03 J1	0.45	113	0.099	< 0.005 U1	0.648	1.05	1.293	0.12	0.697	0.009	< 0.002 U1	0.20	0.2	0.02 J1
5/23/2017	Background	0.05 J1	0.61	99.9	0.149	< 0.005 U1	0.960	1.07	3.44	0.12	1.22	0.020	0.002 J1	0.15	0.3	0.02 J1
6/21/2017	Background	0.04 J1	0.63	101	0.116	< 0.005 U1	0.422	0.994	3.224	0.11	0.793	0.020	< 0.002 U1	0.62	0.3	0.03 J1
7/13/2017	Background	0.02 J1	0.44	93.8	0.062	< 0.005 U1	0.377	1.16	1.707	0.10	0.312	0.011	< 0.002 U1	0.59	0.05 J1	0.01 J1
4/26/2018	Assessment	0.03 J1	0.30	89.1	0.033	< 0.005 U1	0.171	0.886	2.476	0.14	0.034	0.013	< 0.002 U1	0.12	< 0.03 U1	0.03 J1
9/20/2018	Assessment	0.03 J1	0.51	90.1	0.08	< 0.01 U1	0.240	0.916	1.252	0.12	0.05	0.01	--	< 0.4 U1	< 0.03 U1	< 0.1 U1
10/22/2018	Assessment	--	--	--	--	--	--	--	--	--	--	--	< 0.002 U1	--	--	--
3/14/2019	Assessment	0.03 J1	0.23	88.0	0.02 J1	< 0.01 U1	0.391	0.953	1.399	0.11	0.124	< 0.009 U1	< 0.004 U1	< 0.4 U1	< 0.03 U1	< 0.1 U1
6/27/2019	Assessment	< 0.02 U1	0.34	86.8	0.06 J1	< 0.01 U1	0.1 J1	0.909	1.341	0.12	0.1 J1	0.01 J1	< 0.002 U1	< 0.4 U1	< 0.03 U1	< 0.1 U1
8/21/2019	Assessment	< 0.02 U1	0.27	95.4	0.04 J1	< 0.01 U1	0.304	0.774	1.471	0.13	0.06 J1	0.0118	< 0.002 U1	< 0.4 U1	< 0.03 U1	< 0.1 U1
3/17/2020	Assessment	0.02 J1	0.35	91.0	0.06 J1	< 0.01 U1	0.265	0.859	7.524	0.12	0.08 J1	0.0130	< 0.002 U1	< 0.4 U1	< 0.03 U1	< 0.1 U1
6/30/2020	Assessment	0.02 J1	0.47	101	0.08 J1	< 0.01 U1	0.1 J1	0.547	2.29	0.12	0.1 J1	0.0121	< 0.002 U1	< 0.4 U1	< 0.03 U1	< 0.1 U1
10/5/2020	Assessment	0.02 J1	0.59	94.6	0.08 J1	< 0.01 U1	0.2 J1	0.672	1.539	0.14	0.212	0.0114	< 0.002 U1	< 0.4 U1	< 0.03 U1	< 0.1 U1
3/9/2021	Assessment	< 0.02 U1	0.39	93.9	0.05 J1	< 0.004 U1	0.390	0.849	1.287	0.15	0.2 J1	0.0120	< 0.002 U1	< 0.1 U1	< 0.09 U1	< 0.04 U1
6/9/2021	Assessment	0.03 J1	0.22	89.5	0.037 J1	< 0.004 U1	0.11 J1	0.603	1.98	0.15	0.06 J1	0.0109	< 0.002 U1	< 0.1 U1	< 0.09 U1	< 0.04 U1
10/6/2021	Assessment	0.02 J1	0.23	92.7	0.041 J1	< 0.004 U1	0.11 J1	0.677	2.10	0.14	0.08 J1	0.0122	< 0.002 U1	< 0.1 U1	< 0.09 U1	< 0.04 U1
3/23/2022	Assessment	< 0.02 U1	0.24	89.4	0.041 J1	< 0.004 U1	0.13 J1	0.885	3.33	0.12	0.05 J1	0.0137	< 0.002 U1	0.1 J1	< 0.09 U1	< 0.04 U1
6/13/2022	Assessment	0.03 J1	0.32	96.8	0.090	< 0.004 U1	0.09 J1	0.577	1.63	0.13	0.11 J1	0.0132	< 0.002 U1	< 0.1 U1	< 0.09 U1	< 0.04 U1
10/10/2022	Assessment	0.04 J1	0.58	99.6	0.171	< 0.004 U1	0.31	0.651	1.27	0.12	0.09 J1	0.0127	< 0.004 U1	< 0.1 U1	< 0.09 U1	< 0.04 U1

Notes:
µg/L: micrograms per liter
mg/L: milligrams per liter
pCi/L: picocuries per liter
<: Non-detect value. Analytes which were not detected are shown as less than the method detection limit (MDL) followed by a 'U1' flag. In analytical data prior to 5/18/2021, U1 flags were reported as U in the analytical report.
- -: Not analyzed
J1: Concentration estimated. Analyte was detected between the method detection limit and the reporting limit. In analytical data prior to 5/18/2021, J1 flags were reported as J in the analytical report.
M1: The associated matrix spike (MS) or matrix spike duplicate (MSD) was above acceptance limits.
L1: The associated laboratory control sample (LSC) or laboratory control sample duplicate (LCSD) recovery was outside acceptance limits.
P3: The precision on the matrix spike duplicate (MSD) was above acceptance limits.
S7: Sample did not achieve constant weight.
S12: Residue weight is below the method criteria but was already analyzed with 100mL.

Table 1 - Groundwater Data Summary: MW-1601
Big Sandy - FAP
Appendix III Constituents

Collection Date	Monitoring Program	Boron	Calcium	Chloride	Fluoride	pH	Sulfate	Total Dissolved Solids
		mg/L	mg/L	mg/L	mg/L	SU	mg/L	mg/L
9/27/2016	Background	0.317	63.0	25.6	0.32	7.6	122	448
11/9/2016	Background	0.263	55.7	31.2	0.33	7.3	120	438
1/12/2017	Background	0.283	63.5	25.0	0.32	7.5	128	474
2/22/2017	Background	0.241	61.0	23.9	0.29	7.4	111	430
4/26/2017	Background	0.216	50.9	23.8	0.33	6.9	97.4	372
5/24/2017	Background	0.240	55.9	21.5	0.29	7.0	91.7	370
6/22/2017	Background	0.196	47.5	21.0	0.27	7.3	90.6	367
7/13/2017	Background	0.175	51.3	17.4	0.27	7.1	84.6	364
9/18/2017	Detection	0.183	51.5	15.8	0.29	7.2	82.7	362
1/31/2018	Detection	--	--	15.4	--	7.5	84.4	--
4/25/2018	Assessment	0.177	50.4	15.2	0.36	6.9	72.6	326
9/20/2018	Assessment	0.196	68.8	16.1	0.22	7.1	167	448
3/12/2019	Assessment	0.117	54.3	9.09	0.18	6.3	88.5	316
6/25/2019	Assessment	0.1 J1	50.7	8.23	0.15	7.0	86.4	312
8/21/2019	Assessment	0.097	52.1	8.43	0.15	7.1	82.9	326
3/18/2020	Assessment	--	--	--	0.17	8.3	--	--
3/9/2021	Assessment	--	--	--	0.18	6.8	--	--
6/9/2021	Assessment	0.109	62.5	6.58	0.18	6.8	98.0	340
10/6/2021	Assessment	0.069	59.7	3.00	0.24	7.1	105	360
3/22/2022	Assessment	--	--	--	0.16	7.9	--	--
6/15/2022	Assessment	0.119	70.2	3.95	0.17	8.3	96.0	340
10/10/2022	Assessment	0.067	59.0	3.19	0.18	6.9	110	350

Notes:
mg/L: milligrams per liter
SU: standard unit
<: Non-detect value. Analytes which were not detected are shown as less than the method detection limit (MDL) followed by a 'U1' flag.
In analytical data prior to 5/18/2021, U1 flags were reported as U in the analytical report.
- -: Not analyzed
J1: Concentration estimated. Analyte was detected between the method detection limit and the reporting limit.
In analytical data prior to 5/18/2021, J1 flags were reported as J in the analytical report.
M1: The associated matrix spike (MS) or matrix spike duplicate (MSD) was above acceptance limits.
L1: The associated laboratory control sample (LSC) or laboratory control sample duplicate (LCSD) recovery was outside acceptance limits.
P3: The precision on the matrix spike duplicate (MSD) was above acceptance limits.
S7: Sample did not achieve constant weight.
S12: Residue weight is below the method criteria but was already analyzed with 100mL.

Table 1 - Groundwater Data Summary: MW-1601
Big Sandy - FAP
Appendix IV Constituents

Geosyntec Consultants, Inc.

Collection Date	Monitoring Program	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Combined Radium	Fluoride	Lead	Lithium	Mercury	Molybdenum	Selenium	Thallium
		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	pCi/L	mg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L
9/27/2016	Background	0.13	5.03	81.7	0.026	0.009 J1	0.7	1.96	1.22	0.32	0.143	0.040	< 0.002 U1	27.7	0.2	0.124
11/9/2016	Background	0.08	5.49	85.4	0.01 J1	0.01 J1	0.863	1.46	2.335	0.33	0.321	0.035	< 0.002 U1	20.5	0.2	0.02 J1
1/12/2017	Background	0.05 J1	5.24	79.1	0.009 J1	0.01 J1	0.390	1.78	1.695	0.32	0.050	0.038	< 0.002 U1	37.5	0.08 J1	0.03 J1
2/22/2017	Background	0.08	5.15	74.0	0.009 J1	0.006 J1	0.380	1.54	1.603	0.29	0.044	0.037	< 0.002 U1	31.5	0.1	0.02 J1
4/26/2017	Background	0.17	5.48	80.4	0.009 J1	0.006 J1	0.411	1.23	1.3	0.33	0.034	0.025	< 0.002 U1	27.3	0.2	0.02 J1
5/24/2017	Background	0.09	4.30	68.1	0.007 J1	0.006 J1	0.807	0.941	1.317	0.29	0.037	0.026	< 0.002 U1	27.0	0.09 J1	0.01 J1
6/22/2017	Background	0.08	4.19	60.1	< 0.004 U1	< 0.005 U1	0.247	0.926	0.802	0.27	0.02 J1	0.037	< 0.002 U1	27.1	0.07 J1	0.01 J1
7/13/2017	Background	0.11	5.18	64.5	0.009 J1	0.008 J1	0.300	1.02	1.077	0.27	0.081	0.023	< 0.002 U1	28.3	0.07 J1	0.01 J1
4/25/2018	Assessment	0.17	4.58	56.4	0.005 J1	< 0.005 U1	0.245	0.794	2.783	0.36	0.024	0.033	< 0.002 U1	20.6	0.1	0.02 J1
9/20/2018	Assessment	0.29	3.54	75.9	< 0.02 U1	< 0.01 U1	0.378	1.21	0.698	0.22	0.04	0.031	--	19.6	0.2	< 0.1 U1
10/23/2018	Assessment	--	--	--	--	--	--	--	--	--	--	--	< 0.002 U1	--	--	--
3/12/2019	Assessment	0.20	1.39	49.0	< 0.02 U1	< 0.01 U1	0.438	0.395	0.769	0.18	0.05 J1	0.009 J1	< 0.002 U1	7.00	0.2 J1	< 0.1 U1
6/25/2019	Assessment	0.17	1.04	55.5	< 0.02 U1	< 0.01 U1	0.2 J1	0.629	0.689	0.15	< 0.02 U1	< 0.009 U1	< 0.002 U1	4.89	0.2	< 0.1 U1
8/21/2019	Assessment	0.09 J1	1.58	56.6	< 0.02 U1	0.02 J1	0.351	0.831	0.855	0.15	< 0.05 U1	0.0172	< 0.002 U1	5.64	0.09 J1	< 0.1 U1
3/18/2020	Assessment	0.59	0.63	62.9	< 0.02 U1	0.01 J1	0.298	0.152	1.25	0.17	0.07 J1	0.0302	< 0.002 U1	15.6	0.5	< 0.1 U1
3/9/2021	Assessment	0.61	0.76	44.7	0.02 J1	0.02 J1	0.768	0.329	1.227	0.18	0.2 J1	0.0206	< 0.002 U1	10.0	1.0	< 0.04 U1
6/9/2021	Assessment	0.61	0.41	41.6	< 0.007 U1	0.022	0.33	0.195	0.87	0.18	0.06 J1	0.0229	< 0.002 U1	12.1	0.54	< 0.04 U1
10/6/2021	Assessment	0.92	0.53	41.4	< 0.007 U1	0.022	0.49	0.051	1.70	0.24	0.10 J1	0.0132	< 0.002 U1	4.3	0.37 J1	< 0.04 U1
3/22/2022	Assessment	0.49	0.31	39.2	< 0.007 U1	0.015 J1	0.30	0.046	2.19	0.16	< 0.05 U1	0.0205	< 0.002 U1	8.6	0.64	0.06 J1
6/15/2022	Assessment	0.54	0.40	41.3	0.01 J1	0.023	0.85	0.069	2.52	0.17	0.9 J1	0.0171	< 0.002 U1	7.7	0.52	0.04 J1
10/10/2022	Assessment	0.50	0.40	36.9	< 0.007 U1	0.009 J1	0.60	0.073	0.74	0.18	0.19 J1	0.0150	< 0.004 U1	4.3	0.21 J1	< 0.04 U1

Notes:
µg/L: micrograms per liter
mg/L: milligrams per liter
pCi/L: picocuries per liter
<: Non-detect value. Analytes which were not detected are shown as less than the method detection limit (MDL) followed by a 'U1' flag. In analytical data prior to 5/18/2021, U1 flags were reported as U in the analytical report.
- -: Not analyzed
J1: Concentration estimated. Analyte was detected between the method detection limit and the reporting limit. In analytical data prior to 5/18/2021, J1 flags were reported as J in the analytical report.
M1: The associated matrix spike (MS) or matrix spike duplicate (MSD) was above acceptance limits.
L1: The associated laboratory control sample (LSC) or laboratory control sample duplicate (LCSD) recovery was outside acceptance limits.
P3: The precision on the matrix spike duplicate (MSD) was above acceptance limits.
S7: Sample did not achieve constant weight.
S12: Residue weight is below the method criteria but was already analyzed with 100mL.

Table 1 - Groundwater Data Summary: MW-1602
Big Sandy - FAP
Appendix III Constituents

Collection Date	Monitoring Program	Boron	Calcium	Chloride	Fluoride	pH	Sulfate	Total Dissolved Solids
		mg/L	mg/L	mg/L	mg/L	SU	mg/L	mg/L
9/27/2016	Background	0.054	72.5	10.6	0.19	7.7	106	400
11/9/2016	Background	0.037	63.1	8.77	0.18	7.5	86.1	360
1/12/2017	Background	0.039	65.4	7.20	0.17	7.8	81.6	362
2/22/2017	Background	0.041	69.4	8.13	0.14	7.7	96.3	399
4/26/2017	Background	0.052	73.8	7.74	0.13	6.8	83.6	382
5/24/2017	Background	0.074	74.7	9.90	0.12	6.9	103	394
6/21/2017	Background	--	--	--	--	7.5	--	--
6/22/2017	Background	0.062	70.4	10.7	0.11	--	106	416
7/13/2017	Background	0.052	81.9	12.1	0.09 J1	7.0	132	484
10/19/2017	Detection	0.058	72.5	13.0	0.11	7.1	110	434
1/31/2018	Detection	--	--	15.3	--	7.5	128	--
4/26/2018	Assessment	0.143	75.2	13.9	0.14	8.0	106	416
9/20/2018	Assessment	0.070	72.1	15.2	0.11	7.0	150	492
3/13/2019	Assessment	0.07 J1	79.4	12.6	0.10	6.9	133	444
6/25/2019	Assessment	0.06 J1	69.8	12.2	0.11	7.5	111	436
8/20/2019	Assessment	0.04 J1	74.5	13.2	0.10	7.5	117	434
3/18/2020	Assessment	--	--	--	0.09	8.8	--	--
6/30/2020	Assessment	0.05 J1	79.0	17.6	0.09	7.2	--	--
8/26/2020	Assessment	--	--	--	--	4.8	121	454
10/6/2020	Assessment	0.05 J1	82.5	19.2	0.10	7.7	143	479
3/9/2021	Assessment	--	--	--	0.11	7.4	--	--
6/9/2021	Assessment	0.050	83.9	17.1	0.11	7.5	165	500
10/6/2021	Assessment	0.057	86.1	18.3	0.10	7.5	167	510
3/22/2022	Assessment	--	--	--	0.08	8.2	--	--
6/14/2022	Assessment	0.062	91.1	18.9	0.09	7.6	187	550 S7
10/11/2022	Assessment	0.064	82.8	20.2	0.08	7.3	181	540

Notes:
mg/L: milligrams per liter
SU: standard unit
<: Non-detect value. Analytes which were not detected are shown as less than the method detection limit (MDL) followed by a 'U1' flag.
In analytical data prior to 5/18/2021, U1 flags were reported as U in the analytical report.
- -: Not analyzed
J1: Concentration estimated. Analyte was detected between the method detection limit and the reporting limit.
In analytical data prior to 5/18/2021, J1 flags were reported as J in the analytical report.
M1: The associated matrix spike (MS) or matrix spike duplicate (MSD) was above acceptance limits.
L1: The associated laboratory control sample (LSC) or laboratory control sample duplicate (LCSD) recovery was outside acceptance limits.
P3: The precision on the matrix spike duplicate (MSD) was above acceptance limits.
S7: Sample did not achieve constant weight.
S12: Residue weight is below the method criteria but was already analyzed with 100mL.

Table 1 - Groundwater Data Summary: MW-1602
Big Sandy - FAP
Appendix IV Constituents

Geosyntec Consultants, Inc.

Collection Date	Monitoring Program	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Combined Radium	Fluoride	Lead	Lithium	Mercury	Molybdenum	Selenium	Thallium
		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	pCi/L	mg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L
9/27/2016	Background	0.16	0.50	50.7	< 0.005 U1	0.005 J1	0.8	0.060	1.233	0.19	0.067	0.008	0.002 J1	3.41	2.0	0.02 J1
11/9/2016	Background	0.13	0.42	51.1	< 0.005 U1	0.01 J1	0.590	0.028	1.143	0.18	0.059	0.013	0.002 J1	2.63	2.2	0.01 J1
1/12/2017	Background	0.10	0.45	50.2	< 0.005 U1	0.01 J1	0.666	0.043	1.545	0.17	0.030	0.004	< 0.002 U1	2.44	2.2	0.03 J1
2/22/2017	Background	0.09	0.42	48.2	< 0.005 U1	0.009 J1	0.547	0.020	0.712	0.14	0.02 J1	0.008	< 0.002 U1	2.79	2.0	0.02 J1
4/26/2017	Background	0.10	0.47	59.2	< 0.004 U1	0.01 J1	0.692	0.024	0.534	0.13	0.026	0.006	0.002 J1	1.88	2.2	0.03 J1
5/24/2017	Background	0.08	0.37	54.6	< 0.004 U1	0.009 J1	0.703	0.01 J1	1.68	0.12	0.239	0.002	0.004 J1	1.51	1.5	0.02 J1
6/22/2017	Background	0.07	0.50	55.0	< 0.004 U1	0.01 J1	0.566	0.205	0.812	0.11	0.047	0.021	0.002 J1	2.12	1.3	0.02 J1
7/13/2017	Background	0.07	0.71	57.6	< 0.004 U1	< 0.005 U1	0.482	0.850	1.138	0.09 J1	0.031	0.005	0.003 J1	2.29	1.0	0.01 J1
4/26/2018	Assessment	0.05 J1	3.15	60.9	< 0.004 U1	< 0.005 U1	0.290	0.552	1.754	0.14	0.049	0.008	0.003 J1	1.64	0.4	0.01 J1
9/20/2018	Assessment	0.03 J1	3.92	55.1	< 0.02 U1	< 0.01 U1	0.328	0.312	1.044	0.11	0.03	< 0.009 U1	< 0.004 U1	1	0.4	< 0.1 U1
3/13/2019	Assessment	0.06 J1	1.06	52.5	< 0.02 U1	< 0.01 U1	1.03	0.03 J1	0.504	0.10	0.122	0.009 J1	< 0.002 U1	2 J1	1.6	< 0.1 U1
6/25/2019	Assessment	0.07 J1	1.06	52.5	< 0.02 U1	< 0.01 U1	0.632	0.02 J1	0.5359	0.11	0.05 J1	< 0.009 U1	< 0.002 U1	1 J1	1.4	< 0.1 U1
8/20/2019	Assessment	0.06 J1	1.16	49.3	< 0.02 U1	0.01 J1	1.15	0.080	0.543	0.10	0.1 J1	0.00637	< 0.002 U1	1 J1	1.1	< 0.1 U1
3/18/2020	Assessment	0.06 J1	1.36	55.4	< 0.02 U1	< 0.01 U1	0.511	0.04 J1	1.517	0.09	0.08 J1	0.00736	< 0.002 U1	1 J1	1.1	< 0.1 U1
6/30/2020	Assessment	0.04 J1	1.59	55.9	< 0.02 U1	< 0.01 U1	0.679	0.04 J1	0.488	0.09	0.07 J1	0.00717	< 0.002 U1	1 J1	1.0	< 0.1 U1
10/6/2020	Assessment	0.04 J1	1.53	52.4	< 0.02 U1	< 0.01 U1	1.05	0.04 J1	2.003	0.10	< 0.05 U1	0.00707	< 0.002 U1	1 J1	1.1	< 0.1 U1
3/9/2021	Assessment	0.06 J1	1.72	56.9	< 0.007 U1	0.006 J1	1.26	0.075	1.018	0.11	0.1 J1	0.00787	< 0.002 U1	1 J1	2.0	< 0.04 U1
6/9/2021	Assessment	0.06 J1	0.92	53.2	< 0.007 U1	< 0.004 U1	0.62	0.014 J1	2.31	0.11	< 0.05 U1	0.00629	< 0.002 U1	1.2	2.57	< 0.04 U1
10/6/2021	Assessment	0.08 J1	0.99	61.9	< 0.007 U1	< 0.004 U1	0.59	0.009 J1	0.95	0.10	0.11 J1	0.00815	< 0.002 U1	1.3	3.19	< 0.04 U1
3/22/2022	Assessment	0.15	0.66	62.0	< 0.007 U1	0.005 J1	0.53	0.014 J1	2.25	0.08	< 0.05 U1	0.0106	0.002 J1	1	1.88	< 0.04 U1
6/14/2022	Assessment	0.18	0.91	61.9	< 0.007 U1	< 0.004 U1	0.47	0.019 J1	0.82	0.09	< 0.05 U1	0.00760	< 0.002 U1	1.1	4.10	0.05 J1
10/11/2022	Assessment	0.22	0.93	64.3	< 0.007 U1	0.007 J1	0.56	0.038	1.27	0.08	0.06 J1	0.00944	< 0.004 U1	1.1	3.37	< 0.04 U1

Notes:
µg/L: micrograms per liter
mg/L: milligrams per liter
pCi/L: picocuries per liter
<: Non-detect value. Analytes which were not detected are shown as less than the method detection limit (MDL) followed by a 'U1' flag. In analytical data prior to 5/18/2021, U1 flags were reported as U in the analytical report.
- -: Not analyzed
J1: Concentration estimated. Analyte was detected between the method detection limit and the reporting limit. In analytical data prior to 5/18/2021, J1 flags were reported as J in the analytical report.
M1: The associated matrix spike (MS) or matrix spike duplicate (MSD) was above acceptance limits.
L1: The associated laboratory control sample (LSC) or laboratory control sample duplicate (LCSD) recovery was outside acceptance limits.
P3: The precision on the matrix spike duplicate (MSD) was above acceptance limits.
S7: Sample did not achieve constant weight.
S12: Residue weight is below the method criteria but was already analyzed with 100mL.

Table 1 - Groundwater Data Summary: MW-1603
Big Sandy - FAP
Appendix III Constituents

Collection Date	Monitoring Program	Boron	Calcium	Chloride	Fluoride	pH	Sulfate	Total Dissolved Solids
		mg/L	mg/L	mg/L	mg/L	SU	mg/L	mg/L
9/26/2016	Background	0.054	105	3.37	1.24	4.3	801	1,060
11/9/2016	Background	0.053	94.7	3.22	1.10	5.6	733	1,010
1/12/2017	Background	0.037	92.7	3.45	1.11	3.6	636	948
2/21/2017	Background	0.085	91.9	2.93	0.90	4.5	720	1,020
4/26/2017	Background	0.052	90.5	3.28	1.04	3.3	678	994
5/24/2017	Background	0.096	93.9	3.34	0.98	3.3	646	936
6/22/2017	Background	0.051	90.6	3.10	0.98	3.0	873	1,040
7/13/2017	Background	0.039	90.2	3.32	0.93	3.2	694	1,000
10/19/2017	Detection	< 0.002 U1	91.0	3.24	0.93	3.5	784	962
1/31/2018	Detection	--	82.2	--	0.94	3.5	714	915
4/26/2018	Assessment	0.088	83.6	4.12	1.16	2.9	661	926
9/20/2018	Assessment	0.08	97.5	3.92	1.15	3.1	747	974
3/13/2019	Assessment	0.05 J1	84.6	4.42	0.92	3.2	709	896
6/27/2019	Assessment	0.05 J1	83.3	4.13	0.87	3.7	658	954
8/20/2019	Assessment	< 0.1 U1	95.8	3.93	0.84	3.5	704	1,010
3/17/2020	Assessment	--	--	--	0.85	3.5	--	--
6/30/2020	Assessment	0.05 J1	96.6	4.18	0.71	3.4	--	--
8/26/2020	Assessment	--	--	--	--	3.3	798	1,040
10/6/2020	Assessment	0.05 J1	94.5	4.10	0.47	4.1	794	1,020
3/9/2021	Assessment	--	--	--	0.82	3.4	--	--
6/9/2021	Assessment	0.036 J1	79.0	4.16	0.76	3.6	618	880
10/6/2021	Assessment	0.054	93.1	3.93	0.96	3.3	735	1,040
3/22/2022	Assessment	--	--	--	0.65	4.9	--	--
6/15/2022	Assessment	0.071	94.4	4.07	0.69	3.1	675	970
10/11/2022	Assessment	0.051	90.3	3.78	1.11	3.7	841	1,080

Notes:
mg/L: milligrams per liter
SU: standard unit
<: Non-detect value. Analytes which were not detected are shown as less than the method detection limit (MDL) followed by a 'U1' flag.
In analytical data prior to 5/18/2021, U1 flags were reported as U in the analytical report.
- -: Not analyzed
J1: Concentration estimated. Analyte was detected between the method detection limit and the reporting limit.
In analytical data prior to 5/18/2021, J1 flags were reported as J in the analytical report.
M1: The associated matrix spike (MS) or matrix spike duplicate (MSD) was above acceptance limits.
L1: The associated laboratory control sample (LSC) or laboratory control sample duplicate (LCSD) recovery was outside acceptance limits.
P3: The precision on the matrix spike duplicate (MSD) was above acceptance limits.
S7: Sample did not achieve constant weight.
S12: Residue weight is below the method criteria but was already analyzed with 100mL.

Table 1 - Groundwater Data Summary: MW-1603
Big Sandy - FAP
Appendix IV Constituents

Geosyntec Consultants, Inc.

Collection Date	Monitoring Program	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Combined Radium	Fluoride	Lead	Lithium	Mercury	Molybdenum	Selenium	Thallium
		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	pCi/L	mg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L
9/26/2016	Background	0.01 J1	1.51	13.4	18.6	0.84	1.1	101	6.04	1.24	9.75	0.242	< 0.002 U1	0.15	5.4	1.29
11/9/2016	Background	< 0.01 U1	1.19	15.4	18.3	0.93	1.12	94.4	6.6	1.10	8.18	0.237	< 0.002 U1	0.17	4.8	1.55
1/12/2017	Background	< 0.01 U1	1.40	11.4	17.1	0.79	0.731	89.6	5.86	1.11	6.11	0.225	< 0.002 U1	0.06 J1	5.6	1.39
2/21/2017	Background	< 0.01 U1	1.26	10.3	18.9	0.75	0.771	93.2	4.03	0.90	6.30	0.208	< 0.002 U1	0.11	4.9	1.20
4/26/2017	Background	0.01 J1	1.30	12.4	16.7	0.87	0.829	97.1	5.72	1.04	6.41	0.216	0.002 J1	0.18	6.1	1.41
5/24/2017	Background	< 0.01 U1	1.34	11.5	16.4	0.77	0.620	85.3	6.4	0.98	4.96	0.221	< 0.002 U1	0.07 J1	6.3	1.35
6/22/2017	Background	< 0.01 U1	1.29	11.4	16.4	0.86	0.821	92.4	6	0.98	6.47	0.263	< 0.002 U1	0.32	6.1	1.43
7/13/2017	Background	< 0.01 U1	0.89	11.3	18.0	0.80	0.485	92.5	6.36	0.93	3.72	0.217	< 0.002 U1	0.22	2.7	1.43
4/26/2018	Assessment	0.04 J1	1.60	10.5	18.7	0.74	0.771	91.1	5.09	1.16	5.27	0.187	< 0.002 U1	0.03 J1	8.1	1.39
9/20/2018	Assessment	< 0.02 U1	1.40	11.4	19.6	0.83	0.713	93.8	6.75	1.15	4.39	0.255	--	< 0.4 U1	6.3	1.70
10/23/2018	Assessment	--	--	--	--	--	--	--	--	--	--	--	< 0.002 U1	--	--	--
3/13/2019	Assessment	< 0.2 U1	1.26	12.0	24.4	0.78	1 J1	87.9	4.8	0.92	4.28	0.209	< 0.002 U1	< 4 U1	4.0	1 J1
6/27/2019	Assessment	< 0.04 U1	1.36	11.0	21.8	0.70	0.618	84.7	7.149	0.87	3.68	0.192	< 0.002 U1	< 0.8 U1	4.9	1.40
8/20/2019	Assessment	< 0.1 U1	1.39	13.6	25.0	0.89	0.8 J1	96.6	10.92	0.84	4.17	0.226	< 0.002 U1	< 2 U1	5.6	2 J1
3/17/2020	Assessment	< 0.02 U1	0.83	9.92	16.4	0.64	0.560	72.0	7.19	0.85	3.95	0.156	< 0.002 U1	< 0.4 U1	4.0	1.34
6/30/2020	Assessment	< 0.04 U1	1.12	12.2	21.1	0.85	0.694	93.2	6.22	0.71	4.67	0.192	< 0.002 U1	< 0.8 U1	6.2	1.57
10/6/2020	Assessment	< 0.02 U1	1.12	14.6	17.5	0.87	0.743	90.5	2.681	0.47	4.85	0.165	< 0.002 U1	< 0.4 U1	5.8	1.82
3/9/2021	Assessment	< 0.02 U1	0.84	10.1	14.0	0.62	0.659	71.4	3.73	0.82	3.37	0.125	0.002 J1	< 0.1 U1	3.9	1.39
6/9/2021	Assessment	0.04 J1	0.69	13.1	13.3	0.709	0.51	76.8	7.18	0.76	3.39	0.135	0.002 J1	< 0.1 U1	3.30	1.62
10/6/2021	Assessment	< 0.02 U1	1.01	17.1	17.4 M1	0.913	0.59	95.1 M1	10.51	0.96	6.10	0.186 M1	0.003 J1	< 0.1 U1	4.26	2.20
3/22/2022	Assessment	< 0.02 U1	0.96	13.3	14.9	0.690	0.36	79.7	17.94	0.65	3.37	0.151	< 0.002 U1	< 0.1 U1	4.01	1.66
6/15/2022	Assessment	< 0.02 U1	1.55	8.77	15.0	0.734	0.78	98.3	6.22	0.69	6.5	0.153	< 0.002 U1	0.2 J1	6.56	1.71
10/11/2022	Assessment	< 0.02 U1	1.40	15.4	19.5	0.869	0.85	95.2	7.47	1.11	6.03	0.196	< 0.004 U1	< 0.1 U1	6.25	2.02

Notes:
µg/L: micrograms per liter
mg/L: milligrams per liter
pCi/L: picocuries per liter
<: Non-detect value. Analytes which were not detected are shown as less than the method detection limit (MDL) followed by a 'U1' flag. In analytical data prior to 5/18/2021, U1 flags were reported as U in the analytical report.
- -: Not analyzed
J1: Concentration estimated. Analyte was detected between the method detection limit and the reporting limit. In analytical data prior to 5/18/2021, J1 flags were reported as J in the analytical report.
M1: The associated matrix spike (MS) or matrix spike duplicate (MSD) was above acceptance limits.
L1: The associated laboratory control sample (LSC) or laboratory control sample duplicate (LCSD) recovery was outside acceptance limits.
P3: The precision on the matrix spike duplicate (MSD) was above acceptance limits.
S7: Sample did not achieve constant weight.
S12: Residue weight is below the method criteria but was already analyzed with 100mL.

Table 1 - Groundwater Data Summary: MW-1604
Big Sandy - FAP
Appendix III Constituents

Collection Date	Monitoring Program	Boron	Calcium	Chloride	Fluoride	pH	Sulfate	Total Dissolved Solids
		mg/L	mg/L	mg/L	mg/L	SU	mg/L	mg/L
9/27/2016	Background	0.031	6.48	6.20	0.27	7.5	16.6	182
11/8/2016	Background	0.030	4.26	6.22	0.29	3.4	9.1	180
1/11/2017	Background	0.016	3.27	4.07	0.23	6.2	5.9	186
2/21/2017	Background	0.040	3.21	2.60	0.12	6.5	5.7	102
4/25/2017	Background	0.010	3.15	1.71	0.08	5.9	8.6	78
5/23/2017	Background	0.038	2.93	1.56	0.06	5.8	8.2	68
6/21/2017	Background	0.017	2.88	1.41	0.03 J1	5.6	10.5	49
7/12/2017	Background	0.054	3.06	1.84	0.06	5.5	9.8	85
9/18/2017	Detection	0.034	2.81	2.22	0.12	6.5	4.0	124
4/25/2018	Assessment	0.052	2.96	1.58	0.06	5.4	8.4	52
9/18/2018	Assessment	0.056	2.69	1.43	0.06 J1	6.1	7.8	62
3/12/2019	Assessment	0.02 J1	3.55	1.34	0.04 J1	5.2	10.0	46
6/25/2019	Assessment	0.02 J1	2.97	1.21	0.05 J1	6.0	9.5	50
8/20/2019	Assessment	< 0.02 U1	3.42	1.17	0.03 J1	5.4	10.5	50 J1
3/17/2020	Assessment	--	--	--	0.03 J1	5.8	--	--
6/29/2020	Assessment	< 0.02 U1	3.56	1.03	< 0.01 U1	5.2	11.1	--
8/27/2020	Assessment	--	--	--	--	5.7	--	63
10/5/2020	Assessment	< 0.02 U1	3.31	1.09	0.03 J1	6.8	10.3	50 J1
3/10/2021	Assessment	--	--	--	0.03 J1	5.1	--	--
6/8/2021	Assessment	0.018 J1	3.4	1.15	0.03 J1	5.7	10.4	60
10/5/2021	Assessment	0.016 J1	3.2	1.11	0.03 J1	5.7	9.42	60
3/24/2022	Assessment	--	--	--	< 0.02 U1	7.0	--	--
6/14/2022	Assessment	0.017 J1	3.28	1.05	0.02 J1	5.0	10.4	50
10/11/2022	Assessment	0.012 J1	2.97	1.06	0.02 J1	5.6	10.0	60

Notes:
mg/L: milligrams per liter
SU: standard unit
<: Non-detect value. Analytes which were not detected are shown as less than the method detection limit (MDL) followed by a 'U1' flag.
In analytical data prior to 5/18/2021, U1 flags were reported as U in the analytical report.
- -: Not analyzed
J1: Concentration estimated. Analyte was detected between the method detection limit and the reporting limit.
In analytical data prior to 5/18/2021, J1 flags were reported as J in the analytical report.
M1: The associated matrix spike (MS) or matrix spike duplicate (MSD) was above acceptance limits.
L1: The associated laboratory control sample (LSC) or laboratory control sample duplicate (LCSD) recovery was outside acceptance limits.
P3: The precision on the matrix spike duplicate (MSD) was above acceptance limits.
S7: Sample did not achieve constant weight.
S12: Residue weight is below the method criteria but was already analyzed with 100mL.

Table 1 - Groundwater Data Summary: MW-1604
Big Sandy - FAP
Appendix IV Constituents

Geosyntec Consultants, Inc.

Collection Date	Monitoring Program	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Combined Radium	Fluoride	Lead	Lithium	Mercury	Molybdenum	Selenium	Thallium
		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	pCi/L	mg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L
9/27/2016	Background	0.05 J1	2.74	67.1	0.029	0.007 J1	0.6	3.47	1.105	0.27	0.154	0.004	< 0.002 U1	3.48	0.2	0.01 J1
11/8/2016	Background	0.04 J1	3.61	59.0	0.048	0.008 J1	0.583	1.55	1.277	0.29	0.265	0.005	< 0.002 U1	2.34	0.1	< 0.01 U1
1/11/2017	Background	0.08	4.28	54.8	0.027	0.06	0.551	2.02	0.707	0.23	0.188	0.005	< 0.002 U1	2.23	0.2	0.119
2/21/2017	Background	0.02 J1	3.64	52.9	0.028	0.009 J1	0.427	2.78	0.927	0.12	0.103	0.009	< 0.002 U1	1.51	0.1	0.175
4/25/2017	Background	0.03 J1	3.54	65.1	0.034	0.006 J1	0.365	5.59	0.478	0.08	0.01 J1	< 0.0002 U1	< 0.002 U1	0.57	0.08 J1	< 0.01 U1
5/23/2017	Background	0.02 J1	2.24	54.8	0.040	0.03	0.401	4.18	6.707	0.06	0.062	< 0.0002 U1	< 0.002 U1	0.51	0.2	0.01 J1
6/21/2017	Background	0.03 J1	1.28	66.1	0.063	0.05	0.183	5.61	16.848	0.03 J1	0.049	0.002	0.003 J1	0.57	0.2	0.01 J1
7/12/2017	Background	0.04 J1	1.73	59.8	0.041	0.02	0.322	3.67	0.636	0.06	0.097	0.004	< 0.002 U1	15.9	0.1	< 0.01 U1
4/25/2018	Assessment	0.08	0.74	58.9	0.053	0.09	0.285	3.75	0.1535	0.06	0.263	0.010	< 0.002 U1	0.54	0.3	0.04 J1
9/18/2018	Assessment	0.06	1.47	63.5	0.061	0.07	0.388	4.53	0.951	0.06 J1	0.092	0.003	--	0.86	0.2	0.04 J1
10/22/2018	Assessment	--	--	--	--	--	--	--	--	--	--	--	< 0.002 U1	--	--	--
3/12/2019	Assessment	0.03 J1	0.16	66.8	0.06 J1	0.08	0.547	0.844	0.458	0.04 J1	0.04 J1	< 0.009 U1	< 0.002 U1	< 0.4 U1	0.3	< 0.1 U1
6/25/2019	Assessment	0.03 J1	0.12	68.3	0.07 J1	0.09	0.231	0.503	0.799	0.05 J1	0.03 J1	< 0.009 U1	< 0.002 U1	< 0.4 U1	0.2	< 0.1 U1
8/20/2019	Assessment	< 0.02 U1	0.09 J1	78.3	0.117	0.08	0.612	0.246	0.641	0.03 J1	< 0.05 U1	0.00104	< 0.002 U1	< 0.4 U1	0.4	< 0.1 U1
3/17/2020	Assessment	< 0.02 U1	0.05 J1	82.7	0.159	0.08	0.632	0.119	2.93	0.03 J1	< 0.05 U1	0.00113	< 0.002 U1	< 0.4 U1	0.4	< 0.1 U1
6/29/2020	Assessment	< 0.02 U1	0.05 J1	90.0	0.182	0.09	0.681	0.130	1.121	< 0.01 U1	< 0.05 U1	0.00106	< 0.002 U1	< 0.4 U1	0.5	< 0.1 U1
10/5/2020	Assessment	< 0.02 U1	0.10	75.8	0.149	0.09	0.589	0.289	0.491	0.03 J1	0.2 J1	0.000964	< 0.002 U1	< 0.4 U1	0.4	< 0.1 U1
3/10/2021	Assessment	< 0.02 U1	0.07 J1	75.3	0.129	0.09	0.850	0.148	0.2279	0.03 J1	< 0.05 U1	0.000944	< 0.002 U1	< 0.1 U1	0.4	< 0.04 U1
6/8/2021	Assessment	0.02 J1	0.07 J1	82.3	0.167	0.086	0.77	0.257	1.07	0.03 J1	0.06 J1	0.00095	< 0.002 U1	< 0.1 U1	0.36 J1	< 0.04 U1
10/5/2021	Assessment	< 0.02 U1	0.06 J1	70.2	0.143	0.079	0.61	0.154	1.67	0.03 J1	0.06 J1	0.00101	< 0.002 U1	0.1 J1	0.31 J1	< 0.04 U1
3/24/2022	Assessment	< 0.02 U1	0.05 J1	78.5	0.177	0.070	0.76	0.229	1.03	< 0.02 U1	0.08 J1	0.00101	< 0.002 U1	< 0.1 U1	0.42 J1	< 0.04 U1
6/14/2022	Assessment	< 0.02 U1	< 0.03 U1	78.4	0.182	0.070	0.91	0.124	0.83	0.02 J1	< 0.05 U1	0.00100	< 0.002 U1	< 0.1 U1	0.35 J1	< 0.04 U1
10/11/2022	Assessment	< 0.02 U1	< 0.03 U1	69.7	0.148	0.060	0.87	0.096	0.96	0.02 J1	< 0.05 U1	0.00117	< 0.004 U1	< 0.1 U1	0.31 J1	< 0.04 U1

Notes:
µg/L: micrograms per liter
mg/L: milligrams per liter
pCi/L: picocuries per liter
<: Non-detect value. Analytes which were not detected are shown as less than the method detection limit (MDL) followed by a 'U1' flag. In analytical data prior to 5/18/2021, U1 flags were reported as U in the analytical report.
- -: Not analyzed
J1: Concentration estimated. Analyte was detected between the method detection limit and the reporting limit. In analytical data prior to 5/18/2021, J1 flags were reported as J in the analytical report.
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L1: The associated laboratory control sample (LSC) or laboratory control sample duplicate (LCSD) recovery was outside acceptance limits.
P3: The precision on the matrix spike duplicate (MSD) was above acceptance limits.
S7: Sample did not achieve constant weight.
S12: Residue weight is below the method criteria but was already analyzed with 100mL.

Table 1 - Groundwater Data Summary: MW-1605
Big Sandy - FAP
Appendix III Constituents

Collection Date	Monitoring Program	Boron	Calcium	Chloride	Fluoride	pH	Sulfate	Total Dissolved Solids
		mg/L	mg/L	mg/L	mg/L	SU	mg/L	mg/L
9/27/2016	Background	0.008	1.00	0.43	< 0.02 U1	5.7	5.2	30 J1
11/8/2016	Background	0.005	1.01	0.43	< 0.02 U1	2.3	4.2	40
1/11/2017	Background	< 0.002 U1	0.979	0.62	< 0.02 U1	4.6	5.7	35
2/21/2017	Background	0.061	1.37	1.49	< 0.02 U1	5.1	7.4	74
4/25/2017	Background	0.025	1.31	1.21	< 0.02 U1	4.9	6.0	30 J1
5/23/2017	Background	0.063	1.21	1.00	< 0.02 U1	4.8	5.4	30 J1
6/21/2017	Background	0.017	1.15	0.90	< 0.02 U1	4.9	5.8	25
7/12/2017	Background	0.075	1.11	1.32	< 0.02 U1	4.7	4.5	37
9/14/2017	Detection	0.102	1.01	1.72	< 0.02 U1	4.7	4.9	20 J1
4/25/2018	Assessment	0.070	1.30	0.69	< 0.02 U1	4.6	6.5	37
9/18/2018	Assessment	0.036	0.930	0.62	< 0.02 U1	4.0	4.3	29
3/12/2019	Assessment	0.02 J1	1.27	0.53	0.02 J1	4.3	7.2	33
6/25/2019	Assessment	< 0.02 U1	1.20	0.43	< 0.01 U1	5.2	5.7	37
8/20/2019	Assessment	< 0.02 U1	1.01	0.46	0.01 J1	5.5	5.5	30 J1
3/17/2020	Assessment	--	--	--	0.01 J1	5.0	--	--
6/29/2020	Assessment	< 0.02 U1	1.24	0.43	< 0.01 U1	5.0	5.3	--
8/27/2020	Assessment	--	--	--	--	5.1	--	30 J1
10/5/2020	Assessment	< 0.02 U1	1.04	0.39	< 0.01 U1	5.6	5.3	40 J1
3/10/2021	Assessment	--	--	--	0.02 J1	4.6	--	--
6/8/2021	Assessment	0.009 J1	1.2	0.59	0.01 J1	5.2	5.08	50
10/5/2021	Assessment	0.011 J1	1.2	0.41	< 0.02 U1	5.1	4.59	40 J1
3/23/2022	Assessment	0.011 J1	1.60	0.65	< 0.02 U1	6.5	9.21	30 J1
6/14/2022	Assessment	< 0.009 U1	1.18	0.56	< 0.02 U1	4.5	5.24	50
10/12/2022	Assessment	0.010 J1	1.15	0.36	< 0.02 U1	5.2	5.27	< 20 S12, U1

Notes:
mg/L: milligrams per liter
SU: standard unit
<: Non-detect value. Analytes which were not detected are shown as less than the method detection limit (MDL) followed by a 'U1' flag.
In analytical data prior to 5/18/2021, U1 flags were reported as U in the analytical report.
- -: Not analyzed
J1: Concentration estimated. Analyte was detected between the method detection limit and the reporting limit.
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S12: Residue weight is below the method criteria but was already analyzed with 100mL.

Table 1 - Groundwater Data Summary: MW-1605
Big Sandy - FAP
Appendix IV Constituents

Geosyntec Consultants, Inc.

Collection Date	Monitoring Program	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Combined Radium	Fluoride	Lead	Lithium	Mercury	Molybdenum	Selenium	Thallium
		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	pCi/L	mg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L
9/27/2016	Background	< 0.01 U1	0.04 J1	30.3	0.091	0.06	2.7	0.897	0.679	< 0.02 U1	0.126	0.002	< 0.002 U1	0.08 J1	0.2	0.01 J1
11/8/2016	Background	0.01 J1	0.08	30.5	0.121	0.06	2.50	0.917	1.986	< 0.02 U1	0.210	0.007	< 0.002 U1	0.05 J1	0.2	0.01 J1
1/11/2017	Background	0.01 J1	0.07	32.2	0.111	0.07	2.53	1.64	0.1382	< 0.02 U1	0.190	0.008	< 0.002 U1	0.1 J1	0.2	0.01 J1
2/21/2017	Background	< 0.01 U1	0.03 J1	42.6	0.138	0.09	2.61	1.45	0.904	< 0.02 U1	0.107	0.005	< 0.002 U1	0.10	0.2	0.03 J1
4/25/2017	Background	0.01 J1	0.06	39.1	0.119	0.09	2.57	0.991	0.2779	< 0.02 U1	0.121	< 0.0002 U1	< 0.002 U1	0.13	0.2	0.01 J1
5/23/2017	Background	< 0.01 U1	0.03 J1	35.0	0.114	0.07	2.39	0.667	6.077	< 0.02 U1	0.104	0.008	< 0.002 U1	0.07 J1	0.2	0.01 J1
6/21/2017	Background	< 0.01 U1	0.05 J1	33.4	0.105	0.07	2.44	0.592	10.864	< 0.02 U1	0.110	0.002	< 0.002 U1	0.09 J1	0.3	< 0.01 U1
7/12/2017	Background	< 0.01 U1	0.23	31.7	0.103	0.07	2.33	0.495	0.3796	< 0.02 U1	0.107	0.0003 J1	< 0.002 U1	23.7	0.2	0.01 J1
4/25/2018	Assessment	0.04 J1	0.07	37.1	0.123	0.08	2.70	0.434	0.421	< 0.02 U1	0.193	0.009	< 0.002 U1	0.07 J1	0.3	0.03 J1
9/18/2018	Assessment	0.02 J1	0.04 J1	29.7	0.104	0.06	2.58	0.265	0.694	< 0.02 U1	0.092	0.002	--	0.04 J1	0.2	0.03 J1
10/22/2018	Assessment	--	--	--	--	--	--	--	--	--	--	--	< 0.002 U1	--	--	--
3/12/2019	Assessment	< 0.02 U1	0.17	36.6	0.131	0.08	2.91	0.483	0.2025	0.02 J1	0.305	< 0.009 U1	0.003 J1	< 0.4 U1	0.3	< 0.1 U1
6/25/2019	Assessment	< 0.02 U1	0.05 J1	34.8	0.123	0.08	2.53	0.253	0.9023	< 0.01 U1	0.164	< 0.009 U1	< 0.002 U1	< 0.4 U1	0.2	< 0.1 U1
8/20/2019	Assessment	< 0.02 U1	0.03 J1	29.1	0.09 J1	0.06	2.41	0.215	0.268	0.01 J1	0.09 J1	0.000637	< 0.002 U1	< 0.4 U1	0.2	< 0.1 U1
3/17/2020	Assessment	< 0.02 U1	< 0.03 U1	40.9	0.130	0.08	2.47	0.272	1.1942	0.01 J1	0.1 J1	0.000757	< 0.002 U1	< 0.4 U1	0.3	< 0.1 U1
6/29/2020	Assessment	< 0.02 U1	< 0.03 U1	36.5	0.119	0.07	2.41	0.222	0.11	< 0.01 U1	0.05 J1	0.000694	< 0.002 U1	< 0.4 U1	0.3	< 0.1 U1
10/5/2020	Assessment	< 0.02 U1	0.04 J1	33.7	0.113	0.07	2.55	0.219	4.041	< 0.01 U1	0.1 J1	0.000695	< 0.002 U1	< 0.4 U1	0.3	< 0.1 U1
3/10/2021	Assessment	< 0.02 U1	0.06 J1	56.7	0.160	0.11	2.71	0.398	2.826	0.02 J1	0.2 J1	0.000806	0.002 J1	< 0.1 U1	0.2	< 0.04 U1
6/8/2021	Assessment	< 0.02 U1	< 0.03 U1	34.8	0.102	0.067	2.27	0.236	1.12	0.01 J1	0.08 J1	0.00063	< 0.002 U1	< 0.1 U1	0.20 J1	< 0.04 U1
10/5/2021	Assessment	< 0.02 U1	0.04 J1	36.9	0.118	0.074	2.68	0.184	0.97	< 0.02 U1	0.1 J1	0.00075	< 0.004 U1	< 0.1 U1	0.24 J1	< 0.04 U1
3/23/2022	Assessment	< 0.02 U1	0.05 J1	47.9	0.152	0.101	2.55	0.341	1.36	< 0.02 U1	0.14 J1	0.00089	< 0.002 U1	< 0.1 U1	0.22 J1	< 0.04 U1
6/14/2022	Assessment	< 0.02 U1	0.03 J1	34.5	0.111	0.071	2.41	0.242	0.41	< 0.02 U1	0.09 J1	0.00068	< 0.002 U1	< 0.1 U1	0.21 J1	< 0.04 U1
10/12/2022	Assessment	< 0.02 U1	0.04 J1	36.6	0.116	0.069	3.26	0.194	0.77	< 0.02 U1	0.08 J1	0.00071	< 0.002 U1	< 0.1 U1	0.25 J1	< 0.04 U1

Notes:
µg/L: micrograms per liter
mg/L: milligrams per liter
pCi/L: picocuries per liter
<: Non-detect value. Analytes which were not detected are shown as less than the method detection limit (MDL) followed by a 'U1' flag. In analytical data prior to 5/18/2021, U1 flags were reported as U in the analytical report.
- -: Not analyzed
J1: Concentration estimated. Analyte was detected between the method detection limit and the reporting limit. In analytical data prior to 5/18/2021, J1 flags were reported as J in the analytical report.
M1: The associated matrix spike (MS) or matrix spike duplicate (MSD) was above acceptance limits.
L1: The associated laboratory control sample (LSC) or laboratory control sample duplicate (LCSD) recovery was outside acceptance limits.
P3: The precision on the matrix spike duplicate (MSD) was above acceptance limits.
S7: Sample did not achieve constant weight.
S12: Residue weight is below the method criteria but was already analyzed with 100mL.

Table 1 - Groundwater Data Summary: MW-1606
Big Sandy - FAP
Appendix III Constituents

Collection Date	Monitoring Program	Boron	Calcium	Chloride	Fluoride	pH	Sulfate	Total Dissolved Solids
		mg/L	mg/L	mg/L	mg/L	SU	mg/L	mg/L
9/27/2016	Background	1.92	78.6	31.3	0.17	7.4	54.0	362
11/8/2016	Background	1.80	75.9	31.5	0.19	7.2	54.5	400
1/12/2017	Background	1.77	75.1	31.2	0.21	7.3	58.8	396
2/22/2017	Background	1.63	76.7	30.4	0.18	7.2	53.9	358
4/26/2017	Background	1.78	73.8	31.7	0.19	6.7	56.1	380
5/23/2017	Background	1.87	78.1	31.7	0.19	6.8	56.2	360
6/21/2017	Background	1.89	78.1	31.1	0.17	6.7	55.3	369
7/12/2017	Background	1.79	75.7	31.4	0.17	6.5	57.0	382
9/18/2017	Detection	1.83	77.0	31.3	0.19	6.9	58.1	380
1/31/2018	Detection	1.63	--	32.0	--	7.2	--	--
4/25/2018	Assessment	1.81	73.7	31.3	0.26	6.6	56.0	350
9/19/2018	Assessment	1.82	71.8	31.1	0.24	6.6	56.9	380
3/13/2019	Assessment	1.93	74.2	31.7	0.22	6.9	58.8	389
6/25/2019	Assessment	1.84	74.5	30.8	0.23	7.1	58.7	384
8/20/2019	Assessment	1.74	75.1	31.4	0.21	7.0	58.3	385
3/18/2020	Assessment	--	--	--	0.20	9.1	--	--
6/30/2020	Assessment	2.04	79.7	31.8	0.18	6.8	61.2	--
8/26/2020	Assessment	--	--	--	--	6.5	--	392
10/6/2020	Assessment	2.00	78.7	32.0	0.22	6.7	62.8	363
3/10/2021	Assessment	--	--	--	0.26	6.9	--	--
6/8/2021	Assessment	1.99	74.1	31.8	0.24	7.5	61.6	370
10/5/2021	Assessment	2.04	74.5	31.4	0.22	7.0	60.7	400
3/23/2022	Assessment	2.22	81.3	32.7	0.21	7.7	63.3	370
6/14/2022	Assessment	2.08	73.6	31.7	0.21	7.3	64.9	430
10/11/2022	Assessment	2.11	75.9	32.3	0.20	6.7	64.7	390

Notes:
mg/L: milligrams per liter
SU: standard unit
<: Non-detect value. Analytes which were not detected are shown as less than the method detection limit (MDL) followed by a 'U1' flag.
In analytical data prior to 5/18/2021, U1 flags were reported as U in the analytical report.
- -: Not analyzed
J1: Concentration estimated. Analyte was detected between the method detection limit and the reporting limit.
In analytical data prior to 5/18/2021, J1 flags were reported as J in the analytical report.
M1: The associated matrix spike (MS) or matrix spike duplicate (MSD) was above acceptance limits.
L1: The associated laboratory control sample (LSC) or laboratory control sample duplicate (LCSD) recovery was outside acceptance limits.
P3: The precision on the matrix spike duplicate (MSD) was above acceptance limits.
S7: Sample did not achieve constant weight.
S12: Residue weight is below the method criteria but was already analyzed with 100mL.

Table 1 - Groundwater Data Summary: MW-1606
Big Sandy - FAP
Appendix IV Constituents

Geosyntec Consultants, Inc.

Collection Date	Monitoring Program	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Combined Radium	Fluoride	Lead	Lithium	Mercury	Molybdenum	Selenium	Thallium
		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	pCi/L	mg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L
9/27/2016	Background	0.03 J1	0.85	1,030	0.064	0.009 J1	1.7	0.814	2.76	0.17	1.19	0.006	< 0.002 U1	0.68	0.2	0.04 J1
11/8/2016	Background	0.04 J1	1.24	994	0.114	0.01 J1	2.34	1.26	4.082	0.19	1.88	0.014	< 0.002 U1	0.51	0.3	0.03 J1
1/12/2017	Background	0.07	1.19	883	0.058	0.06	1.52	0.919	3.35	0.21	1.02	0.010	< 0.002 U1	0.67	0.2	0.110
2/22/2017	Background	< 0.01 U1	0.97	875	0.025	< 0.004 U1	0.747	0.381	2.289	0.18	0.330	0.008	0.002 J1	0.91	0.2	0.01 J1
4/26/2017	Background	0.03 J1	1.40	1,080	0.053	0.007 J1	1.33	0.951	2.398	0.19	0.862	0.003	< 0.002 U1	0.84	0.1	0.02 J1
5/23/2017	Background	0.01 J1	1.03	949	0.023	< 0.005 U1	0.790	0.411	3.37	0.19	0.341	0.006	0.002 J1	0.54	0.09 J1	< 0.01 U1
6/21/2017	Background	< 0.01 U1	0.98	884	0.01 J1	< 0.005 U1	0.385	0.209	2.79	0.17	0.159	0.004	0.003 J1	0.60	0.06 J1	< 0.01 U1
7/12/2017	Background	0.01 J1	1.14	773	0.01 J1	< 0.005 U1	0.353	0.153	3.37	0.17	0.103	0.008	< 0.002 U1	7.56	0.06 J1	< 0.01 U1
4/25/2018	Assessment	0.05	0.97	767	0.008 J1	< 0.005 U1	0.301	0.101	3.71	0.26	0.077	0.014	< 0.002 U1	0.58	0.06 J1	0.01 J1
9/19/2018	Assessment	0.03 J1	0.97	797	0.01 J1	< 0.005 U1	0.366	0.155	3.28	0.24	0.126	0.001	--	0.58	0.07 J1	0.03 J1
10/22/2018	Assessment	--	--	--	--	--	--	--	--	--	--	--	< 0.002 U1	--	--	--
3/13/2019	Assessment	< 0.02 U1	1.22	764	< 0.02 U1	< 0.01 U1	0.535	0.208	2.63	0.22	0.123	< 0.009 U1	< 0.002 U1	2.60	0.05 J1	< 0.1 U1
6/25/2019	Assessment	< 0.02 U1	0.94	843	< 0.02 U1	< 0.01 U1	0.1 J1	0.055	2.366	0.23	0.05 J1	< 0.009 U1	< 0.002 U1	0.6 J1	0.06 J1	< 0.1 U1
8/20/2019	Assessment	< 0.02 U1	0.85	768	< 0.02 U1	< 0.01 U1	0.304	0.05 J1	3.12	0.21	< 0.05 U1	0.00301	< 0.002 U1	0.6 J1	0.05 J1	< 0.1 U1
3/18/2020	Assessment	< 0.02 U1	1.00	828	< 0.02 U1	< 0.01 U1	0.343	0.196	2.49	0.20	0.1 J1	0.00340	< 0.002 U1	0.6 J1	0.08 J1	< 0.1 U1
6/30/2020	Assessment	< 0.02 U1	0.92	816	< 0.02 U1	< 0.01 U1	0.2 J1	0.068	3.16	0.18	0.1 J1	0.00364	< 0.002 U1	0.5 J1	0.07 J1	< 0.1 U1
10/6/2020	Assessment	< 0.02 U1	1.00	750	< 0.02 U1	< 0.01 U1	0.1 J1	0.060	2.91	0.22	< 0.05 U1	0.00329	< 0.002 U1	0.5 J1	0.07 J1	< 0.1 U1
3/10/2021	Assessment	< 0.02 U1	1.04	739	0.009 J1	< 0.004 U1	0.433	0.100	1.92	0.26	0.08 J1	0.00306	< 0.002 U1	0.5 J1	< 0.09 U1	< 0.04 U1
6/8/2021	Assessment	< 0.02 U1	0.96	768 M1, P3	< 0.007 U1	< 0.004 U1	0.59	0.066	4.12	0.24	0.08 J1	0.00317	< 0.002 U1	0.6	< 0.09 U1	< 0.04 U1
10/5/2021	Assessment	< 0.02 U1	0.98	757 M1, P3	0.007 J1	< 0.004 U1	0.16 J1	0.086	4.15	0.22	0.08 J1	0.00354	< 0.002 U1	0.5	< 0.09 U1	< 0.04 U1
3/23/2022	Assessment	< 0.02 U1	0.80	783	< 0.007 U1	< 0.004 U1	0.09 J1	0.049	2.66	0.21	< 0.05 U1	0.00394	< 0.002 U1	0.5	< 0.09 U1	< 0.04 U1
6/14/2022	Assessment	< 0.02 U1	0.88	764	< 0.007 U1	< 0.004 U1	0.1 J1	0.047	2.75	0.21	< 0.05 U1	0.00328	< 0.002 U1	0.5	< 0.09 U1	< 0.04 U1
10/11/2022	Assessment	< 0.02 U1	0.90	730	0.009 J1	< 0.004 U1	0.91	0.079	2.96	0.20	0.05 J1	0.00378	< 0.004 U1	0.5	< 0.09 U1	< 0.04 U1

Notes:
µg/L: micrograms per liter
mg/L: milligrams per liter
pCi/L: picocuries per liter
<: Non-detect value. Analytes which were not detected are shown as less than the method detection limit (MDL) followed by a 'U1' flag. In analytical data prior to 5/18/2021, U1 flags were reported as U in the analytical report.
- -: Not analyzed
J1: Concentration estimated. Analyte was detected between the method detection limit and the reporting limit. In analytical data prior to 5/18/2021, J1 flags were reported as J in the analytical report.
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L1: The associated laboratory control sample (LSC) or laboratory control sample duplicate (LCSD) recovery was outside acceptance limits.
P3: The precision on the matrix spike duplicate (MSD) was above acceptance limits.
S7: Sample did not achieve constant weight.
S12: Residue weight is below the method criteria but was already analyzed with 100mL.

Table 1 - Groundwater Data Summary: MW-1607
Big Sandy - FAP
Appendix III Constituents

Collection Date	Monitoring Program	Boron	Calcium	Chloride	Fluoride	pH	Sulfate	Total Dissolved Solids
		mg/L	mg/L	mg/L	mg/L	SU	mg/L	mg/L
9/27/2016	Background	0.159	97.6	3.34	0.04 J1	6.9	132	406
11/8/2016	Background	0.202	76.3	15.5	0.06	6.8	88.4	368
1/11/2017	Background	0.171	99.0	5.96	0.06	6.0	171	474
2/21/2017	Background	0.195	105	3.47	0.06	6.5	150	470
4/25/2017	Background	0.273	80.8	10.2	0.07	6.3	85.3	332
5/23/2017	Background	0.186	89.4	3.24	0.06 J1	6.3	114	338
6/21/2017	Background	0.164	92.5	2.42	0.05 J1	6.3	119	368
7/12/2017	Background	0.167	86.0	2.28	0.05 J1	5.8	105	358
9/18/2017	Detection	0.155	90.7	2.73	0.07	6.4	125	398
1/31/2018	Detection	--	110	--	--	6.6	159	--
4/25/2018	Assessment	0.234	101	3.66	0.08	6.2	137	430
9/19/2018	Assessment	0.255	95.6	7.52	0.08	6.0	144	428
3/13/2019	Assessment	0.209	93.7	5.17	0.06	6.1	135	415
6/25/2019	Assessment	0.208	91.9	5.22	0.08	6.6	120	388
8/20/2019	Assessment	0.160	101	3.84	0.07	6.5	141	419
3/18/2020	Assessment	--	--	--	0.06	8.1	--	--
6/30/2020	Assessment	0.195	85.4	8.26	0.06 J1	6.3	94.1	--
8/26/2020	Assessment	--	--	--	--	6.0	--	372
10/6/2020	Assessment	0.155	99.4	4.76	0.07	6.9	129	381
3/10/2021	Assessment	--	--	--	0.08	6.4	--	--
6/8/2021	Assessment	0.151	81.2	3.56	0.09	6.9	89.2	330
10/5/2021	Assessment	0.161	97.0	4.05	0.08	6.5	112	420
3/24/2022	Assessment	--	--	--	0.06	7.7	--	--
6/14/2022	Assessment	0.152	87.0	3.21	0.07	6.9	87.7	370
10/11/2022	Assessment	0.144	83.0	4.12	0.06	6.3	85.2	350

Notes:
mg/L: milligrams per liter
SU: standard unit
<: Non-detect value. Analytes which were not detected are shown as less than the method detection limit (MDL) followed by a 'U1' flag.
In analytical data prior to 5/18/2021, U1 flags were reported as U in the analytical report.
- -: Not analyzed
J1: Concentration estimated. Analyte was detected between the method detection limit and the reporting limit.
In analytical data prior to 5/18/2021, J1 flags were reported as J in the analytical report.
M1: The associated matrix spike (MS) or matrix spike duplicate (MSD) was above acceptance limits.
L1: The associated laboratory control sample (LSC) or laboratory control sample duplicate (LCSD) recovery was outside acceptance limits.
P3: The precision on the matrix spike duplicate (MSD) was above acceptance limits.
S7: Sample did not achieve constant weight.
S12: Residue weight is below the method criteria but was already analyzed with 100mL.

Table 1 - Groundwater Data Summary: MW-1607
Big Sandy - FAP
Appendix IV Constituents

Geosyntec Consultants, Inc.

Collection Date	Monitoring Program	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Combined Radium	Fluoride	Lead	Lithium	Mercury	Molybdenum	Selenium	Thallium
		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	pCi/L	mg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L
9/27/2016	Background	0.02 J1	7.36	34.3	0.01 J1	< 0.004 U1	0.6	1.41	1.551	0.04 J1	0.156	0.003	< 0.002 U1	0.52	0.1 J1	0.03 J1
11/8/2016	Background	0.02 J1	11.6	42.3	0.025	0.007 J1	0.619	1.45	1.683	0.06	0.376	0.002	< 0.002 U1	0.62	0.1	0.02 J1
1/11/2017	Background	0.06	12.5	53.5	0.01 J1	0.05	0.456	1.31	0.577	0.06	0.129	0.007	< 0.002 U1	0.83	0.1	0.119
2/21/2017	Background	0.01 J1	8.71	34.3	0.01 J1	< 0.004 U1	0.359	1.24	1.339	0.06	0.030	0.005	< 0.002 U1	0.54	0.05 J1	0.055
4/25/2017	Background	0.03 J1	15.4	38.1	0.028	0.006 J1	0.682	1.34	1.08	0.07	0.416	0.003	< 0.002 U1	0.53	0.2	0.02 J1
5/23/2017	Background	0.02 J1	8.87	33.9	0.01 J1	0.008 J1	0.350	1.30	6.76	0.06 J1	0.081	0.009	0.004 J1	0.42	0.1	0.02 J1
6/21/2017	Background	0.02 J1	9.22	27.5	0.01 J1	< 0.005 U1	0.324	1.39	1.274	0.05 J1	0.123	0.004	< 0.002 U1	0.45	0.1	0.02 J1
7/12/2017	Background	0.02 J1	7.59	25.0	0.01 J1	< 0.005 U1	0.293	1.13	0.33	0.05 J1	0.070	0.004	< 0.002 U1	9.02	0.1	0.02 J1
4/25/2018	Assessment	0.27	68.5	37.2	0.111	< 0.005 U1	0.851	1.57	3.217	0.08	0.799	0.012	< 0.002 U1	0.90	0.7	0.04 J1
9/19/2018	Assessment	0.04 J1	23.6	42.6	0.02 J1	< 0.005 U1	0.423	1.59	0.611	0.08	0.159	0.001	--	0.59	0.1	0.04 J1
10/22/2018	Assessment	--	--	--	--	--	--	--	--	--	--	--	< 0.002 U1	--	--	--
3/13/2019	Assessment	< 0.02 U1	7.67	31.6	< 0.02 U1	< 0.01 U1	0.424	1.43	0.18541	0.06	0.05 J1	< 0.009 U1	< 0.002 U1	1 J1	0.08 J1	< 0.1 U1
6/25/2019	Assessment	0.02 J1	19.3	38.1	< 0.02 U1	< 0.01 U1	0.250	1.39	0.501	0.08	0.09 J1	< 0.009 U1	< 0.002 U1	0.7 J1	0.1 J1	< 0.1 U1
8/20/2019	Assessment	< 0.02 U1	14.4	29.1	< 0.02 U1	< 0.01 U1	0.347	1.19	0.685	0.07	< 0.05 U1	0.0001 J1	< 0.002 U1	0.6 J1	0.09 J1	< 0.1 U1
3/18/2020	Assessment	0.02 J1	14.2	34.6	< 0.02 U1	< 0.01 U1	0.305	1.34	2.1757	0.06	0.1 J1	0.000332	< 0.002 U1	0.8 J1	0.2 J1	0.1 J1
6/30/2020	Assessment	0.03 J1	17.7	25.7	< 0.02 U1	< 0.01 U1	0.209	1.33	1.398	0.06 J1	0.08 J1	0.0001 J1	< 0.002 U1	0.6 J1	0.1 J1	< 0.1 U1
10/6/2020	Assessment	0.16	24.9	30.2	< 0.02 U1	< 0.01 U1	0.352	1.22	1.017	0.07	0.1 J1	0.0002 J1	< 0.002 U1	0.6 J1	0.1 J1	< 0.1 U1
3/10/2021	Assessment	< 0.02 U1	12.3	54.7	0.01 J1	0.009 J1	0.276	1.75	0.2646	0.08	0.09 J1	0.000310	< 0.002 U1	0.6 J1	0.1 J1	< 0.04 U1
6/8/2021	Assessment	0.02 J1	14.3	24.3	0.009 J1	< 0.004 U1	0.23	0.946	0.88	0.09	0.05 J1	0.00012 J1	< 0.002 U1	0.6	< 0.09 U1	0.05 J1
10/5/2021	Assessment	0.03 J1	16.7	32.4	0.012 J1	0.004 J1	0.20	1.05	2.20	0.08	0.07 J1	0.00018 J1	< 0.002 U1	0.7	< 0.09 U1	< 0.04 U1
3/24/2022	Assessment	< 0.02 U1	16.7	30.2	0.012 J1	0.009 J1	0.22	1.30	0.87	0.06	0.11 J1	0.00013 J1	< 0.002 U1	0.7	0.12 J1	< 0.04 U1
6/14/2022	Assessment	0.02 J1	17.7	31.7	0.011 J1	< 0.004 U1	0.22	1.08	0.73	0.07	0.09 J1	0.00013 J1	< 0.002 U1	0.6	< 0.09 U1	< 0.04 U1
10/11/2022	Assessment	< 0.02 U1	18.7	36.7	0.008 J1	< 0.004 U1	0.33	0.913	0.49	0.06	< 0.05 U1	0.00013 J1	< 0.004 U1	0.6	< 0.09 U1	< 0.04 U1

Notes:
µg/L: micrograms per liter
mg/L: milligrams per liter
pCi/L: picocuries per liter
<: Non-detect value. Analytes which were not detected are shown as less than the method detection limit (MDL) followed by a 'U1' flag. In analytical data prior to 5/18/2021, U1 flags were reported as U in the analytical report.
- -: Not analyzed
J1: Concentration estimated. Analyte was detected between the method detection limit and the reporting limit. In analytical data prior to 5/18/2021, J1 flags were reported as J in the analytical report.
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P3: The precision on the matrix spike duplicate (MSD) was above acceptance limits.
S7: Sample did not achieve constant weight.
S12: Residue weight is below the method criteria but was already analyzed with 100mL.

Table 1: Residence Time Calculation Summary
Big Sandy Fly Ash Pond

CCR Management Unit	Monitoring Well	Well Diameter (inches)	2022-03		2022-06		2022-10	
			Groundwater Velocity (ft/year)	Groundwater Residence Time (days)	Groundwater Velocity (ft/year)	Groundwater Residence Time (days)	Groundwater Velocity (ft/year)	Groundwater Residence Time (days)
Fly Ash Pond	MW-1011 [1]	2.0	33.0	1.8	33.0	1.8	33.0	1.8
	MW-1012 [1]	2.0	33.0	1.8	33.0	1.8	33.0	1.8
	MW-1203 [1]	2.0	33.0	1.8	33.0	1.8	33.0	1.8
	MW-1601 [2]	4.0	33.0	3.7	33.0	3.7	33.0	3.7
	MW-1602 [2]	4.0	33.0	3.7	33.0	3.7	33.0	3.7
	MW-1603 [2]	4.0	33.0	3.7	33.0	3.7	33.0	3.7
	MW-1604 [3]	4.0	22.4	5.4	52.0	2.3	7.1	17.0
	MW-1605 [3]	4.0	22.4	5.4	52.0	2.3	7.1	17.0
	MW-1606 [2]	4.0	22.4	5.4	52.0	2.3	7.1	17.0
	MW-1607 [2]	4.0	22.4	5.4	52.0	2.3	7.1	17.0

Notes:
[1] - Upgradient Well
[2] - Downgradient Well
[3] - Background Well

FIGURES

Monitoring Well Network

- Compliance Sampling Location
- Background Sampling Location
- Fly Ash Pond

Notes

- Monitoring well coordinates provided by AEP.
- Site features based on information available in Groundwater Monitoring Network Evaluation - Big Sandy Fly Ash Pond (Geosyntec, 2016) provided by AEP.

1,000 500 0 1,000 Feet

Site Layout
CCR Fly Ash Pond

AEP Big Sandy Power Plant
Louisa, Kentucky

Geosyntec consultants

Columbus, Ohio | 2018/01/25

Figure **1**

C:\Users\mmuenich\Documents\local_projects\AEP_GIS\Big Sandy\MXDs\FAP\AEP-Big_Sandy_FAP_Site_Layout.mxd. MMuenich. 1/25/2018. Project/Phase/Task.

Legend

- Groundwater Monitoring Well
- Inferred Groundwater Flow Direction

Notes

- Monitoring well coordinates and water level data (collected on March 21, 2022) provided by AEP.
- Site features based on information available in Groundwater Monitoring Network Evaluation - Big Sandy Fly Ash Pond (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level (ft amsl).
- Fly Ash Pond cap liner construction completed in November 2020.

750 375 0 750 Feet

Potentiometric Surface Map - Uppermost Aquifer
March 2022
AEP Big Sandy Plant - Fly Ash Pond
Louisa, Kentucky

Geosyntec consultants

Columbus, Ohio | 2022/11/18

Figure **2**

P:\Projects\AEP\Groundwater Statistical Evaluation - CHA8423\Groundwater Mapping\GIS Files\MXD\Big Sandy\2022\AEP-BigSandy_FAP_GW_2021-03-March.mxd. ASoltero. 11/18/2022. CHA8423/05/08.

Legend

- Groundwater Monitoring Well
- Inferred Groundwater Flow Direction

Notes

- Monitoring well coordinates and water level data (collected on June 16, 2022) provided by AEP.
- Site features based on information available in Groundwater Monitoring Network Evaluation - Big Sandy Fly Ash Pond (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level (ft amsl).
- Fly Ash Pond cap liner construction completed in November 2020.

750 375 0 750 Feet

Potentiometric Surface Map - Uppermost Aquifer
June 2022
AEP Big Sandy Plant - Fly Ash Pond
Louisa, Kentucky

Geosyntec consultants

Columbus, Ohio | 2022/11/18

Figure **3**

P:\Projects\AEP\Groundwater Statistical Evaluation - CHA8423\Groundwater Mapping\GIS Files\MXD\Big Sandy\2022\AEP-BigSandy_FAP_GW_2021-06-June.mxd. ASoltero. 11/18/2022. CHA8423/05/08.

Legend

- Groundwater Monitoring Well
- Inferred Groundwater Flow Direction

Notes

- Monitoring well coordinates and water level data (collected on October 10, 2022) provided by AEP.
- Site features based on information available in Groundwater Monitoring Network Evaluation - Big Sandy Fly Ash Pond (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level (ft amsl).
- Fly Ash Pond cap liner construction completed in November 2020.

750 375 0 750 Feet

Potentiometric Surface Map - Uppermost Aquifer
October 2022
AEP Big Sandy Plant - Fly Ash Pond
Louisa, Kentucky

Geosyntec consultants

Columbus, Ohio | 2023/01/05

Figure **4**

\\annarbor-01\Data\Projects\AEP\Groundwater Statistical Evaluation - CHA8423\Groundwater Mapping\GIS Files\MXD\Big Sandy\2022\AEP-BigSandy_FAP_GW_2022-10-Oct.mxd. ASoltero. 1/5/2023. CHA8423/05/08.

APPENDIX 1
STATISTICAL ANALYSIS SUMMARIES

STATISTICAL ANALYSIS SUMMARY
FLY ASH POND
Big Sandy Plant
Louisa, Kentucky

Submitted to

AMERICAN ELECTRIC POWER℠

1 Riverside Plaza
Columbus, Ohio 43215-2372

Submitted by

Geosyntec consultants

engineers | scientists | innovators

941 Chatham Lane
Suite 103
Columbus, Ohio 43221

February 10, 2022
CHA8500

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ATTACHMENTS

LIST OF ACRONYMS AND ABBREVIATIONS

AEP	American Electric Power
ASD	Alternative Source Demonstration
CCR	Coal Combustion Residuals
CCV	Continuing Calibration Verification
CFR	Code of Federal Regulations
FAP	Fly Ash Pond
GWPS	Groundwater Protection Standard
LCL	Lower Confidence Limit
LFB	Laboratory Fortified Blanks
LPL	Lower Prediction Limit
LRB	Laboratory Reagent Blanks
MCL	Maximum Contaminant Level
NELAP	National Environmental Laboratory Accreditation Program
QA	Quality Assurance
QC	Quality Control
SSI	Statistically Significant Increase
SSL	Statistically Significant Level
TDS	Total Dissolved Solids
UPL	Upper Prediction Limit
USEPA	United States Environmental Protection Agency
UTL	Upper Tolerance Limit

SECTION 1

EXECUTIVE SUMMARY

In accordance with the United States Environmental Protection Agency's (USEPA's) regulations regarding the disposal of coal combustion residuals (CCR) in landfills and surface impoundments (40 CFR 257.90-257.98, "CCR rule"), groundwater monitoring has been conducted at the Fly Ash Pond (FAP), an existing CCR unit at the Big Sandy Power Plant located in Louisa, Kentucky. Recent groundwater monitoring results were compared to site-specific groundwater protection standards (GWPSs) to identify potential exceedances.

Based on detection monitoring conducted in 2017 and 2018, statistically significant increases (SSIs) over background were concluded for boron, calcium, chloride, fluoride, total dissolved solids (TDS), and sulfate at the FAP. An alternative source was not identified at the time, so the FAP initiated assessment monitoring in April 2018. GWPSs were set in accordance with 40 CFR 257.95(d)(2) and a statistical evaluation of the assessment monitoring data was conducted. During 2021, an annual sampling event for Appendix IV parameters required by 257.95(b) was completed in March, and semiannual sampling events for both Appendix III parameters and Appendix IV parameters, as required by 257.95(d)(1), were completed in June and October. During the June 2021 assessment monitoring events, statistically significant levels (SSLs) were observed for beryllium, cobalt, and lithium (Geosyntec, 2021). An alternative source demonstration (ASD) was successfully completed (EHS, 2021); thus, the unit remained in assessment monitoring. One assessment monitoring event was conducted at the FAP in October 2021 in accordance with 40 CFR 257.95. The results of this assessment event are documented in this report.

Prior to conducting the statistical analyses, the groundwater data underwent several validation tests, including those for completeness, sample tracking accuracy, transcription errors, and consistent use of measurement units. No data quality issues were identified which would impact data usability.

The monitoring data were submitted to Groundwater Stats Consulting, LLC for statistical analysis. GWPSs were re-established for the Appendix IV parameters. Confidence intervals were calculated for Appendix IV parameters at the compliance wells to assess whether SSLs of Appendix IV parameters were present above the GWPS. SSLs were identified for beryllium, cobalt, combined radium, and lithium. Thus, either the unit will move to an assessment of corrective measures or an ASD will be conducted to evaluate if the unit can remain in assessment monitoring. Certification of the selected statistical methods by a qualified professional engineer is documented in Attachment A.

SECTION 2

FLY ASH POND EVALUATION

2.1 Data Validation & QA/QC

During the assessment monitoring program, one set of samples was collected for analysis from each upgradient and downgradient well to meet the requirements of 257.95(d)(1) in October 2021. Samples from October 2021 were analyzed for all Appendix III and Appendix IV parameters. A summary of data collected during this assessment monitoring event is presented in Table 1.

Chemical analysis was completed by an analytical laboratory certified by the National Environmental Laboratory Accreditation Program (NELAP). Quality assurance and quality control (QA/QC) samples completed by the analytical laboratory included the use of laboratory reagent blanks (LRBs), continuing calibration verification (CCV) samples, and laboratory fortified blanks (LFBs).

The analytical data were imported into a Microsoft Access database, where checks were completed to assess the accuracy of sample location identification and analyte identification. Where necessary, unit conversions were applied to standardize reported units across all sampling events. Exported data files were created for use with the Sanitas™ v.9.6.32 statistics software. The export file was checked against the analytical data for transcription errors and completeness. No QA/QC issues were noted which would impact data usability.

2.2 Statistical Analysis

Statistical analyses for the FAP were conducted in accordance with the October 2020 *Statistical Analysis Plan* (Geosyntec, 2020). Time series plots and results for all completed statistical tests are provided in Attachment B.

The data obtained in October 2021 were screened for potential outliers. No outliers were identified for this event.

2.2.1 Establishment of GWPSs

A GWPS was established for each Appendix IV parameter in accordance with 40 CFR 257.95(h) and the *Statistical Analysis Plan* (Geosyntec, 2020). The established GWPS was determined to be the greater value of the background concentration and the maximum contaminant level (MCL) or risk-based level specified in 40 CFR 257.95(h)(2) for each Appendix IV parameter. To determine background concentrations, an upper tolerance limit (UTL) was calculated using pooled data from the background wells collected during the background monitoring and assessment monitoring events. Tolerance limits were calculated parametrically with 95% coverage and 95% confidence for barium, beryllium, cobalt, combined radium, and lead. Non-parametric tolerance limits were calculated for antimony, arsenic, cadmium, chromium, fluoride, lithium, molybdenum, selenium,

and thallium due to apparent non-normal distributions and for mercury due to a high non-detect frequency. Tolerance limits and the final GWPSs are summarized in Table 2.

2.2.2 Evaluation of Potential Appendix IV SSLs

A confidence interval was constructed for each Appendix IV parameter at each compliance well. Confidence limits were generally calculated parametrically ($\alpha = 0.01$); however, non-parametric confidence limits were calculated in some cases (e.g., when the data did not appear to be normally distributed or when the non-detect frequency was too high). An SSL was concluded if the lower confidence limit (LCL) exceeded the GWPS (i.e., if the entire confidence interval exceeded the GWPS). Calculated confidence limits are shown in Attachment B.

The following SSLs were identified at the Big Sandy FAP:

- The LCL for beryllium exceeded the GWPS of 0.00400 mg/L at MW-1603 (0.0166 mg/L).
- The LCL for cobalt exceeded the GWPS of 0.00600 mg/L at MW-1603 (0.0855 mg/L).
- The LCL for combined radium exceeded the GWPS of 5.00 pCi/L at MW-1603 (5.11 pCi/L).
- The LCL for lithium exceeded the GWPS of 0.0400 mg/L at MW-1603 (0.181 mg/L).

As a result, the Big Sandy FAP will either move to an assessment of corrective measures or an ASD will be conducted to evaluate if the unit can remain in assessment monitoring.

2.2.3 Establishment of Appendix III Prediction Limits

Upper prediction limits (UPLs) were previously established for all Appendix III parameters following the background monitoring period (Geosyntec, 2018). Intrawell tests were used to evaluate potential SSIs for pH, whereas interwell tests were used to evaluate potential SSIs for boron, calcium, chloride, fluoride, sulfate, and TDS. Interwell and intrawell prediction limits are updated periodically during the assessment monitoring period as sufficient data became available.

Prediction limits for the interwell tests were recalculated using data collected during the 2021 assessment monitoring events. The Sen's Slope/Mann-Kendall trend test was used to evaluate data at upgradient wells for boron, calcium, chloride, fluoride, sulfate and TDS. While statistically significant increasing trends were found for fluoride at MW-1011, and decreasing trends were found for chloride, fluoride, and TDS at MW-1604, the magnitudes of the trends were low compared to the average concentrations and the results were similar to those observed in other upgradient wells; thus, no adjustments were made to the background datasets. The complete results of the interwell Sen's Slope/Mann Kendall trend test are included in Attachment B. The updated boron, calcium, chloride, fluoride, sulfate, and TDS prediction limits were calculated using a one-of-two retesting procedure, as during detection monitoring. The revised interwell prediction limits were used to evaluate potential SSI for boron, calcium, chloride, fluoride, sulfate, and TDS.

For the intrawell tests, insufficient new data was available to compare against the existing background dataset, the prediction limits were not updated for the intrawell tests at this time. The intrawell prediction limits for pH were previously calculated using all historical data through August 2020, except for well MW-1601. MW-1601 had insufficient water for sampling in 2020; therefore, the pH prediction limit for MW-1601 was calculated using historical data through March 2019. Intrawell prediction limits were used to evaluate potential SSIs for pH.

After the revised background set was established, a parametric or non-parametric analysis was selected based on the distribution of the data and the frequency of non-detect data. Estimated results less than the practical quantitation limit (PQL) – i.e., "J-flagged" data – were considered detections and the estimated results were used in the statistical analyses. Non-parametric analyses were selected for datasets with at least 50% non-detect data or datasets that could not be normalized. Parametric analyses were selected for datasets (either transformed or untransformed) that passed the Shapiro-Wilk / Shapiro-Francía test for normality. The Kaplan-Meier non-detect adjustment was applied to datasets with between 15% and 50% non-detect data. For datasets with fewer than 15% non-detect data, non-detect data were replaced with one half of the PQL. The selected analysis (i.e., parametric or non-parametric) and transformation (where applicable) for each background dataset are shown in Attachment B.

Interwell UPLs were updated for boron, calcium, chloride, fluoride, sulfate, and TDS using historical data through October 2021. Intrawell UPLs and lower prediction limits (LPLs) were previously calculated for pH using all the historical data through August 2020 to represent background values, except for well MW-1601, which used data through March 2019. The updated prediction limits are summarized in Table 3. The UPLs were calculated for a one-of-two retesting procedure; i.e., if at least one sample in a series of two does not exceed the UPL, or in the case of pH, is neither less than the LPL nor greater than the UPL, then it can be concluded that an SSI has not occurred. In practice, where the initial result does not exceed the UPL, or in the case of pH, is neither less than the LPL nor greater than the UPL, a second sample will not be collected. The retesting procedures allowed achieving an acceptably high statistical power to detect changes at downgradient wells for constituents evaluated using intrawell prediction limits.

2.2.4 Evaluation of Potential Appendix III SSIs

While SSLs were identified for Appendix IV parameters, a review of the Appendix III results was also completed to assess whether concentrations of Appendix III parameters at the compliance wells exceeded background concentrations.

Data collected during the October 2021 assessment monitoring event from each compliance well were compared to the prediction limits to evaluate results above background values. The results from this event and the prediction limits are summarized in Table 3. The following exceedances of the UPL were noted:

- Boron concentrations exceeded the interwell UPL of 0.244 mg/L at MW-1606 (2.04 mg/L).

- Chloride concentrations exceeded the interwell UPL of 6.22 mg/L at MW-1602 (18.3 mg/L) and MW-1606 (31.4 mg/L).

- Fluoride concentrations exceeded the interwell UPL of 0.850 mg/L at MW-1603 (0.96 mg/L)

- Sulfate concentrations exceeded the interwell UPL of 106 mg/L at MW-1602 (167 mg/L), MW-1603 (735 mg/L), and MW-1607 (112 mg/L).

- TDS concentrations exceeded the interwell UPL of 583 mg/L at MW-1603 (1,040 mg/L).

While the prediction limits were calculated for a one-of-two retesting procedure, SSIs were conservatively assumed if the October 2021 result was above the UPL or below the LPL. Based on these results, concentrations of Appendix III constituents appear to be above background levels at compliance wells.

2.3 Conclusions

A semi-annual assessment monitoring event was conducted in October 2021 in accordance with the CCR Rule. The laboratory and field data were reviewed prior to statistical analysis, with no QA/QC issues identified that impacted data usability. A review of outliers identified no potential outliers in the October 2021 data. GWPSs were re-established for the Appendix IV parameters. A confidence interval was constructed at each compliance well for each Appendix IV parameter; SSLs were concluded if the entire confidence interval exceeded the GWPS. SSLs were identified for beryllium, cobalt, combined radium, and lithium. Appendix III parameters were compared to established prediction limits, with exceedances identified for boron, chloride, fluoride, sulfate, and TDS.

Based on this evaluation, the Big Sandy FAP CCR unit will either move to an assessment of corrective measures or an ASD will be conducted to evaluate if the unit can remain in assessment monitoring.

SECTION 3

REFERENCES

EHS Support. 2021. Alternative Source Demonstration Addendum Report for the March and June 2021 Monitoring Data. Big Sandy Fly Ash Pond. November 2021.

Geosyntec Consultants (Geosyntec). 2020. Statistical Analysis Plan. October 2020.

Geosyntec. 2021. Statistical Analysis Summary – Fly Ash Pond, Big Sandy Plant, Louisa, Kentucky. October 2021.

TABLES

Table 1 - Groundwater Data Summary
Big Sandy Plant - Fly Ash Pond

Geosyntec Consultants, Inc.

Parameter	Unit	MW-1011	MW-1012	MW-1203	MW-1601	MW-1602	MW-1603	MW-1604	MW-1605	MW-1606	MW-1607
		10/5/2021	10/6/2021	10/6/2021	10/6/2021	10/6/2021	10/6/2021	10/5/2021	10/5/2021	10/5/2021	10/5/2021
Antimony	µg/L	0.19	0.77	0.02 J	0.92	0.08 J	0.1 U	0.1 U	0.1 U	0.1 U	0.03 J
Arsenic	µg/L	4.42	17.8	0.23	0.53	0.99	1.01	0.06 J	0.04 J	0.98	16.7
Barium	µg/L	46.1	30.5	92.7	41.4	61.9	17.1	70.2	36.9	757	32.4
Beryllium	µg/L	0.05 U	0.026 J	0.041 J	0.05 U	0.05 U	17.4	0.143	0.118	0.007 J	0.012 J
Boron	mg/L	0.118	0.192	0.099	0.069	0.057	0.054	0.016 J	0.011 J	2.04	0.161
Cadmium	µg/L	0.012 J	0.010 J	0.02 U	0.022	0.02 U	0.913	0.079	0.074	0.02 U	0.004 J
Calcium	mg/L	79.0	1.2	59.1	59.7	86.1	93.1	3.2	1.2	74.5	97.0
Chloride	mg/L	3.74	1.40	5.13	3.00	18.3	3.93	1.11	0.41	31.4	4.05
Chromium	µg/L	0.22	0.25	0.11 J	0.49	0.59	0.59	0.61	2.68	0.16 J	0.20
Cobalt	µg/L	0.305	0.113	0.677	0.051	0.009 J	95.1	0.154	0.184	0.086	1.05
Combined Radium	pCi/L	3.19	0.98	2.1	1.7	0.95	10.51	1.67	0.97	4.15	2.2
Fluoride	mg/L	0.28	0.80	0.14	0.24	0.10	0.96	0.03 J	0.06 U	0.22	0.08
Lead	µg/L	0.10 J	0.48	0.08 J	0.10 J	0.11 J	6.10	0.06 J	0.1 J	0.08 J	0.07 J
Lithium	mg/L	0.00987	0.00564	0.0122	0.0132	0.00815	0.186	0.00101	0.00075	0.00354	0.00018 J
Mercury	µg/L	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.003 J	0.005 U	0.01 U	0.005 U	0.005 U
Molybdenum	µg/L	0.9	1.8	0.5 U	4.3	1.3	0.5 U	0.1 J	0.5 U	0.5	0.7
Selenium	µg/L	0.5 U	0.5 U	0.5 U	0.37 J	3.19	4.26	0.31 J	0.24 J	0.5 U	0.5 U
Sulfate	mg/L	78.1	33.5	27.8	105	167	735	9.42	4.59	60.7	112
Thallium	µg/L	0.06 J	0.05 J	0.2 U	0.2 U	0.2 U	2.20	0.2 U	0.2 U	0.2 U	0.2 U
Total Dissolved Solids	mg/L	380	570	270	360	510	1,040	60	40 J	400	420
pH	SU	6.9	9.2	6.9	7.1	7.5	3.3	5.7	5.1	7.0	6.5

Notes:
mg/L: milligrams per liter
µg/L: micrograms per liter
SU: standard unit
pCi/L: picocuries per liter
U: Parameter was not present in concentrations above method detection limit and is reported as the reporting limit
J: Estimated value. Parameter was detected in concentrations below the reporting limit
All samples were collected as part of the assessment monitoring program in accordance with 40 CFR 257.90(e)(3).

Table 2: Appendix IV Groundwater Protection Standards
Big Sandy Plant - Fly Ash Pond

Constituent Name	MCL	CCR Rule-Specified	Calculated UTL	GWPS
Antimony, Total (mg/L)	0.00600		0.00120	0.00600
Arsenic, Total (mg/L)	0.0100		0.0289	0.0289
Barium, Total (mg/L)	2.00		0.122	2.00
Beryllium, Total (mg/L)	0.00400		0.000174	0.00400
Cadmium, Total (mg/L)	0.00500		0.000140	0.00500
Chromium, Total (mg/L)	0.100		0.00291	0.100
Cobalt, Total (mg/L)	n/a	0.00600	0.00441	0.00600
Combined Radium, Total (pCi/L)	5.00		4.49	5.00
Fluoride, Total (mg/L)	4.00		0.850	4.00
Lead, Total (mg/L)	n/a	0.0150	0.00135	0.0150
Lithium, Total (mg/L)	n/a	0.0400	0.0200	0.0400
Mercury, Total (mg/L)	0.00200		0.0000130	0.00200
Molybdenum, Total (mg/L)	n/a	0.100	0.00348	0.100
Selenium, Total (mg/L)	0.0500		0.000500	0.0500
Thallium, Total (mg/L)	0.00200		0.000229	0.00200

Notes:
MCL = Maximum Contaminant Level
CCR = Coal Combustion Residual
GWPS = Groundwater Protection Standard
Calculated UTL (Upper Tolerance Limit) represents site-specific background values.
Grey cells indicate the GWPS is based on the calculated UTL, which is higher than the MCL or CCR-Rule specified value.

Table 3 - Appendix III Data Summary
Big Sandy - Fly Ash Pond

Geosyntec Consultants, Inc.

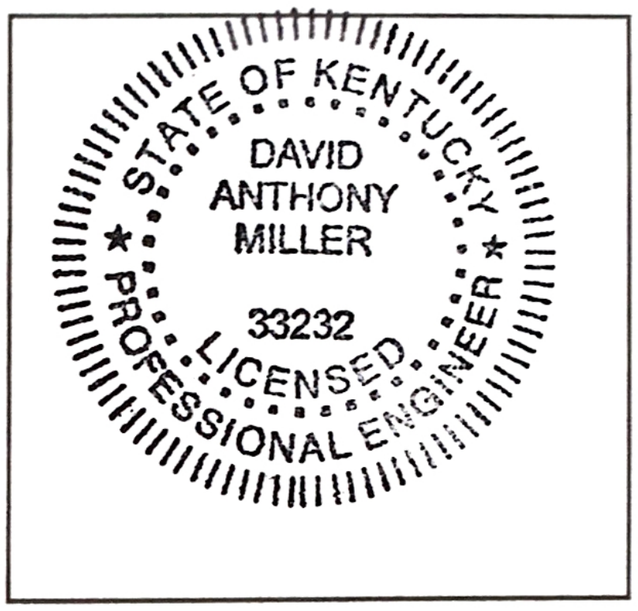
Analyte	Unit	Description	MW-1601	MW-1602	MW-1603	MW-1606	MW-1607
			10/6/2021	10/6/2021	10/6/2021	10/5/2021	10/5/2021
Boron	mg/L	Interwell Background Value (UPL)	0.244				
		Analytical Result	0.069	0.057	0.054	**2.04**	0.161
Calcium	mg/L	Interwell Background Value (UPL)	105				
		Analytical Result	59.7	86.1	93.1	74.5	97.0
Chloride	mg/L	Interwell Background Value (UPL)	6.22				
		Analytical Result	3.00	**18.3**	3.93	**31.4**	4.05
Fluoride	mg/L	Interwell Background Value (UPL)	0.850				
		Analytical Result	0.24	0.10	**0.96**	0.22	0.08
pH	SU	Intrawell Background Value (UPL)	8.0	8.7	5.6	7.5	7.5
		Intrawell Background Value (LPL)	6.3	5.6	2.9	6.3	5.5
		Analytical Result	7.1	7.5	3.3	7.0	6.5
Sulfate	mg/L	Interwell Background Value (UPL)	106				
		Analytical Result	105	**167**	**735**	60.7	**112**
Total Dissolved Solids	mg/L	Interwell Background Value (UPL)	583				
		Analytical Result	360	510	**1,040**	400	420

Notes:
UPL: Upper prediction limit
LPL: Lower prediction limit
Bold values exceed the background value.
Background values are shaded gray.
Due to limited groundwater volume, pH values for some sampling events were collected the day prior to collection of analytical samples.

ATTACHMENT A
Certification by Qualified Professional Engineer

Certification by Qualified Professional Engineer

I certify that the selected and above described statistical method is appropriate for evaluating the groundwater monitoring data for the Big Sandy Fly Ash Pond CCR management area and that the requirements of 40 CFR 257.93(f) have been met.



DAVID ANTHONY MILLER

Printed Name of Licensed Professional Engineer

David Anthony Miller

Signature

33232

License Number

KENTUCKY

Licensing State

02.10.22

Date

ATTACHMENT B

Statistical Analysis Output

GROUNDWATER STATS CONSULTING

January 14, 2022

Geosyntec Consultants
Attn: Ms. Allison Kreinberg
941 Chatham Lane, #103
Columbus, OH 43221

Re: Big Sandy Fly Ash Pond
Assessment Monitoring & Background Update – October 2021

Dear Ms. Kreinberg,

Groundwater Stats Consulting (GSC), formerly the statistical consulting division of Sanitas Technologies, is pleased to provide the background update and analysis of 2021 groundwater data for American Electric Power Company's Big Sandy Bottom Ash Pond. The analysis complies with the federal rule for the Disposal of Coal Combustion Residuals (CCR) from Electric Utilities (CCR Rule, 2015) as well as with the United States Environmental Protection Agency (USEPA) Unified Guidance (2009).

Sampling began at site for the CCR program in 2016. The monitoring well network, as provided by Geosyntec Consultants, consists of the following:

- **Upgradient wells:** MW-1011, MW-1012, MW-1203, MW-1604, and MW-1605
- **Downgradient wells:** MW-1601, MW-1602, MW-1603, MW-1606, and MW-1607

Data were sent electronically, and the statistical analysis was conducted according to the Statistical Analysis Plan and screening evaluation prepared by GSC and approved by Dr. Kirk Cameron, PhD Statistician with MacStat Consulting, primary author of the USEPA Unified Guidance, and Senior Advisor to GSC. The analysis was reviewed by Andrew Collins, Project Manager of Groundwater Stats Consulting.

The CCR program consists of the following constituents listed below. The terms "constituent" and "parameter" are interchangeable.

- **Appendix III** (Detection Monitoring) **-** boron, calcium, chloride, fluoride, pH, sulfate, and TDS
- **Appendix IV** (Assessment Monitoring) **–** antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, combined radium 226 + 228, fluoride, lead, lithium, mercury, molybdenum, selenium, and thallium

Time series and box plots for Appendix III and IV parameters are provided for all wells and constituents, and are used to evaluate concentrations over the entire record (Figures A & B, respectively). A summary of the values identified as outliers in this report and through previous screenings follows this letter. These values are deselected prior to the statistical analysis. All flagged values may also be seen in a lighter font and disconnected symbol on the time series graphs (Figure C).

Note that when there are no detections present in downgradient wells for a given constituent, statistical analyses are not required. A summary of well/constituent pairs with 100% non-detects follows this letter. For all constituents, a substitution of the most recent reporting limit is used for non-detect data. In the time series plots, a single reporting limit substitution is used across all wells for a given parameter since the wells are plotted as a group. For calculating intrawell prediction limits, the substitution is performed for individual wells and may differ across wells. This generally gives the most conservative limit in each case.

For regulatory comparison of current observations against statistical limits for Appendix III constituents, the annual site-wide false positive rate is based on the USEPA Unified Guidance (2009) recommendation of 10% (5% for each semi-annual sample event or 2.5% for quarterly sample events). The EPA suggests the selected statistical method should provide at least 55% power at 3 standard deviations or at least 80% power at 4 standard deviations. Power curves were based on the following:

Semi-Annual Sampling
1-of-2 resample plan
Constituents: 7
Downgradient wells: 5

Data at all wells were evaluated during the initial background screening conducted in December 2017 for the following: 1) outliers; 2) trends; 3) most appropriate statistical method for Appendix III parameters based on site characteristics of groundwater data

upgradient of the facility; and 4) eligibility of downgradient wells when intrawell statistical methods are recommended. Power curves were provided in the previous report and demonstrated that the selected statistical methods for Appendix III parameters comply with the USEPA Unified Guidance recommendations as discussed below.

Summary of Statistical Methods – Appendix III Parameters

Based on the original background screening described below, the following statistical methods were selected for Appendix III parameters:

- Intrawell prediction limits, combined with a 1-of-2 resample plan for pH
- Interwell prediction limits combined with a 1-of-2 resample plan for boron, calcium, chloride, fluoride, sulfate and TDS

Parametric prediction limits are utilized when the screened historical data follow a normal or transformed-normal distribution. When data cannot be normalized or the majority of data are non-detects, a nonparametric test is utilized. While the annual false positive rate associated with parametric limits is fixed at 10% as recommended by the EPA Unified Guidance (2009), the false positive rate associated with nonparametric limits is not fixed and depends upon the available background sample size, number of future comparisons, and verification resample plan. The distribution of data is tested using the Shapiro-Wilk/Shapiro-Francia test for normality. After testing for normality and performing any adjustments as discussed below (US EPA, 2009), data are analyzed using either parametric or non-parametric prediction limits as appropriate. Non-detects are handled as follows:

- No statistical analyses are required on wells and analytes containing 100% non-detects (USEPA Unified Guidance, 2009, Chapter 6).
- When data contain <15% non-detects in background, simple substitution of one-half the reporting limit is utilized in the statistical analysis. The reporting limit utilized for non-detects is the practical quantification limit (PQL) as reported by the laboratory.
- When data contain between 15-50% non-detects, the Kaplan-Meier non-detect adjustment is applied to the background data. This technique adjusts the mean and standard deviation of the historical concentrations to account for concentrations below the reporting limit.
- Nonparametric prediction limits are used on data containing greater than 50% non-detects.

Natural systems continuously evolve due to physical changes made to the environment. Examples include capping a landfill, paving areas near a well, or lining a drainage channel

to prevent erosion. Periodic updating of background statistical limits is necessary to accommodate these types of changes.

In the intrawell case, data for all wells and constituents may be re-evaluated when a minimum of 4 new data points are available to determine whether earlier concentrations are representative of present-day groundwater quality. In the interwell case, prediction limits are updated with upgradient well data following each sampling event after careful screening for any new outliers. In some cases, deselecting the earlier portion of data may be necessary prior to construction of limits so that resulting statistical limits are conservative (lower) from a regulatory perspective and capable of rapidly detecting changes in groundwater quality. Even though the data are excluded from the calculation, the values will continue to be reported and shown in tables and graphs.

Summary of Background Screening Conducted in December 2017

Outlier Analysis

All proposed background data were screened for outliers and trends during the background screening. The findings of those reports were submitted with that analysis. Interwell prediction limits utilize all upgradient well data for construction of statistical limits. During each sample event, upgradient well data are screened for any newly suspected outliers or obvious trending patterns using time series plots. Intrawell prediction limits utilized the background data set that was originally screened in 2017. As recommended in the EPA Unified Guidance (2009), the background data sets are evaluated for the purpose of updating statistical limits, as described below, using the Mann-Whitney two-sample test when an additional four to eight measurements are available.

Seasonality

No true seasonal patterns were observed on the time series plots for any of the detected data; therefore, no deseasonalizing adjustments were made to the data. When seasonal patterns are observed, data may be deseasonalized so that the resulting limits will correctly account for the seasonality as a predictable pattern rather than random variation or a release. It was noted that for each constituent evaluated, the highest concentrations are reported in the upgradient wells.

Trend Test Evaluation

While trends may be visual, a quantification of the trend and its significance is needed. The Sen's Slope/Mann Kendall trend test was used to evaluate all data at each well to identify statistically significant increasing or decreasing trends. In the absence of suspected contamination, significant trending data are typically not included as part of the background data used for construction of prediction limits. This step serves to eliminate the trend and, thus, reduce variation in background. When statistically significant decreasing trends are present, earlier data are evaluated to determine whether earlier concentration levels are significantly different than current reported concentrations and will be deselected as necessary. When the historical records of data are truncated for the reasons above, a summary report will be provided to show the date ranges used in construction of the statistical limits. No adjustments were required at the time, and results of the trend tests were included with the 2017 screening.

Appendix III – Determination of Spatial Variation

The Analysis of Variance (ANOVA) was used to statistically evaluate differences in average concentrations among upgradient wells, which assists in identifying the most appropriate statistical approach. Interwell tests, which compare downgradient well data to statistical limits constructed from pooled upgradient well data, are appropriate when average concentrations are similar across upgradient wells. Intrawell tests, which compare compliance data from a single well to screened historical data within the same well, are appropriate when upgradient wells exhibit spatial variation; when statistical limits constructed from upgradient wells would not be conservative from a regulatory perspective; and when downgradient water quality is unimpacted compared to upgradient water quality for the same parameter.

The results of the 2017 screening demonstrated that intrawell background limits, based on a 1-of-2 resample plan, were appropriate for pH and that interwell background limits, based on a 1-of-2 resample plan, were appropriate for boron, calcium, chloride, fluoride, sulfate, and TDS. A summary of the ANOVA results was included with the 2017 screening.

Appendix III Background Update Summaries

January 2021

Prior to updating background data for the 2020 analysis, samples were re-evaluated using Tukey's outlier test and visual screening at all wells on data through August 2020 for pH, which uses intrawell prediction limits and at upgradient wells through October 2020 for

boron, calcium, chloride, fluoride, sulfate, and TDS which use interwell prediction limits. Tukey's test identified new outliers for pH in wells MW-1012 and MW-1606 and these values were appropriately flagged as outliers in the database. Tukey's outlier test on pooled upgradient well data for constituents tested using interwell prediction limits did not identify any potential outliers; therefore, no new values were flagged in upgradient wells for Appendix III parameters requiring interwell methods.

For constituents requiring intrawell prediction limits, the Mann-Whitney (Wilcoxon Rank Sum) test was used to compare the medians of historical data through March 2019 to the new compliance samples at each well through August 2020 to evaluate whether the groups are statistically similar at the 99% confidence level, in which case background data may be updated with compliance data. No statistically significant differences were found between the two groups for pH among wells that were tested; therefore, all wells for pH with the exception of well MW-1601, which was not sampled during 2020, were updated with compliance samples to use all historical data through August 2020.

The Sen's Slope/Mann Kendall trend test was used to evaluate data at upgradient wells for boron, calcium, chloride, fluoride, sulfate and TDS to identify statistically significant increasing or decreasing trends. Statistically significant decreasing trends were noted for chloride, fluoride and TDS in upgradient well MW-1604. However, the magnitudes of the trends were low relative to average concentrations within this well and reported measurements are consistent with those reported at one or more neighboring upgradient wells. Therefore, no adjustments were made to the records at this time, and all well/constituent pairs for parameters using interwell prediction limits were updated to use all historical data through October 2020. A summary of the background update results was included with the January 2021 report.

January 2022

Outlier Analysis

Prior to updating background data during this analysis, upgradient wells were re-evaluated using Tukey's outlier test and visual screening for Appendix III constituents tested with interwell prediction limits on historical data through October 2021 (Figure C). Tukey's outlier test was not used to evaluate pH, which is tested using intrawell prediction limits, as it could not be updated during this evaluation period.

For parameters which use interwell prediction limits (boron, calcium, chloride, fluoride, sulfate, and TDS), Tukey's outlier test on pooled upgradient well data did not identify any

potential outliers, and no values were flagged in upgradient wells for these Appendix III parameters. A summary of all flagged outliers follows this report (Figure C).

Intrawell – Prediction Limits

Typically, for constituents requiring intrawell prediction limits, the Mann-Whitney (Wilcoxon Rank Sum) test is used to compare the medians of historical data through to the new compliance samples at each well to evaluate whether the groups are statistically similar at the 99% confidence level, in which case background data may be updated with compliance data. As mentioned above, pH did not have the minimum four required samples in the compliance dataset; therefore, sufficient data was not available to update background datasets. Background datasets for all parameters utilizing intrawell prediction limits will be updated after the Fall 2022 sample event.

Intrawell prediction limits using all historical data through August 2020, with the exception of well MW-1601, combined with a 1-of-2 resample plan, were constructed for pH and a summary of the limits follows this letter (Figure D). Intrawell prediction limits for well MW-1601 utilize background data through March 2019 as may be seen on the Date Range Table following this letter.

Interwell – Trend Test Evaluation

The Sen's Slope/Mann Kendall trend test was used to evaluate data at upgradient wells for boron, calcium, chloride, fluoride, sulfate and TDS to identify statistically significant increasing or decreasing trends (Figure E). The results of the trend analyses showed one statistically significant increasing trend for fluoride in upgradient well MW-1011. Statistically significant decreasing trends were noted for chloride, fluoride and TDS in upgradient well MW-1604. However, the magnitudes of the trends are low relative to average concentrations within this well and reported measurements are consistent with those reported at one or more neighboring upgradient wells. Therefore, no adjustments were made to the records at this time. All records will be re-evaluated during the next background update and, if earlier measurements are no longer representative of present-day conditions, the historical portion of the records will be deselected prior to construction of statistical limits.

Interwell – Prediction Limits

Interwell prediction limits, combined with a 1-of-2 resample plan, were constructed using all pooled upgradient well data through October 2021 for boron, calcium, chloride,

fluoride, sulfate and TDS (Figure F). A summary table of the updated limits may be found following this letter in the Prediction Limit Summary Tables.

Evaluation of Appendix IV Parameters – October 2021

Prior to evaluating Appendix IV parameters, all background data are screened through visual screening and Tukey's outlier test for potential outliers and extreme trending patterns that would lead to artificially elevated statistical limits.

For the current analysis, Tukey's outlier test on pooled upgradient well data through October 2021 for Appendix IV parameters did not identify any potential outliers. In previous reports, several high values not identified by Tukey's were flagged as outliers in order to construct limits that are conservative (i.e., lower) from a regulatory perspective. Any flagged values may be seen on the Outlier Summary following this letter as mentioned above (Figure C).

Interwell Upper Tolerance Limits

Interwell upper tolerance limits were used to calculate background limits from all available pooled upgradient well data through October 2021 (Figure G). Parametric limits use a target of 95% confidence and 95% coverage. The confidence and coverage levels for nonparametric tolerance limits are dependent upon the number of background samples.

Groundwater Protection Standards

These limits were compared to the Maximum Contaminant Levels (MCLs) and CCR-Rule specified levels, as shown in the Groundwater Protection Standards (GWPS) table following this letter (Figure H), to determine the highest limit for use as the GWPS in the confidence Interval comparisons.

Confidence Intervals

Confidence intervals were then constructed using data through October 2021 on downgradient wells for each Appendix IV constituent (Figure I). The confidence intervals were then compared against the GWPS (i.e., the highest limit of the MCL or background limit as discussed above). Only when the entire confidence interval is above a GWPS is the well/constituent pair considered to exceed its respective standard. Complete results of the confidence interval analysis follow this letter (Figure J). The following confidence interval exceedances were identified:

- Beryllium: MW-1603
- Cobalt: MW-1603
- Combined Radium 226 + 228: MW-1603
- Lithium: MW-1603

Thank you for the opportunity to assist you in the statistical analysis of groundwater quality for Big Sandy Fly Ash Pond. If you have any questions or comments, please feel free to contact us.

For Groundwater Stats Consulting,

Easton Rayner
Groundwater Analyst

Andrew Collins
Project Manager

100% Non-Detects

Analysis Run 1/11/2022 10:56 AM View: AIV
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Beryllium (mg/L)
MW-1602

Mercury (mg/L)
MW-1601

Date Ranges

Date: 1/11/2022 10:22 AM

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

pH (SU)

MW-1601 overall:9/26/2016-3/14/2019

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Hollow symbols indicate censored values.

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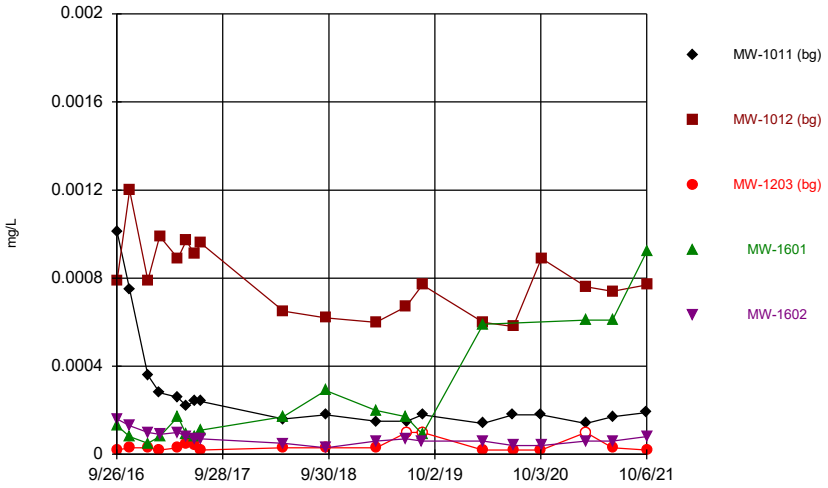

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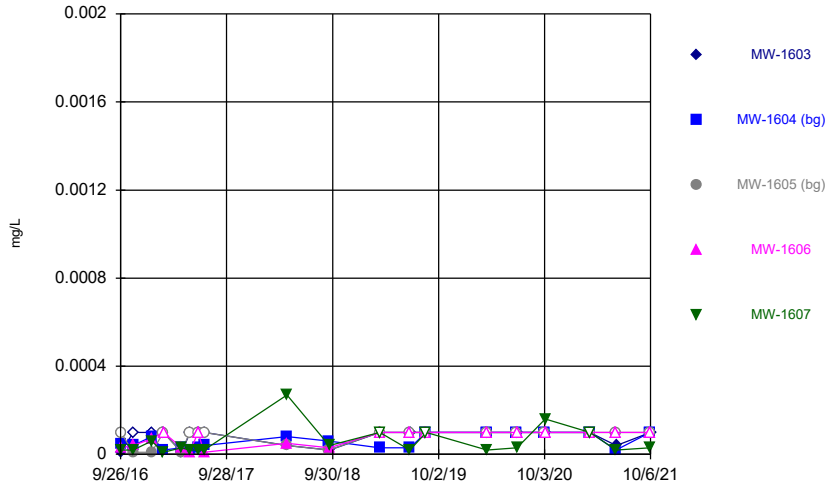
Time Series



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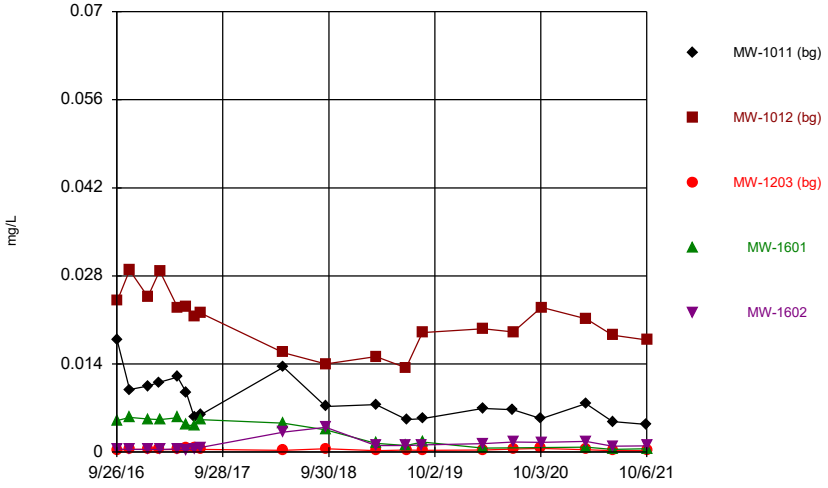

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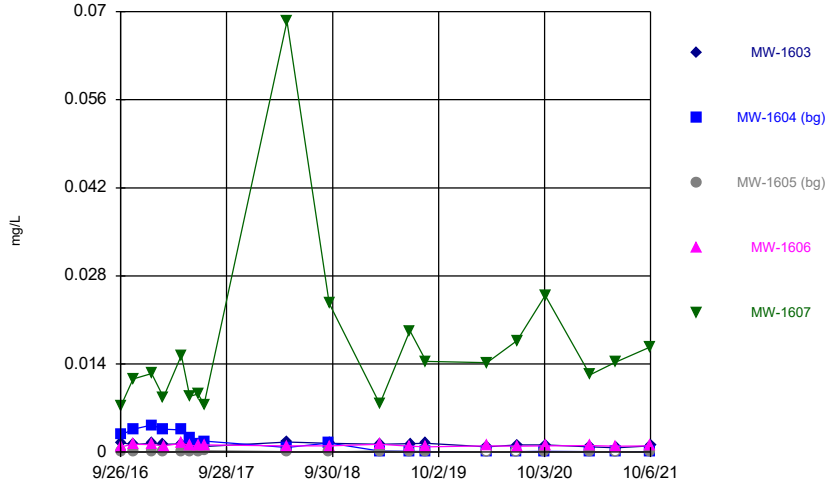

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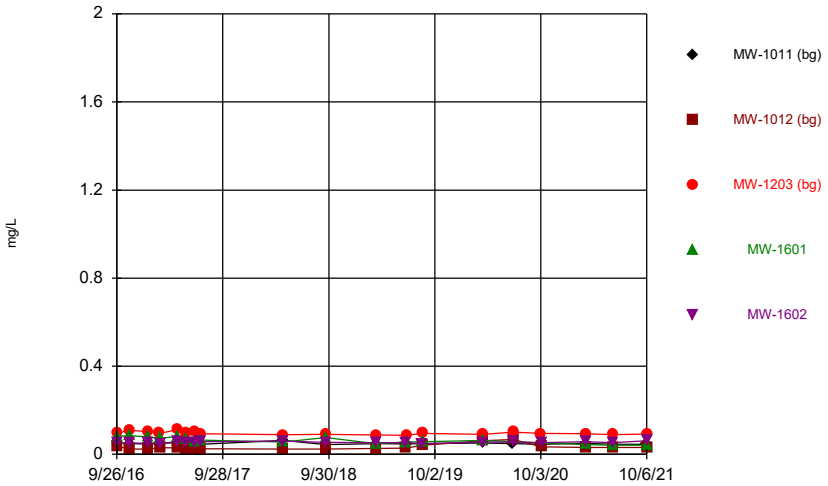

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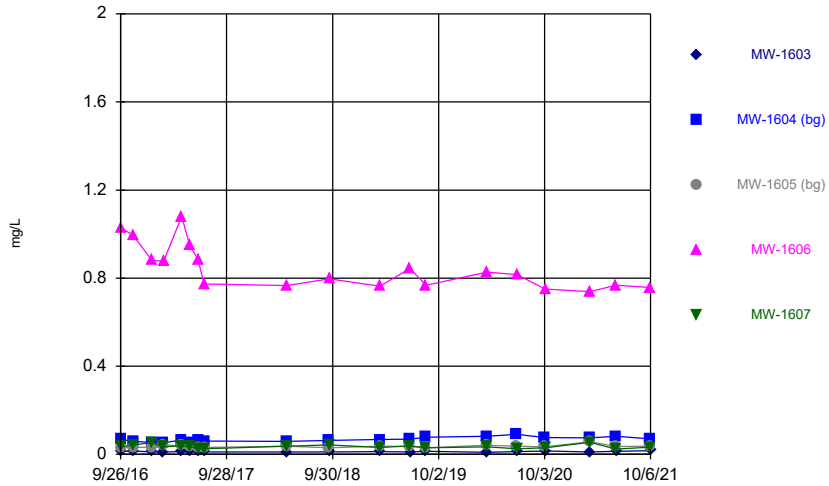

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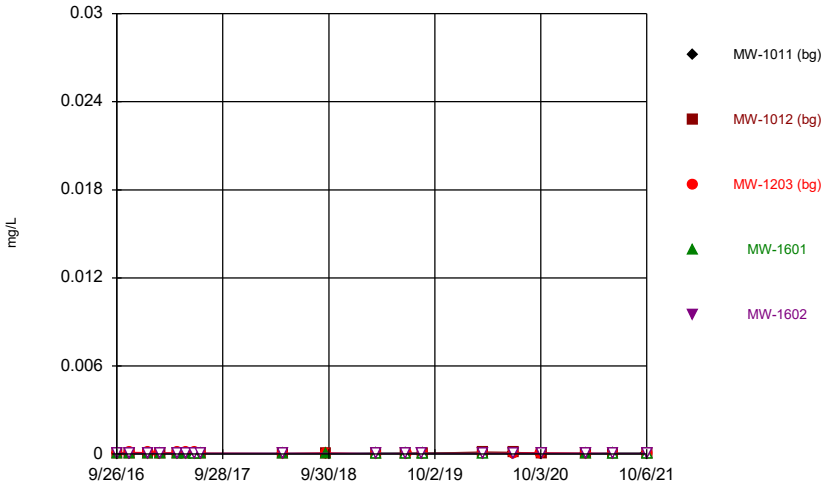

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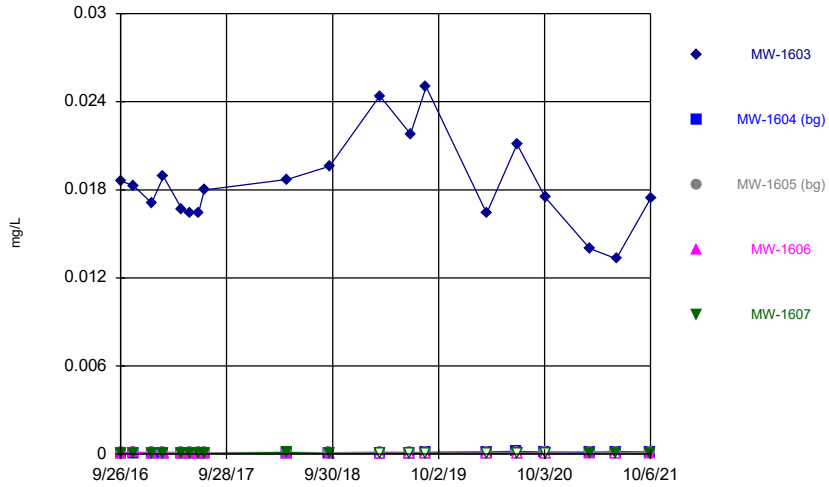

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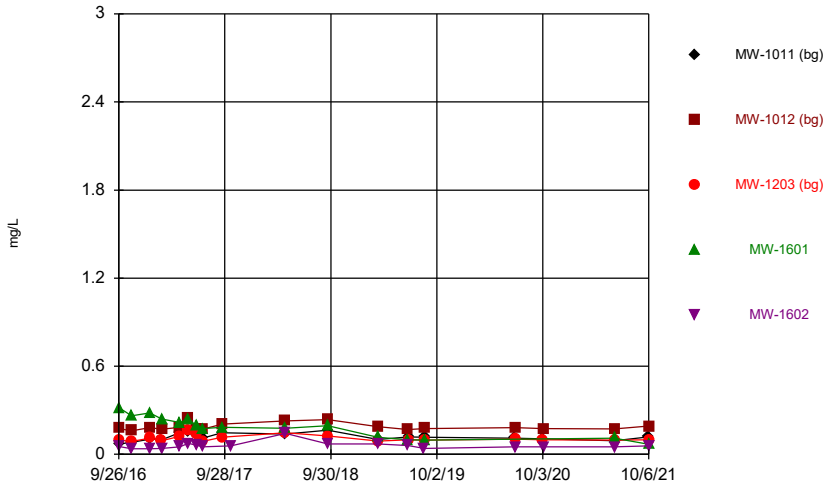

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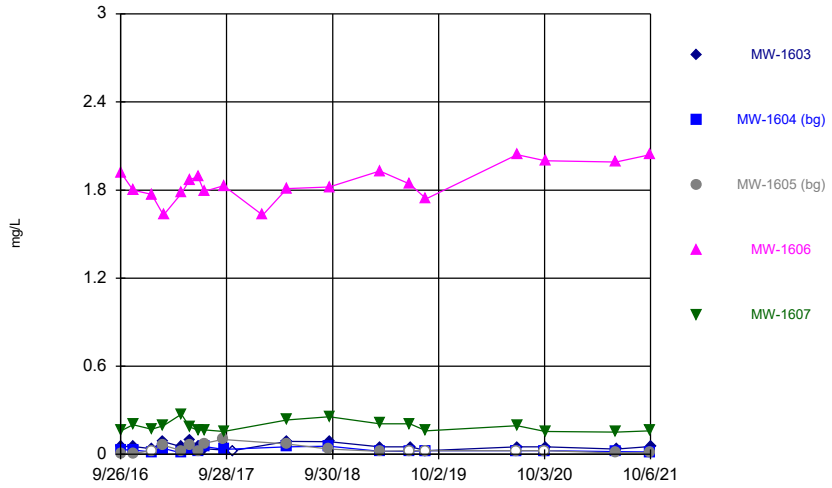

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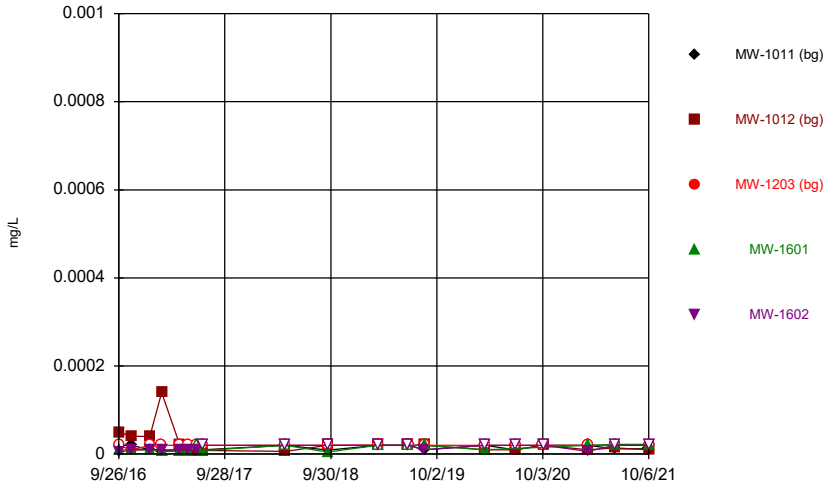

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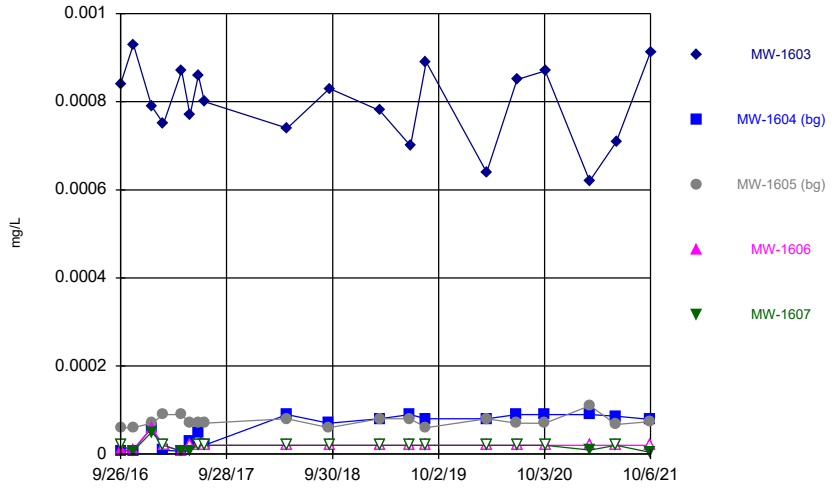

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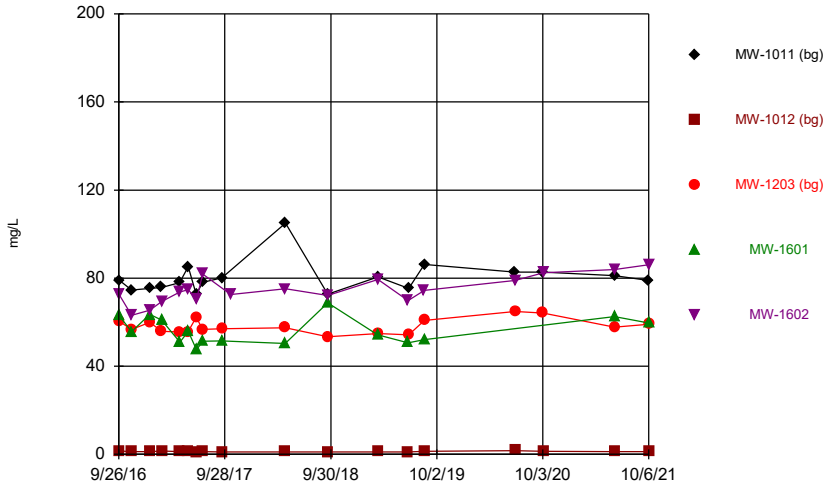

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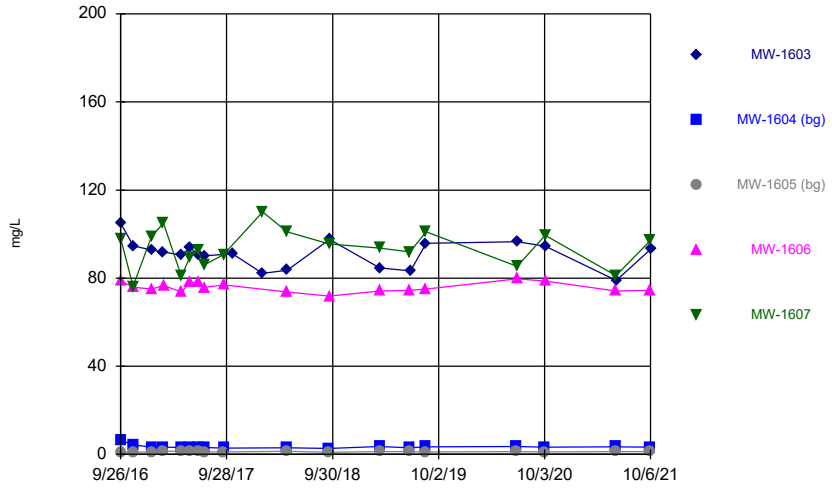

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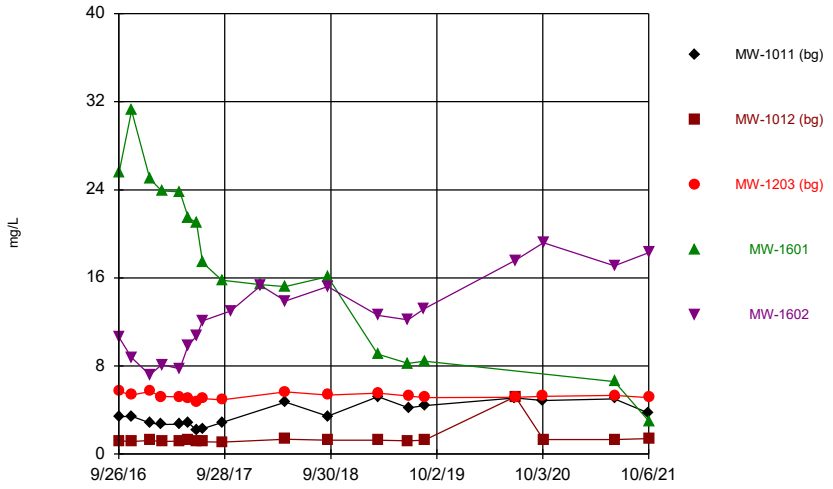

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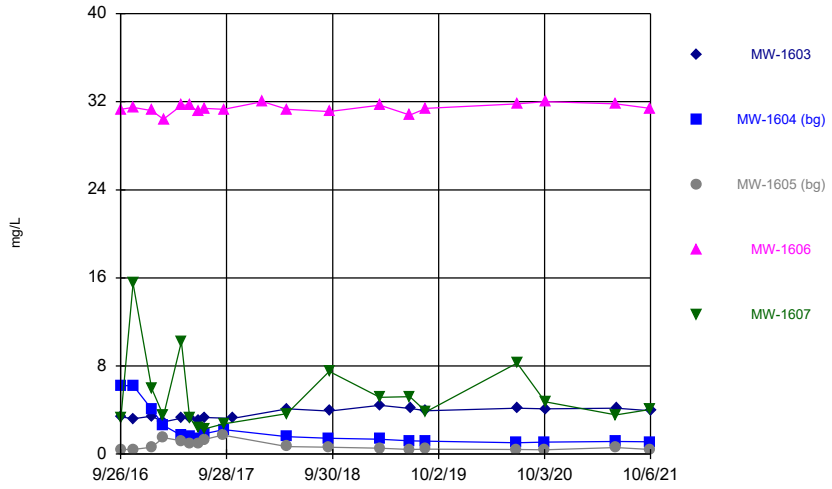
Time Series



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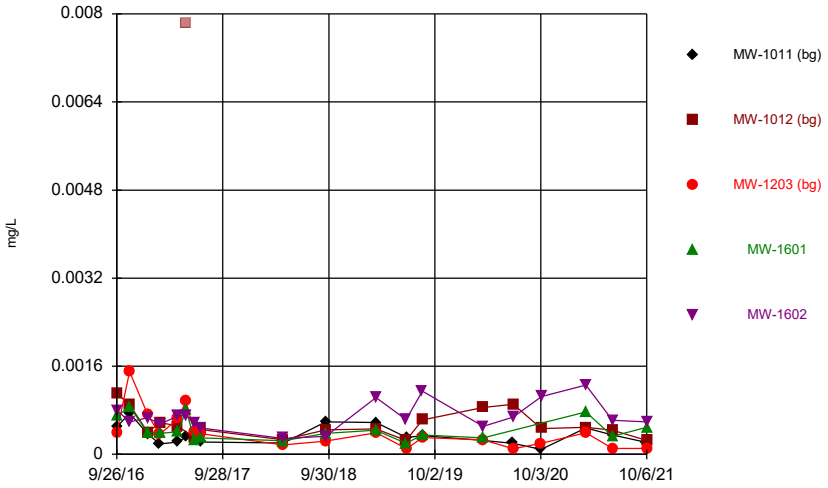

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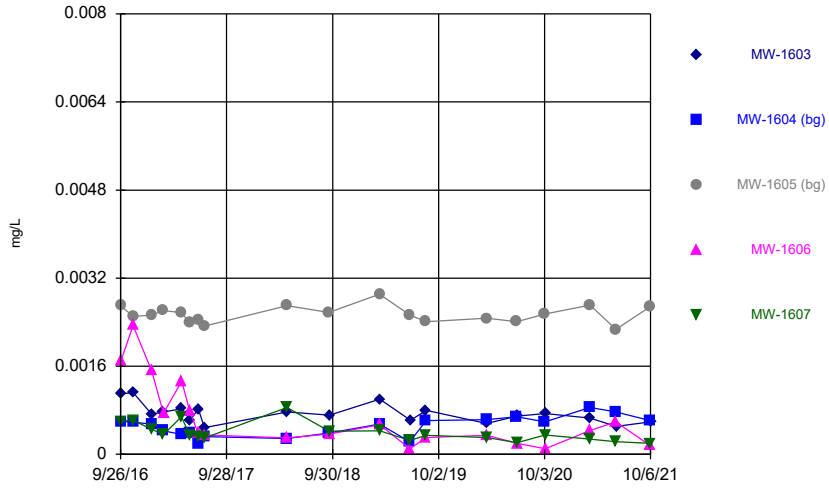
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Time Series



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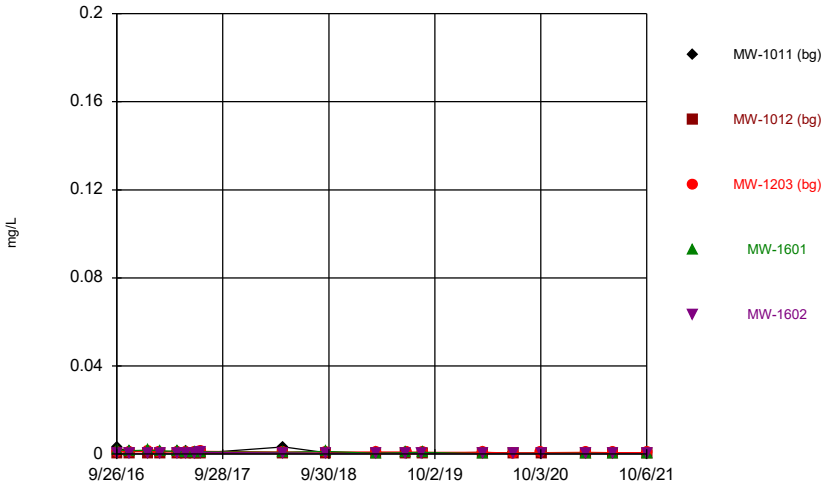
Sanitas™ v.9.6.32 . UG

Time Series



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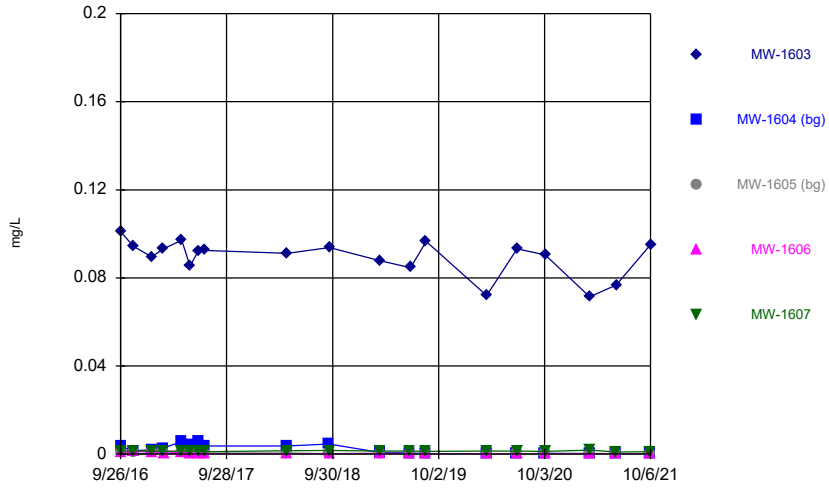
Sanitas™ v.9.6.32 . UG

Time Series



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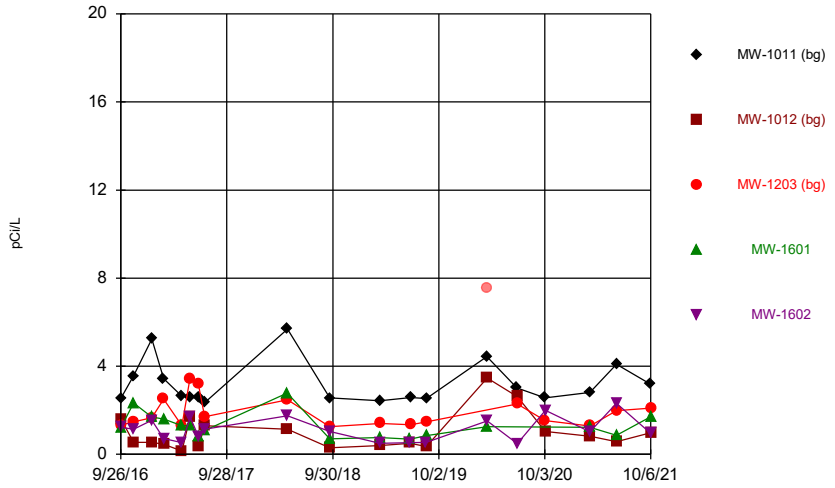
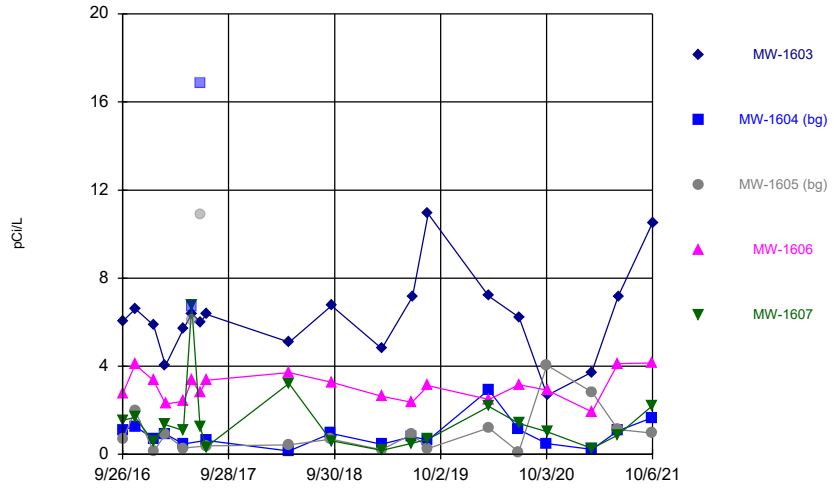


Constituent: Combined Radium 226 + 228 Analysis Run 1/11/2022 9:37 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

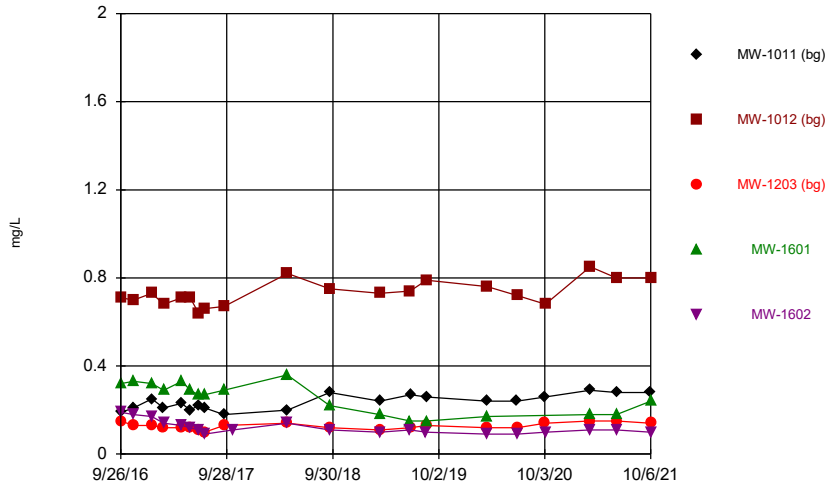
Time Series



Constituent: Combined Radium 226 + 228 Analysis Run 1/11/2022 9:37 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

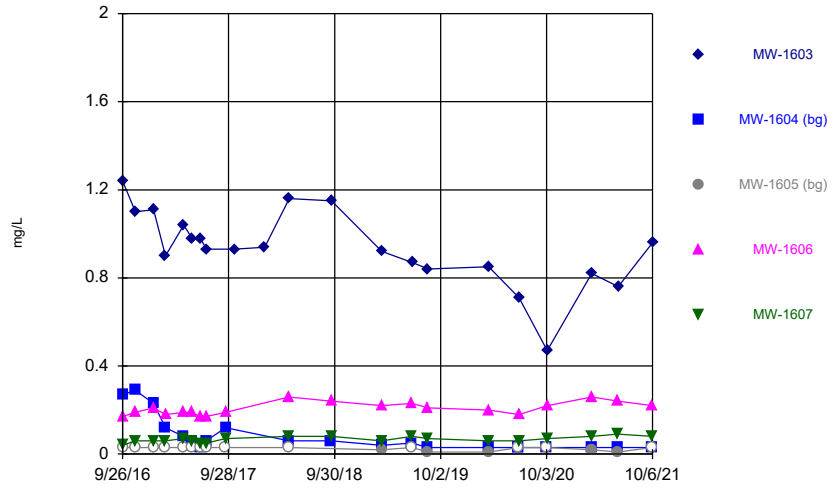
Time Series



Constituent: Fluoride Analysis Run 1/11/2022 9:37 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG
Hollow symbols indicate censored values.

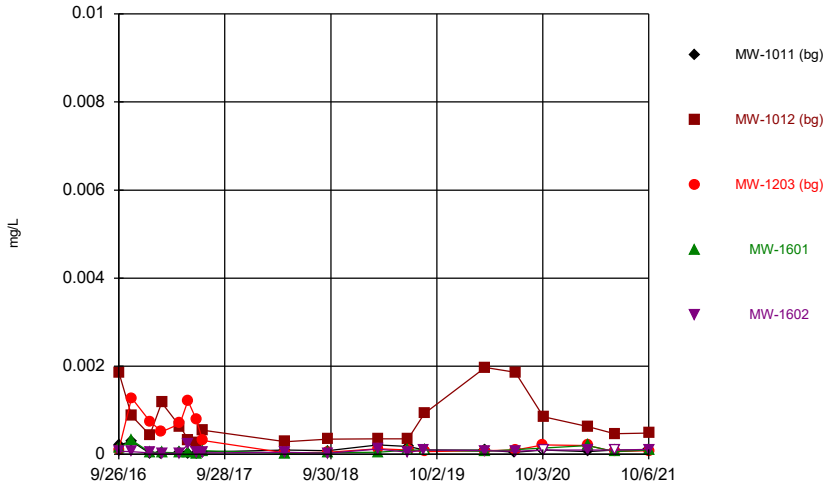
Time Series



Constituent: Fluoride Analysis Run 1/11/2022 9:37 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG
Hollow symbols indicate censored values.

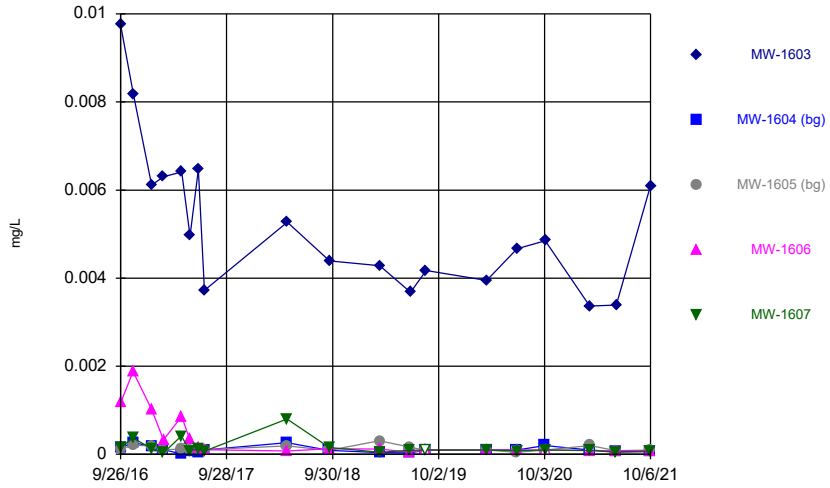
Time Series



Constituent: Lead Analysis Run 1/11/2022 9:37 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG
Hollow symbols indicate censored values.

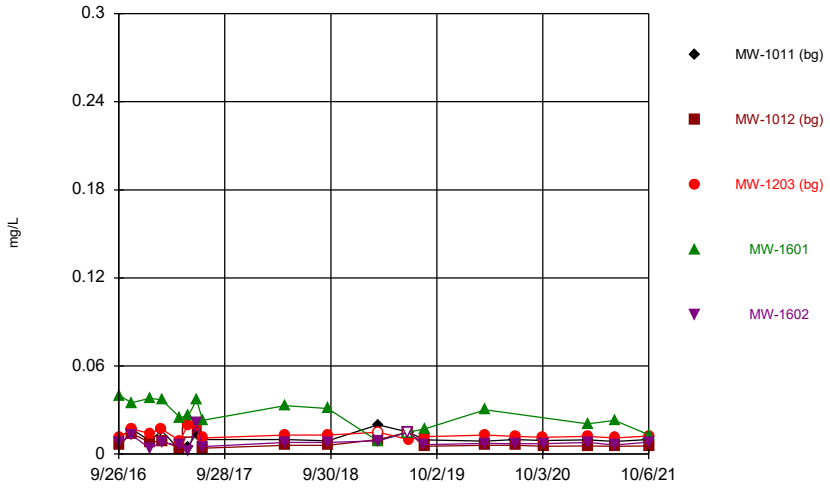
Time Series



Constituent: Lead Analysis Run 1/11/2022 9:37 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG
Hollow symbols indicate censored values.

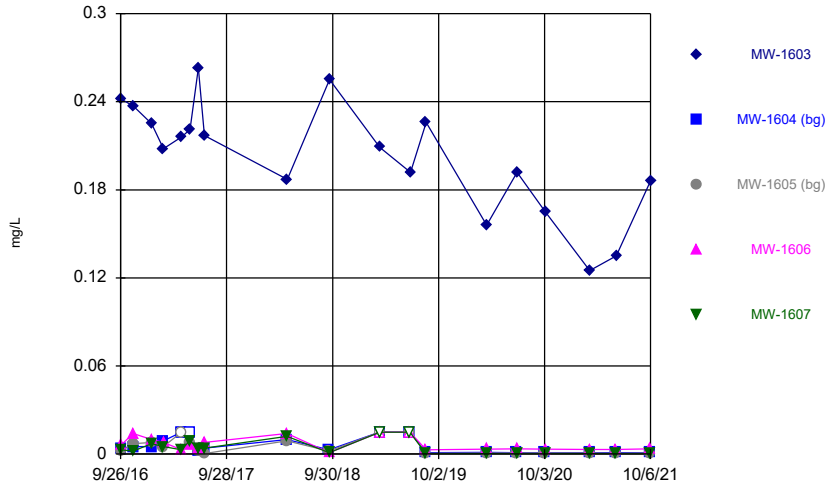
Time Series



Constituent: Lithium Analysis Run 1/11/2022 9:37 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG
Hollow symbols indicate censored values.

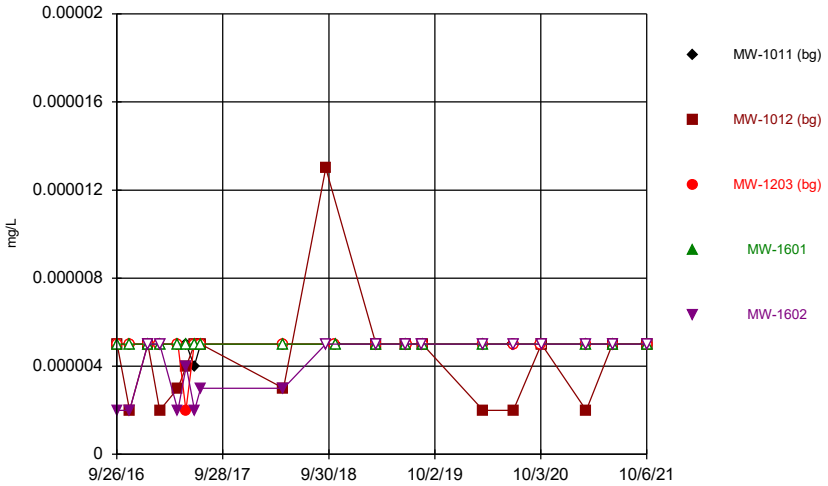
Time Series



Constituent: Lithium Analysis Run 1/11/2022 9:37 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG
Hollow symbols indicate censored values.

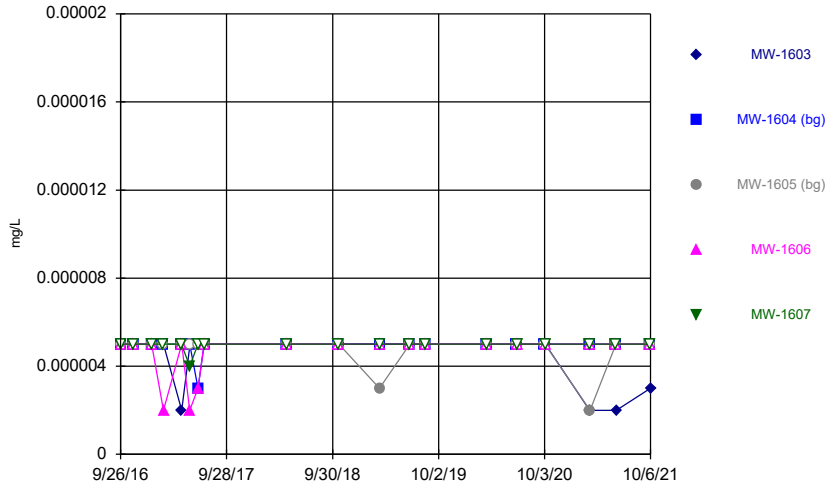
Time Series



Constituent: Mercury Analysis Run 1/11/2022 9:37 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG
Hollow symbols indicate censored values.

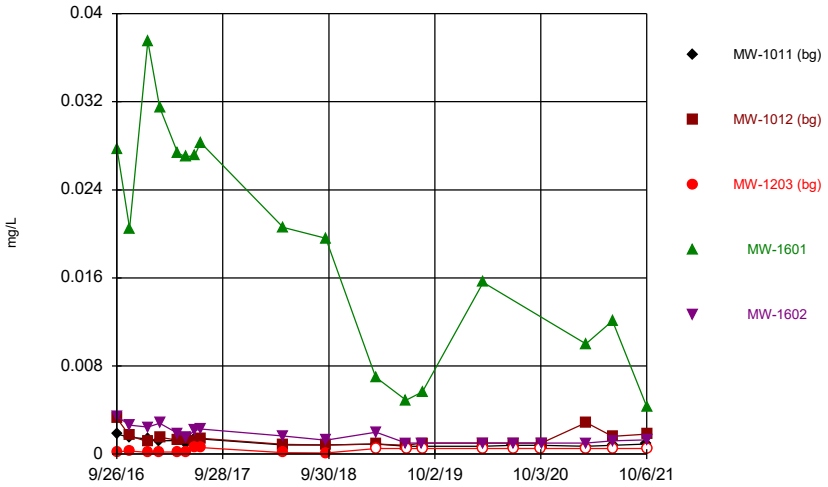
Time Series



Constituent: Mercury Analysis Run 1/11/2022 9:37 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG
Hollow symbols indicate censored values.

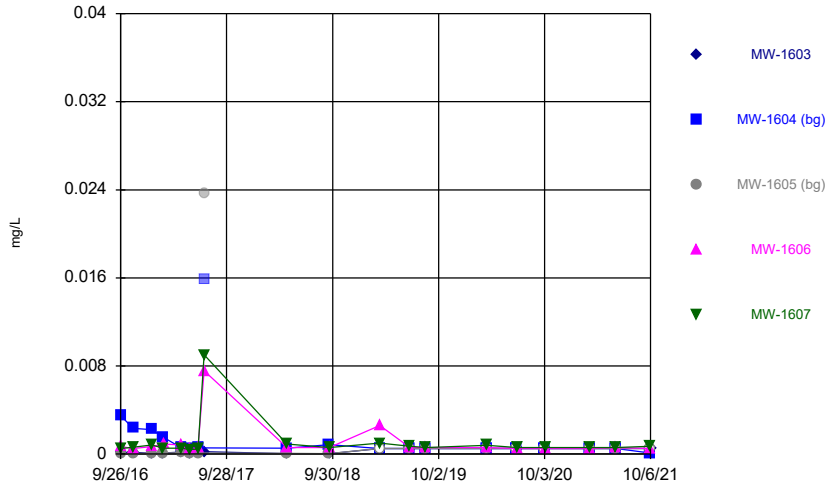
Time Series



Constituent: Molybdenum Analysis Run 1/11/2022 9:37 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG
Hollow symbols indicate censored values.

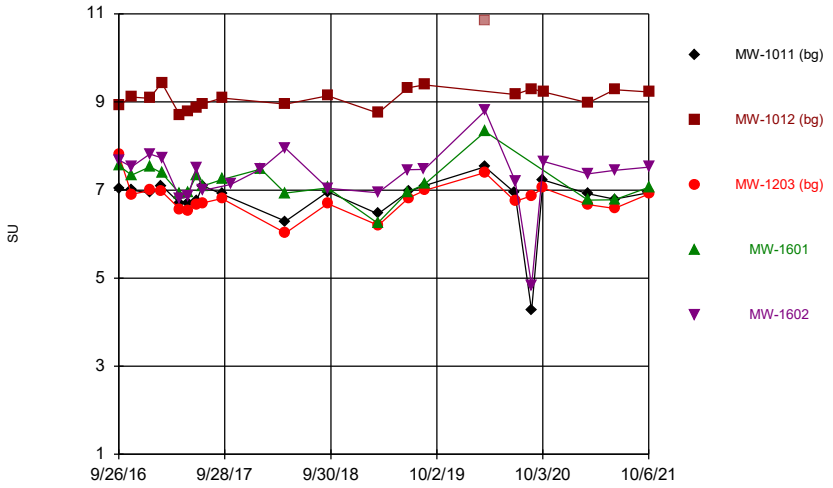
Time Series



Constituent: Molybdenum Analysis Run 1/11/2022 9:37 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

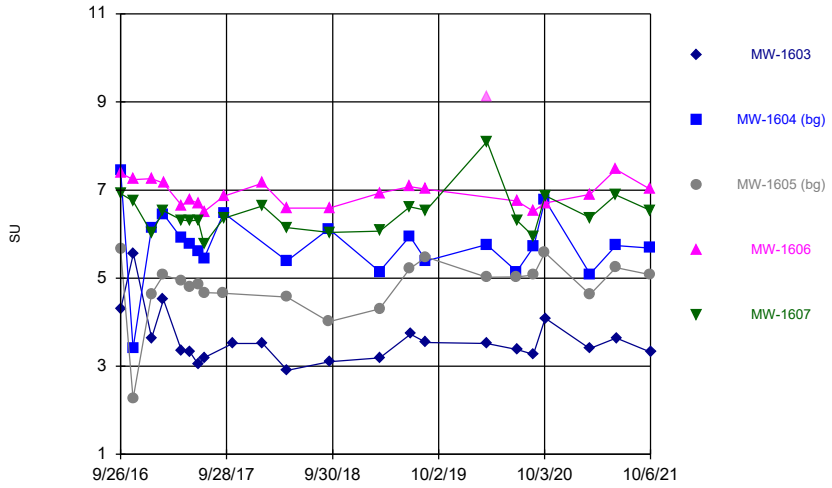
Time Series



Constituent: pH Analysis Run 1/11/2022 9:37 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

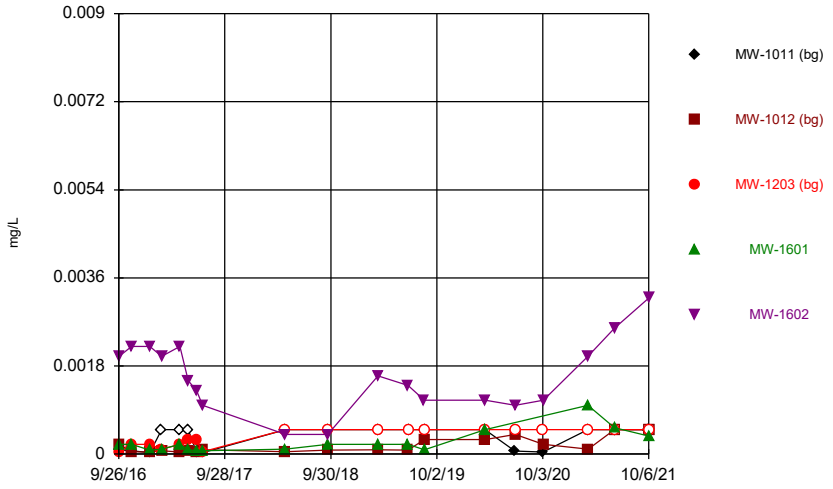
Time Series



Constituent: pH Analysis Run 1/11/2022 9:37 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG
Hollow symbols indicate censored values.

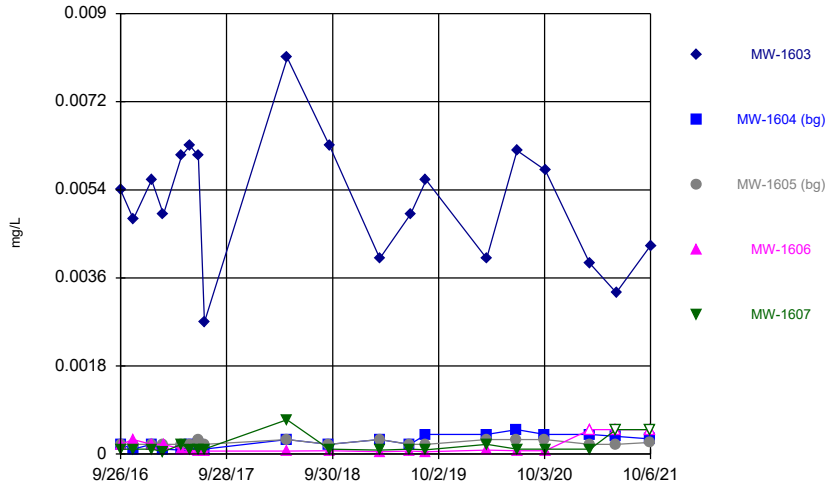
Time Series



Constituent: Selenium Analysis Run 1/11/2022 9:37 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG
Hollow symbols indicate censored values.

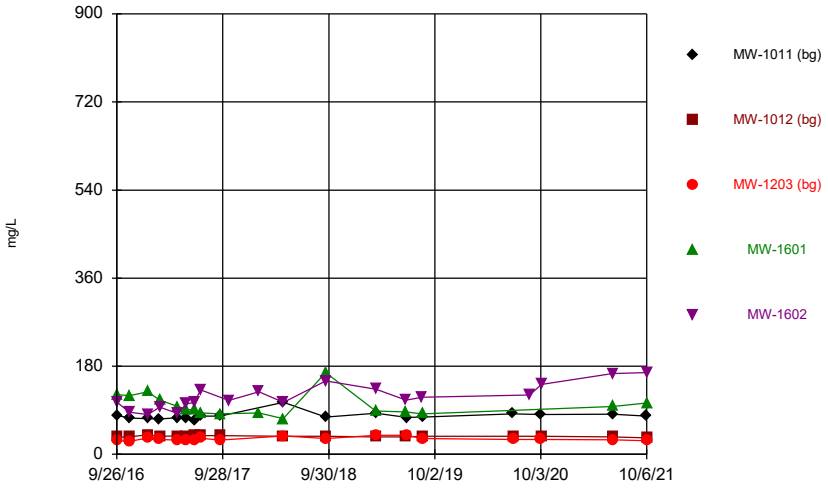
Time Series



Constituent: Selenium Analysis Run 1/11/2022 9:37 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

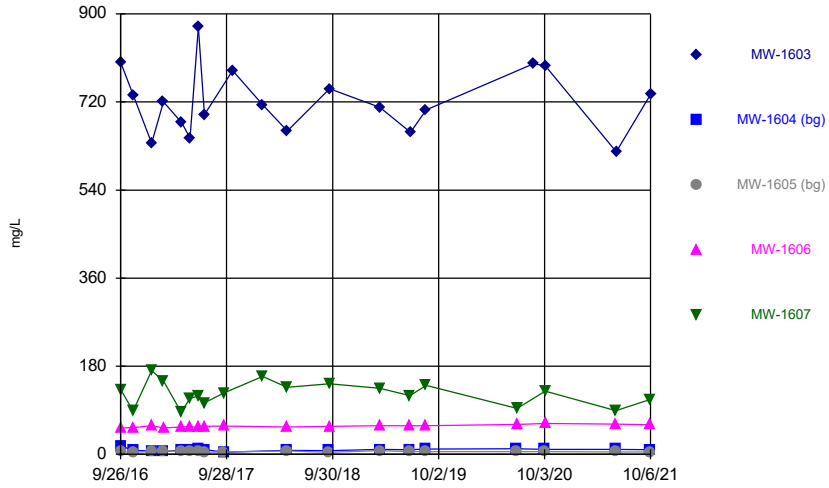
Time Series



Constituent: Sulfate Analysis Run 1/11/2022 9:37 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

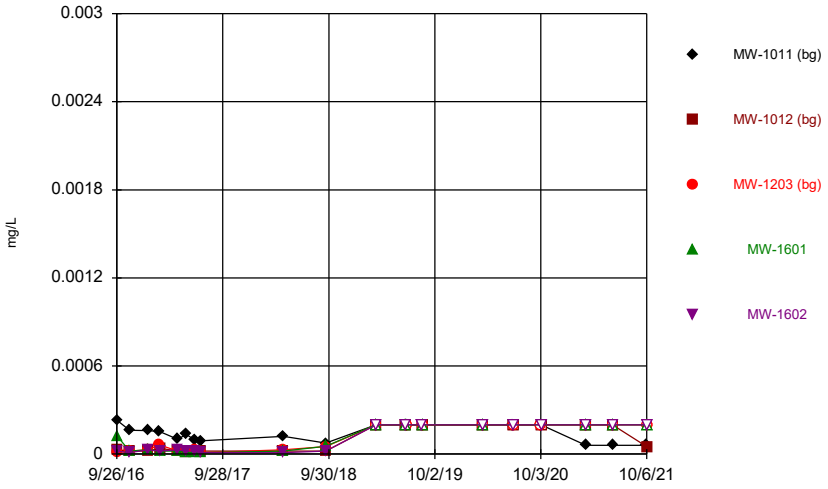
Time Series



Constituent: Sulfate Analysis Run 1/11/2022 9:37 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG
Hollow symbols indicate censored values.

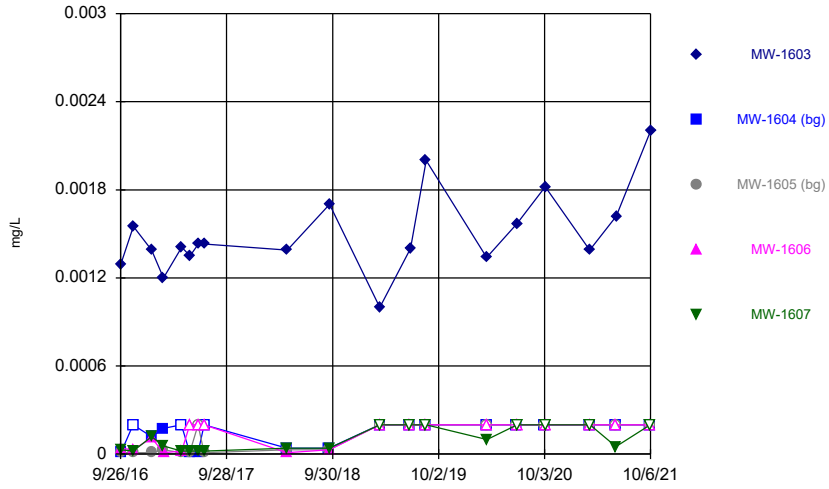
Time Series



Constituent: Thallium Analysis Run 1/11/2022 9:37 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

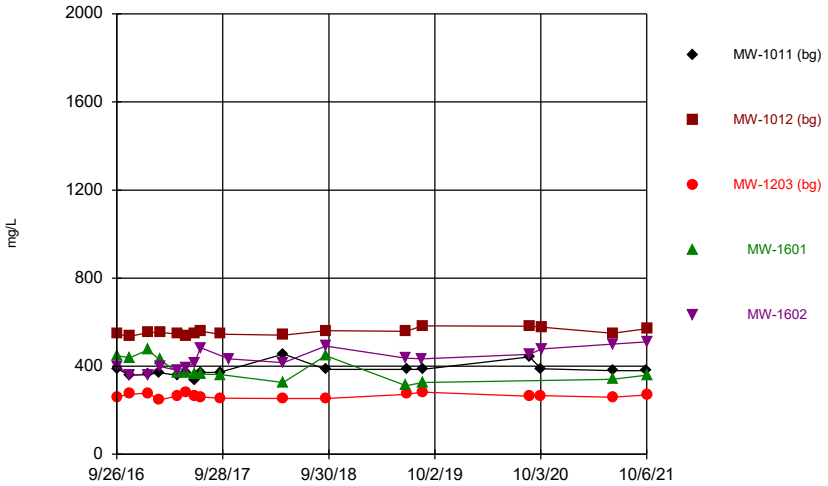
Sanitas™ v.9.6.32 . UG
Hollow symbols indicate censored values.

Time Series



Constituent: Thallium Analysis Run 1/11/2022 9:37 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

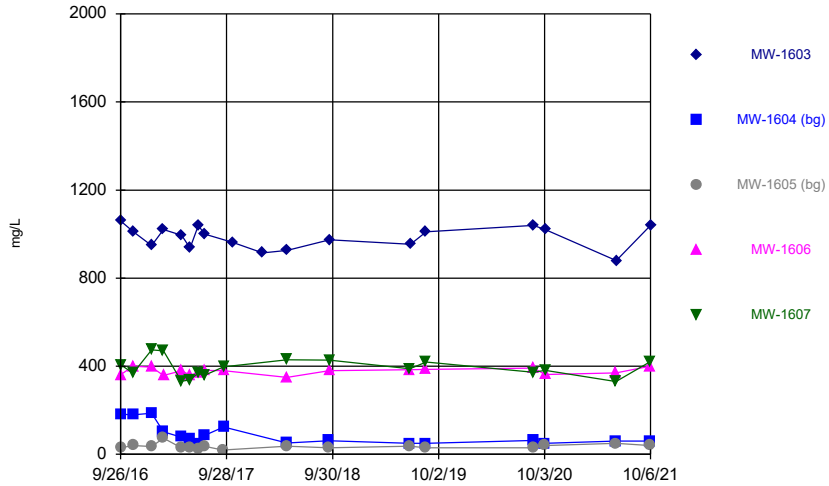
Time Series



Constituent: Total Dissolved Solids Analysis Run 1/11/2022 9:37 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

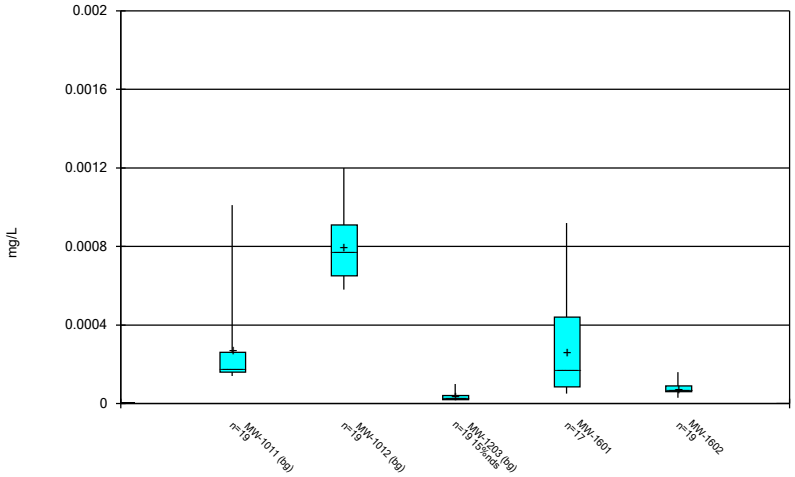
Time Series



Constituent: Total Dissolved Solids Analysis Run 1/11/2022 9:37 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

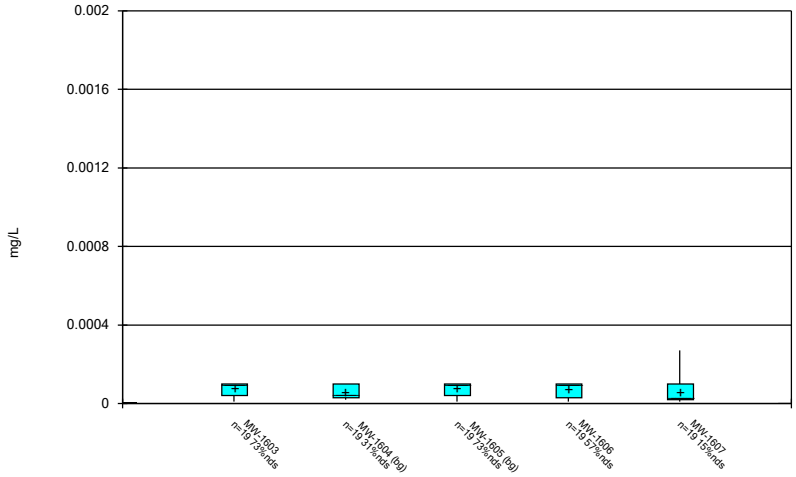
Box & Whiskers Plot



Constituent: Antimony Analysis Run 1/11/2022 9:42 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

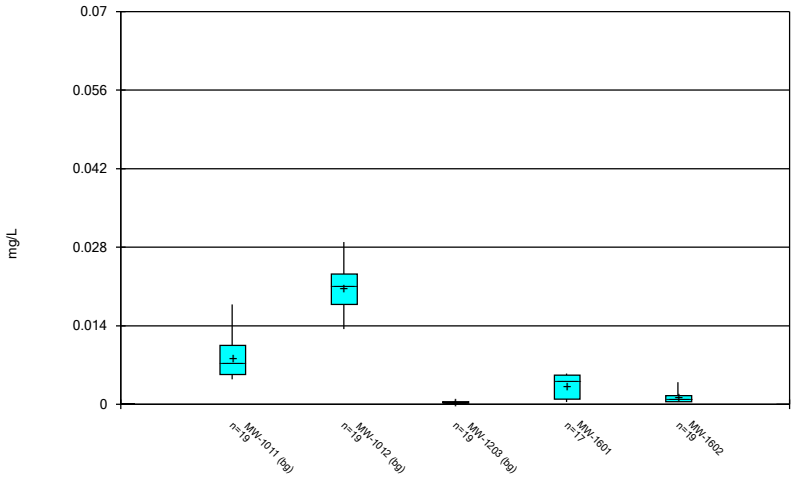
Box & Whiskers Plot



Constituent: Antimony Analysis Run 1/11/2022 9:42 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

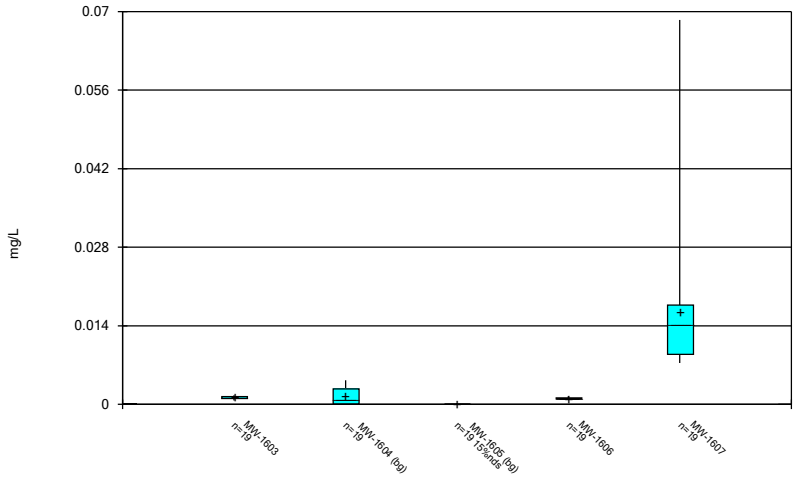
Box & Whiskers Plot



Constituent: Arsenic Analysis Run 1/11/2022 9:42 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

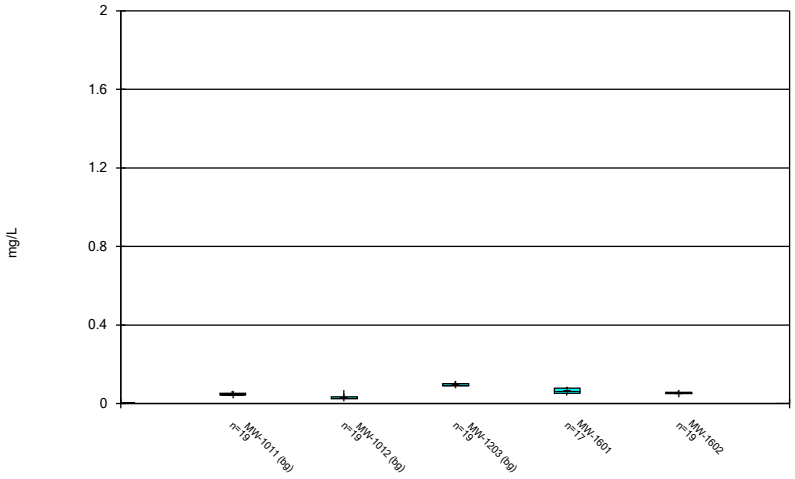
Box & Whiskers Plot



Constituent: Arsenic Analysis Run 1/11/2022 9:42 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

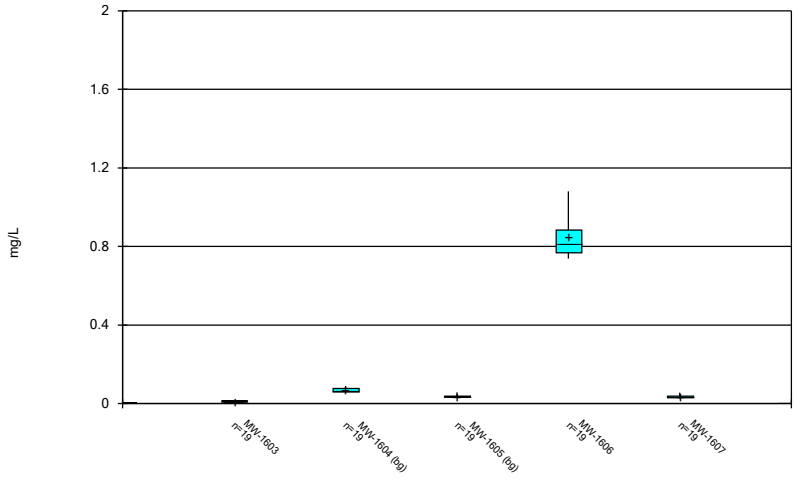
Box & Whiskers Plot



Constituent: Barium Analysis Run 1/11/2022 9:42 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

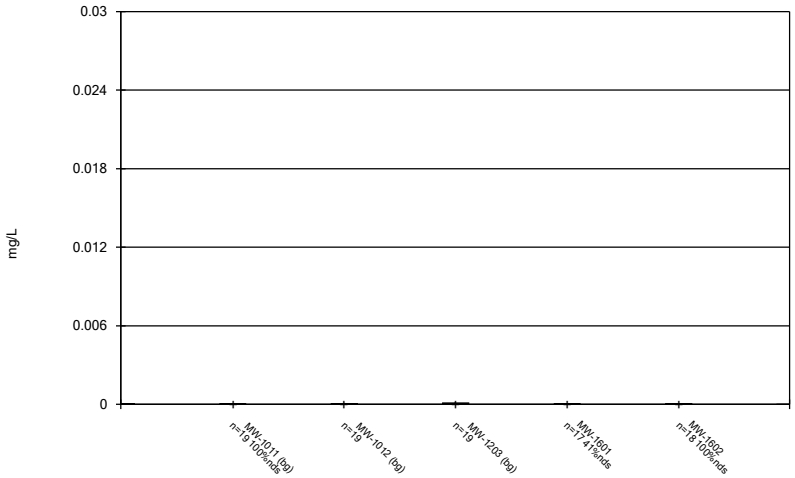
Box & Whiskers Plot



Constituent: Barium Analysis Run 1/11/2022 9:42 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

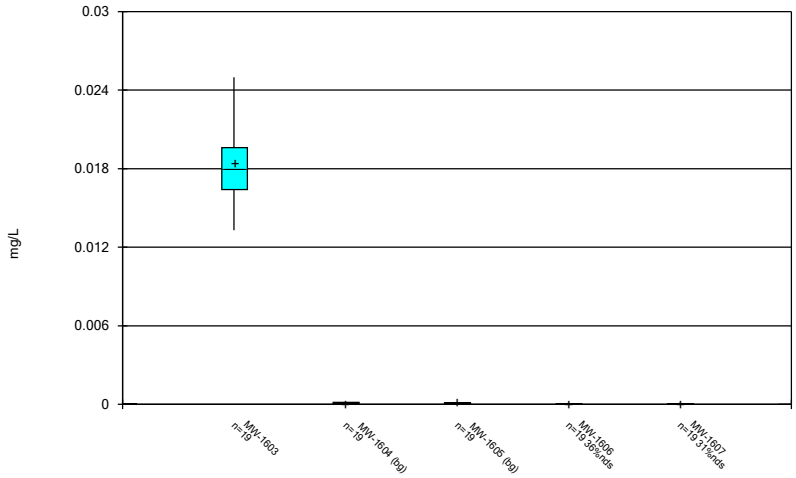
Box & Whiskers Plot



Constituent: Beryllium Analysis Run 1/11/2022 9:42 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

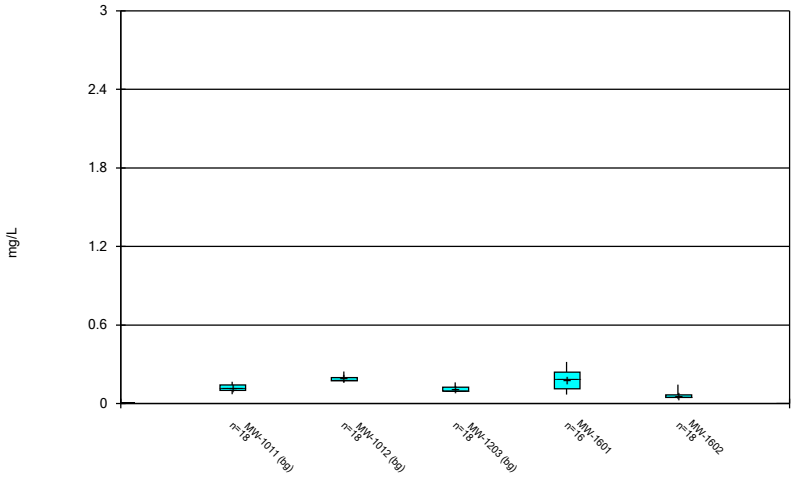
Box & Whiskers Plot



Constituent: Beryllium Analysis Run 1/11/2022 9:42 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

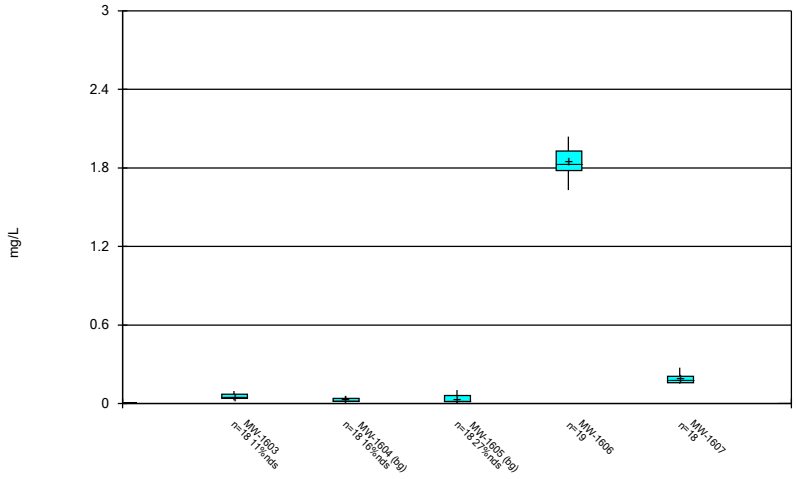
Box & Whiskers Plot



Constituent: Boron Analysis Run 1/11/2022 9:42 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

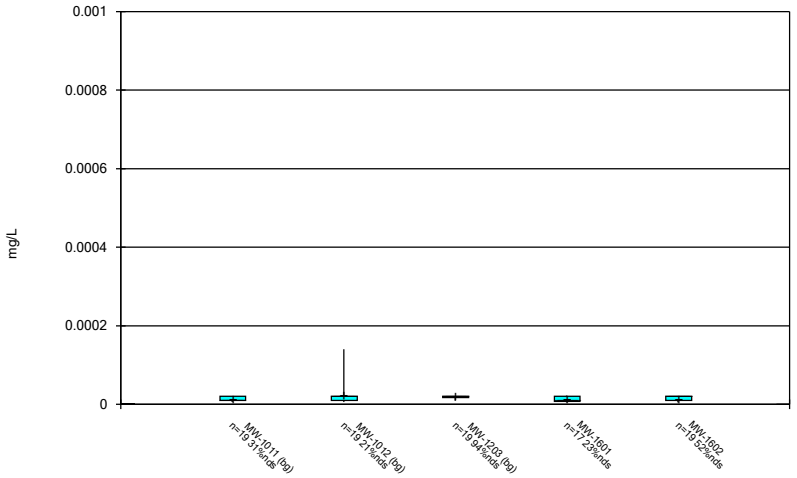
Box & Whiskers Plot



Constituent: Boron Analysis Run 1/11/2022 9:42 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

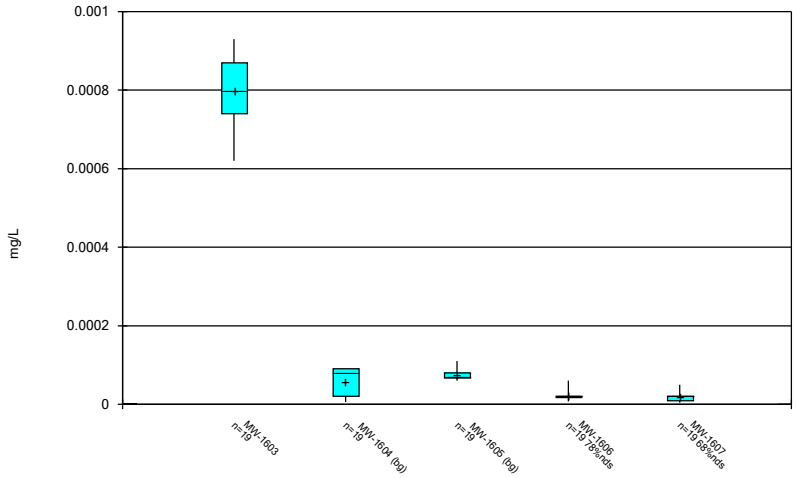
Box & Whiskers Plot



Constituent: Cadmium Analysis Run 1/11/2022 9:42 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

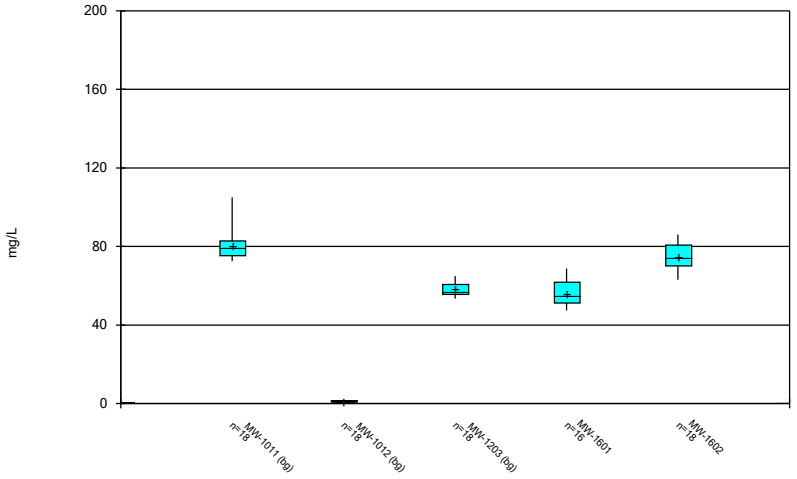
Box & Whiskers Plot



Constituent: Cadmium Analysis Run 1/11/2022 9:42 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

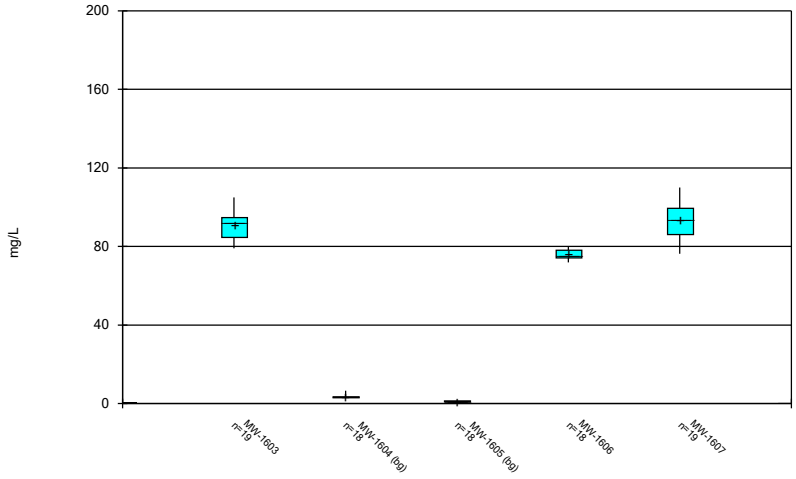
Box & Whiskers Plot



Constituent: Calcium Analysis Run 1/11/2022 9:42 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

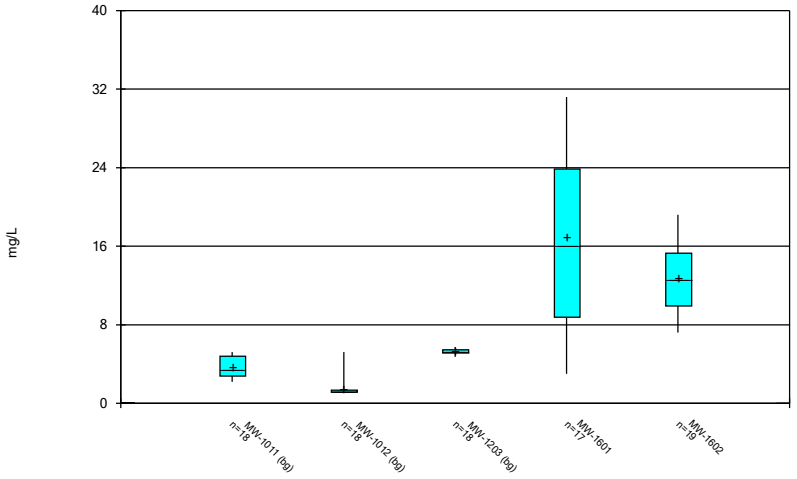
Box & Whiskers Plot



Constituent: Calcium Analysis Run 1/11/2022 9:42 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

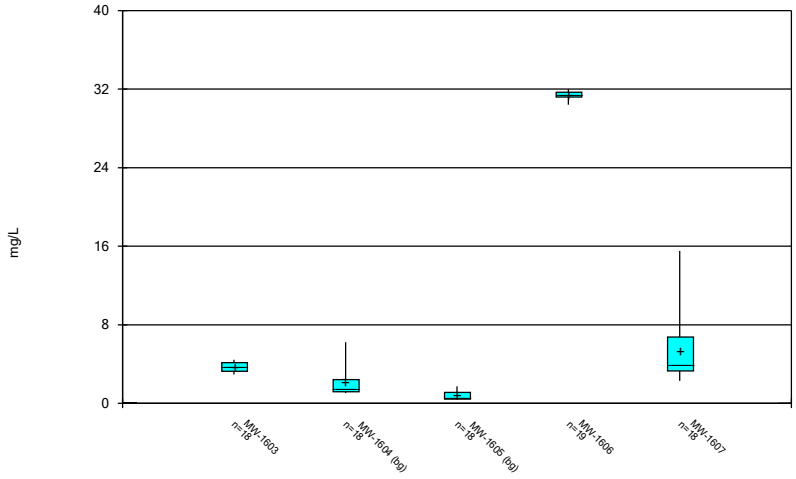
Box & Whiskers Plot



Constituent: Chloride Analysis Run 1/11/2022 9:42 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

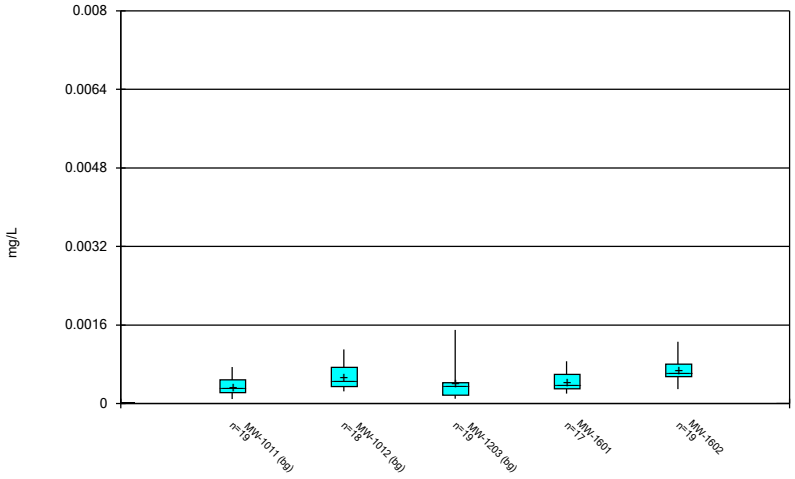
Box & Whiskers Plot



Constituent: Chloride Analysis Run 1/11/2022 9:42 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

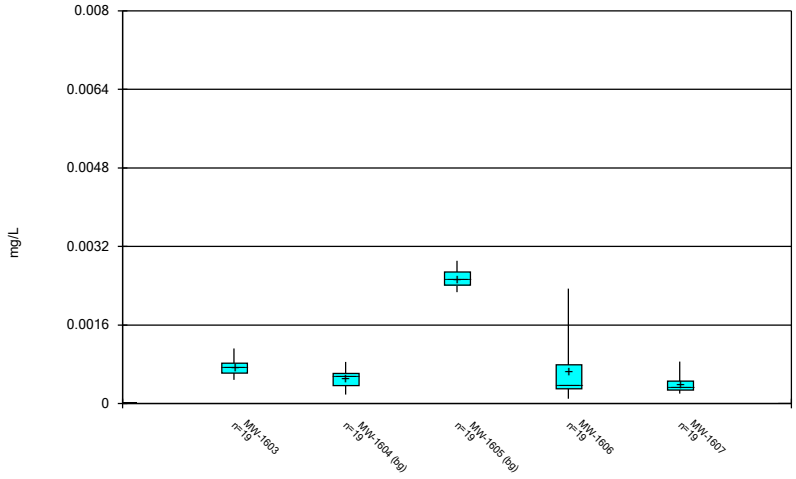
Box & Whiskers Plot



Constituent: Chromium Analysis Run 1/11/2022 9:42 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

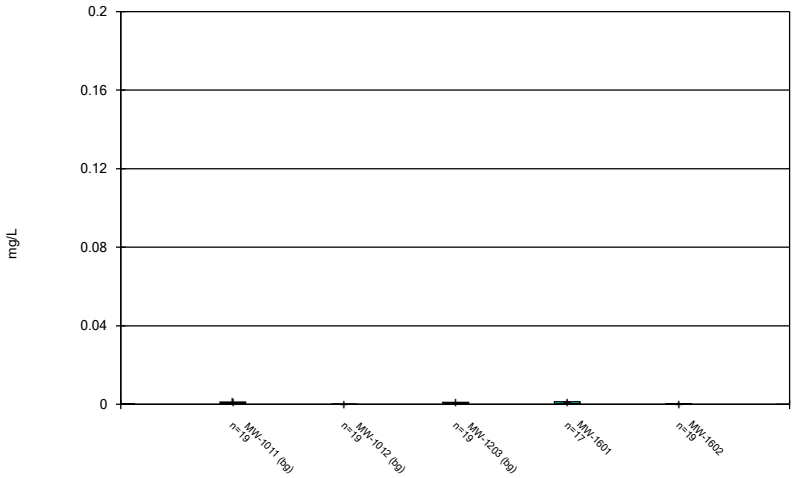
Box & Whiskers Plot



Constituent: Chromium Analysis Run 1/11/2022 9:42 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

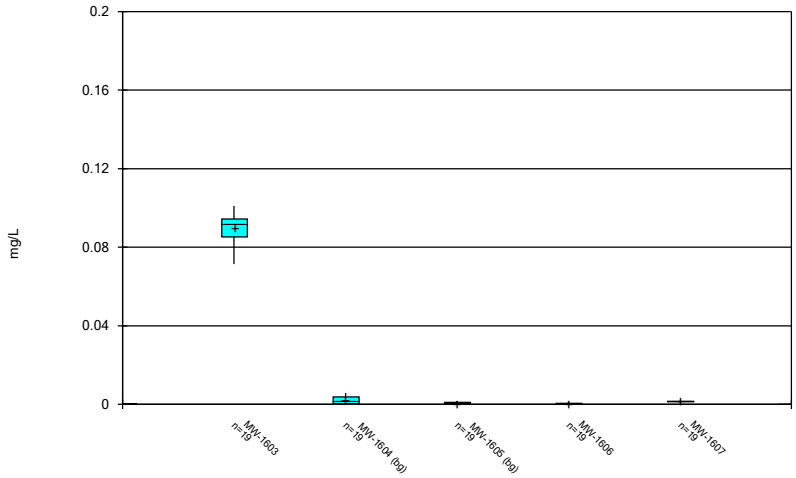
Box & Whiskers Plot



Constituent: Cobalt Analysis Run 1/11/2022 9:42 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

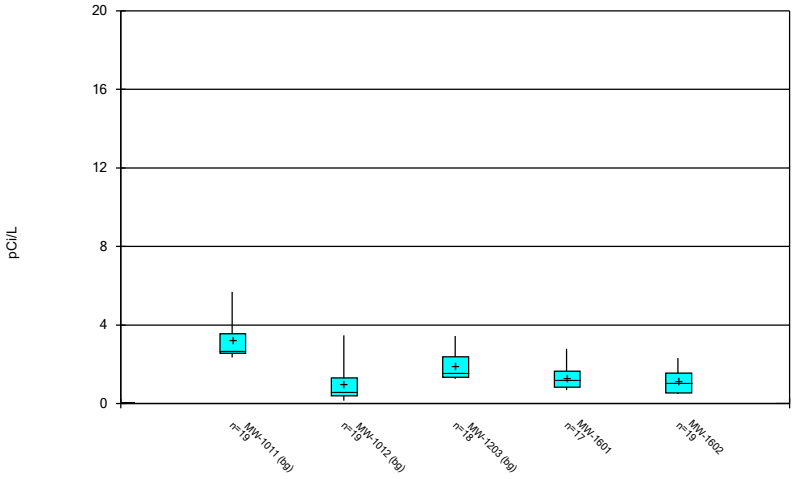
Box & Whiskers Plot



Constituent: Cobalt Analysis Run 1/11/2022 9:42 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

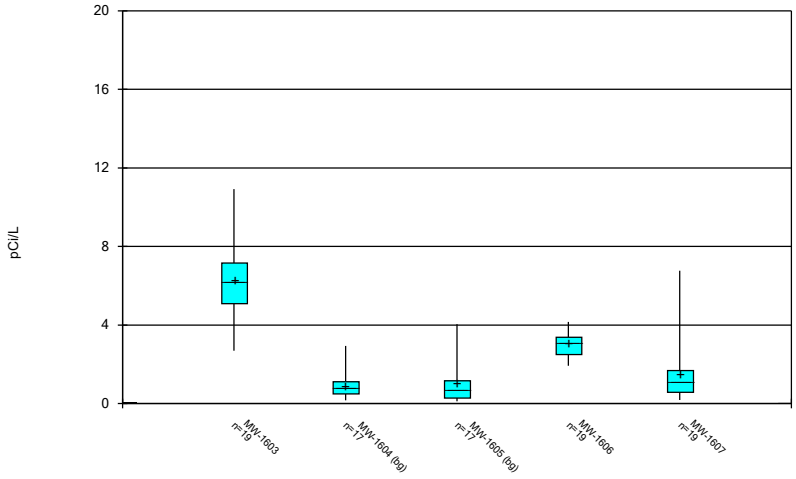
Box & Whiskers Plot



Constituent: Combined Radium 226 + 228 Analysis Run 1/11/2022 9:42 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

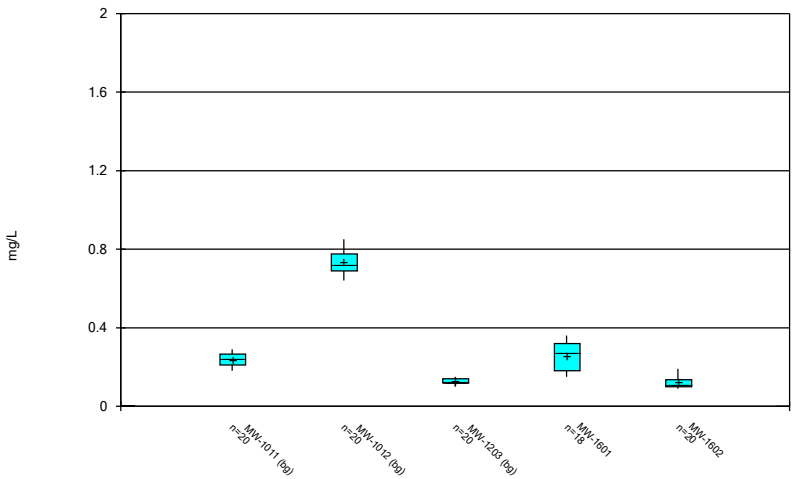
Box & Whiskers Plot



Constituent: Combined Radium 226 + 228 Analysis Run 1/11/2022 9:42 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

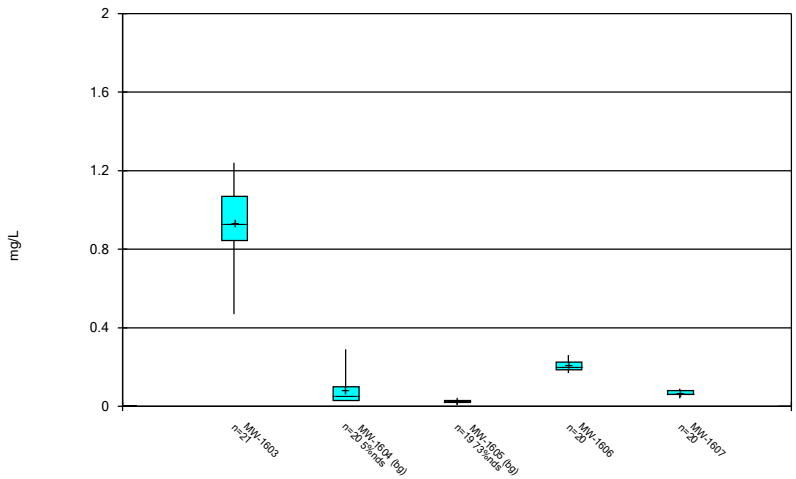
Box & Whiskers Plot



Constituent: Fluoride Analysis Run 1/11/2022 9:42 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

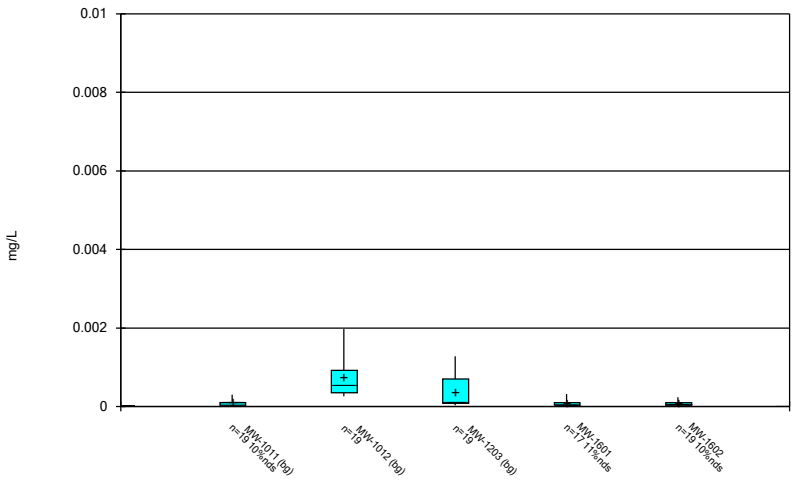
Box & Whiskers Plot



Constituent: Fluoride Analysis Run 1/11/2022 9:42 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

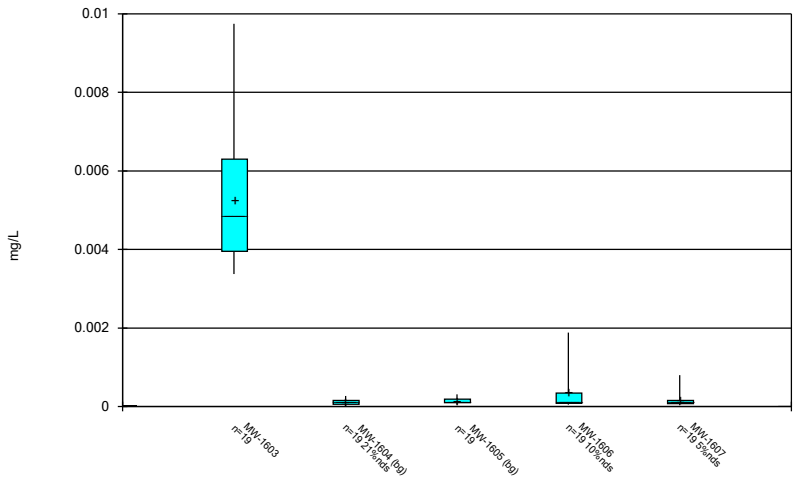
Box & Whiskers Plot



Constituent: Lead Analysis Run 1/11/2022 9:42 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

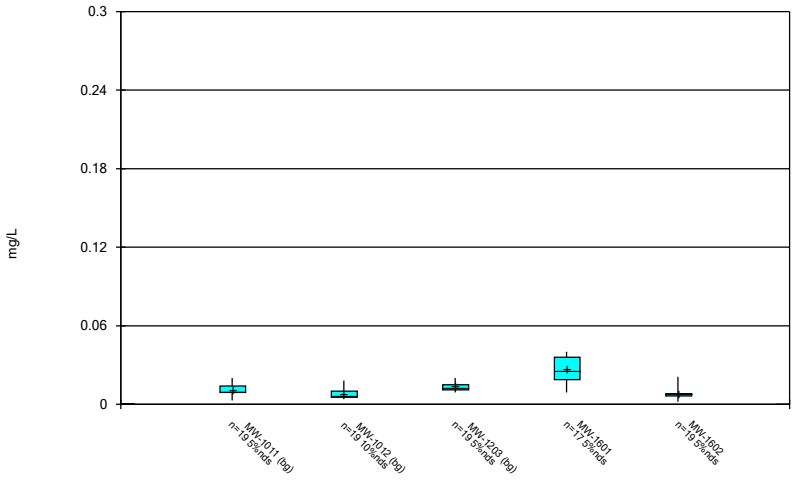
Box & Whiskers Plot



Constituent: Lead Analysis Run 1/11/2022 9:42 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

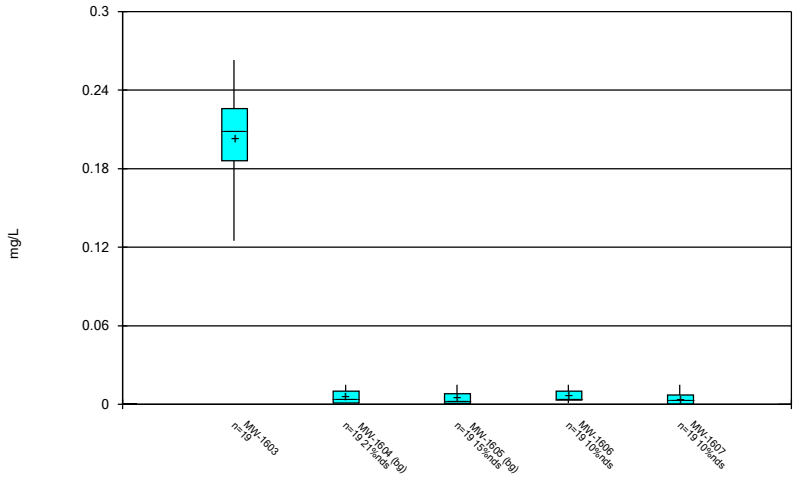
Box & Whiskers Plot



Constituent: Lithium Analysis Run 1/11/2022 9:43 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

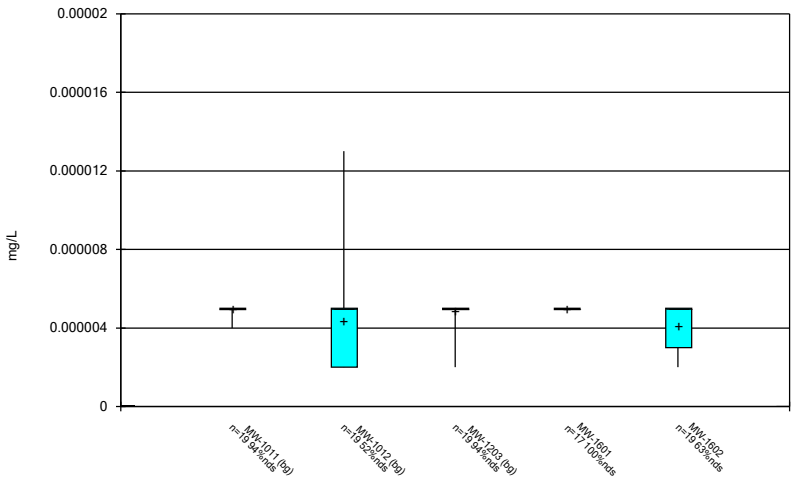
Box & Whiskers Plot



Constituent: Lithium Analysis Run 1/11/2022 9:43 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

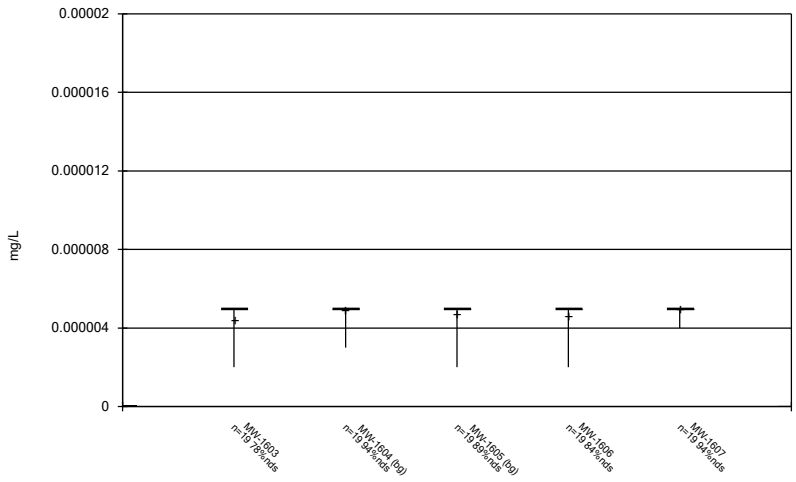
Box & Whiskers Plot



Constituent: Mercury Analysis Run 1/11/2022 9:43 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

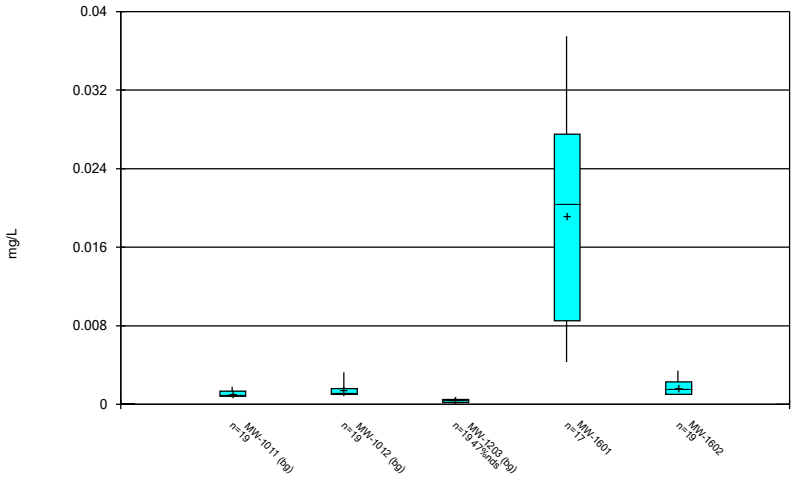
Box & Whiskers Plot



Constituent: Mercury Analysis Run 1/11/2022 9:43 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

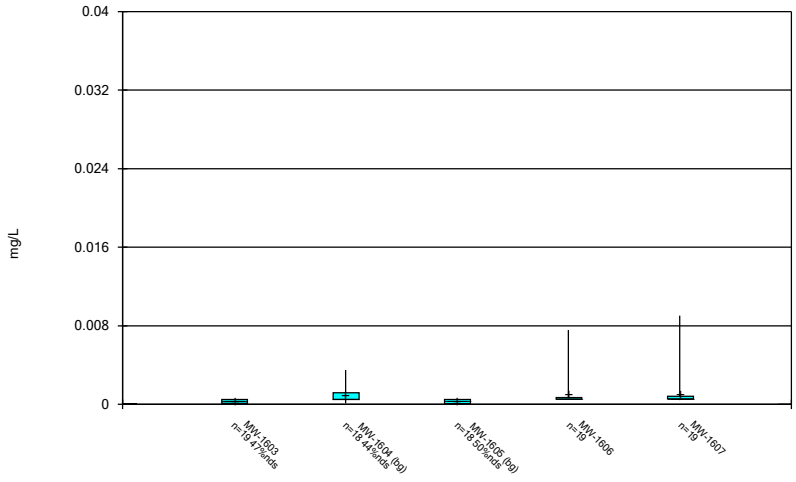
Box & Whiskers Plot



Constituent: Molybdenum Analysis Run 1/11/2022 9:43 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

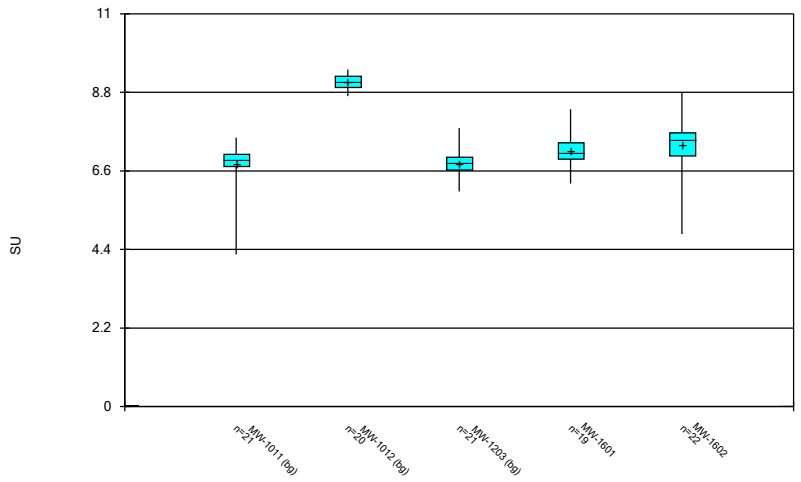
Box & Whiskers Plot



Constituent: Molybdenum Analysis Run 1/11/2022 9:43 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

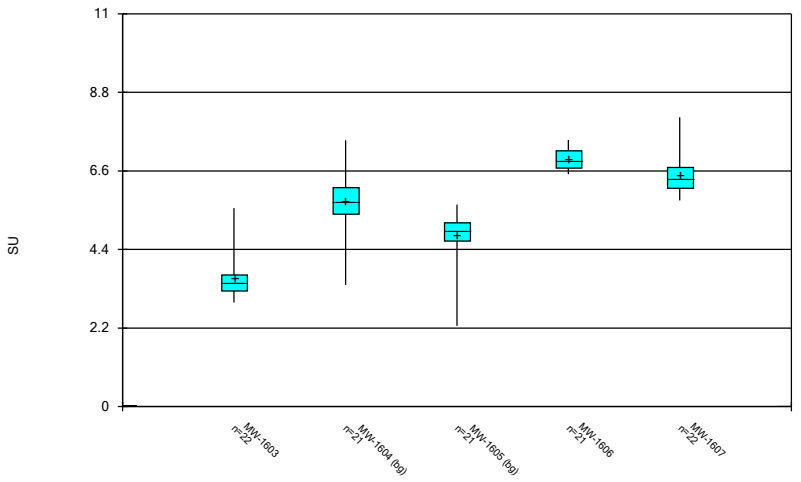
Box & Whiskers Plot



Constituent: pH Analysis Run 1/11/2022 9:43 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

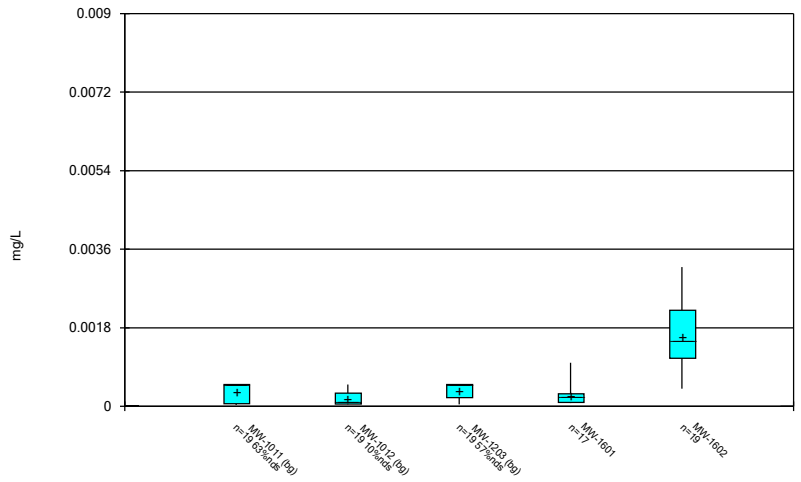
Box & Whiskers Plot



Constituent: pH Analysis Run 1/11/2022 9:43 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

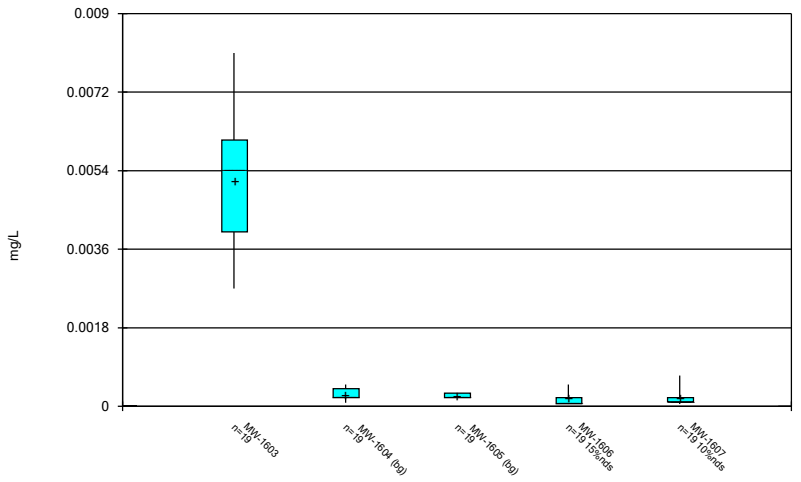
Box & Whiskers Plot



Constituent: Selenium Analysis Run 1/11/2022 9:43 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

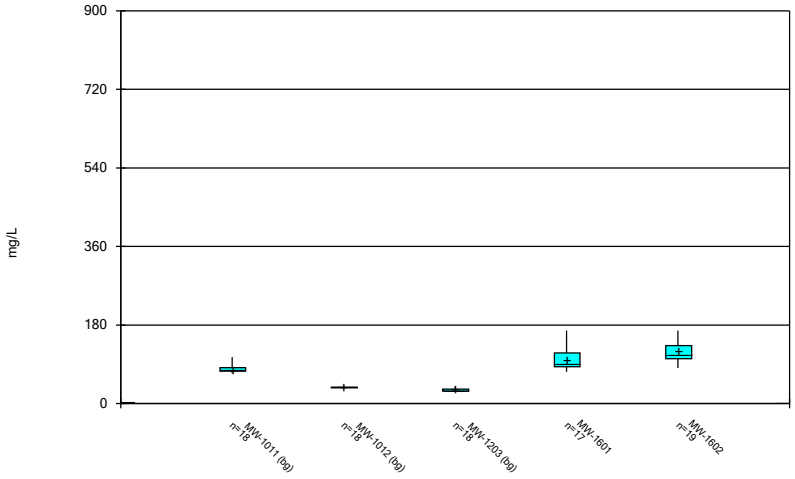
Box & Whiskers Plot



Constituent: Selenium Analysis Run 1/11/2022 9:43 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

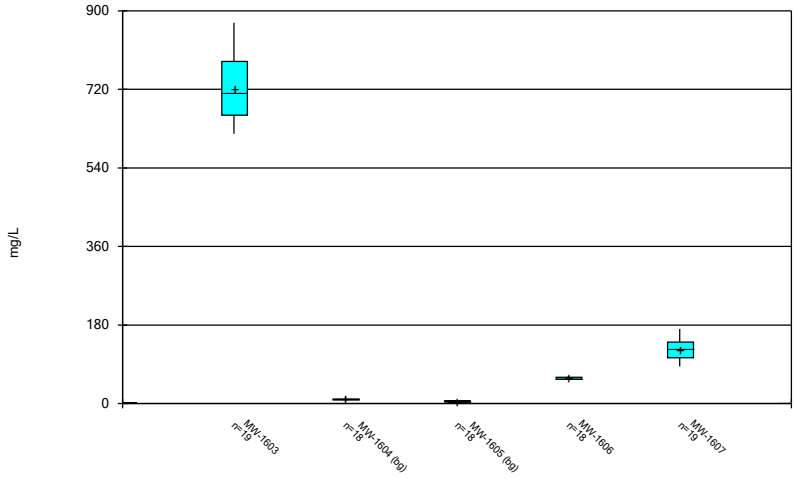
Box & Whiskers Plot



Constituent: Sulfate Analysis Run 1/11/2022 9:43 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

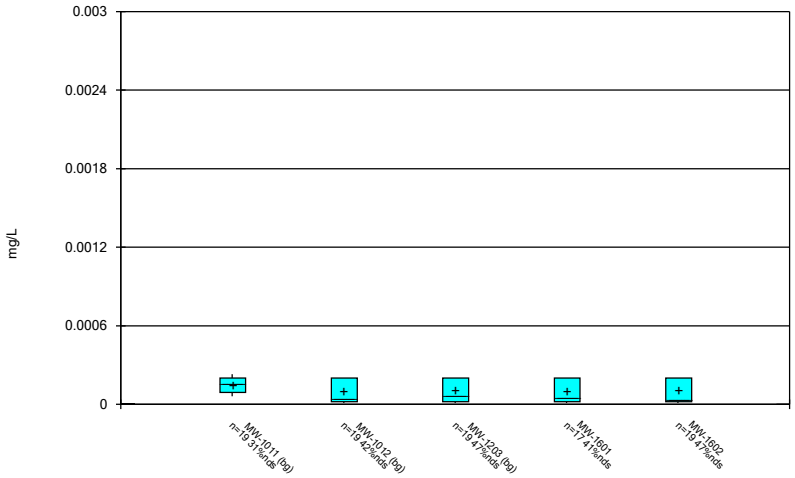
Box & Whiskers Plot



Constituent: Sulfate Analysis Run 1/11/2022 9:43 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

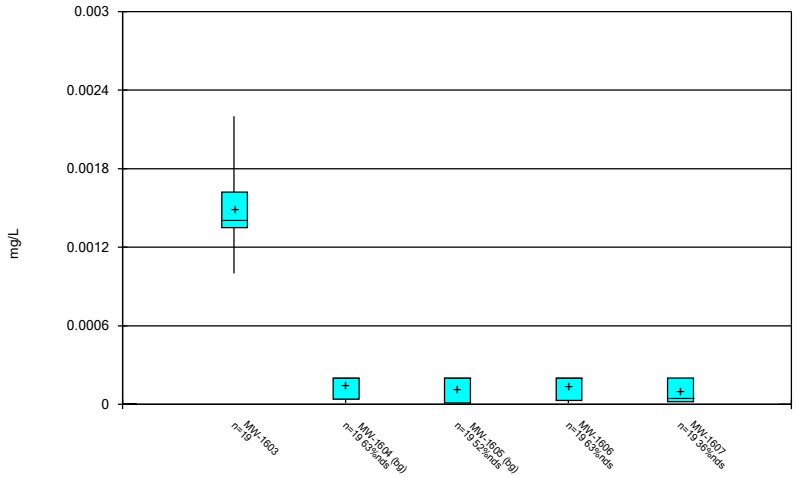
Box & Whiskers Plot



Constituent: Thallium Analysis Run 1/11/2022 9:43 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

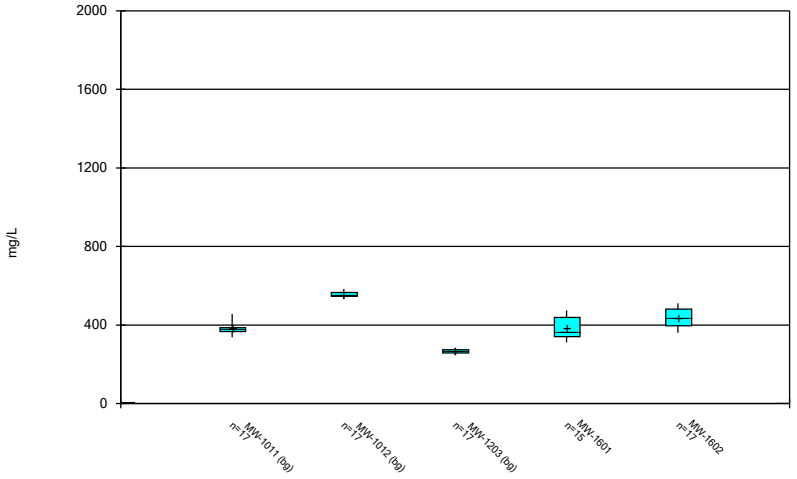
Sanitas™ v.9.6.32 . UG

Box & Whiskers Plot



Constituent: Thallium Analysis Run 1/11/2022 9:43 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

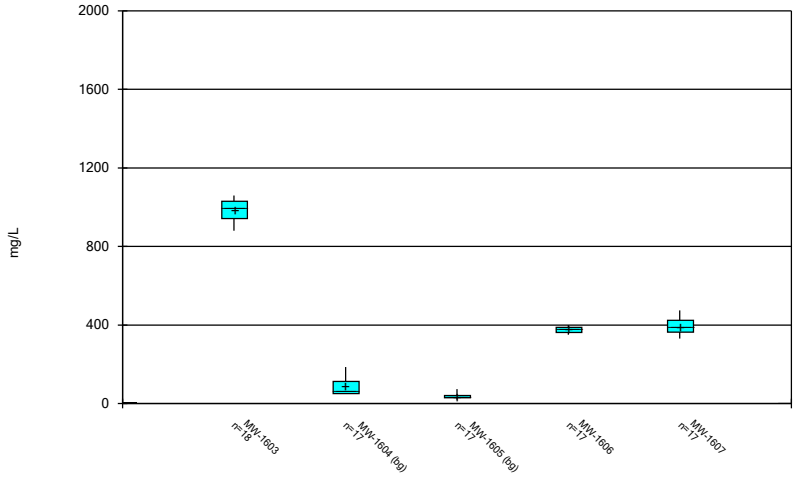
Box & Whiskers Plot



Constituent: Total Dissolved Solids Analysis Run 1/11/2022 9:43 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Box & Whiskers Plot



Constituent: Total Dissolved Solids Analysis Run 1/11/2022 9:43 AM View: Descriptive
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Outlier Summary

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP Printed 1/11/2022, 11:27 AM

	MW-1012 Chromium (mg/L)	MW-1203 Combined Radium 226 + 228 (pCi/L)	MW-1604 Combined Radium 226 + 228 (pCi/L)	MW-1605 Combined Radium 226 + 228 (pCi/L)	MW-1604 Molybdenum (mg/L)	MW-1605 Molybdenum (mg/L)	MW-1012 pH (SU)	MW-1606 pH (SU)
5/23/2017			6.707 (o)	6.077 (o)				
5/24/2017	0.00784 (o)							
6/21/2017			16.848 (o)	10.864 (o)				
7/12/2017					0.0159 (o)	0.0237 (o)		
3/17/2020		7.524 (o)						
3/18/2020							10.85 (o)	9.11 (o)

Tukey's Outlier Analysis - All Results (no significant)

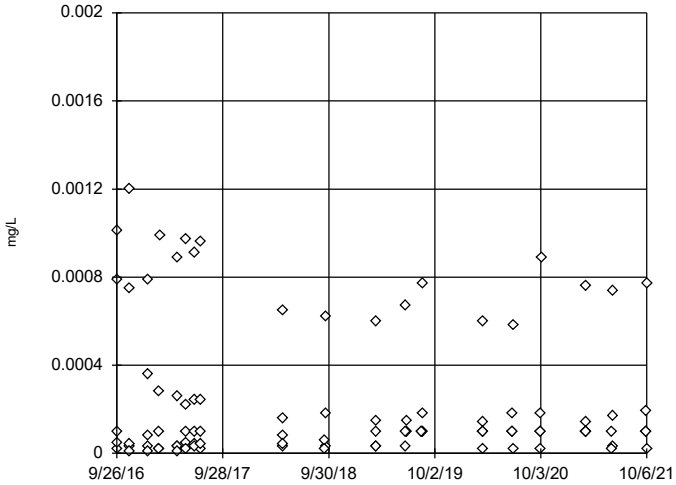
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP Printed 1/11/2022, 11:21 AM

Constituent	Well	Outlier	Value(s)	Date(s)	Method	Alpha	N	Mean	Std. Dev.	Distribution	Normality Test
Antimony (mg/L)	MW-1011,MW-1012,M...	No	n/a	n/a w/combined bg	NP	NaN	95	0.0002494	0.0003138	ln(x)	ShapiroFrancia
Arsenic (mg/L)	MW-1011,MW-1012,M...	No	n/a	n/a w/combined bg	NP	NaN	95	0.006154	0.0083	ln(x)	ShapiroFrancia
Barium (mg/L)	MW-1011,MW-1012,M...	No	n/a	n/a w/combined bg	NP	NaN	95	0.05634	0.02499	ln(x)	ShapiroFrancia
Beryllium (mg/L)	MW-1011,MW-1012,M...	No	n/a	n/a w/combined bg	NP	NaN	95	0.00007148	0.00004293	x^(1/3)	ShapiroFrancia
Boron (mg/L)	MW-1011,MW-1012,M...	No	n/a	n/a w/combined bg	NP	NaN	90	0.09576	0.06327	sqrt(x)	ShapiroFrancia
Cadmium (mg/L)	MW-1011,MW-1012,M...	No	n/a	n/a w/combined bg	NP	NaN	95	0.00003826	0.00003171	ln(x)	ShapiroFrancia
Calcium (mg/L)	MW-1011,MW-1012,M...	No	n/a	n/a w/combined bg	NP	NaN	90	28.84	34.07	ln(x)	ShapiroFrancia
Chloride (mg/L)	MW-1011,MW-1012,M...	No	n/a	n/a w/combined bg	NP	NaN	90	2.66	1.894	ln(x)	ShapiroFrancia
Chromium (mg/L)	MW-1011,MW-1012,M...	No	n/a	n/a w/combined bg	NP	NaN	94	0.0008706	0.0008781	ln(x)	ShapiroFrancia
Cobalt (mg/L)	MW-1011,MW-1012,M...	No	n/a	n/a w/combined bg	NP	NaN	95	0.0009367	0.001167	ln(x)	ShapiroFrancia
Combined Radium 226 + 228 (pCi/L)	MW-1011,MW-1012,M...	No	n/a	n/a w/combined bg	NP	NaN	90	1.625	1.227	x^(1/3)	ShapiroFrancia
Fluoride (mg/L)	MW-1011,MW-1012,M...	No	n/a	n/a w/combined bg	NP	NaN	99	0.2481	0.2575	ln(x)	ShapiroFrancia
Lead (mg/L)	MW-1011,MW-1012,M...	No	n/a	n/a w/combined bg	NP	NaN	95	0.0002933	0.000399	ln(x)	ShapiroFrancia
Lithium (mg/L)	MW-1011,MW-1012,M...	No	n/a	n/a w/combined bg	NP	NaN	95	0.008575	0.005462	normal	ShapiroFrancia
Mercury (mg/L)	MW-1011,MW-1012,M...	n/a	n/a	n/a w/combined bg	NP	NaN	95	0.000004758	0.000001218	unknown	ShapiroFrancia
Molybdenum (mg/L)	MW-1011,MW-1012,M...	No	n/a	n/a w/combined bg	NP	NaN	93	0.0008074	0.0006643	x^(1/3)	ShapiroFrancia
Selenium (mg/L)	MW-1011,MW-1012,M...	No	n/a	n/a w/combined bg	NP	NaN	95	0.0002721	0.0001689	sqrt(x)	ShapiroFrancia
Sulfate (mg/L)	MW-1011,MW-1012,M...	No	n/a	n/a w/combined bg	NP	NaN	90	32.29	26.61	x^(1/3)	ShapiroFrancia
Thallium (mg/L)	MW-1011,MW-1012,M...	No	n/a	n/a w/combined bg	NP	NaN	95	0.0001222	0.00008352	x^(1/3)	ShapiroFrancia
Total Dissolved Solids (mg/L)	MW-1011,MW-1012,M...	No	n/a	n/a w/combined bg	NP	NaN	85	265.5	193.7	sqrt(x)	ShapiroFrancia

Sanitas™ v.9.6.32 . UG

Tukey's Outlier Screening, Pooled Background

MW-1011,MW-1012,MW-1203,MW-1604,MW-16...



n = 95

No outliers found. Tukey's method selected by user.

Data were natural log transformed to achieve best W statistic (graph shown in original units).

High cutoff = 0.1693, low cutoff = 4.6e-8, based on IQR multiplier of 3.

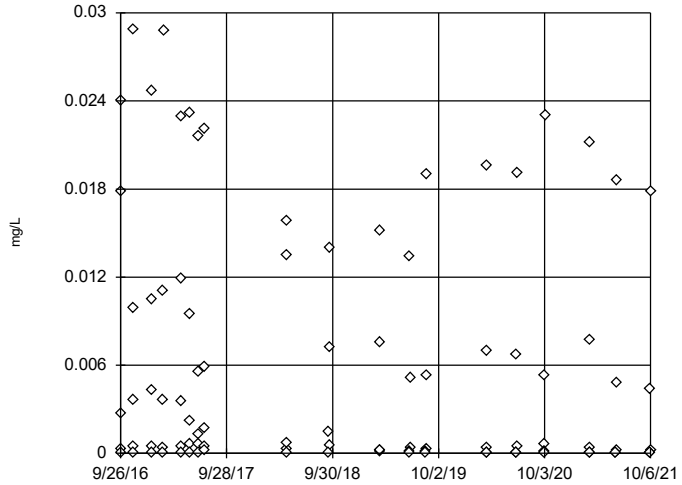
Constituent: Antimony Analysis Run 1/11/2022 11:19 AM View: Descriptive

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Tukey's Outlier Screening, Pooled Background

MW-1011,MW-1012,MW-1203,MW-1604,MW-16...



n = 95

No outliers found. Tukey's method selected by user.

Data were natural log transformed to achieve best W statistic (graph shown in original units).

High cutoff = 12155, low cutoff = 8.6e-11, based on IQR multiplier of 3.

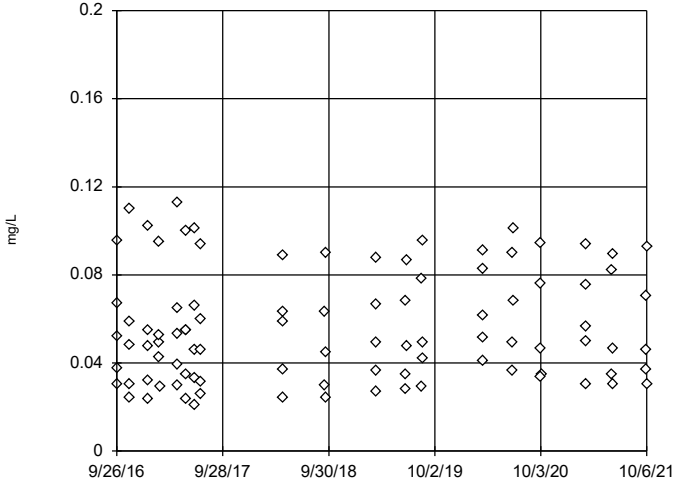
Constituent: Arsenic Analysis Run 1/11/2022 11:19 AM View: Descriptive

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Tukey's Outlier Screening, Pooled Background

MW-1011,MW-1012,MW-1203,MW-1604,MW-16...



n = 95

No outliers found. Tukey's method selected by user.

Data were natural log transformed to achieve best W statistic (graph shown in original units).

High cutoff = 0.7833, low cutoff = 0.003368, based on IQR multiplier of 3.

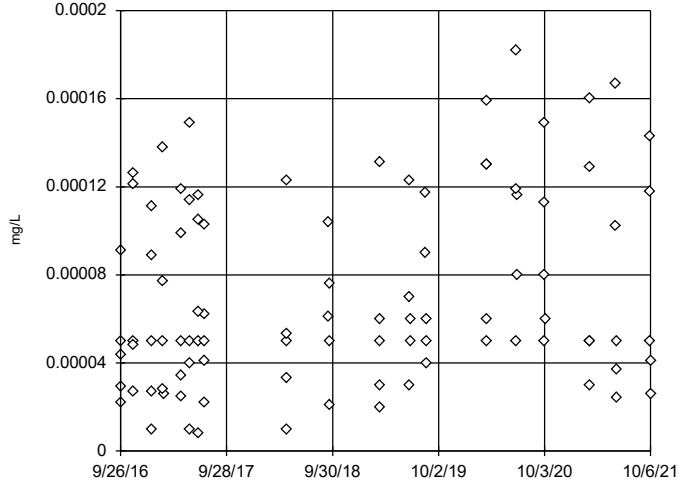
Constituent: Barium Analysis Run 1/11/2022 11:19 AM View: Descriptive

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Tukey's Outlier Screening, Pooled Background

MW-1011,MW-1012,MW-1203,MW-1604,MW-16...



n = 95

No outliers found. Tukey's method selected by user.

Data were cube root transformed to achieve best W statistic (graph shown in original units).

High cutoff = 0.0007482, low cutoff = -5.6e-7, based on IQR multiplier of 3.

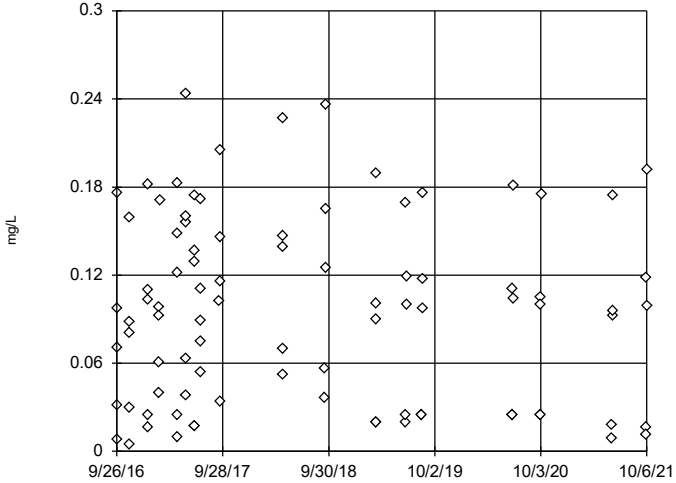
Constituent: Beryllium Analysis Run 1/11/2022 11:19 AM View: Descriptive

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Tukey's Outlier Screening, Pooled Background

MW-1011,MW-1012,MW-1203,MW-1604,MW-16...



n = 90

No outliers found. Tukey's method selected by user.

Data were square root transformed to achieve best W statistic (graph shown in original units).

High cutoff = 1.08, low cutoff = -0.2396, based on IQR multiplier of 3.

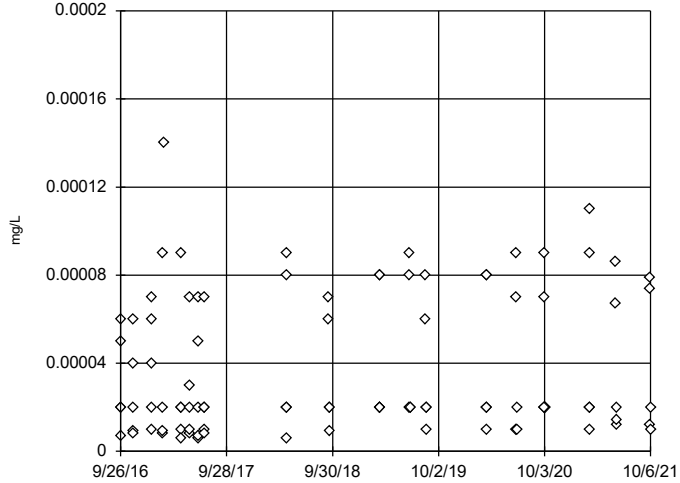
Constituent: Boron Analysis Run 1/11/2022 11:20 AM View: Descriptive

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Tukey's Outlier Screening, Pooled Background

MW-1011,MW-1012,MW-1203,MW-1604,MW-16...



n = 95

No outliers found. Tukey's method selected by user.

Data were natural log transformed to achieve best W statistic (graph shown in original units).

High cutoff = 0.01389, low cutoff = 6.0e-8, based on IQR multiplier of 3.

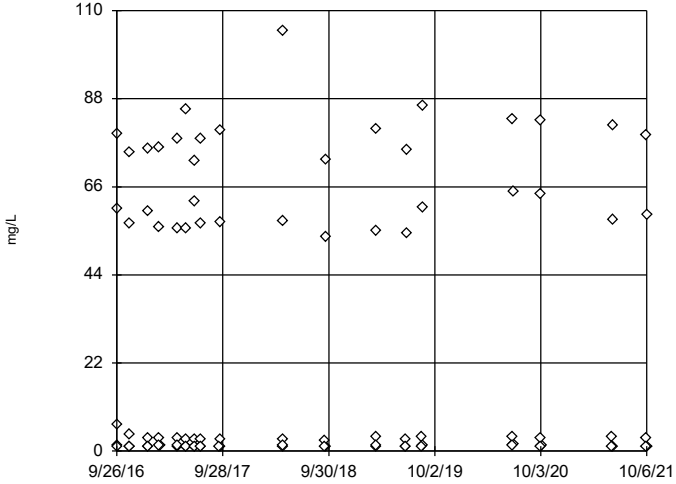
Constituent: Cadmium Analysis Run 1/11/2022 11:20 AM View: Descriptive

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Tukey's Outlier Screening, Pooled Background

MW-1011,MW-1012,MW-1203,MW-1604,MW-16...



n = 90

No outliers found. Tukey's method selected by user.

Data were natural log transformed to achieve best W statistic (graph shown in original units).

High cutoff = 7830224, low cutoff = 0.000009295, based on IQR multiplier of 3.

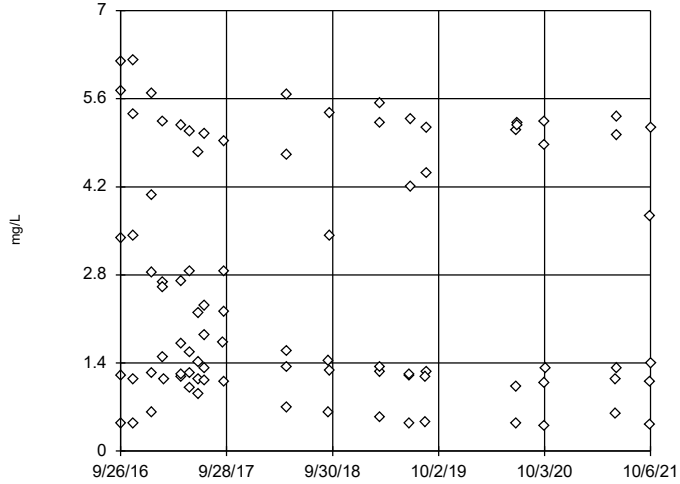
Constituent: Calcium Analysis Run 1/11/2022 11:20 AM View: Descriptive

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Tukey's Outlier Screening, Pooled Background

MW-1011,MW-1012,MW-1203,MW-1604,MW-16...



n = 90

No outliers found. Tukey's method selected by user.

Data were natural log transformed to achieve best W statistic (graph shown in original units).

High cutoff = 401.1, low cutoff = 0.01425, based on IQR multiplier of 3.

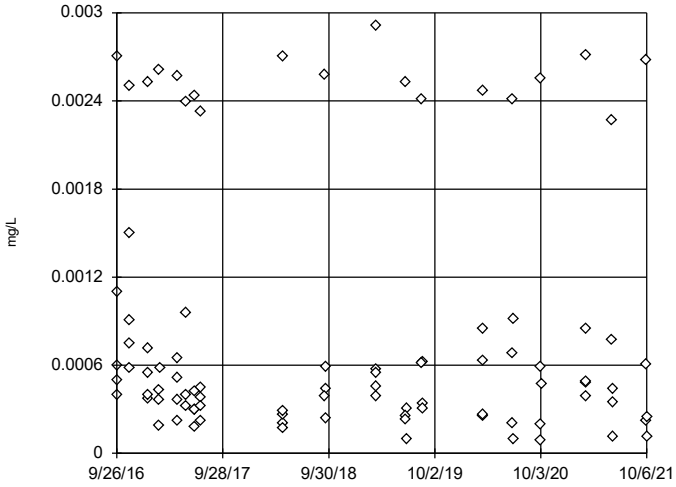
Constituent: Chloride Analysis Run 1/11/2022 11:20 AM View: Descriptive

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Tukey's Outlier Screening, Pooled Background

MW-1011,MW-1012,MW-1203,MW-1604,MW-16...



n = 94

No outliers found. Tukey's method selected by user.

Data were natural log transformed to achieve best W statistic (graph shown in original units).

High cutoff = 0.02683, low cutoff = 0.000009929, based on IQR multiplier of 3.

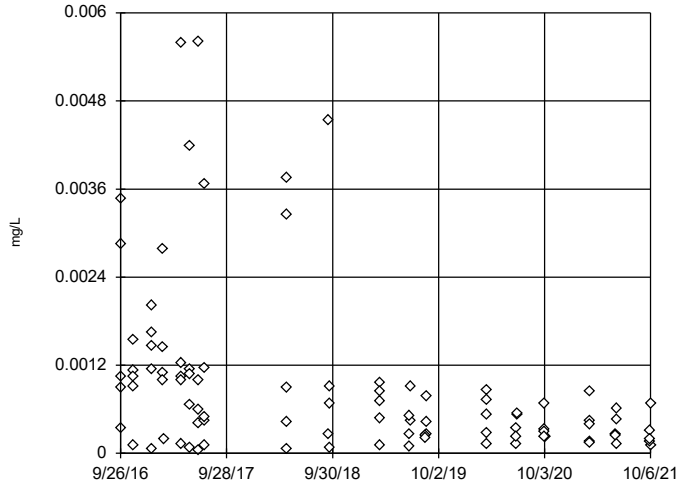
Constituent: Chromium Analysis Run 1/11/2022 11:20 AM View: Descriptive

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Tukey's Outlier Screening, Pooled Background

MW-1011,MW-1012,MW-1203,MW-1604,MW-16...



n = 95

No outliers found. Tukey's method selected by user.

Data were natural log transformed to achieve best W statistic (graph shown in original units).

High cutoff = 0.089, low cutoff = 0.000002758, based on IQR multiplier of 3.

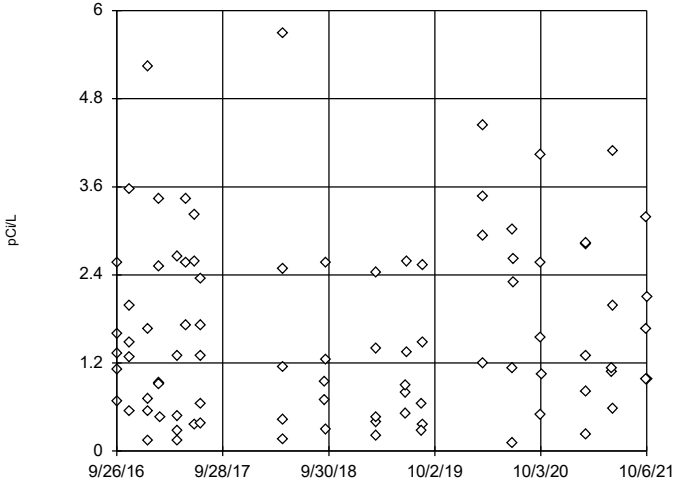
Constituent: Cobalt Analysis Run 1/11/2022 11:20 AM View: Descriptive

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Tukey's Outlier Screening, Pooled Background

MW-1011,MW-1012,MW-1203,MW-1604,MW-16...



n = 90

No outliers found. Tukey's method selected by user.

Data were cube root transformed to achieve best W statistic (graph shown in original units).

High cutoff = 25.18, low cutoff = -0.3672, based on IQR multiplier of 3.

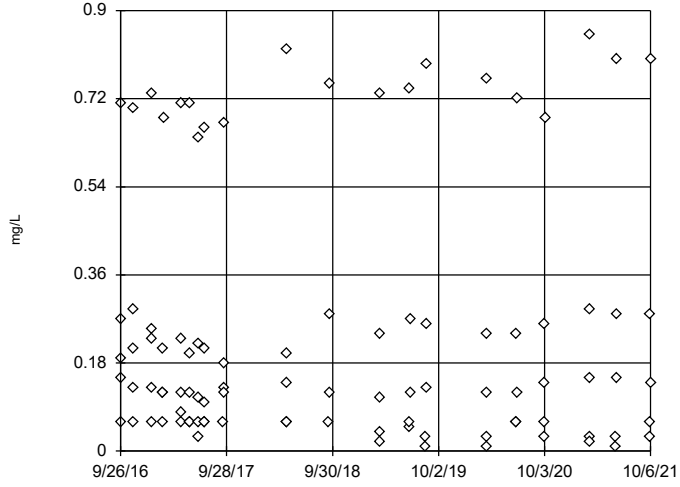
Constituent: Combined Radium 226 + 228 Analysis Run 1/11/2022 11:20 AM View: Descriptive

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Tukey's Outlier Screening, Pooled Background

MW-1011,MW-1012,MW-1203,MW-1604,MW-16...



n = 99

No outliers found. Tukey's method selected by user.

Data were natural log transformed to achieve best W statistic (graph shown in original units).

High cutoff = 28.46, low cutoff = 0.0005904, based on IQR multiplier of 3.

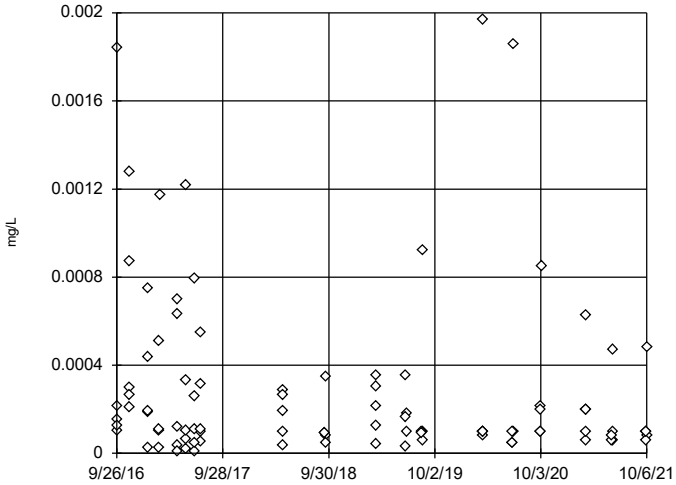
Constituent: Fluoride Analysis Run 1/11/2022 11:20 AM View: Descriptive

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Tukey's Outlier Screening, Pooled Background

MW-1011,MW-1012,MW-1203,MW-1604,MW-16...



n = 95

No outliers found. Tukey's method selected by user.

Data were natural log transformed to achieve best W statistic (graph shown in original units).

High cutoff = 0.01657, low cutoff = 0.000001563, based on IQR multiplier of 3.

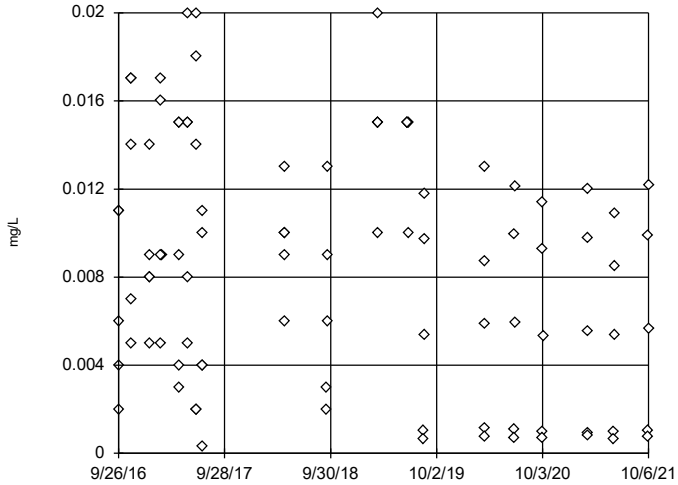
Constituent: Lead Analysis Run 1/11/2022 11:20 AM View: Descriptive

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Tukey's Outlier Screening, Pooled Background

MW-1011,MW-1012,MW-1203,MW-1604,MW-16...



n = 95

No outliers found. Tukey's method selected by user.

Ladder of Powers transformations did not improve normality; analysis run on raw data.

High cutoff = 0.04, low cutoff = -0.023, based on IQR multiplier of 3.

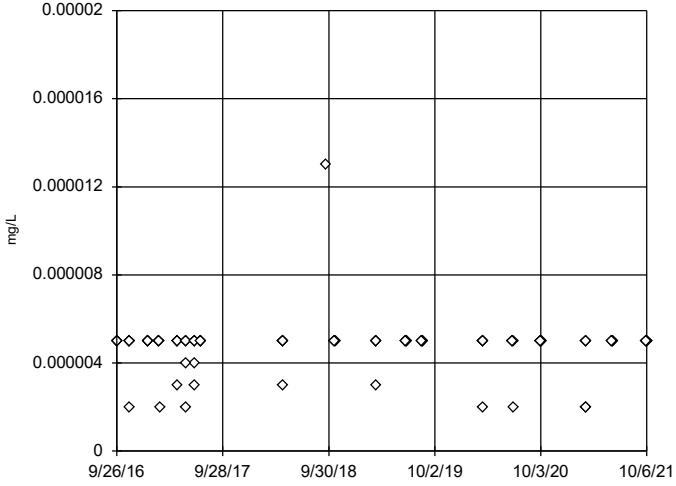
Constituent: Lithium Analysis Run 1/11/2022 11:20 AM View: Descriptive

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Tukey's Outlier Screening, Pooled Background

MW-1011,MW-1012,MW-1203,MW-1604,MW-16...



n = 95

No outliers found. Tukey's method selected by user.

Data were natural log transformed to achieve best W statistic (graph shown in original units).

The results were invalidated, because the lower and upper quartiles are equal.

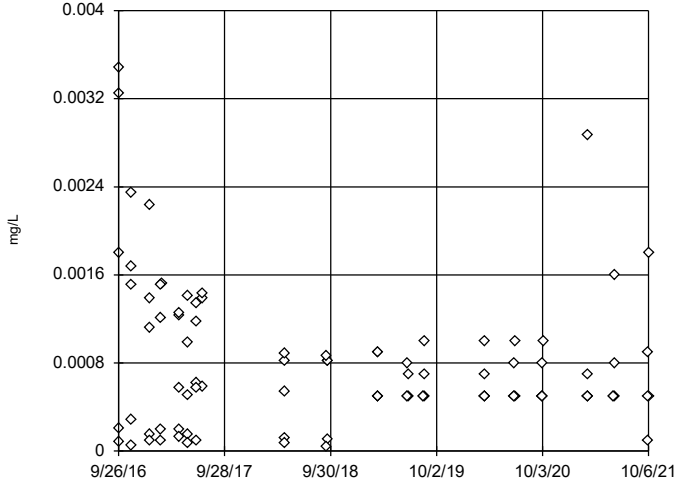
Constituent: Mercury Analysis Run 1/11/2022 11:20 AM View: Descriptive

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Tukey's Outlier Screening, Pooled Background

MW-1011,MW-1012,MW-1203,MW-1604,MW-16...



n = 93

No outliers found. Tukey's method selected by user.

Data were cube root transformed to achieve best W statistic (graph shown in original units).

High cutoff = 0.004243, low cutoff = 0.000005341, based on IQR multiplier of 3.

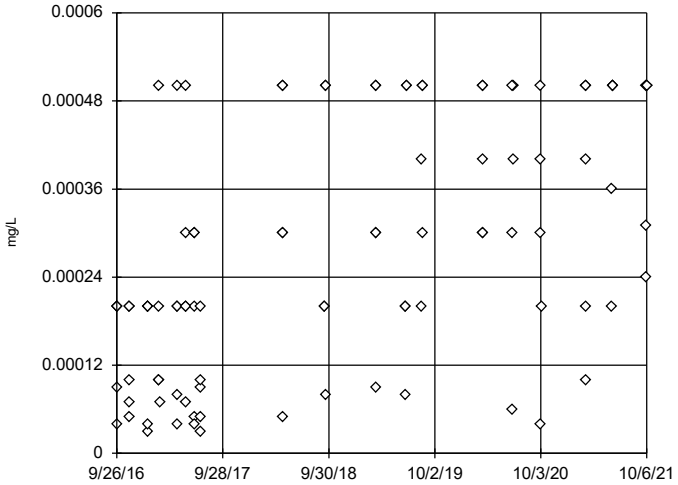
Constituent: Molybdenum Analysis Run 1/11/2022 11:20 AM View: Descriptive

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Tukey's Outlier Screening, Pooled Background

MW-1011,MW-1012,MW-1203,MW-1604,MW-16...



n = 95

No outliers found. Tukey's method selected by user.

Data were square root transformed to achieve best W statistic (graph shown in original units).

High cutoff = 0.003533, low cutoff = -0.0007334, based on IQR multiplier of 3.

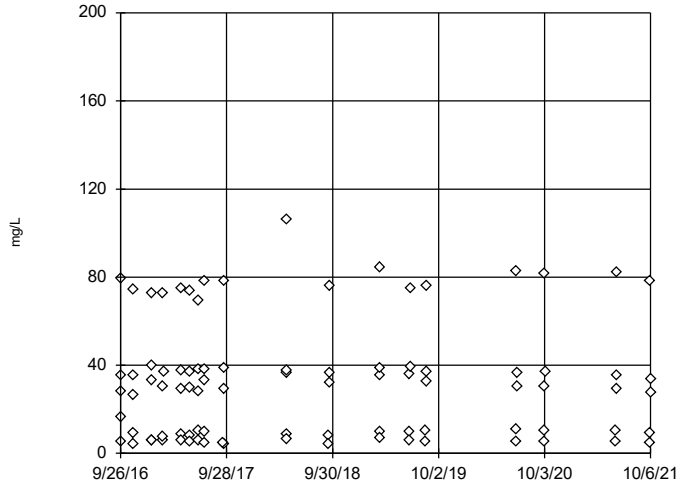
Constituent: Selenium Analysis Run 1/11/2022 11:20 AM View: Descriptive

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Tukey's Outlier Screening, Pooled Background

MW-1011,MW-1012,MW-1203,MW-1604,MW-16...



n = 90

No outliers found. Tukey's method selected by user.

Data were cube root transformed to achieve best W statistic (graph shown in original units).

High cutoff = 419.1, low cutoff = -9.433, based on IQR multiplier of 3.

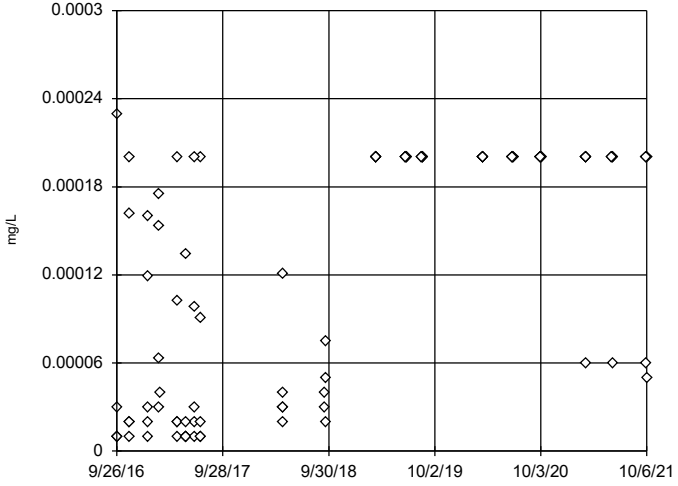
Constituent: Sulfate Analysis Run 1/11/2022 11:20 AM View: Descriptive

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Tukey's Outlier Screening, Pooled Background

MW-1011,MW-1012,MW-1203,MW-1604,MW-16...



n = 95

No outliers found. Tukey's method selected by user.

Data were cube root transformed to achieve best W statistic (graph shown in original units).

High cutoff = 0.002786, low cutoff = -0.0001338, based on IQR multiplier of 3.

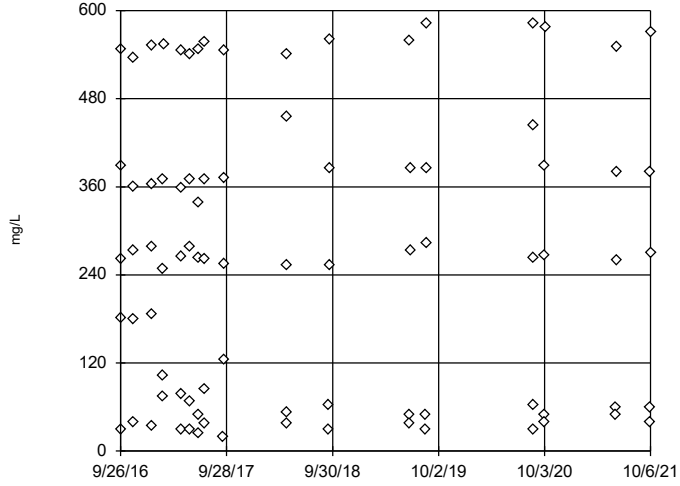
Constituent: Thallium Analysis Run 1/11/2022 11:20 AM View: Descriptive

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Tukey's Outlier Screening, Pooled Background

MW-1011,MW-1012,MW-1203,MW-1604,MW-16...



n = 85

No outliers found. Tukey's method selected by user.

Data were square root transformed to achieve best W statistic (graph shown in original units).

High cutoff = 3164, low cutoff = -847, based on IQR multiplier of 3.

Constituent: Total Dissolved Solids Analysis Run 1/11/2022 11:20 AM View: Descriptive

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

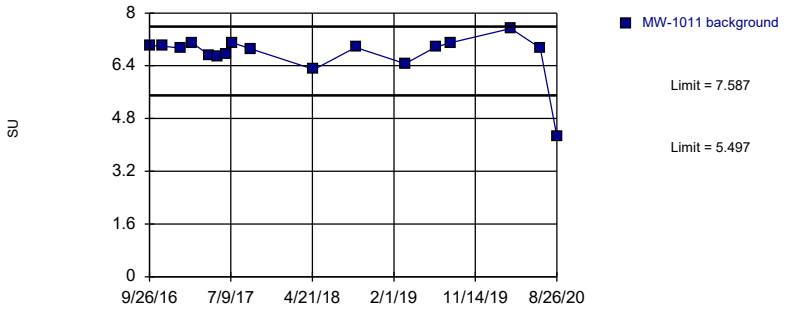
Intrawell Prediction Limits

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP Printed 1/11/2022, 10:24 AM

Constituent	Well	Upper Lim.	Lower Lim.	Date	Observ.	Sig.	Bg N	Bg Mean	Std. Dev.	%NDs	ND Adj.	Transform	Alpha	Method
pH (SU)	MW-1011	7.587	5.497	n/a	1 future	n/a	17	15079	4730	0	None	x^5	0.000752	Param Intra 1 of 2
pH (SU)	MW-1012	9.552	8.568	n/a	1 future	n/a	16	9.06	0.229	0	None	No	0.000752	Param Intra 1 of 2
pH (SU)	MW-1203	7.664	5.948	n/a	1 future	n/a	17	6.806	0.4033	0	None	No	0.000752	Param Intra 1 of 2
pH (SU)	MW-1601	7.969	6.349	n/a	1 future	n/a	13	7.159	0.3554	0	None	No	0.000752	Param Intra 1 of 2
pH (SU)	MW-1602	8.718	5.606	n/a	1 future	n/a	18	53.72	10.6	0	None	x^2	0.000752	Param Intra 1 of 2
pH (SU)	MW-1603	5.56	2.91	n/a	1 future	n/a	18	n/a	n/a	0	n/a	n/a	0.01075	NP Intra (normality) 1 of 2
pH (SU)	MW-1604	7.478	3.972	n/a	1 future	n/a	17	5.725	0.8241	0	None	No	0.000752	Param Intra 1 of 2
pH (SU)	MW-1605	5.962	3.174	n/a	1 future	n/a	17	22.81	5.987	0	None	x^2	0.000752	Param Intra 1 of 2
pH (SU)	MW-1606	7.499	6.288	n/a	1 future	n/a	17	6.894	0.2847	0	None	No	0.000752	Param Intra 1 of 2
pH (SU)	MW-1607	7.509	5.473	n/a	1 future	n/a	18	1.858	0.07518	0	None	ln(x)	0.000752	Param Intra 1 of 2

Prediction Limit

Intrawell Parametric, MW-1011 (bg)



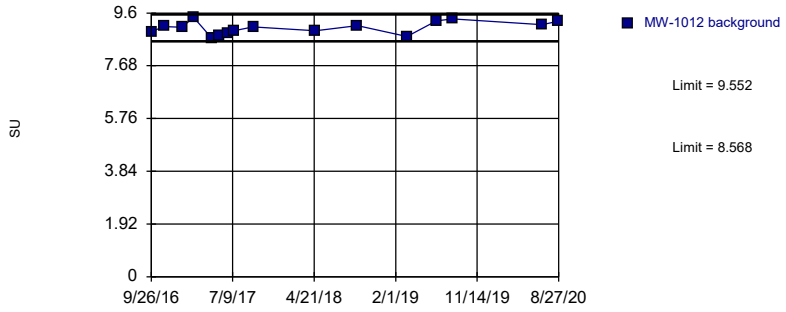
Background Data Summary (based on x^5 transformation): Mean=15079, Std. Dev.=4730, n=17. Normality test: Shapiro Wilk @alpha = 0.01, calculated = 0.8619, critical = 0.851. Kappa = 2.127 (c=7, w=5, 1 of 2, event alpha = 0.05132). Report alpha = 0.001504. Assumes 1 future value.

Constituent: pH Analysis Run 1/11/2022 10:22 AM View: AIII Intrawell
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Prediction Limit

Intrawell Parametric, MW-1012 (bg)



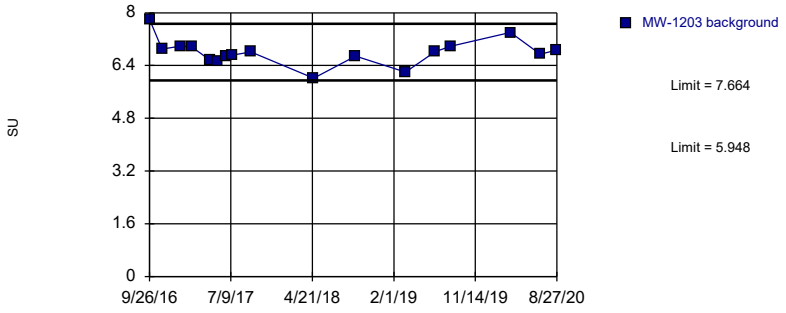
Background Data Summary: Mean=9.06, Std. Dev.=0.229, n=16. Normality test: Shapiro Wilk @alpha = 0.01, calculated = 0.9634, critical = 0.844. Kappa = 2.15 (c=7, w=5, 1 of 2, event alpha = 0.05132). Report alpha = 0.001504. Assumes 1 future value.

Constituent: pH Analysis Run 1/11/2022 10:22 AM View: AIII Intrawell
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Prediction Limit

Intrawell Parametric, MW-1203 (bg)



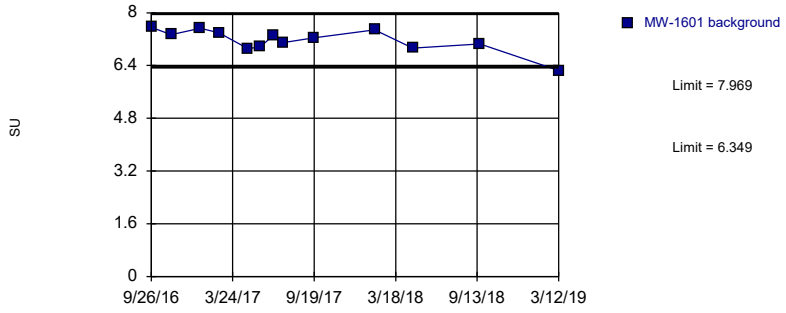
Background Data Summary: Mean=6.806, Std. Dev.=0.4033, n=17. Normality test: Shapiro Wilk @alpha = 0.01, calculated = 0.9311, critical = 0.851. Kappa = 2.127 (c=7, w=5, 1 of 2, event alpha = 0.05132). Report alpha = 0.001504. Assumes 1 future value.

Constituent: pH Analysis Run 1/11/2022 10:22 AM View: AIII Intrawell
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Prediction Limit

Intrawell Parametric, MW-1601

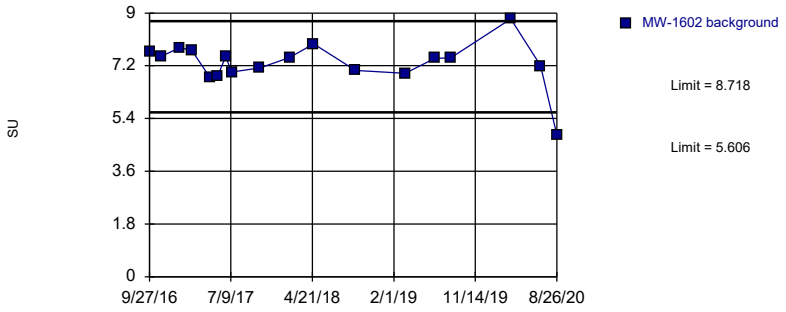


Background Data Summary: Mean=7.159, Std. Dev.=0.3554, n=13. Normality test: Shapiro Wilk @alpha = 0.01, calculated = 0.8814, critical = 0.814. Kappa = 2.279 (c=7, w=5, 1 of 2, event alpha = 0.05132). Report alpha = 0.001504. Assumes 1 future value.

Constituent: pH Analysis Run 1/11/2022 10:22 AM View: AIII Intrawell
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Prediction Limit

Intrawell Parametric, MW-1602



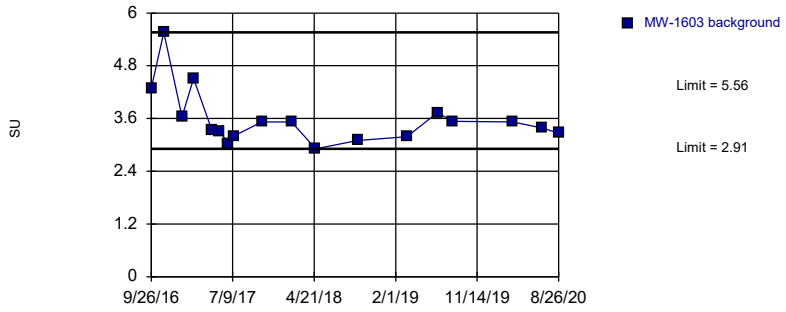
Background Data Summary (based on square transformation): Mean=53.72, Std. Dev.=10.6, n=18. Normality test: Shapiro Wilk @alpha = 0.01, calculated = 0.882, critical = 0.858. Kappa = 2.104 (c=7, w=5, 1 of 2, event alpha = 0.05132). Report alpha = 0.001504. Assumes 1 future value.

Constituent: pH Analysis Run 1/11/2022 10:23 AM View: AIII Intrawell
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Prediction Limit

Intrawell Non-parametric, MW-1603



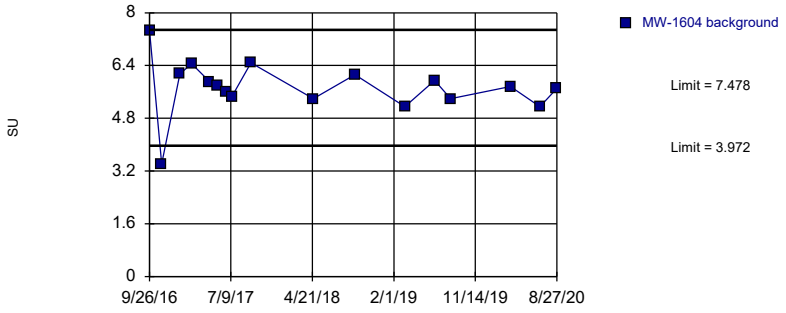
Non-parametric test used in lieu of parametric prediction limit because the Shapiro Wilk normality test showed the data to be non-normal at the 0.01 alpha level. Limits are highest and lowest of 18 background values. Well-constituent pair annual alpha = 0.02143. Individual comparison alpha = 0.01075 (1 of 2). Assumes 1 future value.

Constituent: pH Analysis Run 1/11/2022 10:23 AM View: AIII Intrawell
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Prediction Limit

Intrawell Parametric, MW-1604 (bg)



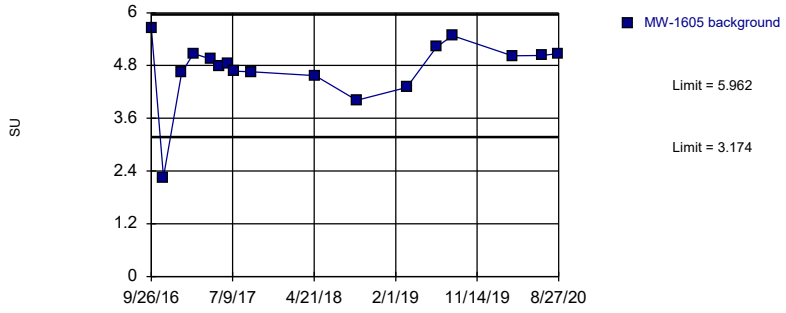
Background Data Summary: Mean=5.725, Std. Dev.=0.8241, n=17. Normality test: Shapiro Wilk @alpha = 0.01, calculated = 0.8957, critical = 0.851. Kappa = 2.127 (c=7, w=5, 1 of 2, event alpha = 0.05132). Report alpha = 0.001504. Assumes 1 future value.

Constituent: pH Analysis Run 1/11/2022 10:23 AM View: AIII Intrawell
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Prediction Limit

Intrawell Parametric, MW-1605 (bg)

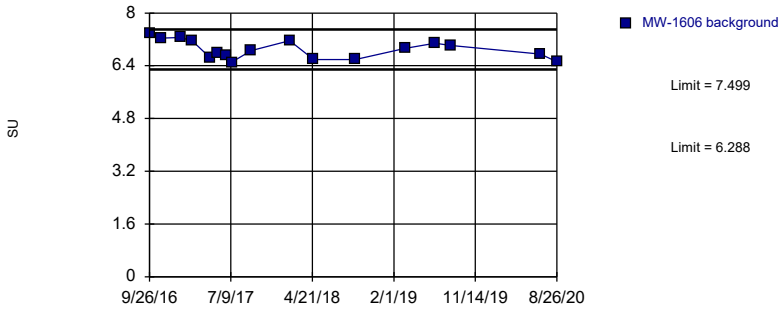


Background Data Summary (based on square transformation): Mean=22.81, Std. Dev.=5.987, n=17. Normality test: Shapiro Wilk @alpha = 0.01, calculated = 0.8791, critical = 0.851. Kappa = 2.127 (c=7, w=5, 1 of 2, event alpha = 0.05132). Report alpha = 0.001504. Assumes 1 future value.

Constituent: pH Analysis Run 1/11/2022 10:23 AM View: AIII Intrawell
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Prediction Limit

Intrawell Parametric, MW-1606



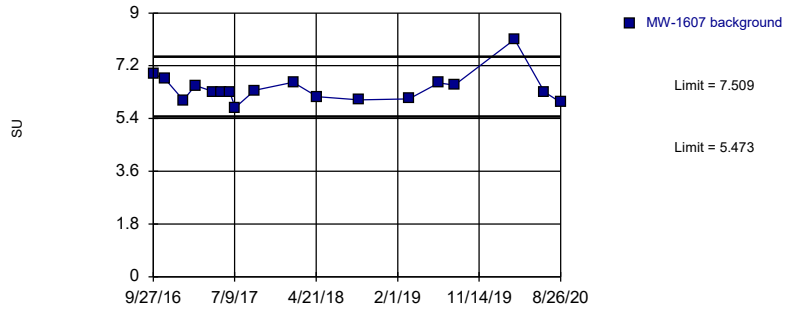
Background Data Summary: Mean=6.894, Std. Dev.=0.2847, n=17. Normality test: Shapiro Wilk @alpha = 0.01, calculated = 0.9372, critical = 0.851. Kappa = 2.127 (c=7, w=5, 1 of 2, event alpha = 0.05132). Report alpha = 0.001504. Assumes 1 future value.

Constituent: pH Analysis Run 1/11/2022 10:23 AM View: AIII Intrawell
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Prediction Limit

Intrawell Parametric, MW-1607



Background Data Summary (based on natural log transformation): Mean=1.858, Std. Dev.=0.07518, n=18. Normality test: Shapiro Wilk @alpha = 0.01, calculated = 0.8619, critical = 0.858. Kappa = 2.104 (c=7, w=5, 1 of 2, event alpha = 0.05132). Report alpha = 0.001504. Assumes 1 future value.

Constituent: pH Analysis Run 1/11/2022 10:23 AM View: AIII Intrawell
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Trend Test - Significant Results

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP Printed 1/11/2022, 10:38 AM

Constituent	Well	Slope	Calc.	Critical	Sig.	N	%NDs	Normality	Xform	Alpha	Method
Chloride (mg/L)	**MW-1604 (bg)**	**-0.3224**	**-121**	**-68**	**Yes**	**18**	**0**	**n/a**	**n/a**	**0.01**	**NP**
Fluoride (mg/L)	**MW-1011 (bg)**	**0.01513**	**95**	**81**	**Yes**	**20**	**0**	**n/a**	**n/a**	**0.01**	**NP**
Fluoride (mg/L)	**MW-1604 (bg)**	**-0.02003**	**-126**	**-81**	**Yes**	**20**	**5**	**n/a**	**n/a**	**0.01**	**NP**
Total Dissolved Solids (mg/L)	**MW-1604 (bg)**	**-16.21**	**-70**	**-63**	**Yes**	**17**	**0**	**n/a**	**n/a**	**0.01**	**NP**

Trend Test - All Results

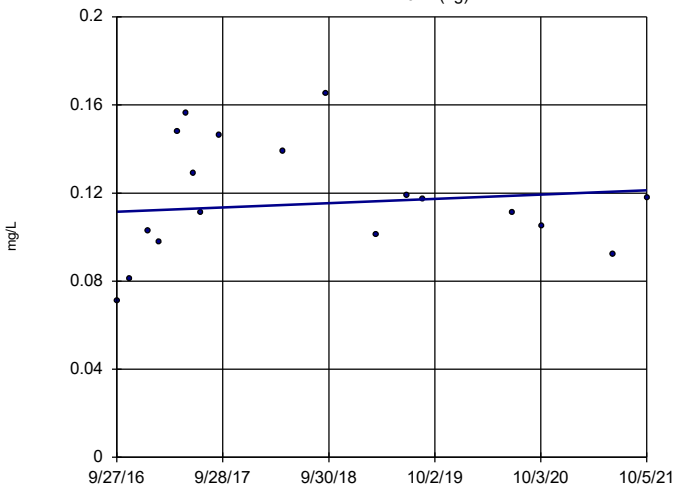
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP Printed 1/11/2022, 10:38 AM

Constituent	Well	Slope	Calc.	Critical	Sig.	N	%NDs	Normality	Xform	Alpha	Method
Boron (mg/L)	MW-1011 (bg)	0.001933	10	68	No	18	0	n/a	n/a	0.01	NP
Boron (mg/L)	MW-1012 (bg)	0.001104	13	68	No	18	0	n/a	n/a	0.01	NP
Boron (mg/L)	MW-1203 (bg)	-0.0004387	-5	-68	No	18	0	n/a	n/a	0.01	NP
Boron (mg/L)	MW-1604 (bg)	-0.001597	-20	-68	No	18	16.67	n/a	n/a	0.01	NP
Boron (mg/L)	MW-1605 (bg)	0	-8	-68	No	18	27.78	n/a	n/a	0.01	NP
Calcium (mg/L)	MW-1011 (bg)	1.256	43	68	No	18	0	n/a	n/a	0.01	NP
Calcium (mg/L)	MW-1012 (bg)	-0.006003	-14	-68	No	18	0	n/a	n/a	0.01	NP
Calcium (mg/L)	MW-1203 (bg)	0.4109	16	68	No	18	0	n/a	n/a	0.01	NP
Calcium (mg/L)	MW-1604 (bg)	-0.09745	-13	-68	No	18	0	n/a	n/a	0.01	NP
Calcium (mg/L)	MW-1605 (bg)	0.003453	7	68	No	18	0	n/a	n/a	0.01	NP
Chloride (mg/L)	MW-1011 (bg)	0.4299	68	68	No	18	0	n/a	n/a	0.01	NP
Chloride (mg/L)	MW-1012 (bg)	0.03956	66	68	No	18	0	n/a	n/a	0.01	NP
Chloride (mg/L)	MW-1203 (bg)	-0.03795	-29	-68	No	18	0	n/a	n/a	0.01	NP
Chloride (mg/L)	**MW-1604 (bg)**	**-0.3224**	**-121**	**-68**	**Yes**	**18**	**0**	**n/a**	**n/a**	**0.01**	**NP**
Chloride (mg/L)	MW-1605 (bg)	-0.08118	-54	-68	No	18	0	n/a	n/a	0.01	NP
Fluoride (mg/L)	**MW-1011 (bg)**	**0.01513**	**95**	**81**	**Yes**	**20**	**0**	**n/a**	**n/a**	**0.01**	**NP**
Fluoride (mg/L)	MW-1012 (bg)	0.01888	74	81	No	20	0	n/a	n/a	0.01	NP
Fluoride (mg/L)	MW-1203 (bg)	0	30	81	No	20	0	n/a	n/a	0.01	NP
Fluoride (mg/L)	**MW-1604 (bg)**	**-0.02003**	**-126**	**-81**	**Yes**	**20**	**5**	**n/a**	**n/a**	**0.01**	**NP**
Fluoride (mg/L)	MW-1605 (bg)	0	-48	-74	No	19	73.68	n/a	n/a	0.01	NP
Sulfate (mg/L)	MW-1011 (bg)	1.151	51	68	No	18	0	n/a	n/a	0.01	NP
Sulfate (mg/L)	MW-1012 (bg)	-0.3091	-32	-68	No	18	0	n/a	n/a	0.01	NP
Sulfate (mg/L)	MW-1203 (bg)	0.3607	21	68	No	18	0	n/a	n/a	0.01	NP
Sulfate (mg/L)	MW-1604 (bg)	0.3847	34	68	No	18	0	n/a	n/a	0.01	NP
Sulfate (mg/L)	MW-1605 (bg)	-0.1154	-21	-68	No	18	0	n/a	n/a	0.01	NP
Total Dissolved Solids (mg/L)	MW-1011 (bg)	5.395	48	63	No	17	0	n/a	n/a	0.01	NP
Total Dissolved Solids (mg/L)	MW-1012 (bg)	6.377	60	63	No	17	0	n/a	n/a	0.01	NP
Total Dissolved Solids (mg/L)	MW-1203 (bg)	0	-1	-63	No	17	0	n/a	n/a	0.01	NP
Total Dissolved Solids (mg/L)	**MW-1604 (bg)**	**-16.21**	**-70**	**-63**	**Yes**	**17**	**0**	**n/a**	**n/a**	**0.01**	**NP**
Total Dissolved Solids (mg/L)	MW-1605 (bg)	0.6115	18	63	No	17	0	n/a	n/a	0.01	NP

Sanitas™ v.9.6.32 . UG

Sen's Slope Estimator

MW-1011 (bg)



n = 18

Slope = 0.001933 units per year.

Mann-Kendall statistic = 10
critical = 68

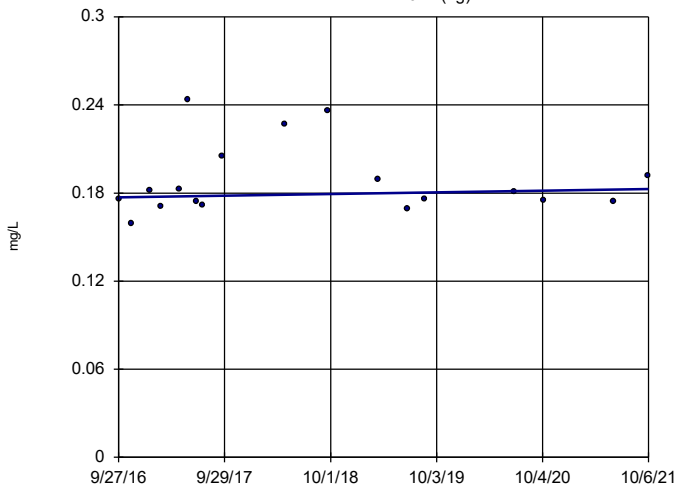
Trend not significant at 99% confidence level (α = 0.005 per tail).

Constituent: Boron Analysis Run 1/11/2022 10:36 AM View: AIII
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Sen's Slope Estimator

MW-1012 (bg)



n = 18

Slope = 0.001104 units per year.

Mann-Kendall statistic = 13
critical = 68

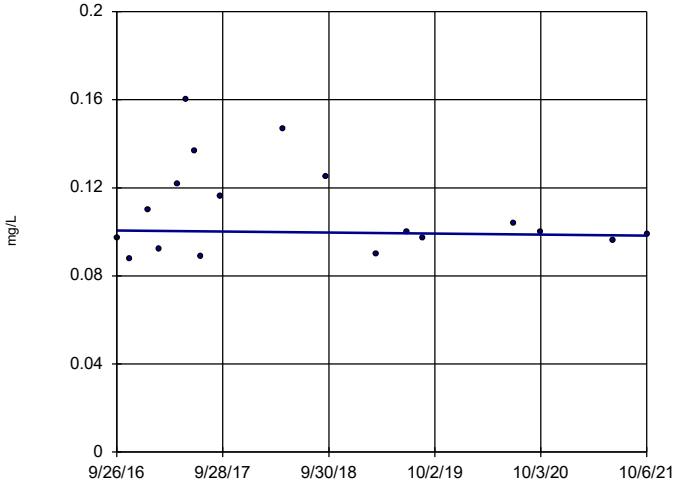
Trend not significant at 99% confidence level (α = 0.005 per tail).

Constituent: Boron Analysis Run 1/11/2022 10:36 AM View: AIII
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Sen's Slope Estimator

MW-1203 (bg)



n = 18

Slope = -0.0004387 units per year.

Mann-Kendall statistic = -5
critical = -68

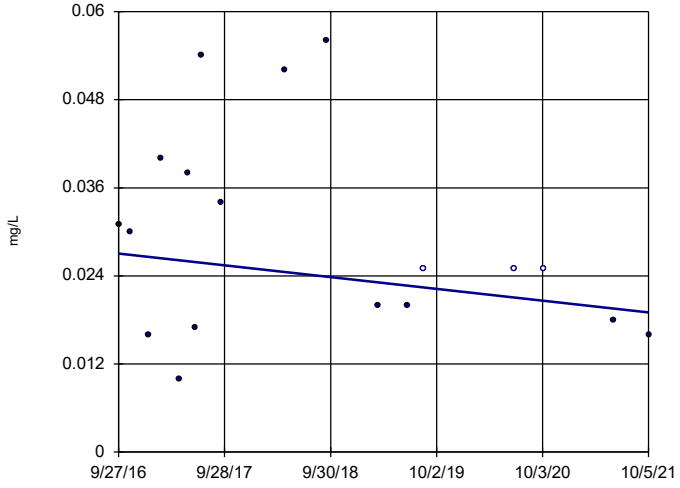
Trend not significant at 99% confidence level (α = 0.005 per tail).

Constituent: Boron Analysis Run 1/11/2022 10:36 AM View: AIII
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG
Hollow symbols indicate censored values.

Sen's Slope Estimator

MW-1604 (bg)



n = 18

Slope = -0.001597 units per year.

Mann-Kendall statistic = -20
critical = -68

Trend not significant at 99% confidence level (α = 0.005 per tail).

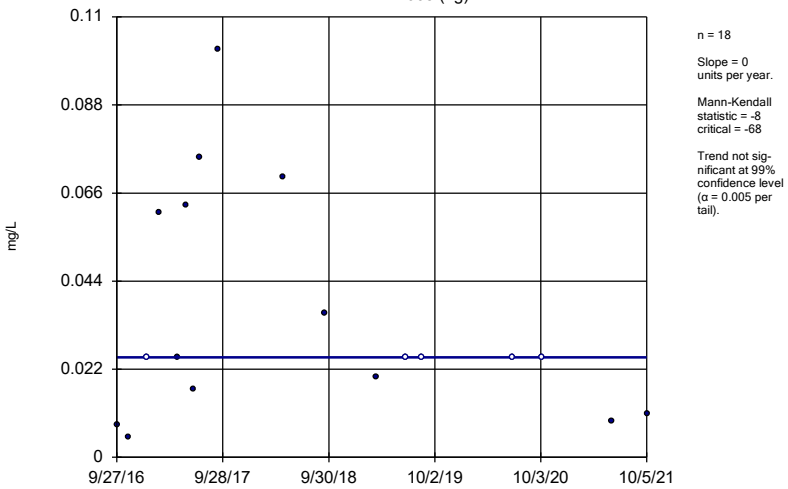
Constituent: Boron Analysis Run 1/11/2022 10:36 AM View: AIII
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Hollow symbols indicate censored values.

Sen's Slope Estimator

MW-1605 (bg)



n = 18

Slope = 0 units per year.

Mann-Kendall statistic = -8
critical = -68

Trend not significant at 99% confidence level (α = 0.005 per tail).

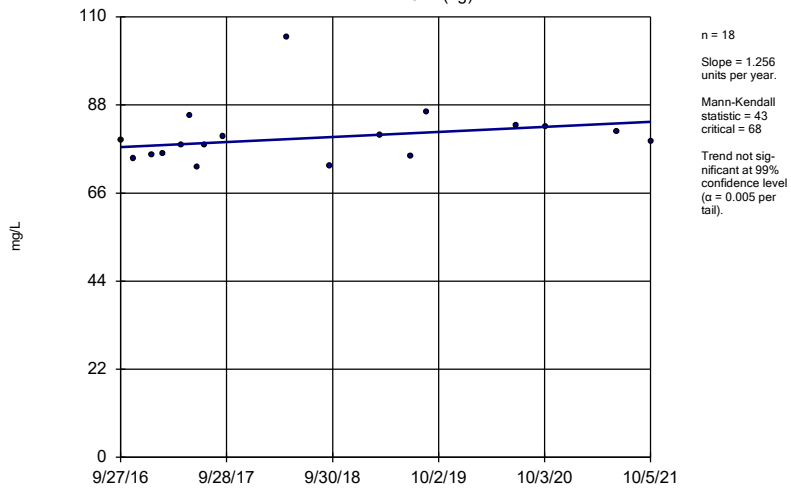
Constituent: Boron Analysis Run 1/11/2022 10:36 AM View: AIII

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Sen's Slope Estimator

MW-1011 (bg)



n = 18

Slope = 1.256 units per year.

Mann-Kendall statistic = 43
critical = 68

Trend not significant at 99% confidence level (α = 0.005 per tail).

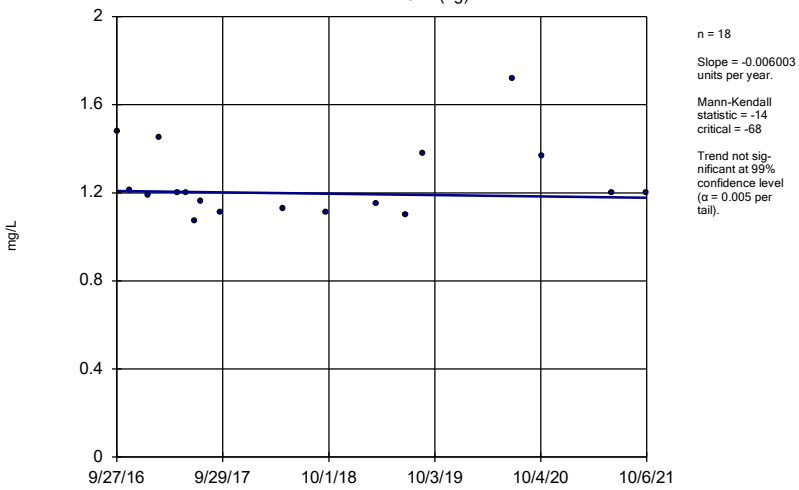
Constituent: Calcium Analysis Run 1/11/2022 10:36 AM View: AIII

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Sen's Slope Estimator

MW-1012 (bg)



n = 18

Slope = -0.006003 units per year.

Mann-Kendall statistic = -14
critical = -68

Trend not significant at 99% confidence level (α = 0.005 per tail).

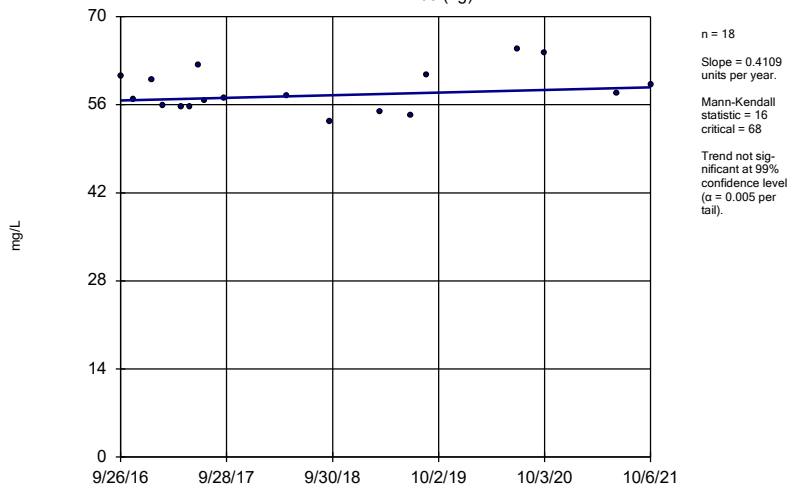
Constituent: Calcium Analysis Run 1/11/2022 10:36 AM View: AIII

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Sen's Slope Estimator

MW-1203 (bg)



n = 18

Slope = 0.4109 units per year.

Mann-Kendall statistic = 16
critical = 68

Trend not significant at 99% confidence level (α = 0.005 per tail).

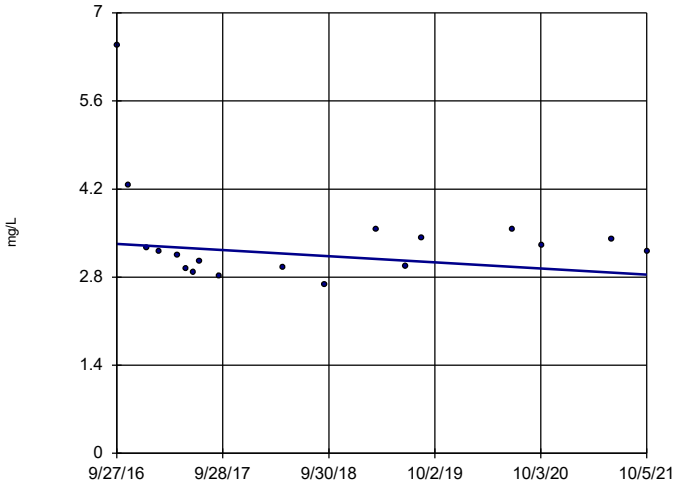
Constituent: Calcium Analysis Run 1/11/2022 10:36 AM View: AIII

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Sen's Slope Estimator

MW-1604 (bg)



n = 18

Slope = -0.09745 units per year.

Mann-Kendall statistic = -13
critical = -68

Trend not significant at 99% confidence level (α = 0.005 per tail).

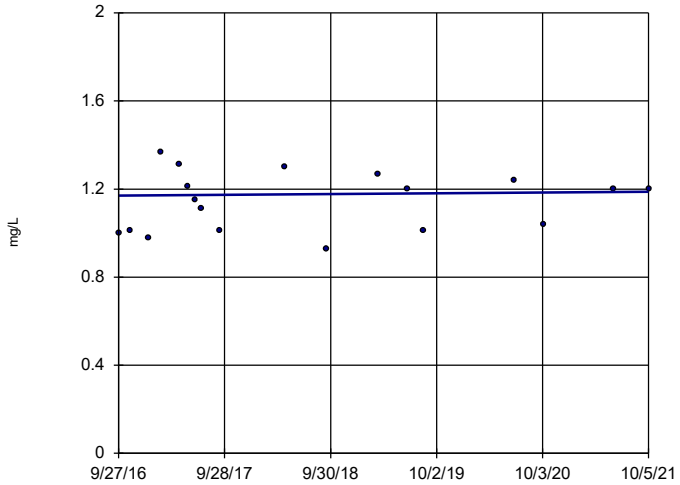
Constituent: Calcium Analysis Run 1/11/2022 10:36 AM View: AIII

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Sen's Slope Estimator

MW-1605 (bg)



n = 18

Slope = 0.003453 units per year.

Mann-Kendall statistic = 7
critical = 68

Trend not significant at 99% confidence level (α = 0.005 per tail).

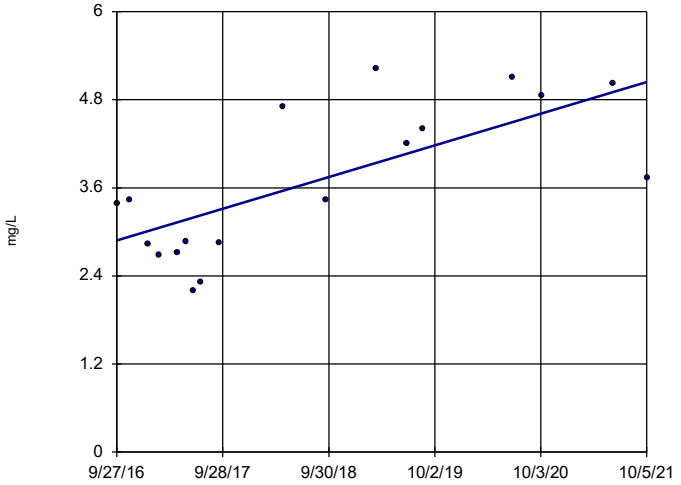
Constituent: Calcium Analysis Run 1/11/2022 10:36 AM View: AIII

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Sen's Slope Estimator

MW-1011 (bg)



n = 18

Slope = 0.4299 units per year.

Mann-Kendall statistic = 68
critical = 68

Trend not significant at 99% confidence level (α = 0.005 per tail).

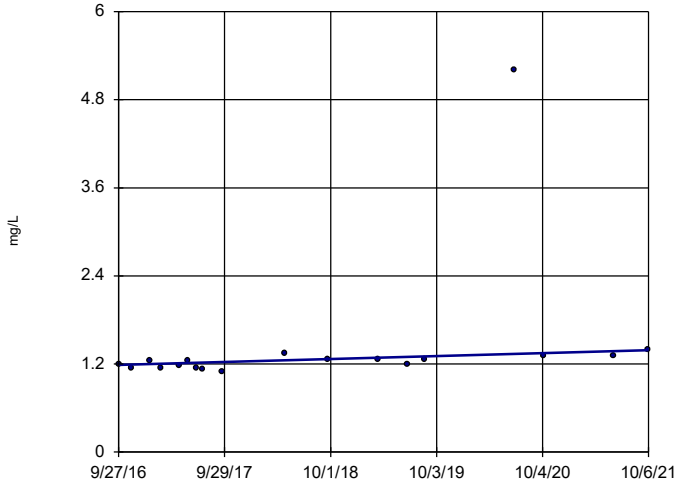
Constituent: Chloride Analysis Run 1/11/2022 10:36 AM View: AIII

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Sen's Slope Estimator

MW-1012 (bg)



n = 18

Slope = 0.03956 units per year.

Mann-Kendall statistic = 66
critical = 68

Trend not significant at 99% confidence level (α = 0.005 per tail).

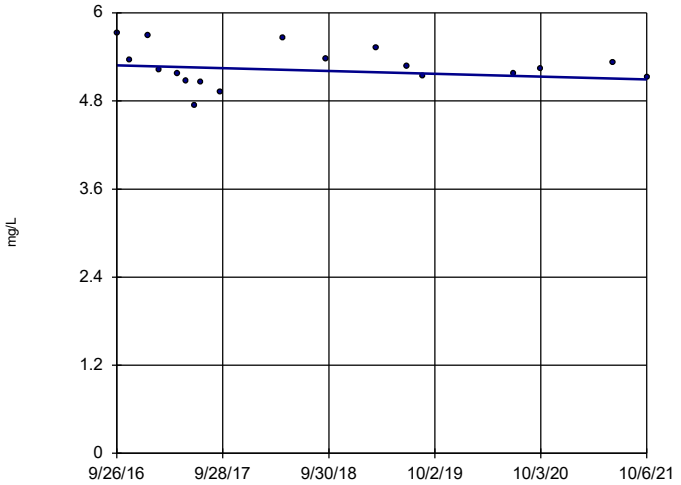
Constituent: Chloride Analysis Run 1/11/2022 10:36 AM View: AIII

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Sen's Slope Estimator

MW-1203 (bg)



n = 18

Slope = -0.03795 units per year.

Mann-Kendall statistic = -29
critical = -68

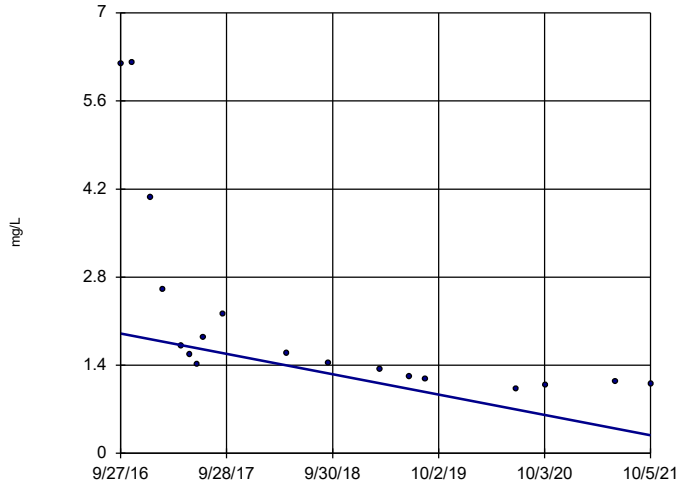
Trend not significant at 99% confidence level (α = 0.005 per tail).

Constituent: Chloride Analysis Run 1/11/2022 10:36 AM View: AIII
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Sen's Slope Estimator

MW-1604 (bg)



n = 18

Slope = -0.3224 units per year.

Mann-Kendall statistic = -121
critical = -68

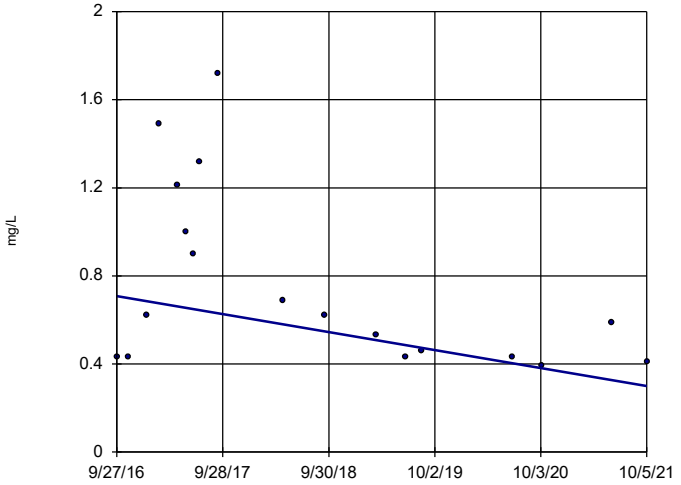
Decreasing trend significant at 99% confidence level (α = 0.005 per tail).

Constituent: Chloride Analysis Run 1/11/2022 10:36 AM View: AIII
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Sen's Slope Estimator

MW-1605 (bg)



n = 18

Slope = -0.08118 units per year.

Mann-Kendall statistic = -54
critical = -68

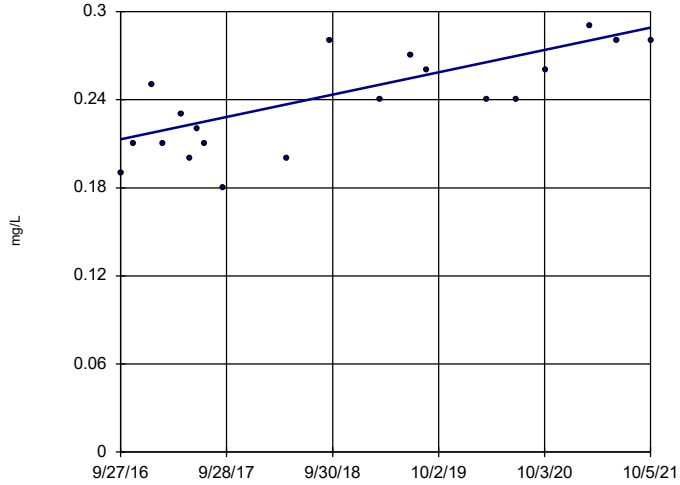
Trend not significant at 99% confidence level (α = 0.005 per tail).

Constituent: Chloride Analysis Run 1/11/2022 10:36 AM View: AIII
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Sen's Slope Estimator

MW-1011 (bg)



n = 20

Slope = 0.01513 units per year.

Mann-Kendall statistic = 95
critical = 81

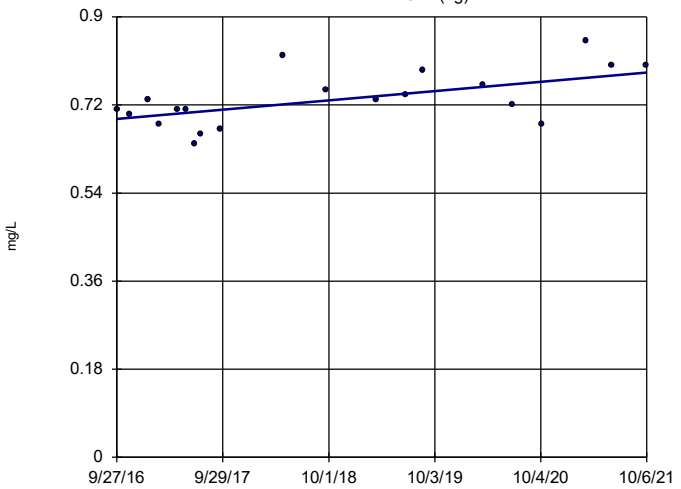
Increasing trend significant at 99% confidence level (α = 0.005 per tail).

Constituent: Fluoride Analysis Run 1/11/2022 10:36 AM View: AIII
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Sen's Slope Estimator

MW-1012 (bg)



n = 20

Slope = 0.01888 units per year.

Mann-Kendall statistic = 74
critical = 81

Trend not significant at 99% confidence level (α = 0.005 per tail).

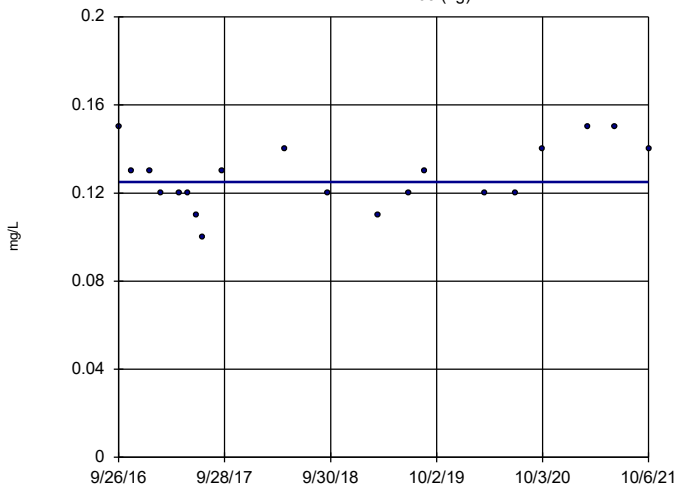
Constituent: Fluoride Analysis Run 1/11/2022 10:36 AM View: AIII

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Sen's Slope Estimator

MW-1203 (bg)



n = 20

Slope = 0 units per year.

Mann-Kendall statistic = 30
critical = 81

Trend not significant at 99% confidence level (α = 0.005 per tail).

Constituent: Fluoride Analysis Run 1/11/2022 10:36 AM View: AIII

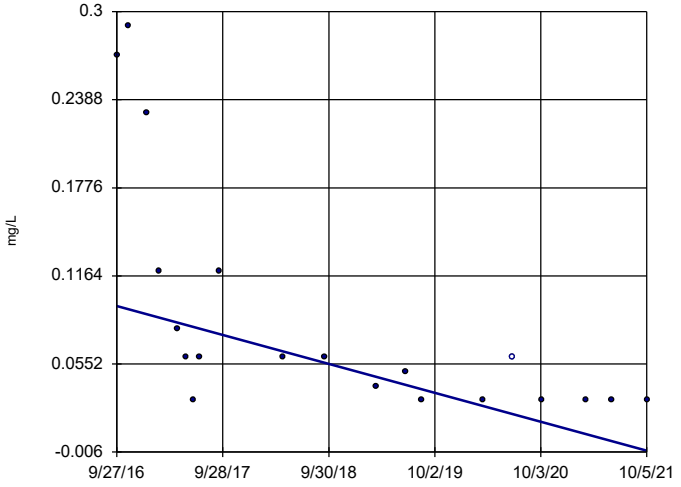
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Hollow symbols indicate censored values.

Sen's Slope Estimator

MW-1604 (bg)



n = 20

Slope = -0.02003 units per year.

Mann-Kendall statistic = -126
critical = -81

Decreasing trend significant at 99% confidence level (α = 0.005 per tail).

Constituent: Fluoride Analysis Run 1/11/2022 10:36 AM View: AIII

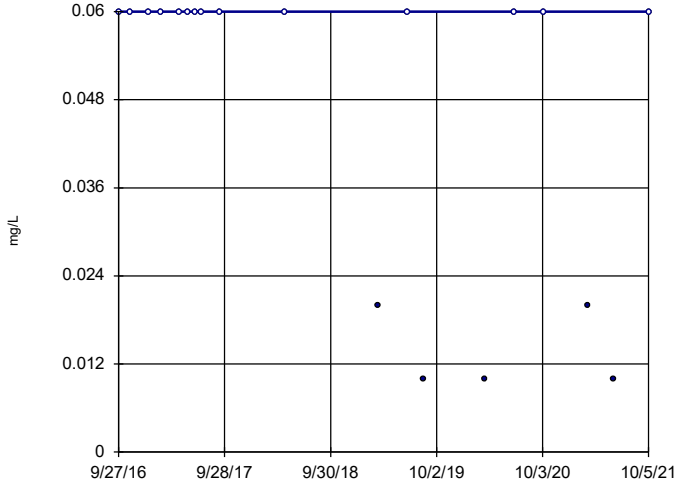
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Hollow symbols indicate censored values.

Sen's Slope Estimator

MW-1605 (bg)



n = 19

Slope = 0 units per year.

Mann-Kendall statistic = -48
critical = -74

Trend not significant at 99% confidence level (α = 0.005 per tail).

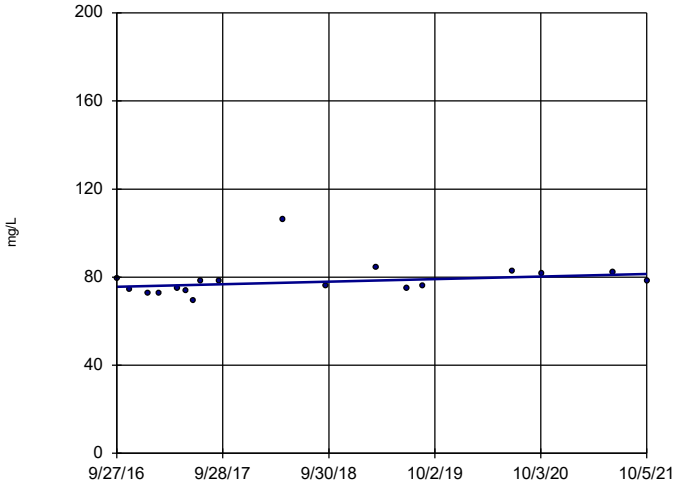
Constituent: Fluoride Analysis Run 1/11/2022 10:36 AM View: AIII

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Sen's Slope Estimator

MW-1011 (bg)



n = 18

Slope = 1.151 units per year.

Mann-Kendall statistic = 51 critical = 68

Trend not significant at 99% confidence level (α = 0.005 per tail).

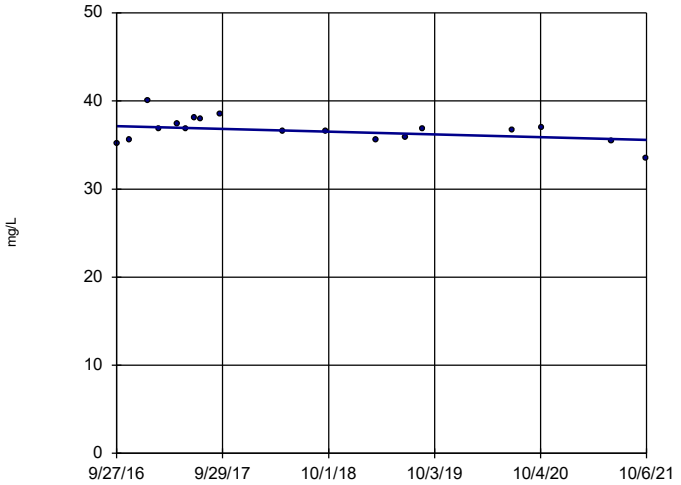
Constituent: Sulfate Analysis Run 1/11/2022 10:36 AM View: AIII

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Sen's Slope Estimator

MW-1012 (bg)



n = 18

Slope = -0.3091 units per year.

Mann-Kendall statistic = -32 critical = -68

Trend not significant at 99% confidence level (α = 0.005 per tail).

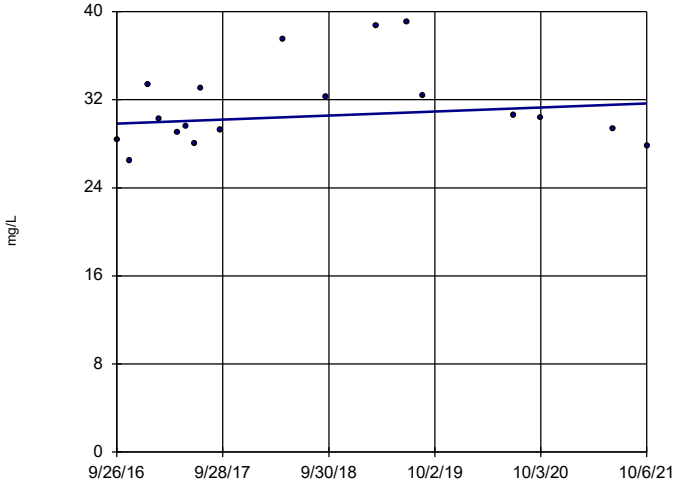
Constituent: Sulfate Analysis Run 1/11/2022 10:36 AM View: AIII

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Sen's Slope Estimator

MW-1203 (bg)



n = 18

Slope = 0.3607 units per year.

Mann-Kendall statistic = 21 critical = 68

Trend not significant at 99% confidence level (α = 0.005 per tail).

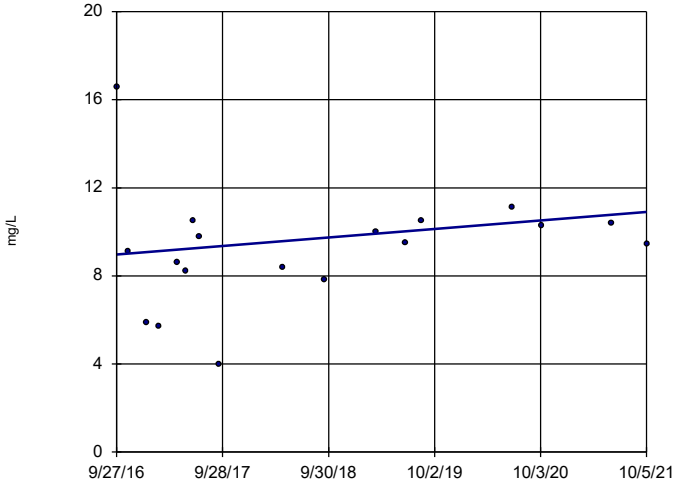
Constituent: Sulfate Analysis Run 1/11/2022 10:36 AM View: AIII

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Sen's Slope Estimator

MW-1604 (bg)



n = 18

Slope = 0.3847 units per year.

Mann-Kendall statistic = 34 critical = 68

Trend not significant at 99% confidence level (α = 0.005 per tail).

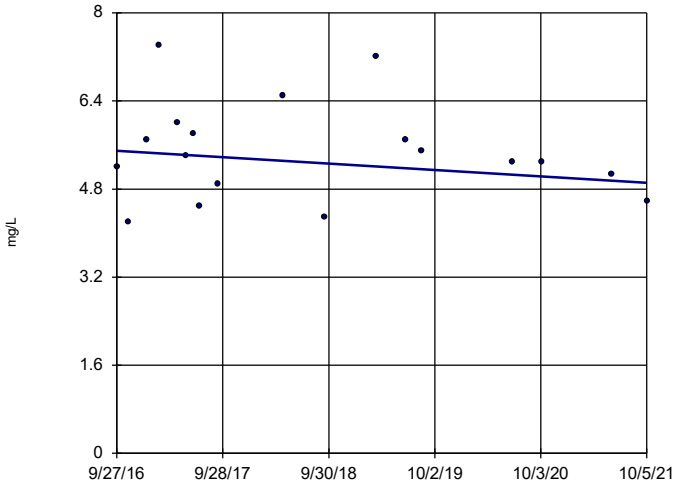
Constituent: Sulfate Analysis Run 1/11/2022 10:36 AM View: AIII

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Sen's Slope Estimator

MW-1605 (bg)



n = 18

Slope = -0.1154 units per year.

Mann-Kendall statistic = -21
critical = -68

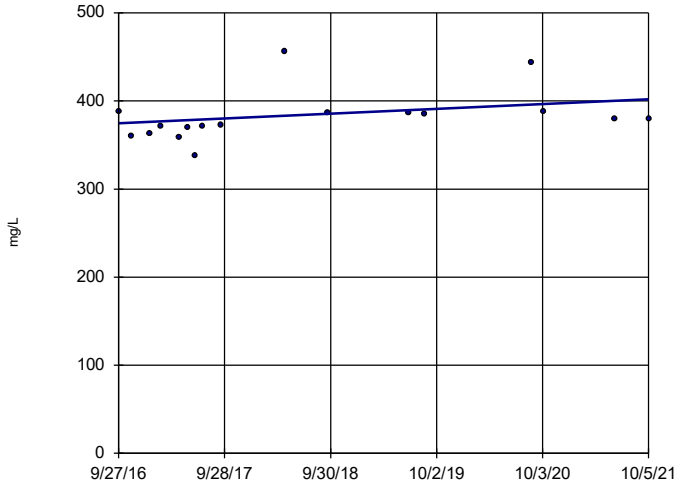
Trend not significant at 99% confidence level (α = 0.005 per tail).

Constituent: Sulfate Analysis Run 1/11/2022 10:36 AM View: AIII
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Sen's Slope Estimator

MW-1011 (bg)



n = 17

Slope = 5.395 units per year.

Mann-Kendall statistic = 48
critical = 63

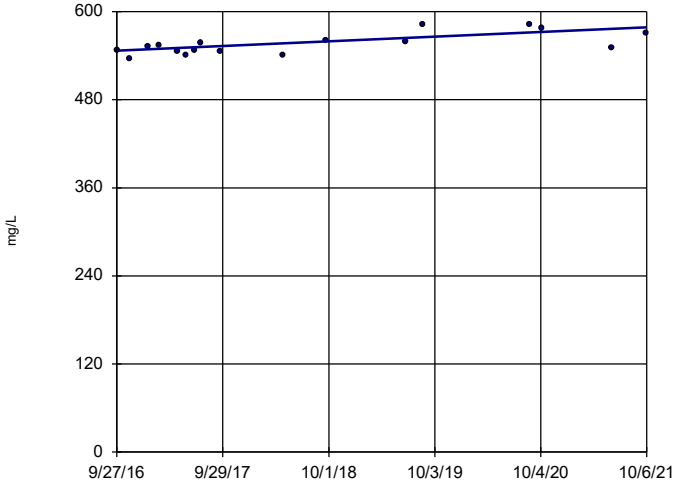
Trend not significant at 99% confidence level (α = 0.005 per tail).

Constituent: Total Dissolved Solids Analysis Run 1/11/2022 10:36 AM View: AIII
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Sen's Slope Estimator

MW-1012 (bg)



n = 17

Slope = 6.377 units per year.

Mann-Kendall statistic = 60
critical = 63

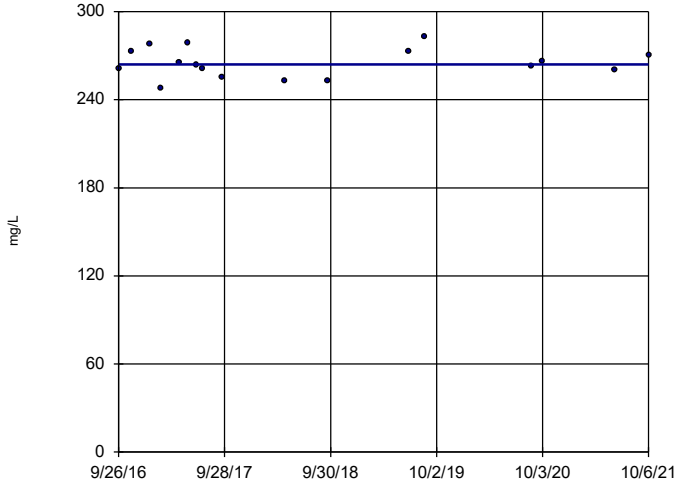
Trend not significant at 99% confidence level (α = 0.005 per tail).

Constituent: Total Dissolved Solids Analysis Run 1/11/2022 10:36 AM View: AIII
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Sen's Slope Estimator

MW-1203 (bg)



n = 17

Slope = 0 units per year.

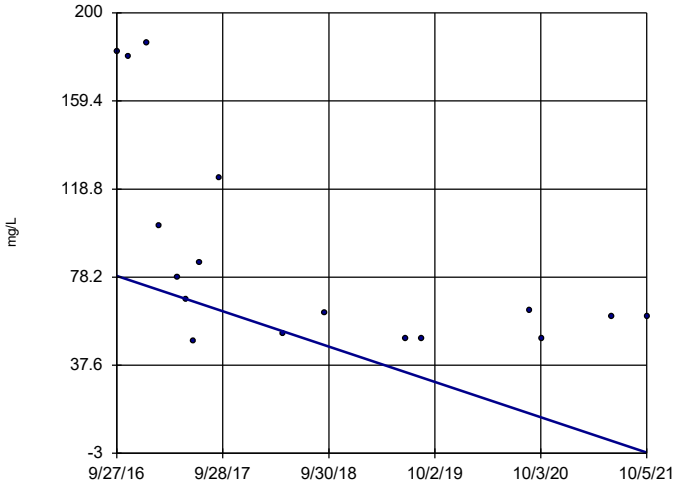
Mann-Kendall statistic = -1
critical = -63

Trend not significant at 99% confidence level (α = 0.005 per tail).

Constituent: Total Dissolved Solids Analysis Run 1/11/2022 10:36 AM View: AIII
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sen's Slope Estimator

MW-1604 (bg)



n = 17

Slope = -16.21 units per year.

Mann-Kendall statistic = -70
critical = -63

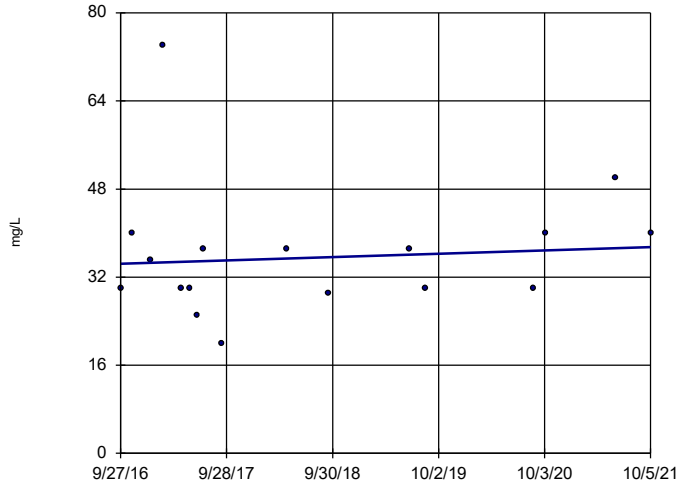
Decreasing trend significant at 99% confidence level (α = 0.005 per tail).

Constituent: Total Dissolved Solids Analysis Run 1/11/2022 10:36 AM View: AIII
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Sen's Slope Estimator

MW-1605 (bg)



n = 17

Slope = 0.6115 units per year.

Mann-Kendall statistic = 18
critical = 63

Trend not significant at 99% confidence level (α = 0.005 per tail).

Constituent: Total Dissolved Solids Analysis Run 1/11/2022 10:36 AM View: AIII
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Interwell Prediction Limits

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP Printed 1/11/2022, 10:41 AM

Constituent	Well	Upper Lim.	Date	Observ.	Sig.	Bg N	Bg Mean	Std. Dev.	%NDs	ND Adj.	Transform	Alpha	Method
Boron (mg/L)	n/a	0.244	n/a	5 future	n/a	90	n/a	n/a	8.889	n/a	n/a	0.0002377	NP Inter (normality) 1 of 2
Calcium (mg/L)	n/a	105	n/a	5 future	n/a	90	n/a	n/a	0	n/a	n/a	0.0002377	NP Inter (normality) 1 of 2
Chloride (mg/L)	n/a	6.22	n/a	5 future	n/a	90	n/a	n/a	0	n/a	n/a	0.0002377	NP Inter (normality) 1 of 2
Fluoride (mg/L)	n/a	0.85	n/a	5 future	n/a	99	n/a	n/a	15.15	n/a	n/a	0.0001978	NP Inter (normality) 1 of 2
Sulfate (mg/L)	n/a	106	n/a	5 future	n/a	90	n/a	n/a	0	n/a	n/a	0.0002377	NP Inter (normality) 1 of 2
Total Dissolved Solids (mg/L)	n/a	583	n/a	5 future	n/a	85	n/a	n/a	0	n/a	n/a	0.0002684	NP Inter (normality) 1 of 2

Prediction Limit

Interwell Non-parametric

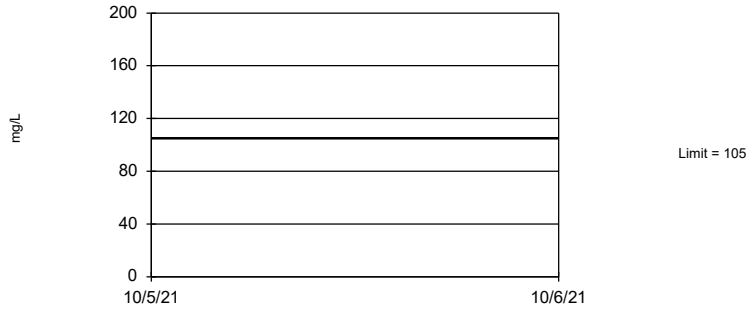
Non-parametric test used in lieu of parametric prediction limit because the Shapiro Francia normality test showed the data to be non-normal at the 0.01 alpha level. Limit is highest of 90 background values. 8.889% NDs. Annual per-constituent alpha = 0.002374. Individual comparison alpha = 0.0002377 (1 of 2). Assumes 5 future values.

Constituent: Boron Analysis Run 1/11/2022 10:40 AM View: AIII
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Prediction Limit

Interwell Non-parametric



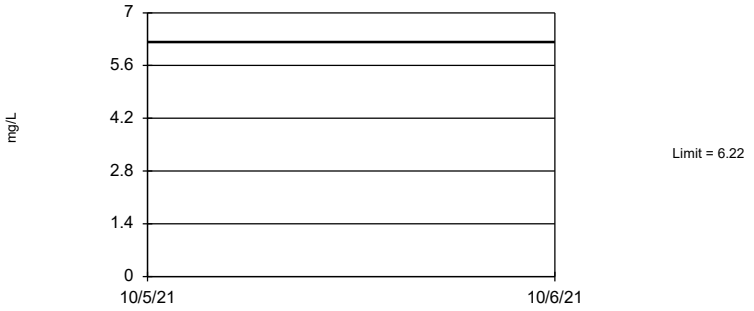
Non-parametric test used in lieu of parametric prediction limit because the Shapiro Francia normality test showed the data to be non-normal at the 0.01 alpha level. Limit is highest of 90 background values. Annual per-constituent alpha = 0.002374. Individual comparison alpha = 0.0002377 (1 of 2). Assumes 5 future values.

Constituent: Calcium Analysis Run 1/11/2022 10:40 AM View: AIII
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Prediction Limit

Interwell Non-parametric



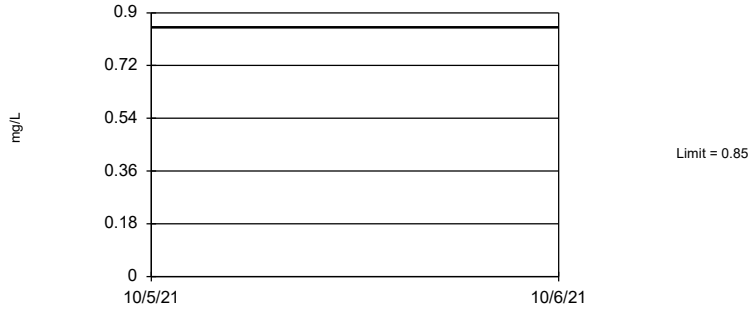
Non-parametric test used in lieu of parametric prediction limit because the Shapiro Francia normality test showed the data to be non-normal at the 0.01 alpha level. Limit is highest of 90 background values. Annual per-constituent alpha = 0.002374. Individual comparison alpha = 0.0002377 (1 of 2). Assumes 5 future values.

Constituent: Chloride Analysis Run 1/11/2022 10:40 AM View: AIII
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Prediction Limit

Interwell Non-parametric

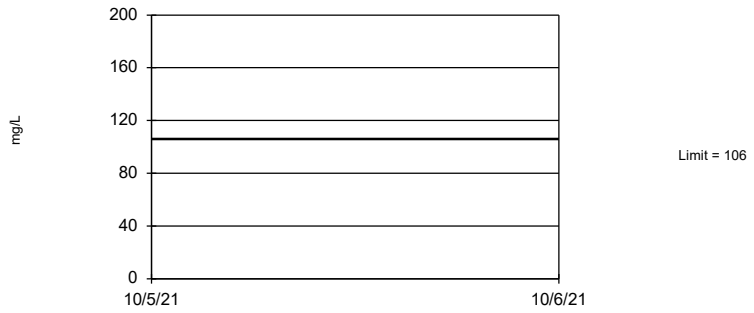


Non-parametric test used in lieu of parametric prediction limit because the Shapiro Francia normality test showed the data to be non-normal at the 0.01 alpha level. Limit is highest of 99 background values. 15.15% NDs. Annual per-constituent alpha = 0.001976. Individual comparison alpha = 0.0001978 (1 of 2). Assumes 5 future values.

Constituent: Fluoride Analysis Run 1/11/2022 10:40 AM View: AIII
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Prediction Limit

Interwell Non-parametric



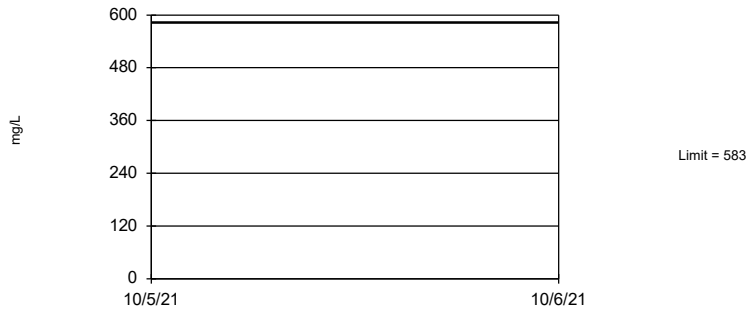
Non-parametric test used in lieu of parametric prediction limit because the Shapiro Francia normality test showed the data to be non-normal at the 0.01 alpha level. Limit is highest of 90 background values. Annual per-constituent alpha = 0.002374. Individual comparison alpha = 0.0002377 (1 of 2). Assumes 5 future values.

Constituent: Sulfate Analysis Run 1/11/2022 10:40 AM View: AIII
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Prediction Limit

Interwell Non-parametric



Non-parametric test used in lieu of parametric prediction limit because the Shapiro Francia normality test showed the data to be non-normal at the 0.01 alpha level. Limit is highest of 85 background values. Annual per-constituent alpha = 0.002681. Individual comparison alpha = 0.0002684 (1 of 2). Assumes 5 future values.

Constituent: Total Dissolved Solids Analysis Run 1/11/2022 10:40 AM View: AIII
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Upper Tolerance Limits

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP Printed 1/11/2022, 10:54 AM

Constituent	Well	Upper Lim.	Date	Observ.	Sig.	Bg N	%NDs	Transform	Alpha	Method
Antimony (mg/L)	n/a	0.0012	n/a	n/a	n/a	95	24.21	n/a	0.007651	NP Inter(normality)
Arsenic (mg/L)	n/a	0.0289	n/a	n/a	n/a	95	3.158	n/a	0.007651	NP Inter(normality)
Barium (mg/L)	n/a	0.1222	n/a	n/a	n/a	95	0	ln(x)	0.05	Inter
Beryllium (mg/L)	n/a	0.0001742	n/a	n/a	n/a	95	20	sqrt(x)	0.05	Inter
Cadmium (mg/L)	n/a	0.00014	n/a	n/a	n/a	95	29.47	n/a	0.007651	NP Inter(normality)
Chromium (mg/L)	n/a	0.00291	n/a	n/a	n/a	94	0	n/a	0.008054	NP Inter(normality)
Cobalt (mg/L)	n/a	0.004414	n/a	n/a	n/a	95	0	ln(x)	0.05	Inter
Combined Radium 226 + 228 (pCi/L)	n/a	4.488	n/a	n/a	n/a	90	0	sqrt(x)	0.05	Inter
Fluoride (mg/L)	n/a	0.85	n/a	n/a	n/a	99	15.15	n/a	0.006232	NP Inter(normality)
Lead (mg/L)	n/a	0.001347	n/a	n/a	n/a	95	6.316	ln(x)	0.05	Inter
Lithium (mg/L)	n/a	0.02	n/a	n/a	n/a	95	11.58	n/a	0.007651	NP Inter(normality)
Mercury (mg/L)	n/a	0.000013	n/a	n/a	n/a	95	85.26	n/a	0.007651	NP Inter(NDs)
Molybdenum (mg/L)	n/a	0.00348	n/a	n/a	n/a	93	27.96	n/a	0.008478	NP Inter(normality)
Selenium (mg/L)	n/a	0.0005	n/a	n/a	n/a	95	26.32	n/a	0.007651	NP Inter(normality)
Thallium (mg/L)	n/a	0.000229	n/a	n/a	n/a	95	47.37	n/a	0.007651	NP Inter(normality)

BIG SANDY FAP GWPS				
Constituent Name	**MCL**	**CCR-Rule**	**Background**	**GWPS**
Antimony, Total (mg/L)	0.006		0.0012	0.006
Arsenic, Total (mg/L)	0.01		0.029	0.029
Barium, Total (mg/L)	2		0.12	2
Beryllium, Total (mg/L)	0.004		0.00017	0.004
Cadmium, Total (mg/L)	0.005		0.00014	0.005
Chromium, Total (mg/L)	0.1		0.0029	0.1
Cobalt, Total (mg/L)	n/a	0.006	0.0044	0.006
Combined Radium, Total (pCi/L)	5		4.49	5
Fluoride, Total (mg/L)	4		0.85	4
Lead, Total (mg/L)	0.015		0.0013	0.015
Lithium, Total (mg/L)	n/a	0.04	0.02	0.04
Mercury, Total (mg/L)	0.002		0.000013	0.002
Molybdenum, Total (mg/L)	n/a	0.1	0.0035	0.1
Selenium, Total (mg/L)	0.05		0.0005	0.05
Thallium, Total (mg/L)	0.002		0.00023	0.002

**Grey cell indicates Background is higher than MCL or CCR-Rule Specified Level*

**GWPS = Groundwater Protection Standard*

**MCL = Maximum Contaminant Level*

**CCR = Coal Combustion Residual*

Confidence Intervals - Significant Results

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP Printed 1/11/2022, 10:59 AM

Constituent	Well	Upper Lim.	Lower Lim.	Compliance	Sig.	N	%NDs	Transform	Alpha	Method
Beryllium (mg/L)	**MW-1603**	**0.02017**	**0.01663**	**0.004**	**Yes**	**19**	**0**	**No**	**0.01**	**Param.**
Cobalt (mg/L)	**MW-1603**	**0.09421**	**0.08553**	**0.006**	**Yes**	**19**	**0**	**x^3**	**0.01**	**Param.**
Combined Radium 226 + 228 (pCi/L)	**MW-1603**	**7.438**	**5.113**	**5**	**Yes**	**19**	**0**	**No**	**0.01**	**Param.**
Lithium (mg/L)	**MW-1603**	**0.2252**	**0.1808**	**0.04**	**Yes**	**19**	**0**	**No**	**0.01**	**Param.**

Confidence Intervals - All Results

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP Printed 1/11/2022, 10:59 AM

Constituent	Well	Upper Lim.	Lower Lim.	Compliance	Sig.	N	%NDs	Transform	Alpha	Method
Antimony (mg/L)	MW-1601	0.0003067	0.0001026	0.006	No	17	0	ln(x)	0.01	Param.
Antimony (mg/L)	MW-1602	0.00008965	0.00005508	0.006	No	19	0	sqrt(x)	0.01	Param.
Antimony (mg/L)	MW-1603	0.0001	0.00004	0.006	No	19	73.68	No	0.01	NP (NDs)
Antimony (mg/L)	MW-1606	0.0001	0.00003	0.006	No	19	57.89	No	0.01	NP (NDs)
Antimony (mg/L)	MW-1607	0.0001	0.00002	0.006	No	19	15.79	No	0.01	NP (normality)
Arsenic (mg/L)	MW-1601	0.00518	0.00076	0.029	No	17	0	No	0.01	NP (normality)
Arsenic (mg/L)	MW-1602	0.00138	0.0006129	0.029	No	19	0	ln(x)	0.01	Param.
Arsenic (mg/L)	MW-1603	0.001346	0.001054	0.029	No	19	0	No	0.01	Param.
Arsenic (mg/L)	MW-1606	0.00111	0.0009507	0.029	No	19	0	x^(1/3)	0.01	Param.
Arsenic (mg/L)	MW-1607	0.0193	0.00871	0.029	No	19	0	No	0.01	NP (normality)
Barium (mg/L)	MW-1601	0.07241	0.05433	2	No	17	0	No	0.01	Param.
Barium (mg/L)	MW-1602	0.05658	0.05212	2	No	19	0	No	0.01	Param.
Barium (mg/L)	MW-1603	0.01336	0.01113	2	No	19	0	No	0.01	Param.
Barium (mg/L)	MW-1606	0.949	0.764	2	No	19	0	No	0.01	NP (normality)
Barium (mg/L)	MW-1607	0.04021	0.03025	2	No	19	0	No	0.01	Param.
Beryllium (mg/L)	MW-1601	0.00005	0.000007	0.004	No	17	41.18	No	0.01	NP (normality)
Beryllium (mg/L)	**MW-1603**	**0.02017**	**0.01663**	**0.004**	**Yes**	**19**	**0**	**No**	**0.01**	**Param.**
Beryllium (mg/L)	MW-1606	0.000053	0.00001	0.004	No	19	36.84	No	0.01	NP (normality)
Beryllium (mg/L)	MW-1607	0.00005	0.00001	0.004	No	19	31.58	No	0.01	NP (normality)
Cadmium (mg/L)	MW-1601	0.00002	0.000006	0.005	No	17	23.53	No	0.01	NP (normality)
Cadmium (mg/L)	MW-1602	0.00002	0.000009	0.005	No	19	52.63	No	0.01	NP (NDs)
Cadmium (mg/L)	MW-1603	0.0008491	0.0007459	0.005	No	19	0	No	0.01	Param.
Cadmium (mg/L)	MW-1606	0.00006	0.00001	0.005	No	19	78.95	No	0.01	NP (NDs)
Cadmium (mg/L)	MW-1607	0.00005	0.000008	0.005	No	19	68.42	No	0.01	NP (NDs)
Chromium (mg/L)	MW-1601	0.0005558	0.0003138	0.1	No	17	0	sqrt(x)	0.01	Param.
Chromium (mg/L)	MW-1602	0.0008467	0.0005413	0.1	No	19	0	No	0.01	Param.
Chromium (mg/L)	MW-1603	0.0008484	0.0006395	0.1	No	19	0	No	0.01	Param.
Chromium (mg/L)	MW-1606	0.00089	0.0002942	0.1	No	19	0	sqrt(x)	0.01	Param.
Chromium (mg/L)	MW-1607	0.0004814	0.0002928	0.1	No	19	0	sqrt(x)	0.01	Param.
Cobalt (mg/L)	MW-1601	0.001269	0.0005481	0.006	No	17	0	No	0.01	Param.
Cobalt (mg/L)	MW-1602	0.0001087	0.00002415	0.006	No	19	0	ln(x)	0.01	Param.
Cobalt (mg/L)	**MW-1603**	**0.09421**	**0.08553**	**0.006**	**Yes**	**19**	**0**	**x^3**	**0.01**	**Param.**
Cobalt (mg/L)	MW-1606	0.0003519	0.0001017	0.006	No	19	0	ln(x)	0.01	Param.
Cobalt (mg/L)	MW-1607	0.001447	0.001225	0.006	No	19	0	No	0.01	Param.
Combined Radium 226 + 228 (pCi/L)	MW-1601	1.608	0.9395	5	No	17	0	sqrt(x)	0.01	Param.
Combined Radium 226 + 228 (pCi/L)	MW-1602	1.449	0.8097	5	No	19	0	No	0.01	Param.
Combined Radium 226 + 228 (pCi/L)	**MW-1603**	**7.438**	**5.113**	**5**	**Yes**	**19**	**0**	**No**	**0.01**	**Param.**
Combined Radium 226 + 228 (pCi/L)	MW-1606	3.448	2.685	5	No	19	0	No	0.01	Param.
Combined Radium 226 + 228 (pCi/L)	MW-1607	1.857	0.6403	5	No	19	0	x^(1/3)	0.01	Param.
Fluoride (mg/L)	MW-1601	0.2943	0.2101	4	No	18	0	No	0.01	Param.
Fluoride (mg/L)	MW-1602	0.1329	0.1029	4	No	20	0	ln(x)	0.01	Param.
Fluoride (mg/L)	MW-1603	1.031	0.841	4	No	21	0	No	0.01	Param.
Fluoride (mg/L)	MW-1606	0.2233	0.1907	4	No	20	0	No	0.01	Param.
Fluoride (mg/L)	MW-1607	0.0737	0.0593	4	No	20	0	No	0.01	Param.
Lead (mg/L)	MW-1601	0.000118	0.00004228	0.015	No	17	11.76	sqrt(x)	0.01	Param.
Lead (mg/L)	MW-1602	0.00009675	0.00004435	0.015	No	19	10.53	sqrt(x)	0.01	Param.
Lead (mg/L)	MW-1603	0.006118	0.004264	0.015	No	19	0	sqrt(x)	0.01	Param.
Lead (mg/L)	MW-1606	0.000862	0.00008	0.015	No	19	10.53	No	0.01	NP (normality)
Lead (mg/L)	MW-1607	0.0001784	0.00007102	0.015	No	19	5.263	ln(x)	0.01	Param.
Lithium (mg/L)	MW-1601	0.03261	0.02069	0.04	No	17	5.882	No	0.01	Param.
Lithium (mg/L)	MW-1602	0.01008	0.00573	0.04	No	19	5.263	x^(1/3)	0.01	Param.
Lithium (mg/L)	**MW-1603**	**0.2252**	**0.1808**	**0.04**	**Yes**	**19**	**0**	**No**	**0.01**	**Param.**
Lithium (mg/L)	MW-1606	0.008082	0.003433	0.04	No	19	10.53	ln(x)	0.01	Param.
Lithium (mg/L)	MW-1607	0.005263	0.0007575	0.04	No	19	10.53	x^(1/3)	0.01	Param.
Mercury (mg/L)	MW-1602	0.000005	0.000003	0.002	No	19	63.16	No	0.01	NP (NDs)
Mercury (mg/L)	MW-1603	0.000005	0.000003	0.002	No	19	78.95	No	0.01	NP (NDs)
Mercury (mg/L)	MW-1606	0.000005	0.000003	0.002	No	19	84.21	No	0.01	NP (NDs)
Mercury (mg/L)	MW-1607	0.000005	0.000004	0.002	No	19	94.74	No	0.01	NP (NDs)
Molybdenum (mg/L)	MW-1601	0.02575	0.01268	0.1	No	17	0	No	0.01	Param.
Molybdenum (mg/L)	MW-1602	0.00244	0.001	0.1	No	19	0	No	0.01	NP (normality)
Molybdenum (mg/L)	MW-1603	0.00025	0.00007	0.1	No	19	47.37	No	0.01	NP (normality)
Molybdenum (mg/L)	MW-1606	0.00084	0.00051	0.1	No	19	0	No	0.01	NP (normality)
Molybdenum (mg/L)	MW-1607	0.00083	0.00053	0.1	No	19	0	No	0.01	NP (normality)
Selenium (mg/L)	MW-1601	0.0002932	0.0001096	0.05	No	17	0	ln(x)	0.01	Param.
Selenium (mg/L)	MW-1602	0.002018	0.001167	0.05	No	19	0	No	0.01	Param.
Selenium (mg/L)	MW-1603	0.005925	0.004418	0.05	No	19	0	No	0.01	Param.
Selenium (mg/L)	MW-1606	0.00025	0.00006	0.05	No	19	15.79	No	0.01	NP (normality)
Selenium (mg/L)	MW-1607	0.0002	0.00009	0.05	No	19	10.53	No	0.01	NP (normality)

Confidence Intervals - All Results

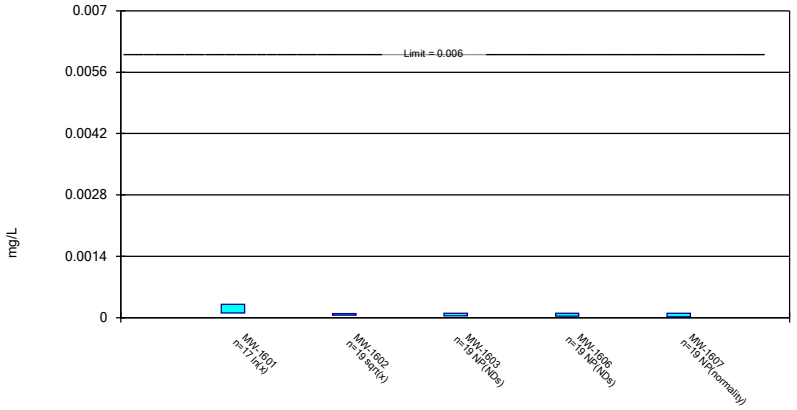
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP Printed 1/11/2022, 10:59 AM

Constituent	Well	Upper Lim.	Lower Lim.	Compliance	Sig.	N	%NDs	Transform	Alpha	Method
Thallium (mg/L)	MW-1601	0.0002	0.00001	0.002	No	17	41.18	No	0.01	NP (normality)
Thallium (mg/L)	MW-1602	0.0002	0.00002	0.002	No	19	47.37	No	0.01	NP (normality)
Thallium (mg/L)	MW-1603	0.001662	0.001336	0.002	No	19	0	No	0.01	Param.
Thallium (mg/L)	MW-1606	0.0002	0.00003	0.002	No	19	63.16	No	0.01	NP (NDs)
Thallium (mg/L)	MW-1607	0.0002	0.00002	0.002	No	19	36.84	No	0.01	NP (normality)

Sanitas™ v.9.6.32 . UG

Parametric and Non-Parametric (NP) Confidence Interval

Compliance Limit is not exceeded. Per-well alpha = 0.01. Normality Test: Shapiro Wilk, alpha based on n.



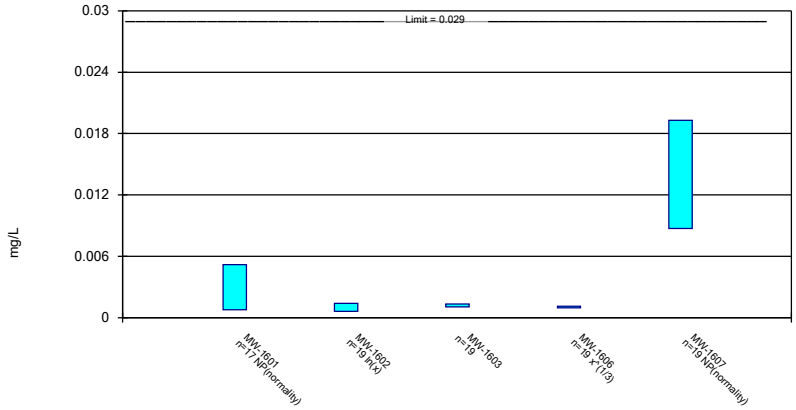
Constituent: Antimony Analysis Run 1/11/2022 10:57 AM View: AIV

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Parametric and Non-Parametric (NP) Confidence Interval

Compliance Limit is not exceeded. Per-well alpha = 0.01. Normality Test: Shapiro Wilk, alpha based on n.



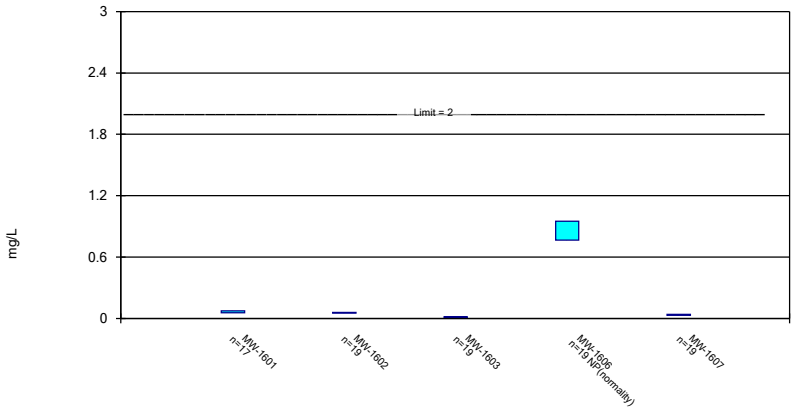
Constituent: Arsenic Analysis Run 1/11/2022 10:57 AM View: AIV

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Parametric and Non-Parametric (NP) Confidence Interval

Compliance Limit is not exceeded. Per-well alpha = 0.01. Normality Test: Shapiro Wilk, alpha based on n.



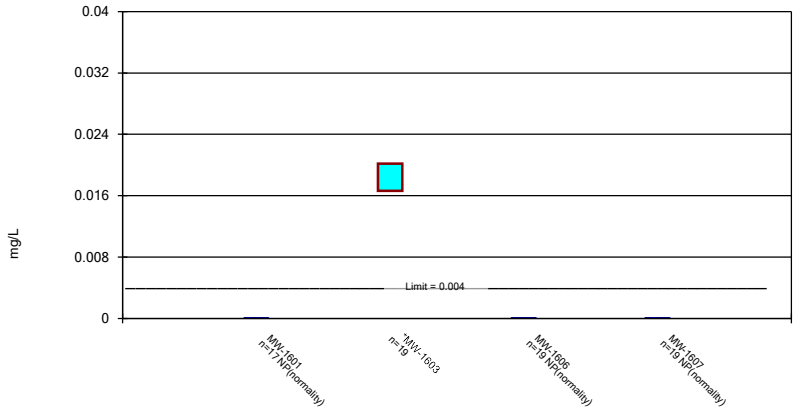
Constituent: Barium Analysis Run 1/11/2022 10:57 AM View: AIV

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Parametric and Non-Parametric (NP) Confidence Interval

Compliance limit is exceeded.* Per-well alpha = 0.01. Normality Test: Shapiro Wilk, alpha based on n.



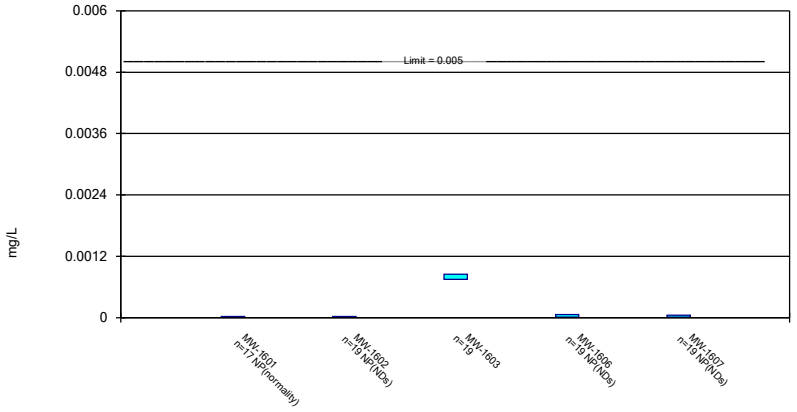
Constituent: Beryllium Analysis Run 1/11/2022 10:57 AM View: AIV

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Parametric and Non-Parametric (NP) Confidence Interval

Compliance Limit is not exceeded. Per-well alpha = 0.01. Normality Test: Shapiro Wilk, alpha based on n.

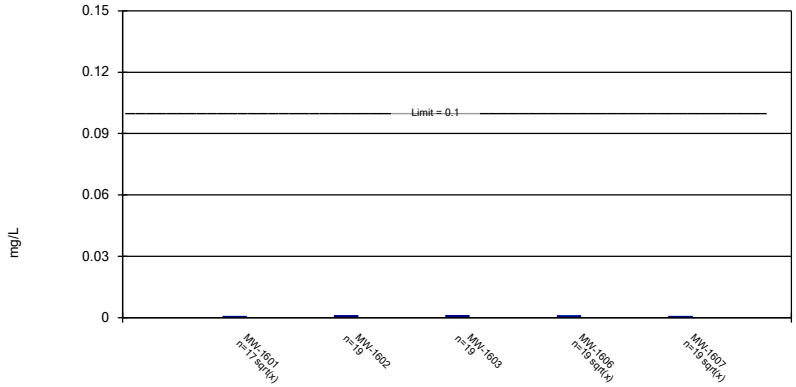


Constituent: Cadmium Analysis Run 1/11/2022 10:57 AM View: AIV
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Parametric Confidence Interval

Compliance Limit is not exceeded. Per-well alpha = 0.01. Normality Test: Shapiro Wilk, alpha based on n.

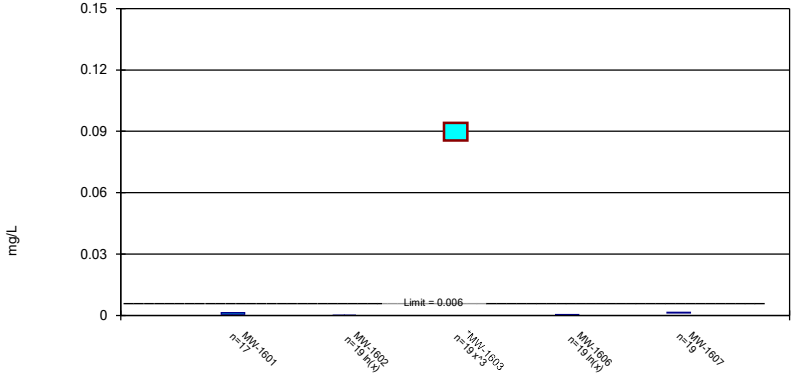


Constituent: Chromium Analysis Run 1/11/2022 10:57 AM View: AIV
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Parametric Confidence Interval

Compliance limit is exceeded.* Per-well alpha = 0.01. Normality Test: Shapiro Wilk, alpha based on n.

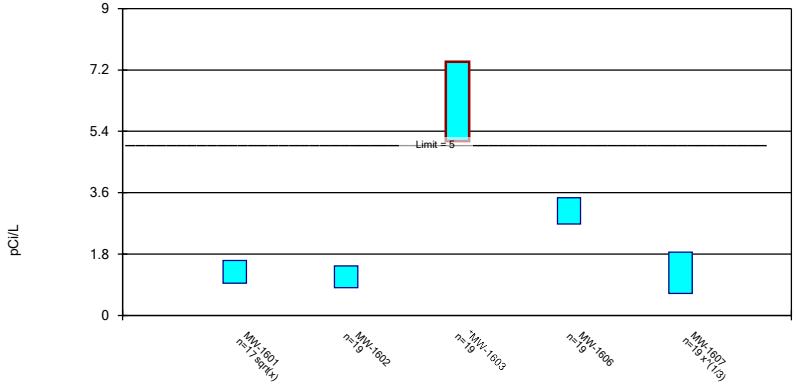


Constituent: Cobalt Analysis Run 1/11/2022 10:57 AM View: AIV
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Parametric Confidence Interval

Compliance limit is exceeded.* Per-well alpha = 0.01. Normality Test: Shapiro Wilk, alpha based on n.

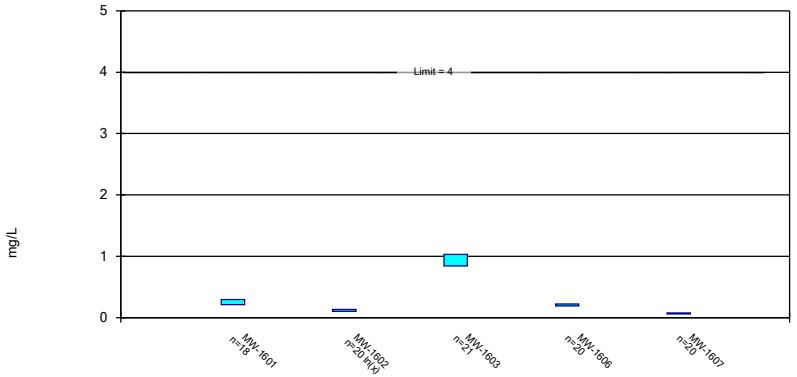


Constituent: Combined Radium 226 + 228 Analysis Run 1/11/2022 10:57 AM View: AIV
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Parametric Confidence Interval

Compliance Limit is not exceeded. Per-well alpha = 0.01. Normality Test: Shapiro Wilk, alpha based on n.



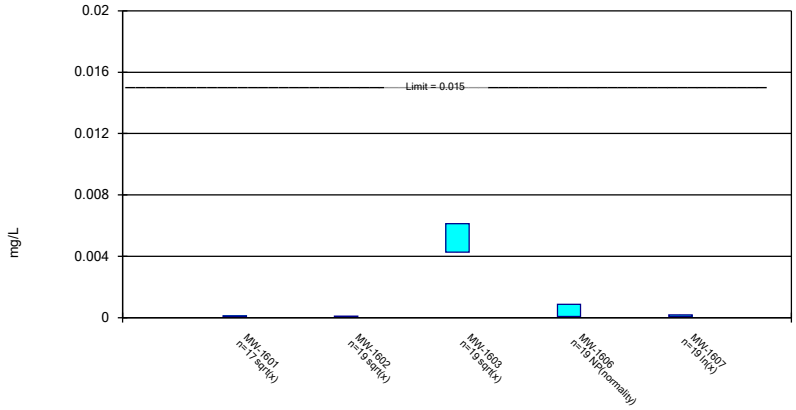
Constituent: Fluoride Analysis Run 1/11/2022 10:57 AM View: AIV

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Parametric and Non-Parametric (NP) Confidence Interval

Compliance Limit is not exceeded. Per-well alpha = 0.01. Normality Test: Shapiro Wilk, alpha based on n.



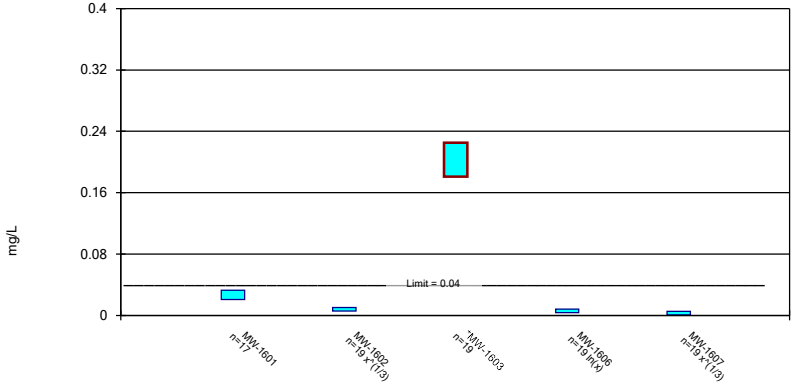
Constituent: Lead Analysis Run 1/11/2022 10:57 AM View: AIV

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Parametric Confidence Interval

Compliance limit is exceeded.* Per-well alpha = 0.01. Normality Test: Shapiro Wilk, alpha based on n.



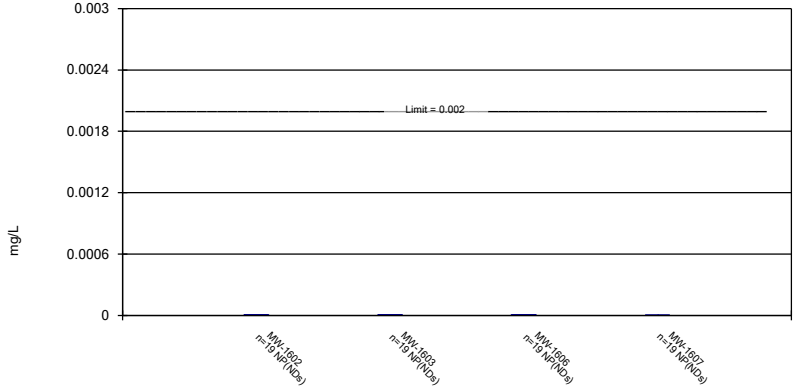
Constituent: Lithium Analysis Run 1/11/2022 10:57 AM View: AIV

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Non-Parametric Confidence Interval

Compliance Limit is not exceeded. Per-well alpha = 0.01.



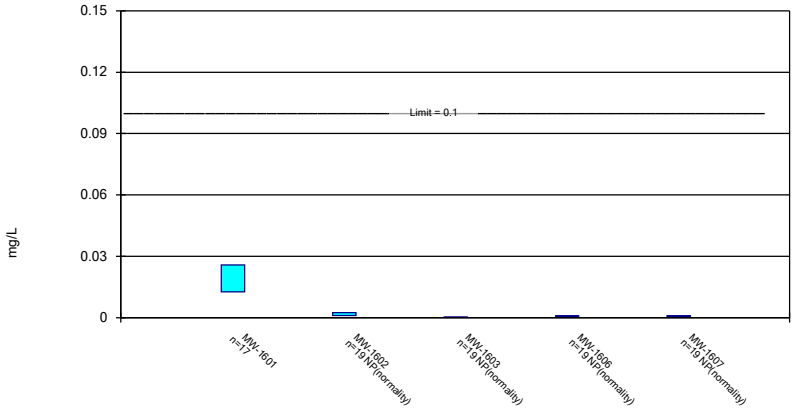
Constituent: Mercury Analysis Run 1/11/2022 10:57 AM View: AIV

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Parametric and Non-Parametric (NP) Confidence Interval

Compliance Limit is not exceeded. Per-well alpha = 0.01. Normality Test: Shapiro Wilk, alpha based on n.



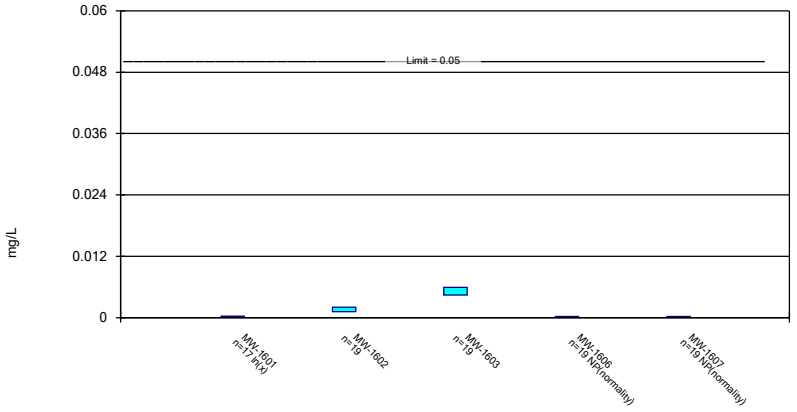
Constituent: Molybdenum Analysis Run 1/11/2022 10:57 AM View: AIV

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Parametric and Non-Parametric (NP) Confidence Interval

Compliance Limit is not exceeded. Per-well alpha = 0.01. Normality Test: Shapiro Wilk, alpha based on n.



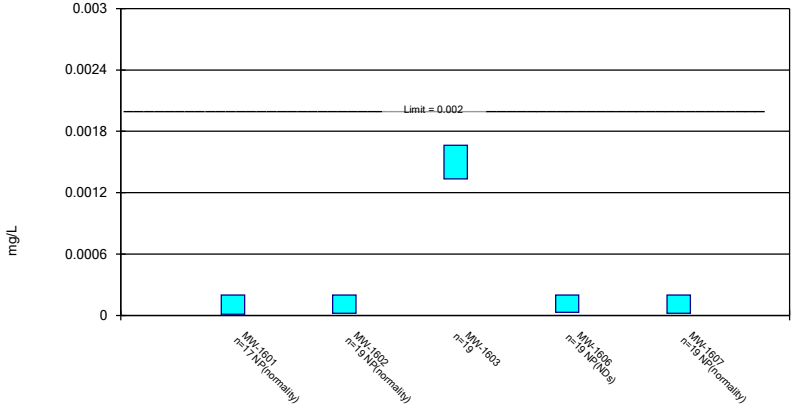
Constituent: Selenium Analysis Run 1/11/2022 10:57 AM View: AIV

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.32 . UG

Parametric and Non-Parametric (NP) Confidence Interval

Compliance Limit is not exceeded. Per-well alpha = 0.01. Normality Test: Shapiro Wilk, alpha based on n.



Constituent: Thallium Analysis Run 1/11/2022 10:57 AM View: AIV

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

STATISTICAL ANALYSIS SUMMARY
FLY ASH POND
Big Sandy Plant
Louisa, Kentucky

Submitted to

AMERICAN ELECTRIC POWER℠

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Submitted by

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October 13, 2022
CHA8500B

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ATTACHMENTS

LIST OF ACRONYMS AND ABBREVIATIONS

AEP	American Electric Power
ASD	Alternative Source Demonstration
CCR	Coal Combustion Residuals
CCV	Continuing Calibration Verification
CFR	Code of Federal Regulations
FAP	Fly Ash Pond
GWPS	Groundwater Protection Standard
LCL	Lower Confidence Limit
LFB	Laboratory Fortified Blanks
LPL	Lower Prediction Limit
LRB	Laboratory Reagent Blanks
MCL	Maximum Contaminant Level
NELAP	National Environmental Laboratory Accreditation Program
QA	Quality Assurance
QC	Quality Control
SSI	Statistically Significant Increase
SSL	Statistically Significant Level
SU	Standard Units
TDS	Total Dissolved Solids
UPL	Upper Prediction Limit
UTL	Upper Tolerance Limit
USEPA	United States Environmental Protection Agency

SECTION 1

EXECUTIVE SUMMARY

In accordance with the United States Environmental Protection Agency's (USEPA's) regulations regarding the disposal of coal combustion residuals (CCR) in landfills and surface impoundments (40 CFR 257 Subpart D, "CCR rule"), groundwater monitoring has been conducted at the Fly Ash Pond (FAP), an existing CCR unit at the Big Sandy Power Plant located in Louisa, Kentucky. Recent groundwater monitoring results were compared to the site-specific groundwater protection standards (GWPS) to identify potential exceedances.

Based on detection monitoring conducted in 2017 and 2018, statistically significant increases (SSIs) over background were concluded for boron, calcium, chloride, fluoride, total dissolved solids (TDS), and sulfate at the FAP. An alternative source was not identified at the time, so the FAP initiated assessment monitoring in April 2018. Groundwater protection standards (GWPS) were set in accordance with 40 CFR 257.95(d)(2) and a statistical evaluation of the assessment monitoring data was conducted. During the most recent assessment monitoring event, statistically significant levels (SSLs) were observed for beryllium, cobalt, combined radium, and lithium (Geosyntec, 2022). An alternative source demonstration (ASD) was successfully completed (EHS, 2022); thus, the unit remained in assessment monitoring.

During 2022, an annual sampling event for the Appendix III and Appendix IV parameters required by 257.95(b) was completed in March, and a semi-annual sampling event for Appendix III and Appendix IV parameters required by 40 CFR 257.95(d)(1) was completed in June. The results of these annual and semi-annual assessment monitoring events are documented in this report.

Groundwater data underwent several validation tests, including those for completeness, sample tracking accuracy, transcription errors, and consistent use of measurement units. No data quality issues were identified which would impact data usability.

The monitoring data were submitted to Groundwater Stats Consulting, LLC for statistical analysis. Confidence intervals were calculated for Appendix IV parameters at the compliance wells to assess whether SSLs of Appendix IV parameters were present above the GWPS. SSLs were identified for beryllium, cobalt, combined radium, and lithium. Thus, either the unit will move to an assessment of corrective measures or an ASD will be conducted to evaluate if the unit can remain in assessment monitoring. Certification of the selected statistical methods by a qualified professional engineer is documented in Attachment A.

SECTION 2

FLY ASH POND EVALUATION

2.1 Data Validation & QA/QC

During the 2022 assessment monitoring program through June, two sets of samples were collected for analysis from each upgradient and downgradient well to meet the requirements of 40 CFR 257.95b (March 2022) and 257.95(d)(1) (June 2022). For the March 2022 event, all samples were were analyzed for all Appendix IV parameters and select samples were also analyzed for Appendix III parameters. All samples from the June 2022 sample event were analyzed for all Appendix III and Appendix IV parameters. A summary of data collected during this assessment monitoring event is presented in Table 1.

Chemical analysis was completed by an analytical laboratory certified by the National Environmental Laboratory Accreditation Program (NELAP). Quality assurance and quality control (QA/QC) samples completed by the analytical laboratory included the use of laboratory reagent blanks (LRBs), continuing calibration verification (CCV) samples, and laboratory fortified blanks (LFBs).

The analytical data were imported into a Microsoft Access database, where checks were completed to assess the accuracy of sample location identification and analyte identification. Where necessary, unit conversions were applied to standardize reported units across all sampling events. Exported data files were created for use with the Sanitas™ v.9.6.35 statistics software. The export file was checked against the analytical data for transcription errors and completeness. No QA/QC issues were noted which would impact data usability.

2.2 Statistical Analysis

Statistical analyses for the FAP were conducted in accordance with the October 2020 *Statistical Analysis Plan* (Geosyntec, 2020). Time series plots and results for all completed statistical tests are provided in Attachment B.

The data obtained in March and June 2022 were screened for potential outliers. No outliers were identified in either set of data (Attachment B).

2.2.1 Evaluation of Potential Appendix IV SSLs

A confidence interval was constructed for each Appendix IV parameter at each compliance well. Confidence limits were generally calculated parametrically ($\alpha = 0.01$); however, non-parametric confidence limits were calculated in some cases (e.g., when the data did not appear to be normally distributed or when the non-detect frequency was too high). An SSL was concluded if the lower confidence limit (LCL) exceeded the GWPS (i.e., if the entire confidence interval exceeded the GWPS). Calculated confidence limits are shown in Attachment B. Calculated confidence limits

were compared to the GWPS provided in Table 2. The GWPS were established during a previous statistical analysis as either the greater value of the background concentration or the maximum contaminant level (MCL) and risk-based level specified in 40 CFR 257.95(h)(2) (Geosynte, 2022).

The following SSLs were identified at the Big Sandy FAP:

- The LCL for beryllium exceeded the GWPS of 0.00400 mg/L at MW-1603 (0.0164 mg/L).
- The LCL for cobalt exceeded the GWPS of 0.00600 mg/L at MW-1603 (0.0848 mg/L).
- The LCL for combined radium exceeded the GWPS of 5.00 pCi/L at MW-1603 (5.12 pCi/L).
- The LCL for lithium exceeded the GWPS of 0.0400 mg/L at MW-1603 (0.177 mg/L).

As a result, the Big Sandy FAP will either move to an assessment of corrective measures or an ASD will be conducted to evaluate if the unit can remain in assessment monitoring.

2.2.2 Evaluation of Potential Appendix III SSIs

While SSLs were identified, a review of the Appendix III results was also completed to assess whether concentrations of Appendix III parameters at the compliance wells exceeded background concentrations.

Data collected during the June 2022 assessment monitoring event from each compliance well were compared to previously established prediction limits to assess whether the results are above background values. The results from this event and the prediction limits are summarized in Table 3. The following exceedances of the upper prediction limits (UPLs) were noted:

- Boron concentrations exceeded the interwell UPL of 0.244 mg/L at MW-1606 (2.08 mg/L).
- Chloride concentrations exceeded the interwell UPL of 6.22 mg/L at MW-1602 (18.9 mg/L) and MW-1606 (31.7 mg/L).
- pH values exceeded the intrawell UPL of 8.0 SU at MW-1601 (8.3 SU).
- Sulfate concentrations exceeded the interwell UPL of 106 mg/L at MW-1602 (187 mg/L) and MW-1603 (675 mg/L).
- TDS concentrations exceeded the interwell UPL of 583 mg/L at MW-1603 (970 mg/L).

While the prediction limits were calculated for a one-of-two retesting procedure, SSIs were conservatively assumed if the June 2022 sample was above the UPL or below the lower prediction limit (LPL). Based on these results, concentrations of Appendix III constituents appear to be above background levels at compliance wells.

2.3 Conclusions

An annual and a semi-annual assessment monitoring event were conducted in accordance with the CCR Rule. The laboratory and field data were reviewed prior to statistical analysis, with no QA/QC issues identified that impacted data usability. A review of outliers identified no potential outliers in the March 2022 and June 2022 data. A confidence interval was constructed at each compliance well for each Appendix IV parameter; SSLs were concluded if the entire confidence interval exceeded the GWPS. SSLs were identified for beryllium, cobalt, combined radium, and lithium at MW-1603. Appendix III parameters were compared to established prediction limits with exceedances identified for boron, chloride, pH, sulfate, and TDS at select downgradient wells.

Based on this evaluation, the Big Sandy FAP CCR unit will either move to an assessment of corrective measures or an ASD will be conducted to evaluate if the unit can remain in assessment monitoring.

SECTION 3

REFERENCES

EHS Support. 2022. Alternative Source Demonstration Addendum Report for the October 2021 Monitoring Data. Big Sandy Fly Ash Pond. March 2022.

Geosyntec. 2020. Statistical Analysis Plan. October 2020.

Geosyntec Consultants (Geosyntec). 2022. Statistical Analysis Summary – Fly Ash Pond, Big Sandy Plant, Louisa, Kentucky. February 10, 2022.

TABLES

Table 1 - Groundwater Data Summary
Big Sandy Plant - Fly Ash Pond

Parameter	Unit	MW-1011		MW-1012		MW-1203		MW-1601		MW-1602	
		3/23/2022	6/13/2022	3/24/2022	6/15/2022	3/23/2022	6/13/2022	3/22/2022	6/15/2022	3/22/2022	6/14/2022
Antimony	µg/L	0.37	0.16	1.52	1.14	0.10	0.10	0.49	0.54	0.15	0.18
Arsenic	µg/L	19.3	3.55	49.9	45.4	0.24	0.15	0.31	0.40	0.66	0.91
Barium	µg/L	57.5	47.2	32.6	28.2	89.4	95.0 P3	39.2	41.3	62.0	61.9
Beryllium	µg/L	0.050	0.050	0.050	0.050	0.050	0.050	0.05 U1	0.050	0.05 U1	0.05 U1
Boron	mg/L	0.052	0.105	-	0.237	0.098	0.101	-	0.119	-	0.062
Cadmium	µg/L	0.020	0.020	0.020	0.020	0.020	0.020	0.015 J1	0.023	0.005 J1	0.02 U1
Calcium	mg/L	123 M1, P3	82.4	-	1.46	60.2	62.1 M1, P3	-	70.2	-	91.1
Chloride	mg/L	6.11	4.02	-	1.41	5.40	4.94	-	3.95	-	18.9
Chromium	µg/L	0.36	0.21	0.24	0.52	0.20	0.20	0.30	0.85	0.53	0.47
Cobalt	µg/L	1.12	0.284	0.124	0.084	0.885	0.586	0.046	0.069	0.014 J1	0.019 J1
Combined Radium	pCi/L	3.69	3.29	1.31	0.5	3.33	1.31	2.19	2.52	2.25	0.82
Fluoride	mg/L	0.23	0.26	0.82	0.77	0.12	0.13	0.16	0.17	0.08	0.09
Lead	µg/L	0.20	0.20	0.41	2.4	0.20	0.20	0.2 U1	2.0	0.2 U1	0.2 U1
Lithium	mg/L	0.0106	0.00948	0.00552	0.00493	0.0137	0.0110	0.0205	0.0171	0.0106	0.00760
Mercury	µg/L	0.005	0.005	0.005	0.005	0.005	0.005	0.005 U1	0.005	0.002 J1	0.005 U1
Molybdenum	µg/L	0.7	0.9	5.5	4.0	0.5	0.5	8.6	7.7	1	1.1
Selenium	µg/L	0.50	0.50	0.50	0.50	0.50	0.50	0.64	0.52	1.88	4.10
Sulfate	mg/L	80.8	85.1	-	38.6	42.9	28.9	-	96.0	-	187
Thallium	µg/L	0.20	0.20	0.20	0.20	0.20	0.20	0.06 J1	0.20	0.2 U1	0.05 J1
Total Dissolved Solids	mg/L	380	390	-	570	260	270	-	340	-	550 S7
pH	SU	8.09	7.56	8.69	10.32	8.87	7.58	7.91	8.3	8.2	7.6

Notes:
µg/L: micrograms per liter
mg/L: milligrams per liter
pCi/L: picocuries per liter
SU: standard unit
U1: Non-detect value. For statistical analysis, parameters which were not detected were replaced with the reporting limit.
J1: Estimated value. Parameter was detected in concentrations below the reporting limit.
M1: The associated matrix spike (MS) or matrix spike duplicate (MSD) recovery was outside acceptance limits.
P3: The precision on the matrix spike duplicate (MSD) was above acceptance limits.
S7: Sample did not achieve constant weight.
-: Not sampled

Table 1 - Groundwater Data Summary
Big Sandy Plant - Fly Ash Pond

Parameter	Unit	MW-1603		MW-1604		MW-1605		MW-1606		MW-1607	
		3/22/2022	6/15/2022	3/24/2022	6/14/2022	3/23/2022	6/14/2022	3/23/2022	6/14/2022	3/24/2022	6/14/2022
Antimony	µg/L	0.1 U1	0.10	0.10	0.1 U1	0.10	0.1 U1	0.10	0.1 U1	0.10	0.02 J1
Arsenic	µg/L	0.96	1.55	0.10	0.1 U1	0.10	0.03 J1	0.80	0.88	16.7	17.7
Barium	µg/L	13.3	8.77	78.5	78.4	47.9	34.5	783	764	30.2	31.7
Beryllium	µg/L	14.9	15.0	0.177	0.182	0.152	0.111	0.050	0.05 U1	0.050	0.011 J1
Boron	mg/L	-	0.071	-	0.017 J1	0.050	0.05 U1	2.22	2.08	-	0.152
Cadmium	µg/L	0.690	0.734	0.070	0.070	0.101	0.071	0.020	0.02 U1	0.020	0.02 U1
Calcium	mg/L	-	94.4	-	3.28	1.60	1.18	81.3	73.6	-	87.0
Chloride	mg/L	-	4.07	-	1.05	0.65	0.56	32.7	31.7	-	3.21
Chromium	µg/L	0.36	0.78	0.76	0.91	2.55	2.41	0.20	0.1 J1	0.22	0.22
Cobalt	µg/L	79.7	98.3	0.229	0.124	0.341	0.242	0.049	0.047	1.30	1.08
Combined Radium	pCi/L	17.94	6.22	1.03	0.83	1.36	0.41	2.66	2.75	0.87	0.73
Fluoride	mg/L	0.65	0.69	0.06	0.02 J1	0.06	0.06 U1	0.21	0.21	0.06	0.07
Lead	µg/L	3.37	6.5	0.20	0.2 U1	0.20	0.09 J1	0.20	0.2 U1	0.20	0.09 J1
Lithium	mg/L	0.151	0.153	0.00101	0.00100	0.00089	0.00068	0.00394	0.00328	0.00020	0.00013 J1
Mercury	µg/L	0.005 U1	0.005	0.005	0.005 U1	0.005	0.005 U1	0.005	0.005 U1	0.005	0.005 U1
Molybdenum	µg/L	0.5 U1	0.5	0.5	0.5 U1	0.5	0.5 U1	0.5	0.5	0.7	0.6
Selenium	µg/L	4.01	6.56	0.50	0.35 J1	0.50	0.21 J1	0.50	0.5 U1	0.50	0.5 U1
Sulfate	mg/L	-	675	-	10.4	9.21	5.24	63.3	64.9	-	87.7
Thallium	µg/L	1.66	1.71	0.20	0.2 U1	0.20	0.2 U1	0.20	0.2 U1	0.20	0.2 U1
Total Dissolved Solids	mg/L	-	970	-	50	50	50	370	430	-	370
pH	SU	4.87	3.1	7.02	4.95	6.49	4.45	7.73	7.28	7.65	6.88

Notes:
µg/L: micrograms per liter
mg/L: milligrams per liter
pCi/L: picocuries per liter
SU: standard unit
U1: Non-detect value. For statistical analysis, parameters which were not detected were replaced with the reporting limit.
J1: Estimated value. Parameter was detected in concentrations below the reporting limit.
M1: The associated matrix spike (MS) or matrix spike duplicate (MSD) recovery was outside acceptance limits.
P3: The precision on the matrix spike duplicate (MSD) was above acceptance limits.
S7: Sample did not achieve constant weight.
-: Not sampled

Table 2 - Appendix IV Groundwater Protection Standards
Big Sandy Plant - Fly Ash Pond

Geosyntec Consultants, Inc.

Constituent Name	MCL	CCR Rule Specified	Calculated UTL	GWPS
Antimony, Total (mg/L)	0.00600		0.00120	0.00600
Arsenic, Total (mg/L)	0.0100		0.0289	0.0289
Barium, Total (mg/L)	2.00		0.122	2.00
Beryllium, Total (mg/L)	0.00400		0.000174	0.00400
Cadmium, Total (mg/L)	0.00500		0.000140	0.00500
Chromium, Total (mg/L)	0.100		0.00291	0.100
Cobalt, Total (mg/L)	n/a	0.00600	0.00441	0.00600
Combined Radium, Total (pCi/L)	5.00		4.49	5.00
Fluoride, Total (mg/L)	4.00		0.850	4.00
Lead, Total (mg/L)	n/a	0.0150	0.00135	0.0150
Lithium, Total (mg/L)	n/a	0.0400	0.0200	0.0400
Mercury, Total (mg/L)	0.00200		0.0000130	0.00200
Molybdenum, Total (mg/L)	n/a	0.100	0.00348	0.100
Selenium, Total (mg/L)	0.0500		0.000500	0.0500
Thallium, Total (mg/L)	0.00200		0.000229	0.00200

Notes:
MCL = Maximum Contaminant Level
CCR = Coal Combustion Residual
GWPS = Groundwater Protection Standard
Calculated UTL (Upper Tolerance Limit) represents site-specific background values.
Grey cells indicate the GWPS is based on the calculated UTL, which is higher than the MCL or CCR-Rule specified value.

Table 3 - Appendix III Data Summary
Big Sandy Plant - Fly Ash Pond

Geosyntec Consultants, Inc.

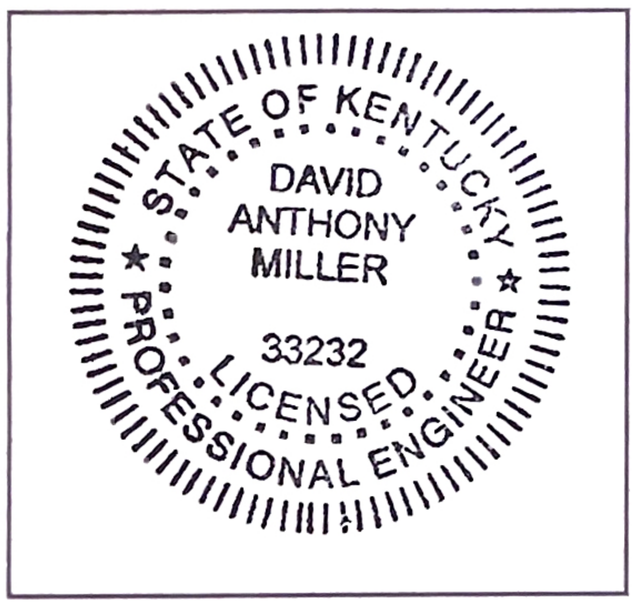
Analyte	Unit	Description	MW-1601	MW-1602	MW-1603	MW-1606	MW-1607
			6/15/2022	6/14/2022	6/15/2022	6/14/2022	6/14/2022
Boron	mg/L	Interwell Background Value (UPL)	0.244				
		Analytical Result	0.119	0.062	0.071	**2.08**	0.152
Calcium	mg/L	Interwell Background Value (UPL)	105				
		Analytical Result	70.2	91.1	94.4	73.6	87.0
Chloride	mg/L	Interwell Background Value (UPL)	6.22				
		Analytical Result	3.95	**18.9**	4.07	**31.7**	3.21
Fluoride	mg/L	Interwell Background Value (UPL)	0.850				
		Analytical Result	0.17	0.09	0.69	0.21	0.07
pH	SU	Intrawell Background Value (UPL)	8.0	8.7	5.6	7.5	7.5
		Intrawell Background Value (LPL)	6.3	5.6	2.9	6.3	5.5
		Analytical Result	**8.3**	7.6	3.1	7.3	6.9
Sulfate	mg/L	Interwell Background Value (UPL)	106				
		Analytical Result	96.0	**187**	**675**	64.9	87.7
Total Dissolved Solids	mg/L	Interwell Background Value (UPL)	583				
		Analytical Result	340	550	**970**	430	370

Notes:
UPL: Upper prediction limit
LPL: Lower prediction limit
Bold values exceed the background value.
Background values are shaded gray.

ATTACHMENT A
Certification by Qualified Professional Engineer

Certification by Qualified Professional Engineer

I certify that the selected and above described statistical method is appropriate for evaluating the groundwater monitoring data for the Big Sandy Fly Ash Pond CCR management area and that the requirements of 40 CFR 257.93(f) have been met.



DAVID ANTHONY MILLER

Printed Name of Licensed Professional Engineer

David Anthony Miller

Signature

33232

License Number

KENTUCKY

Licensing State

10.14.22

Date

ATTACHMENT B

Statistical Analysis Output

GROUNDWATER STATS CONSULTING

September 9, 2022

Geosyntec Consultants
Attn: Ms. Allison Kreinberg
941 Chatham Lane, #103
Columbus, OH 43221

Re: Big Sandy Fly Ash Pond
Assessment Monitoring Summary – June 2022

Dear Ms. Kreinberg,

Groundwater Stats Consulting (GSC), formerly the statistical consulting division of Sanitas Technologies, is pleased to provide the Assessment Monitoring statistical analysis of groundwater data through June 2022 at American Electric Power Company's Big Sandy Fly Ash Pond. The analysis complies with the federal rule for the Disposal of Coal Combustion Residuals (CCR) from Electric Utilities (CCR Rule, 2015) as well as with the United States Environmental Protection Agency (USEPA) Unified Guidance (2009).

Sampling began at the site for the CCR program in 2016. The monitoring well network, as provided by Geosyntec Consultants, consists of the following:

- **Upgradient wells:** MW-1011, MW-1012, MW-1203, MW-1604, and MW-1605
- **Downgradient wells:** MW-1601, MW-1602, MW-1603, MW-1606, and MW-1607

Data were sent electronically, and the statistical analysis was conducted according to the Statistical Analysis Plan and screening evaluation prepared by GSC and approved by Dr. Kirk Cameron, PhD Statistician with MacStat Consulting, primary author of the USEPA Unified Guidance, and Senior Advisor to GSC. The analysis was reviewed by Andrew Collins, Project Manager for Groundwater Stats Consulting.

The CCR program consists of the following constituents:

- **Appendix IV** (Assessment Monitoring) **–** antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, combined radium 226 + 228, fluoride, lead, lithium, mercury, molybdenum, selenium, and thallium

Time series and box plots for Appendix IV parameters are provided for all wells and constituents; and are used to evaluate concentrations over the entire record (Figures A and B, respectively). Values in background which have previously been flagged as outliers may be seen in a lighter font and disconnected symbol on the graphs. Additionally, a summary of flagged values follows this letter (Figure C). While the reporting limits may vary from well to well, a single reporting limit substitution is used across all wells for a given parameter in the time series plots since the wells are plotted as a group.

Summary of Statistical Methods – Appendix IV Parameters

Parametric tolerance limits are utilized when the screened historical data follow a normal or transformed-normal distribution. When data cannot be normalized or the majority of data are non-detects, a nonparametric test is utilized. The distribution of data is tested using the Shapiro-Wilk/Shapiro-Francia test for normality. After testing for normality and performing any adjustments as discussed below (USEPA, 2009), data are analyzed using either parametric or non-parametric tolerance limits as appropriate.

- No statistical analyses are required on wells and analytes containing 100% non-detects (USEPA Unified Guidance, 2009, Chapter 6).
- When data contain <15% non-detects in background, simple substitution of one-half the reporting limit is utilized in the statistical analysis. The reporting limit utilized for non-detects is the most recent practical quantification limit (PQL) as reported by the laboratory.
- When data contain between 15-50% non-detects, the Kaplan-Meier non-detect adjustment is applied to the background data. This technique adjusts the mean and standard deviation of the historical concentrations to account for concentrations below the reporting limit.
- Nonparametric tolerance limits are used on data containing greater than 50% non-detects.

Summary of Background Update – Conducted in January 2022

Outlier Analysis

Appendix IV parameters were screened through visual screening and Tukey's outlier test for potential outliers and extreme trending patterns that would lead to artificially elevated statistical limits. High outliers are also 'cautiously' flagged in the downgradient wells when they are clearly much different from the rest of the data. This is intended to be a regulatory conservative approach in that it will reduce the variance and thus reduce the width of parametric confidence intervals; although it will also reduce the mean and thus lower the entire interval. The intent is to better represent the actual downgradient mean.

For the January 2022 analysis, Tukey's outlier test on pooled upgradient well data through October 2021 for Appendix IV parameters did not identify any potential outliers. In previous reports, such as the original screening in 2017 and the February 2021 screening, several high values not identified by Tukey's were flagged as outliers in order to construct limits that are conservative (i.e., lower) from a regulatory perspective. Tukey's outlier test results and a discussion for Appendix IV parameters were included with the background update conducted in January 2022. As mentioned above, a list of flagged values follows this report (Figure C).

Interwell Upper Tolerance Limits

Interwell upper tolerance limits were used to calculate background limits from all available pooled upgradient well data for each Appendix IV parameter through October 2021 (Figure D). These limits are updated on an annual basis and will be updated again during the Fall 2022 sample event. Parametric tolerance limits are calculated, with a target of 95% confidence and 95% coverage, when data follow a normal or transformed-normal distribution. When data contained greater than 50% non-detects or did not follow a normal or transformed-normal distribution, non-parametric tolerance limits were constructed using the highest background measurement. The confidence and coverage levels for nonparametric tolerance limits are dependent upon the number of background samples.

Groundwater Protection Standards

The upper tolerance limits were compared to the Maximum Contaminant Levels (MCLs) and CCR-Rule specified levels in the Groundwater Protection Standard (GWPS) table following this letter to determine the highest limit for use as the GWPS in the Confidence Interval comparisons (Figure E).

Evaluation of Appendix IV Parameters – June 2022

Time series plots were used to visually identify potential outliers in downgradient wells during the June 2022 sample event. When suspected outliers are identified, Tukey's outlier test is used to formally test whether measurements are statistically significant. High outliers are 'cautiously' flagged in the downgradient wells when measurements are clearly much different from remaining data within a given well. This is intended to be a regulatory conservative approach in that it will reduce the variance and thus reduce the width of parametric confidence intervals; although it will also reduce the mean and thus lower the entire interval. The intent is to better represent the actual downgradient mean. No suspected outliers were identified.

Confidence intervals were then constructed with data through June 2022 on downgradient wells for each of the Appendix IV parameters using the highest limit of the MCL, CCR-Rule specified levels, or background limit as the GWPS as discussed above (Figure F). Only when the entire confidence interval is above a GWPS is the well/constituent pair considered to exceed its respective standard. A summary of the confidence interval results follows this letter. The following confidence interval exceedances were identified:

- Beryllium: MW-1603
- Cobalt: MW-1603
- Combined Radium 226 + 228: MW-1603
- Lithium: MW-1603

Thank you for the opportunity to assist you in the statistical analysis of groundwater quality for the Big Sandy Fly Ash Pond. If you have any questions or comments, please feel free to contact us.

For Groundwater Stats Consulting,

Andrew T. Collins
Project Manager

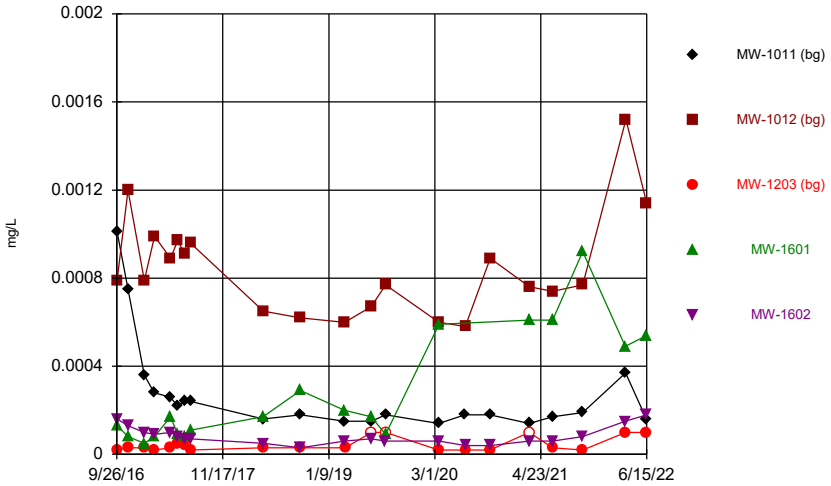
Kristina L. Rayner
Groundwater Statistician

Easton Rayner
Groundwater Analyst

FIGURE A: TIME SERIES

Sanitas™ v.9.6.35 . UG
Hollow symbols indicate censored values.

Time Series



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Hollow symbols indicate censored values.

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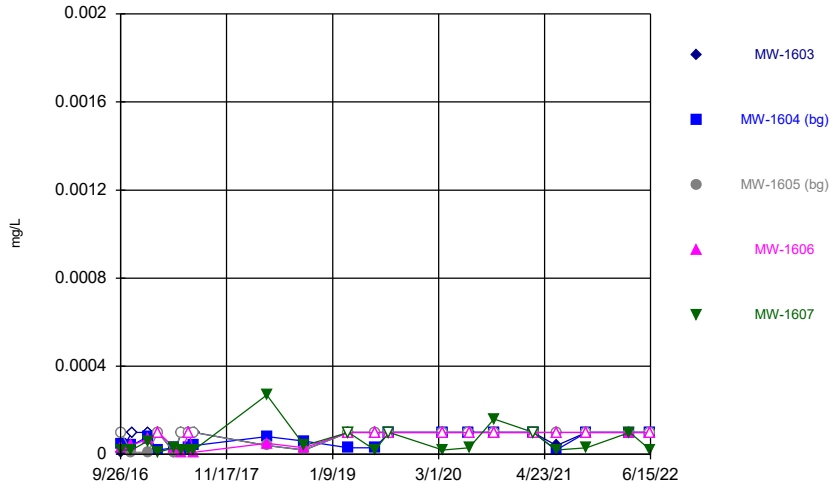

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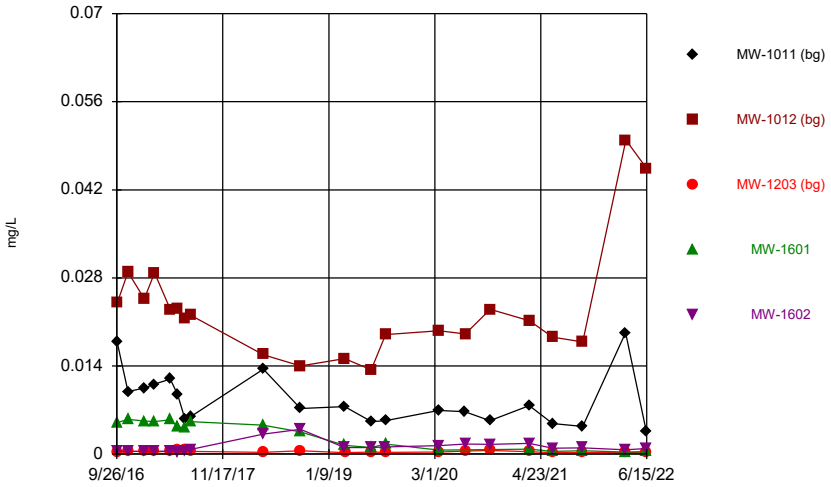

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Hollow symbols indicate censored values.

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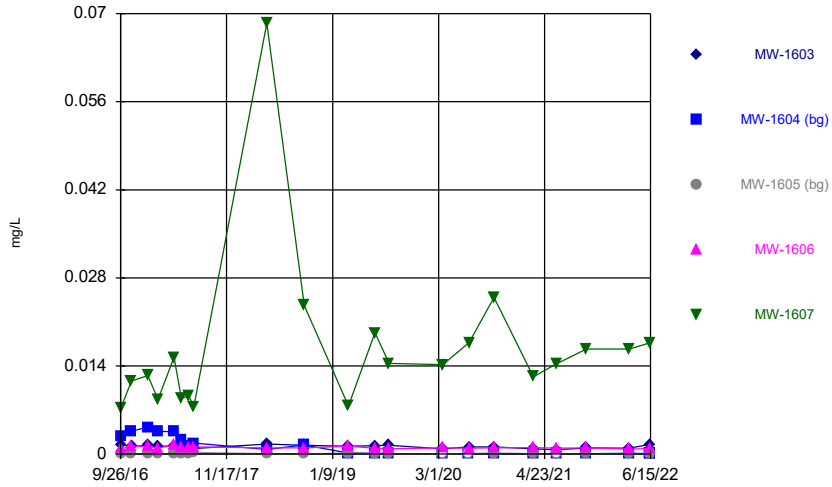

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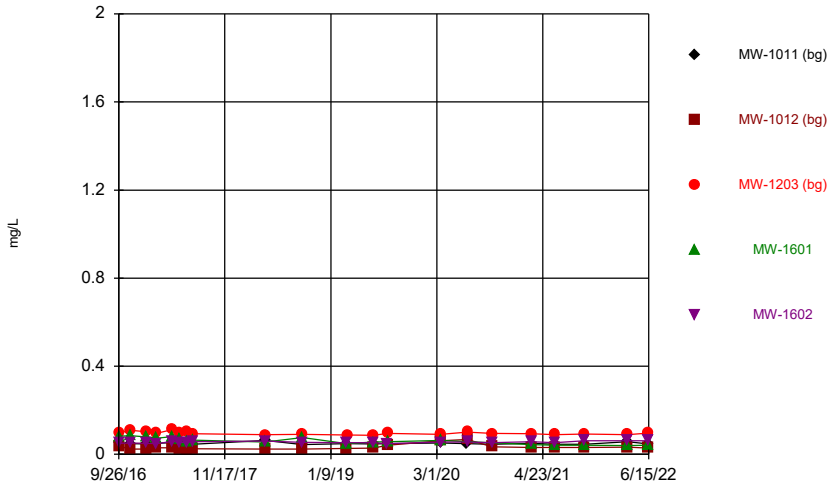

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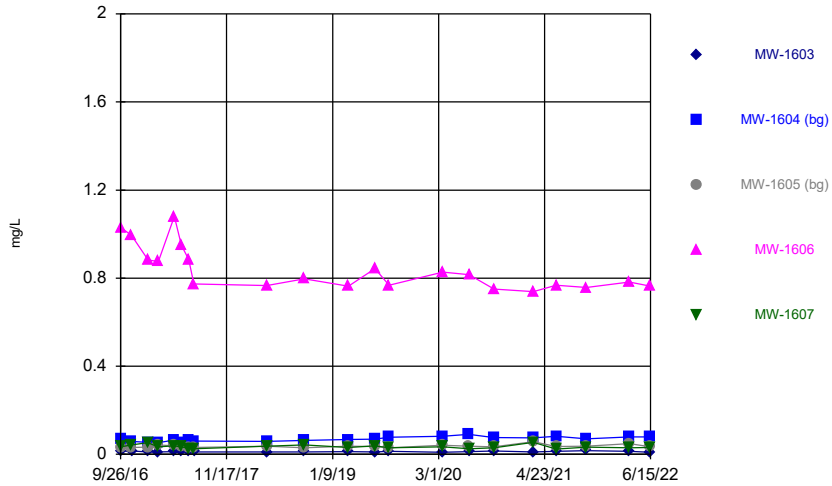
Time Series



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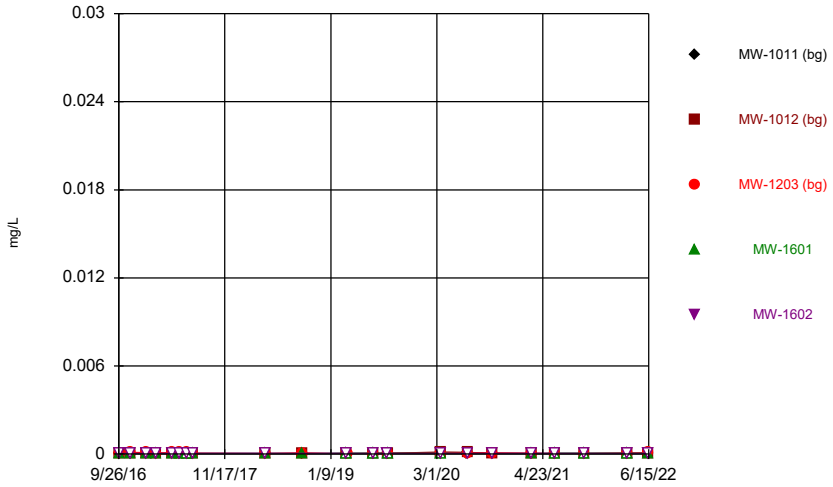

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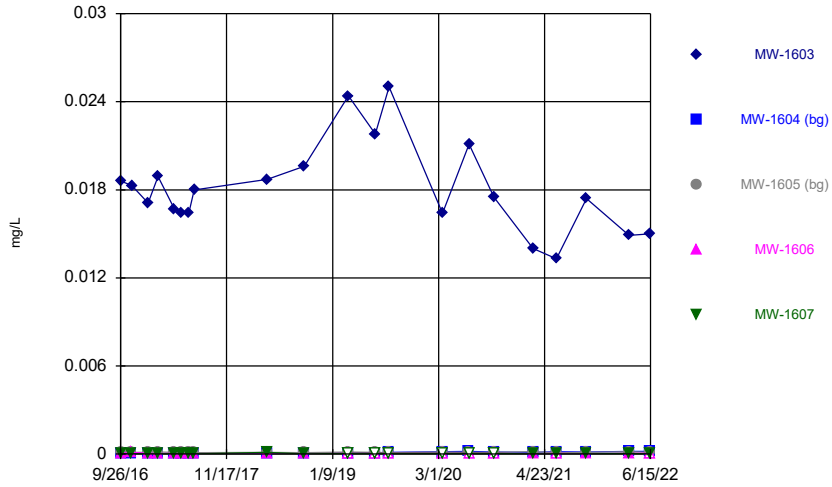

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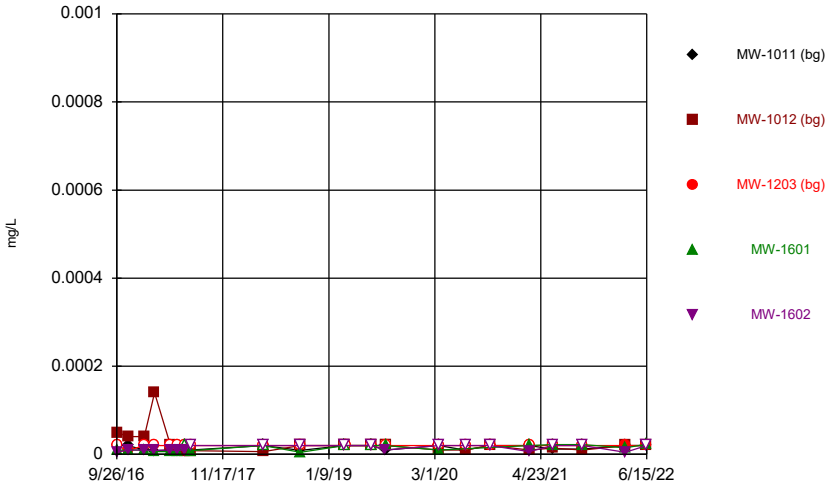

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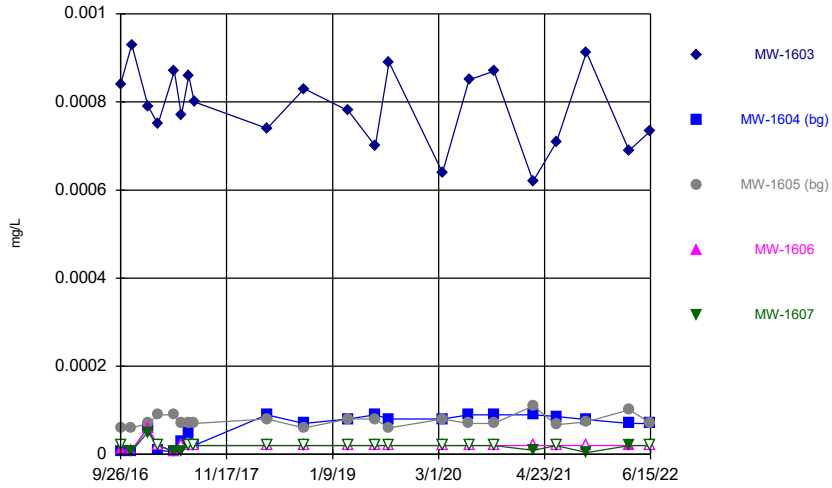

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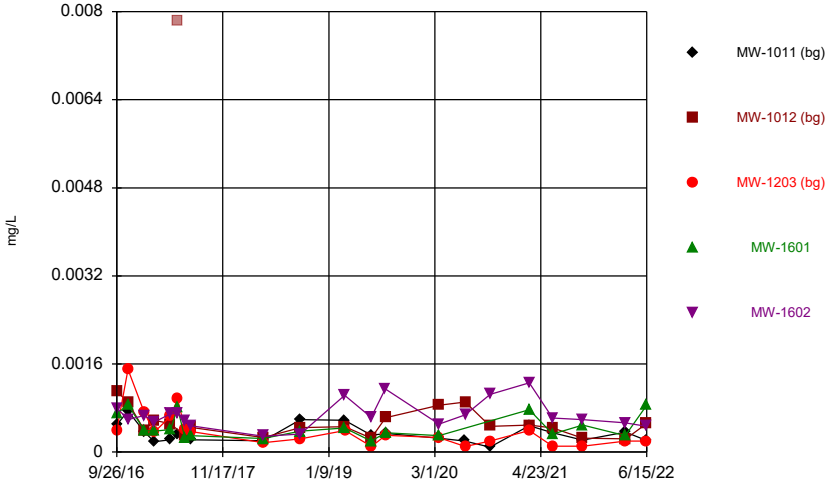
Sanitas™ v.9.6.35 . UG

Time Series



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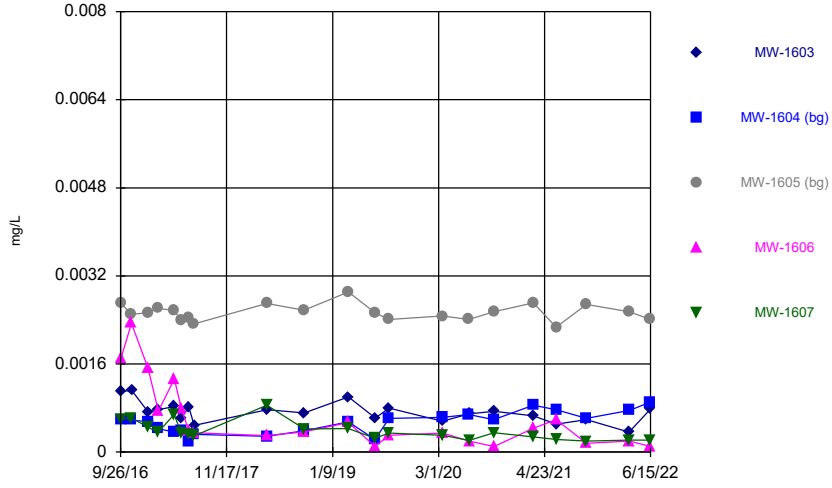
Sanitas™ v.9.6.35 . UG

Time Series



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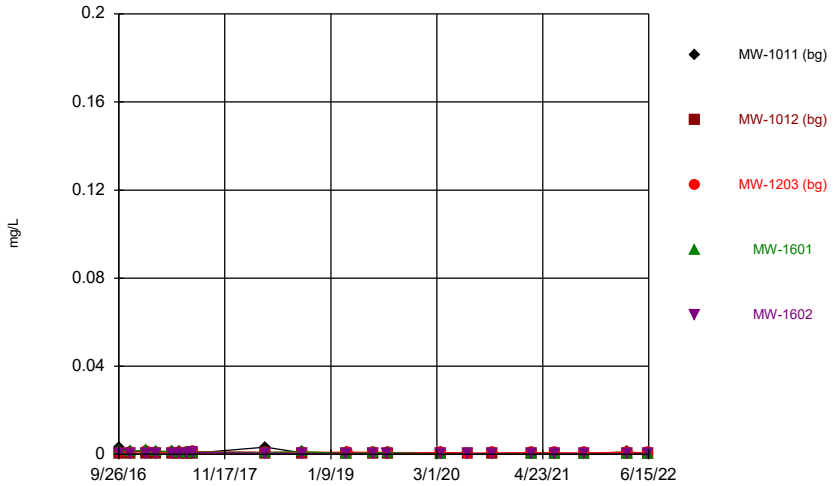
Time Series



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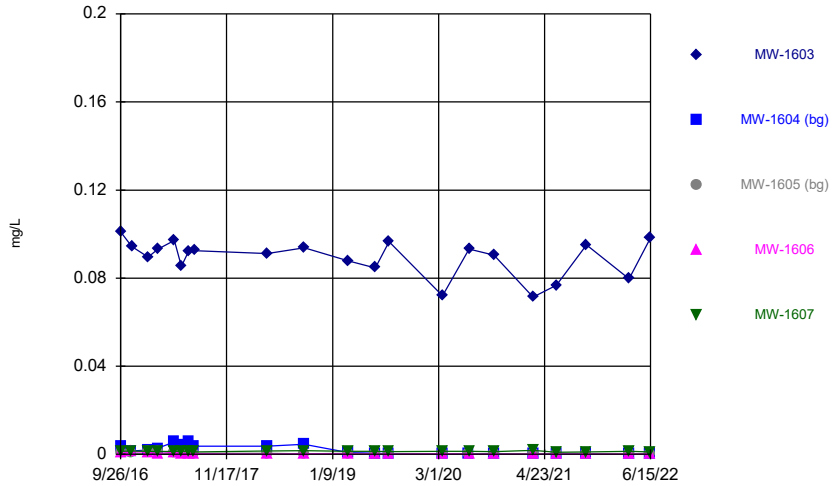

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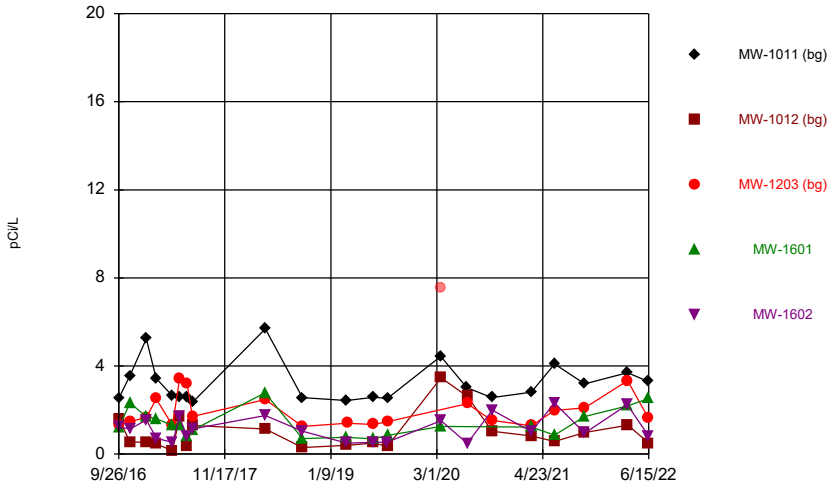
Sanitas™ v.9.6.35 . UG

Time Series



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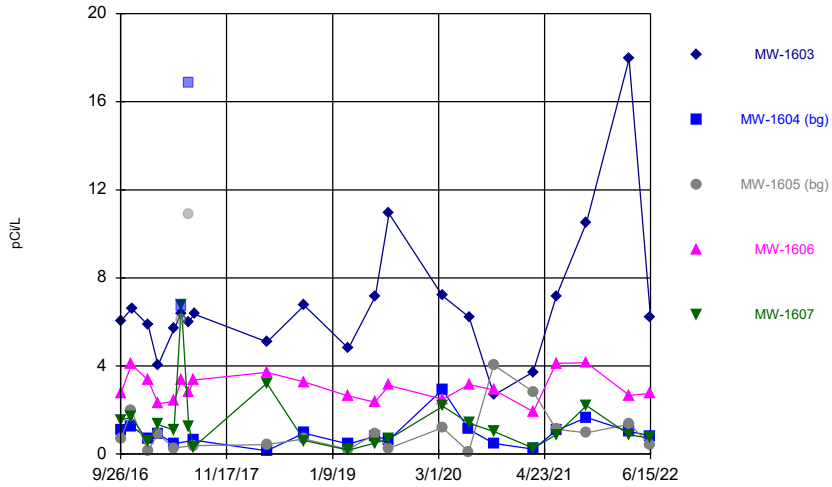
Sanitas™ v.9.6.35 . UG

Time Series



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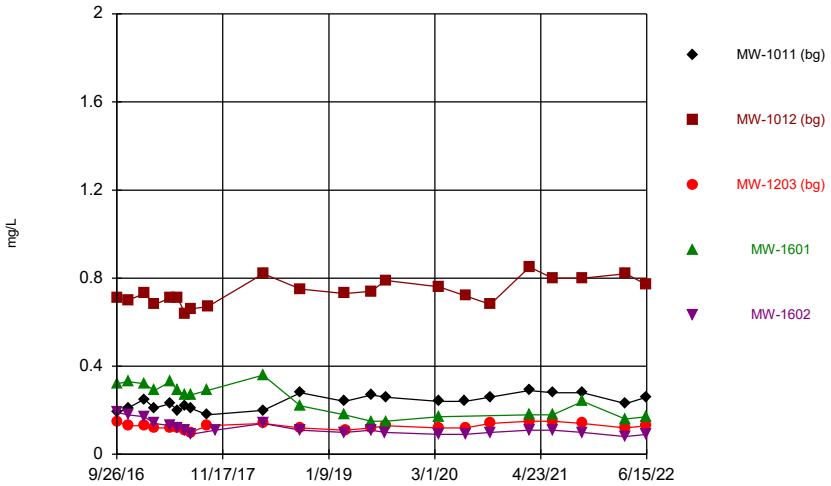
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.35 . UG

Time Series



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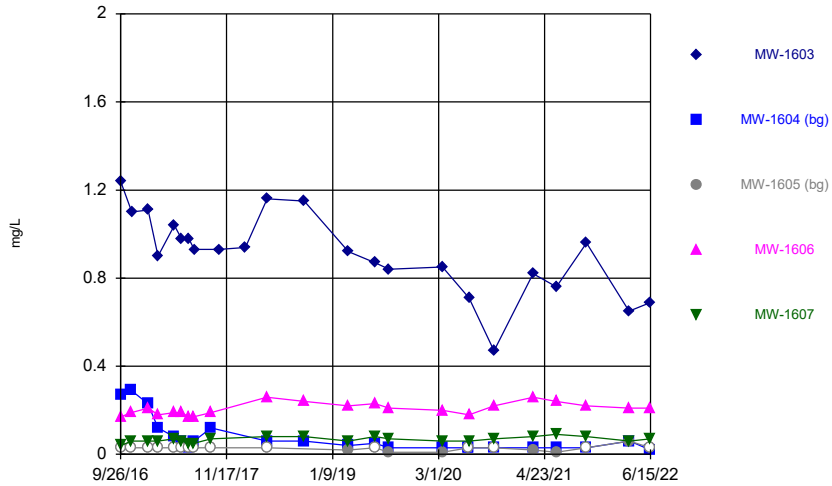

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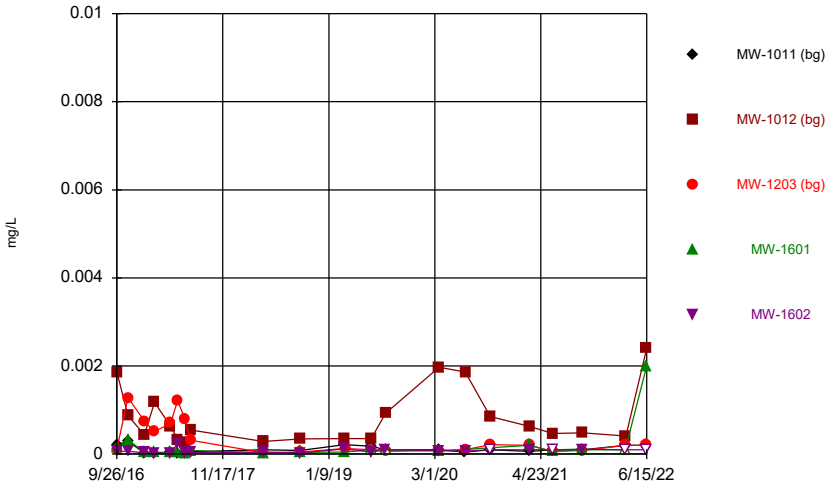

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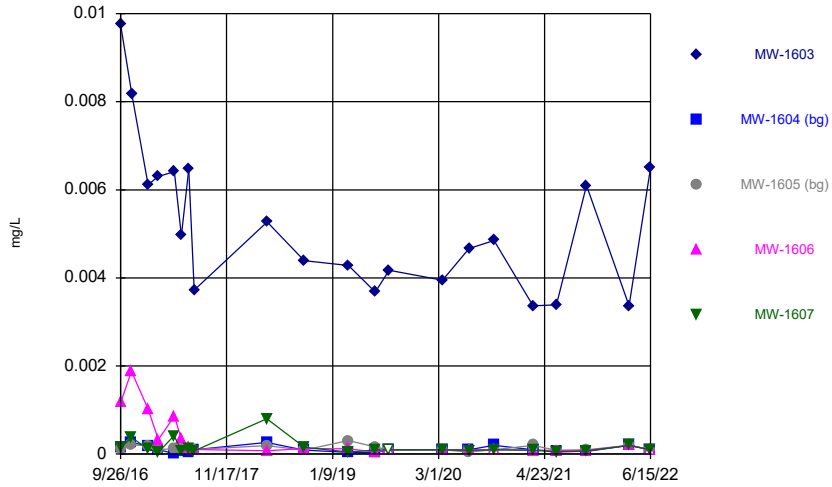

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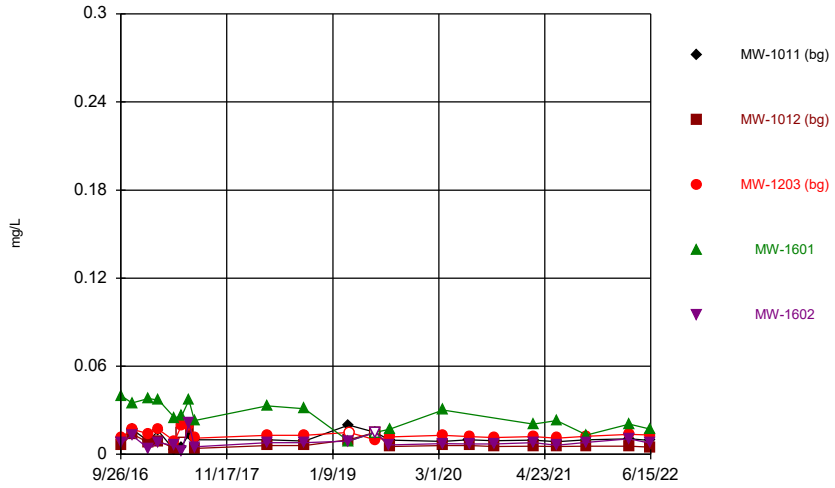

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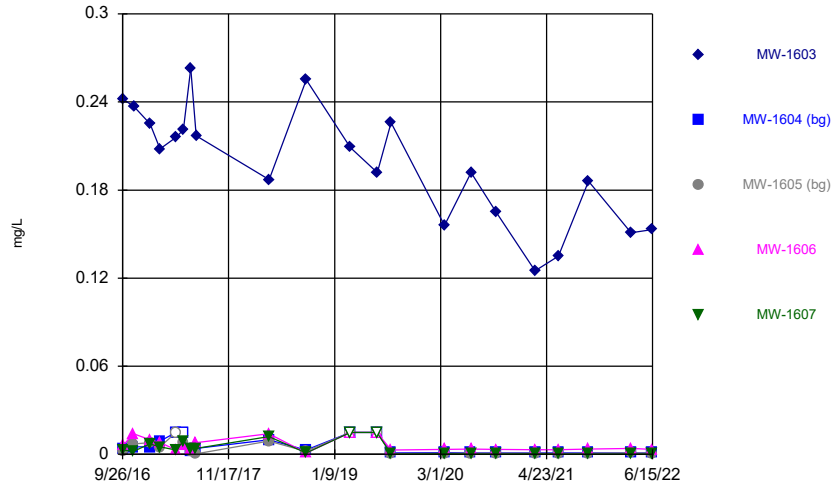
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.35 . UG
Hollow symbols indicate censored values.

Time Series



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Sanitas™ v.9.6.35 . UG
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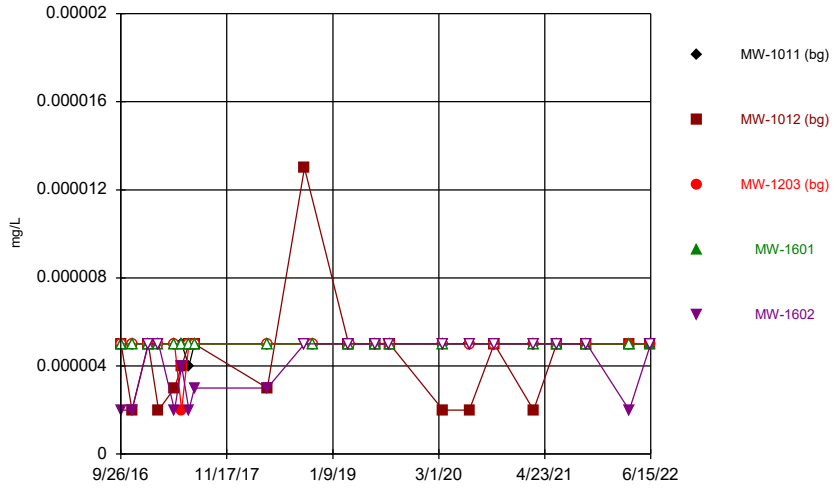
Time Series



Constituent: Mercury Analysis Run 8/18/2022 11:35 PM View: AIV
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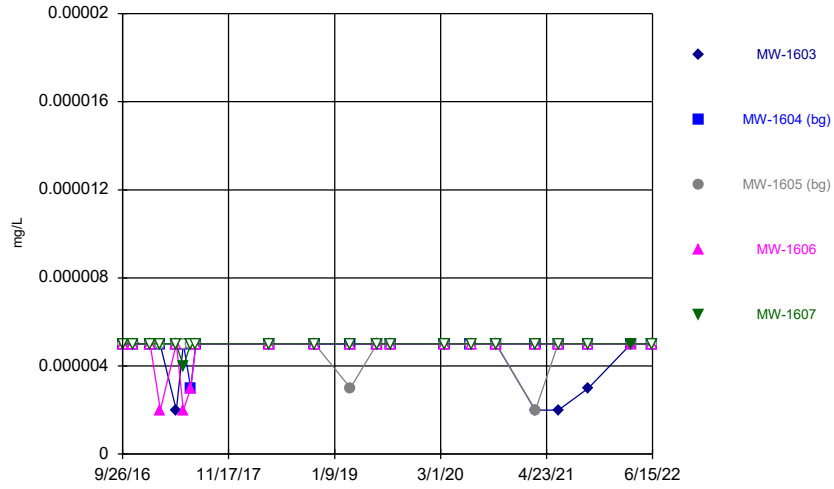
Sanitas™ v.9.6.35 . UG
Hollow symbols indicate censored values.

Time Series



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Sanitas™ v.9.6.35 . UG
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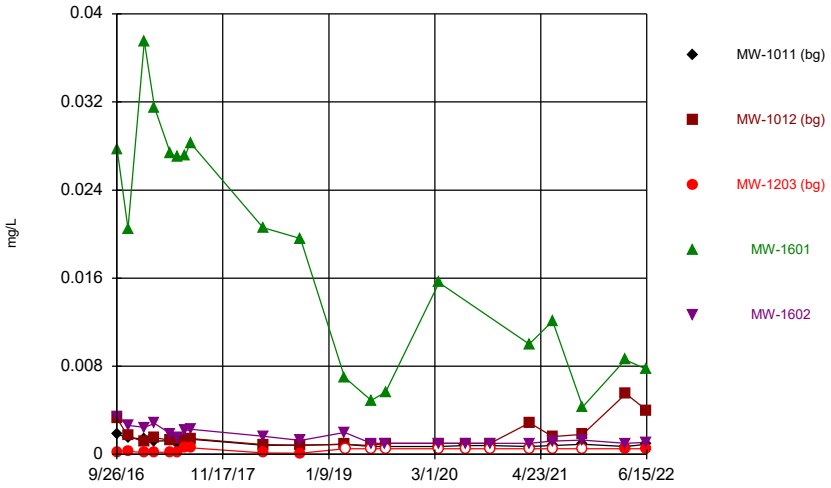
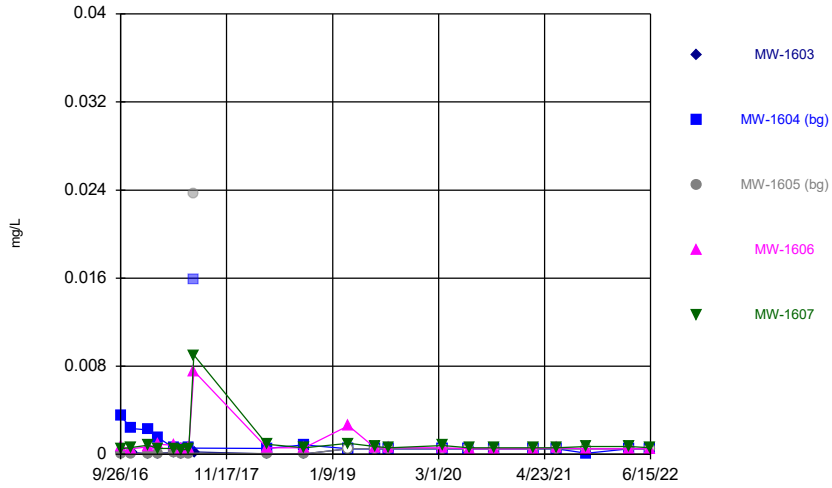
Time Series



Constituent: Molybdenum Analysis Run 8/18/2022 11:35 PM View: AIV
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.35 . UG
Hollow symbols indicate censored values.

Time Series



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Sanitas™ v.9.6.35 . UG
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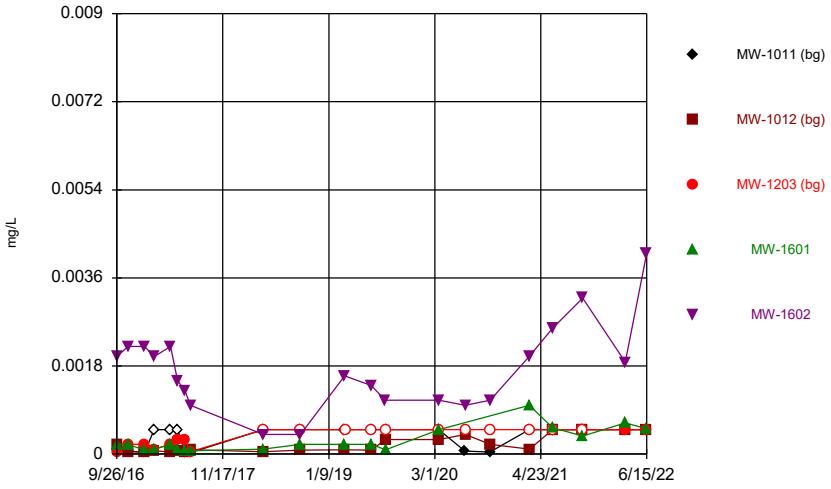
Time Series



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Sanitas™ v.9.6.35 . UG
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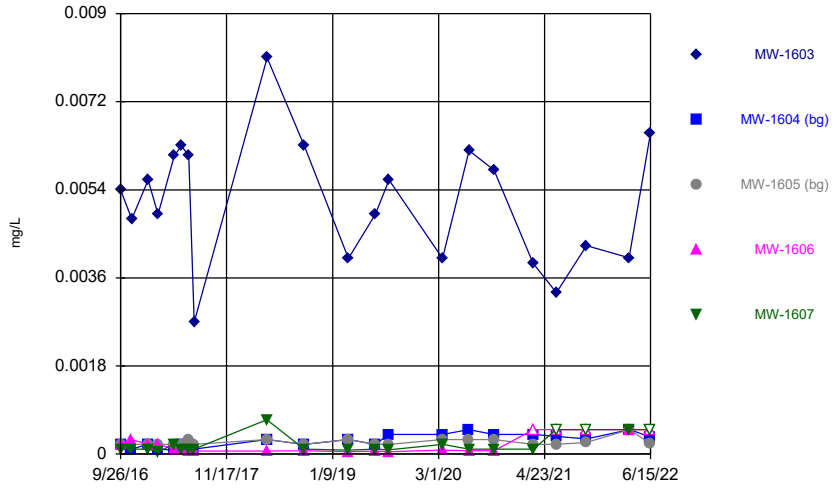
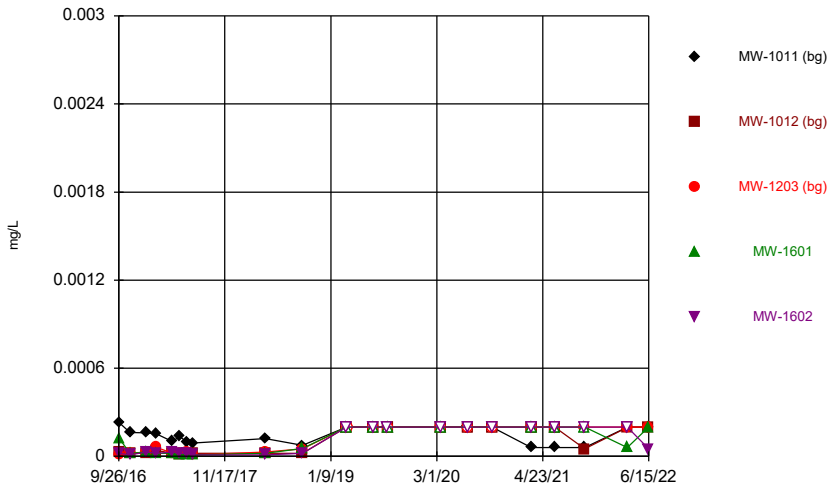
Time Series



Constituent: Selenium Analysis Run 8/18/2022 11:35 PM View: AIV
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.35 . UG
Hollow symbols indicate censored values.

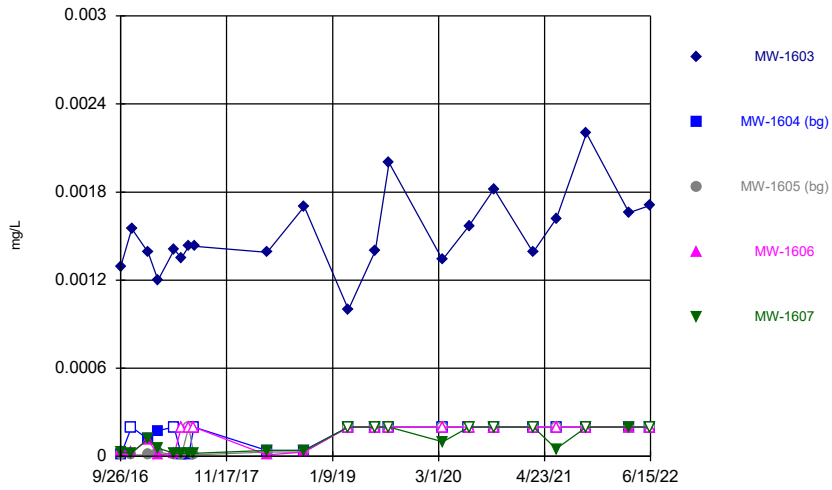
Time Series



Constituent: Thallium Analysis Run 8/18/2022 11:35 PM View: AIV
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.35 . UG
Hollow symbols indicate censored values.

Time Series

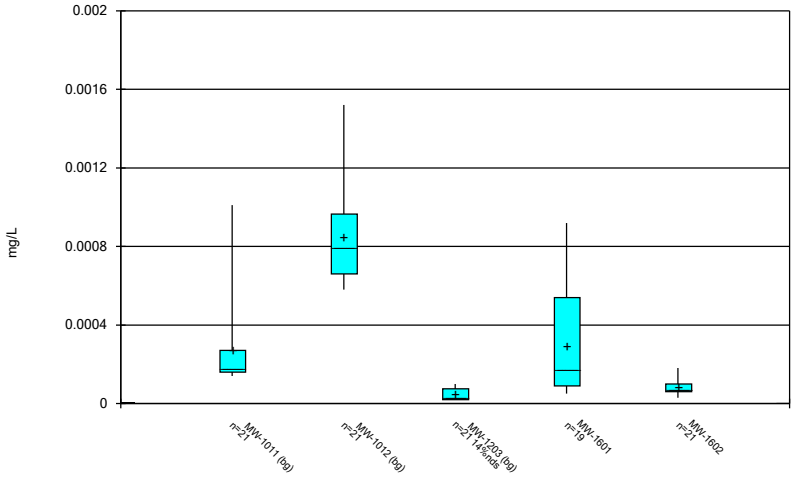


Constituent: Thallium Analysis Run 8/18/2022 11:35 PM View: AIV
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

FIGURE B: BOX PLOTS

Sanitas™ v.9.6.35 . UG

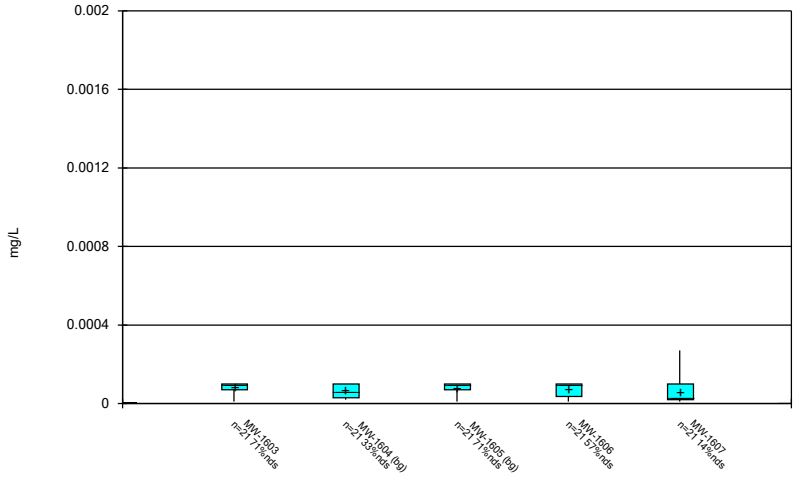
Box & Whiskers Plot



Constituent: Antimony Analysis Run 8/18/2022 11:36 PM View: AIV
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.35 . UG

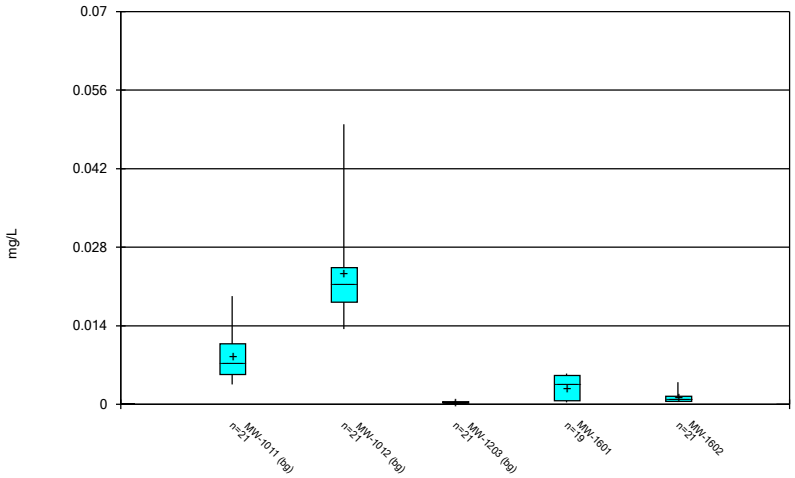
Box & Whiskers Plot



Constituent: Antimony Analysis Run 8/18/2022 11:36 PM View: AIV
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.35 . UG

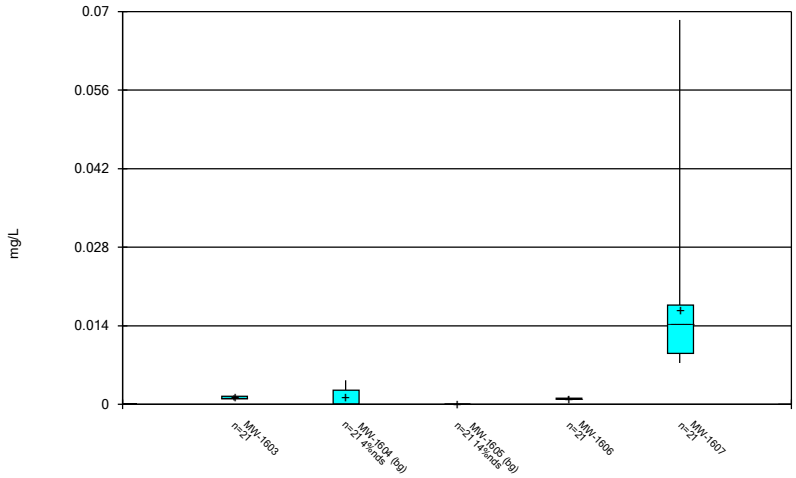
Box & Whiskers Plot



Constituent: Arsenic Analysis Run 8/18/2022 11:36 PM View: AIV
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.35 . UG

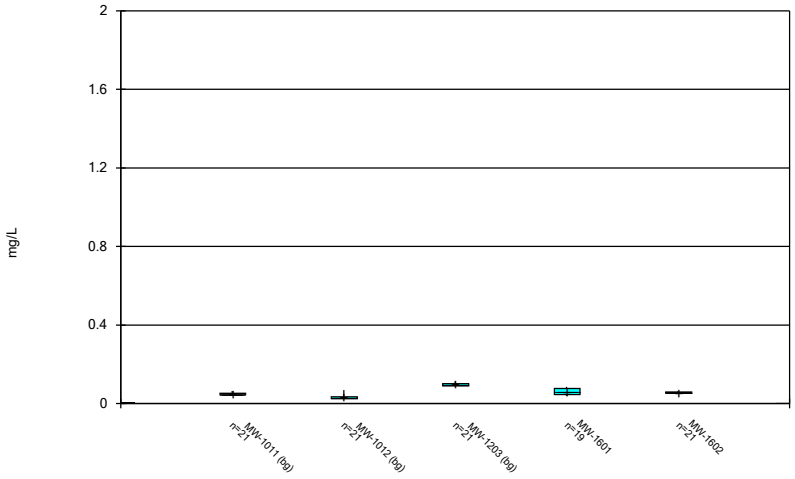
Box & Whiskers Plot



Constituent: Arsenic Analysis Run 8/18/2022 11:36 PM View: AIV
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.35 . UG

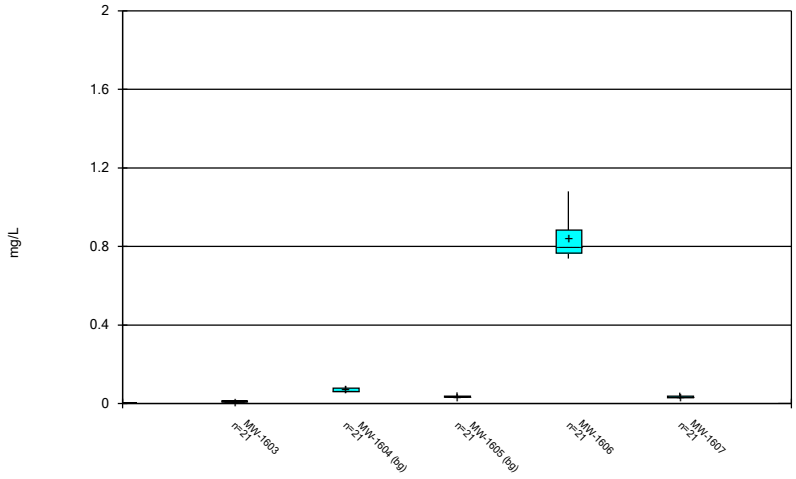
Box & Whiskers Plot



Constituent: Barium Analysis Run 8/18/2022 11:36 PM View: AIV
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.35 . UG

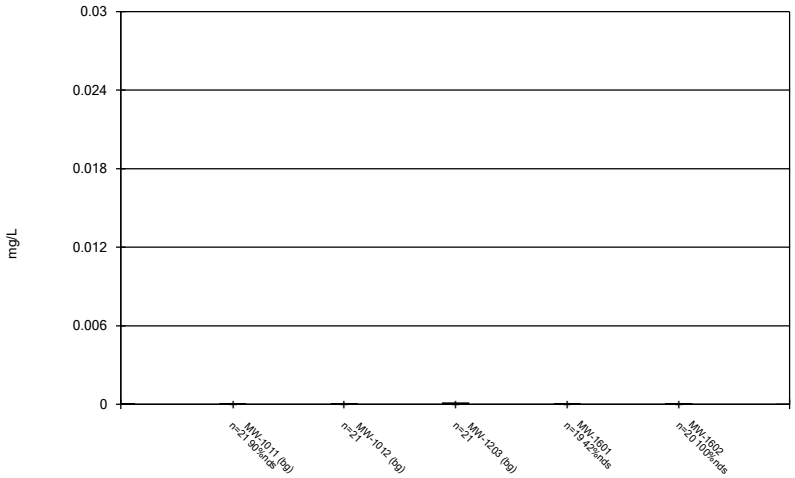
Box & Whiskers Plot



Constituent: Barium Analysis Run 8/18/2022 11:36 PM View: AIV
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.35 . UG

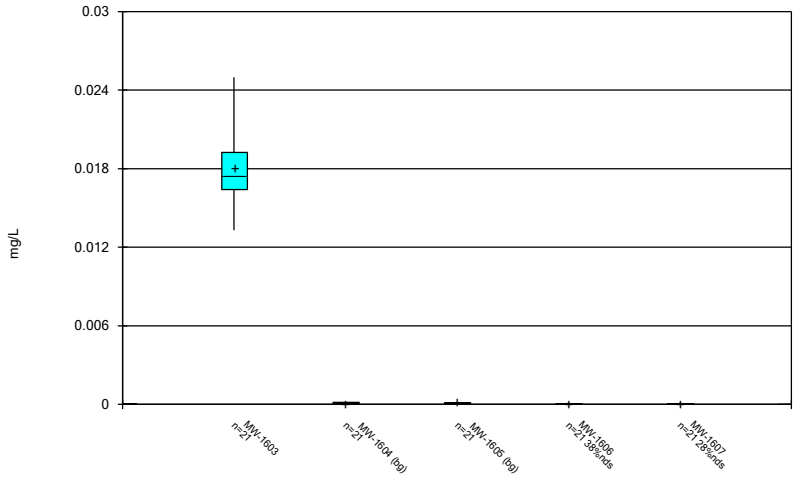
Box & Whiskers Plot



Constituent: Beryllium Analysis Run 8/18/2022 11:36 PM View: AIV
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.35 . UG

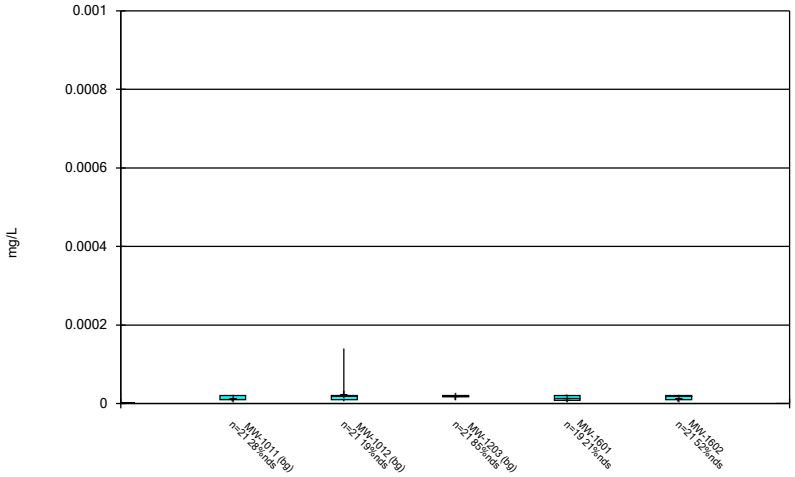
Box & Whiskers Plot



Constituent: Beryllium Analysis Run 8/18/2022 11:36 PM View: AIV
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.35 . UG

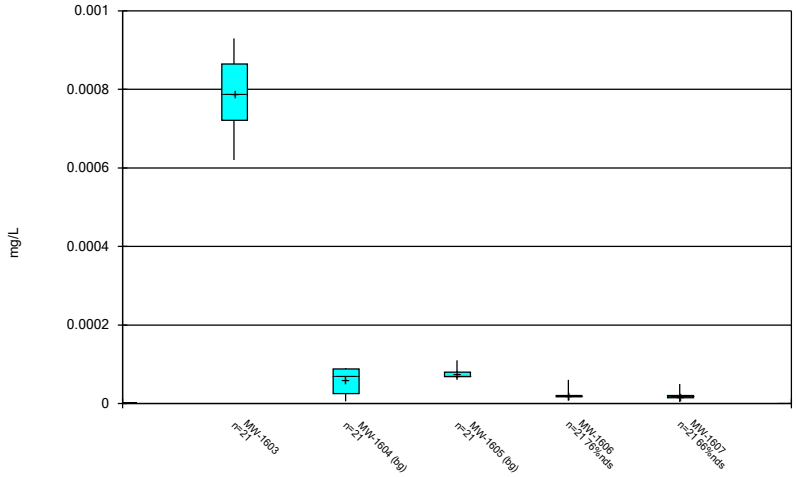
Box & Whiskers Plot



Constituent: Cadmium Analysis Run 8/18/2022 11:36 PM View: AIV
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.35 . UG

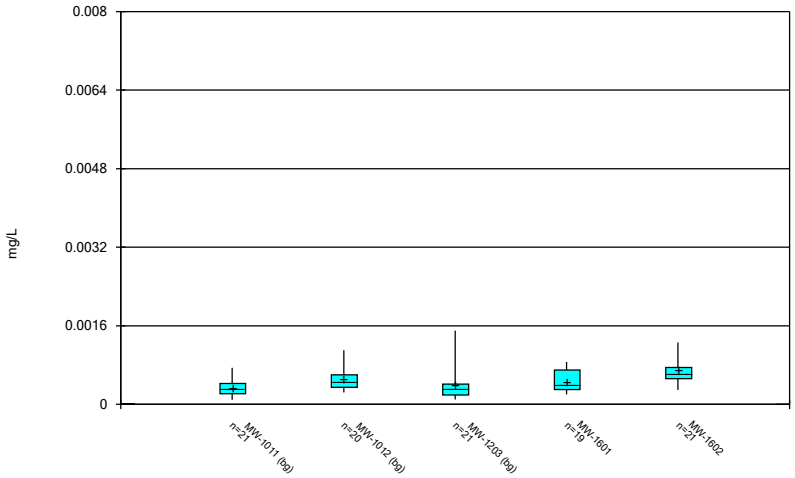
Box & Whiskers Plot



Constituent: Cadmium Analysis Run 8/18/2022 11:36 PM View: AIV
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.35 . UG

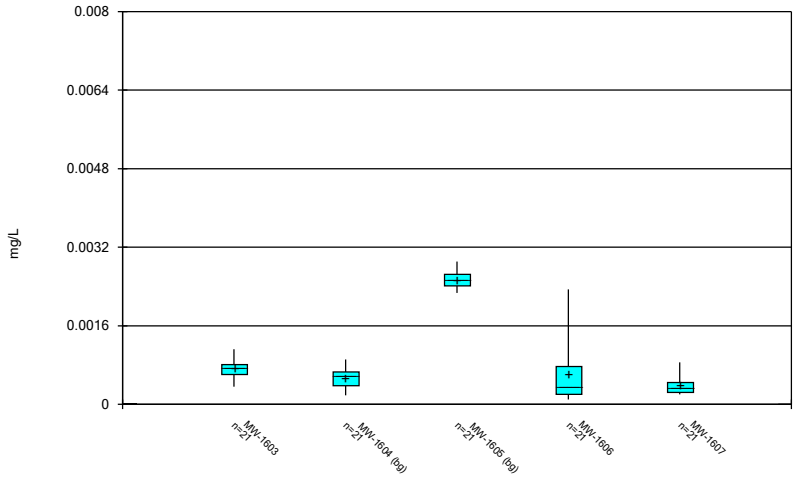
Box & Whiskers Plot



Constituent: Chromium Analysis Run 8/18/2022 11:36 PM View: AIV
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.35 . UG

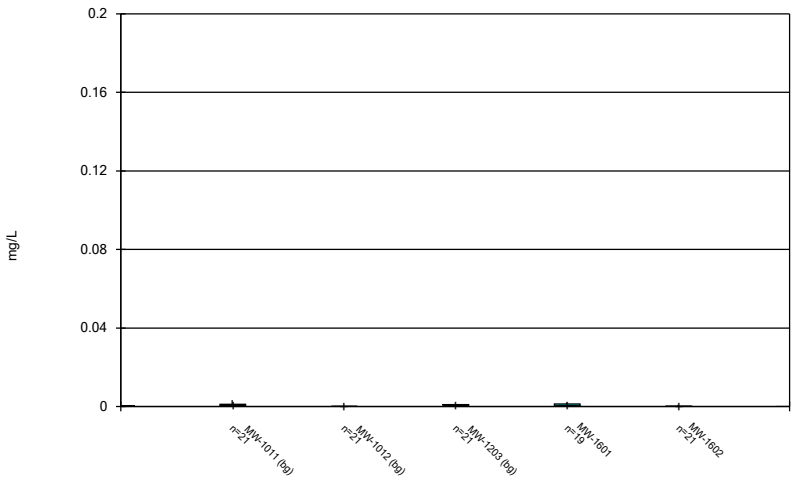
Box & Whiskers Plot



Constituent: Chromium Analysis Run 8/18/2022 11:36 PM View: AIV
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.35 . UG

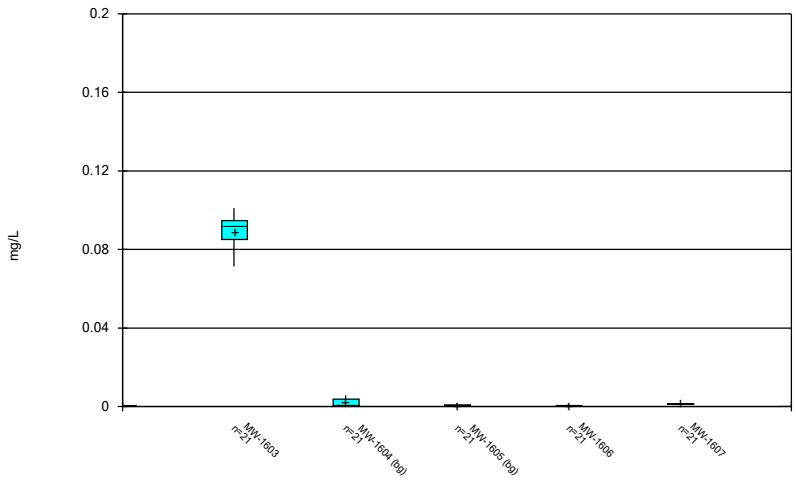
Box & Whiskers Plot



Constituent: Cobalt Analysis Run 8/18/2022 11:36 PM View: AIV
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.35 . UG

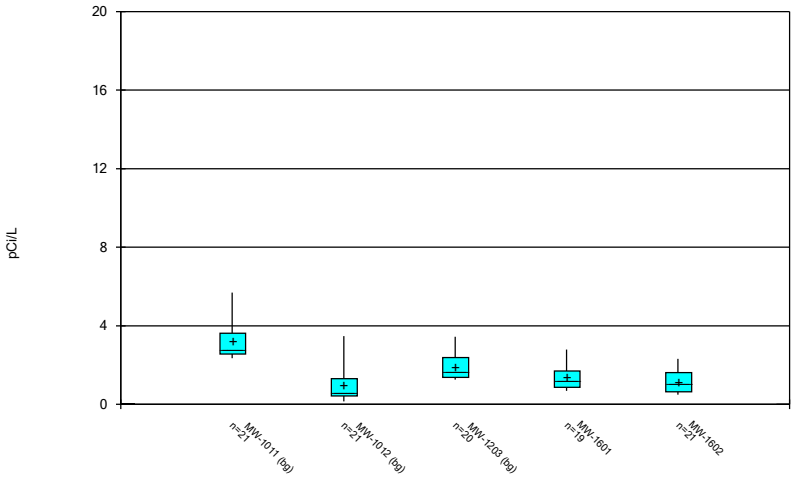
Box & Whiskers Plot



Constituent: Cobalt Analysis Run 8/18/2022 11:36 PM View: AIV
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.35 . UG

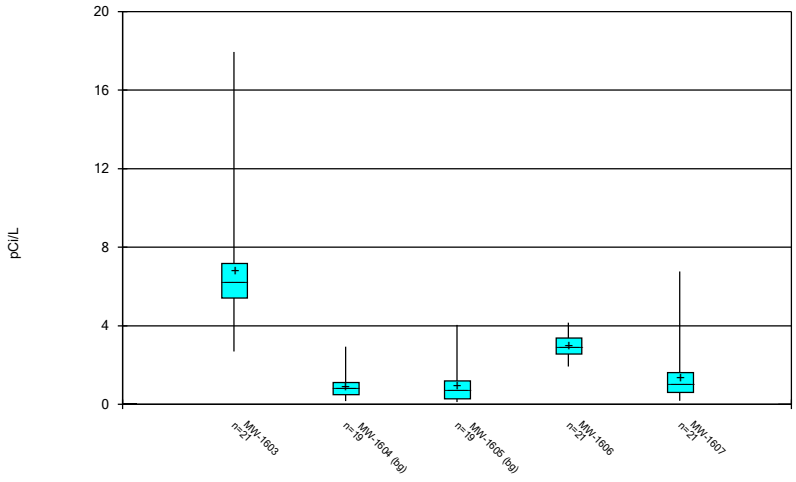
Box & Whiskers Plot



Constituent: Combined Radium 226 + 228 Analysis Run 8/18/2022 11:36 PM View: AIV
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.35 . UG

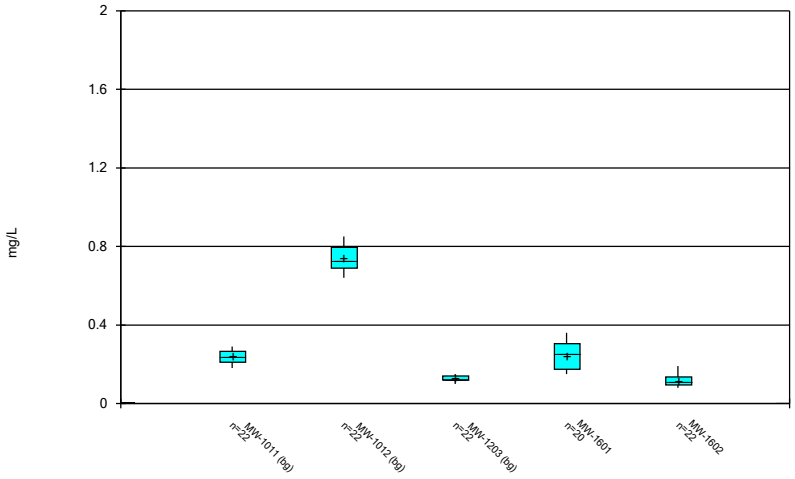
Box & Whiskers Plot



Constituent: Combined Radium 226 + 228 Analysis Run 8/18/2022 11:36 PM View: AIV
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.35 . UG

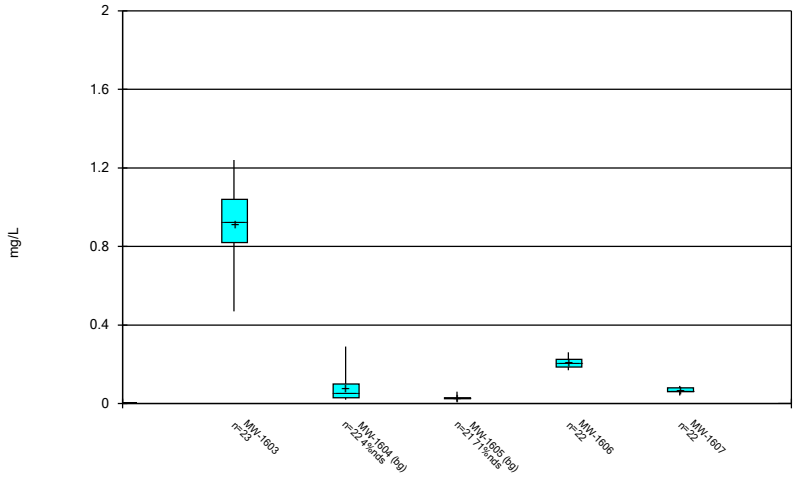
Box & Whiskers Plot



Constituent: Fluoride Analysis Run 8/18/2022 11:36 PM View: AIV
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.35 . UG

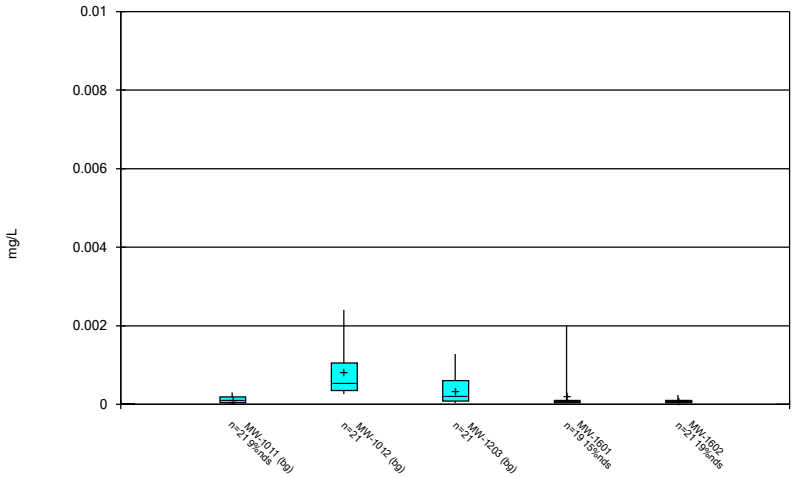
Box & Whiskers Plot



Constituent: Fluoride Analysis Run 8/18/2022 11:36 PM View: AIV
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.35 . UG

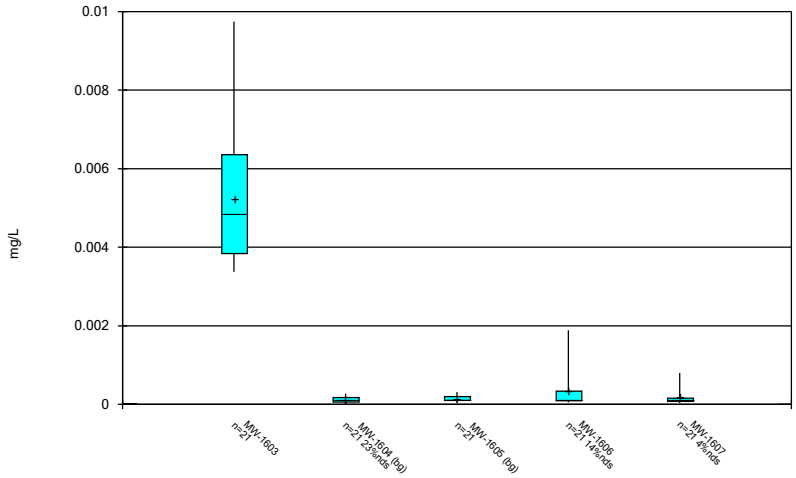
Box & Whiskers Plot



Constituent: Lead Analysis Run 8/18/2022 11:36 PM View: AIV
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.35 . UG

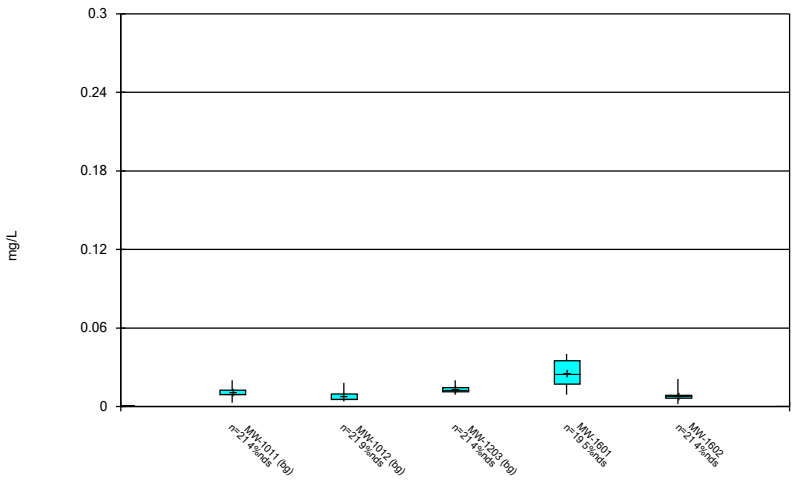
Box & Whiskers Plot



Constituent: Lead Analysis Run 8/18/2022 11:36 PM View: AIV
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.35 . UG

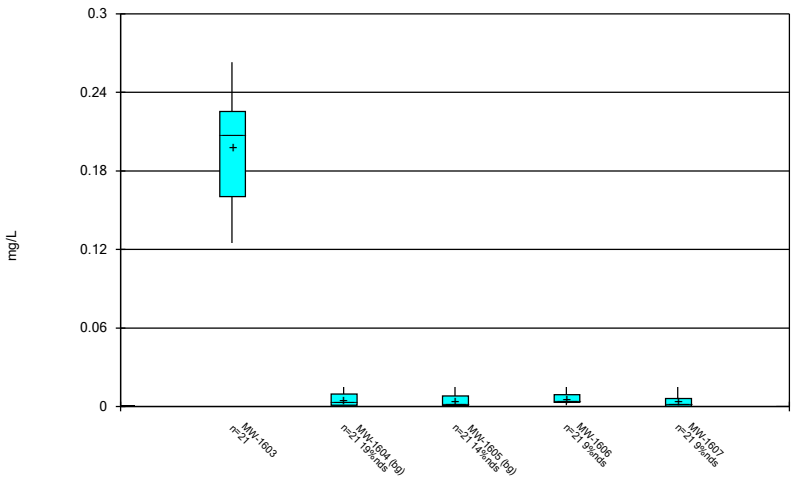
Box & Whiskers Plot



Constituent: Lithium Analysis Run 8/18/2022 11:36 PM View: AIV
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.35 . UG

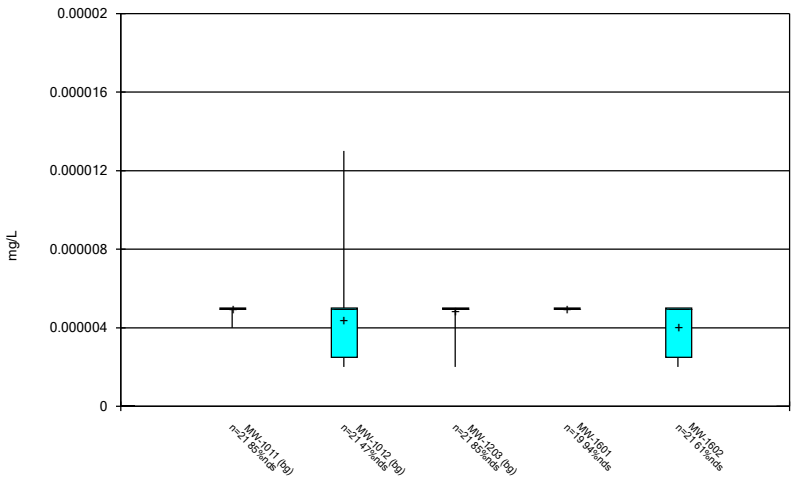
Box & Whiskers Plot



Constituent: Lithium Analysis Run 8/18/2022 11:37 PM View: AIV
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.35 . UG

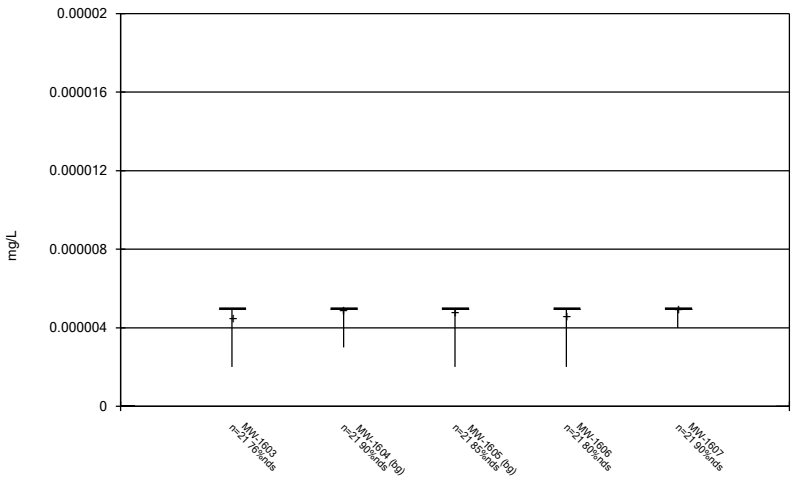
Box & Whiskers Plot



Constituent: Mercury Analysis Run 8/18/2022 11:37 PM View: AIV
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.35 . UG

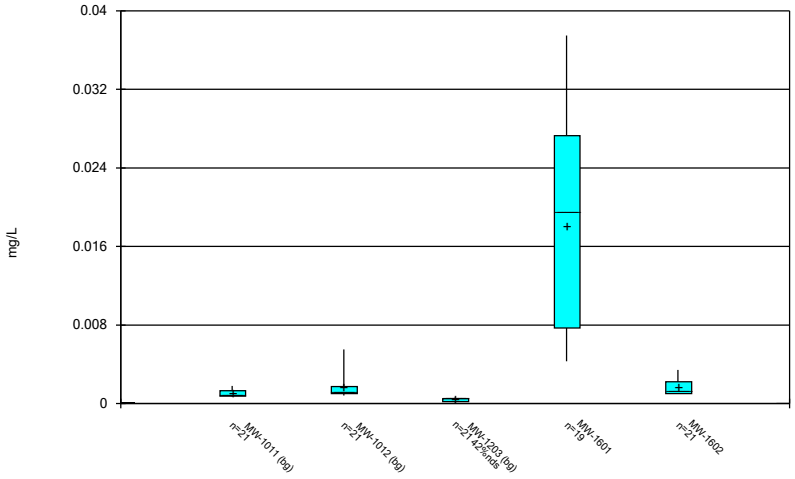
Box & Whiskers Plot



Constituent: Mercury Analysis Run 8/18/2022 11:37 PM View: AIV
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.35 . UG

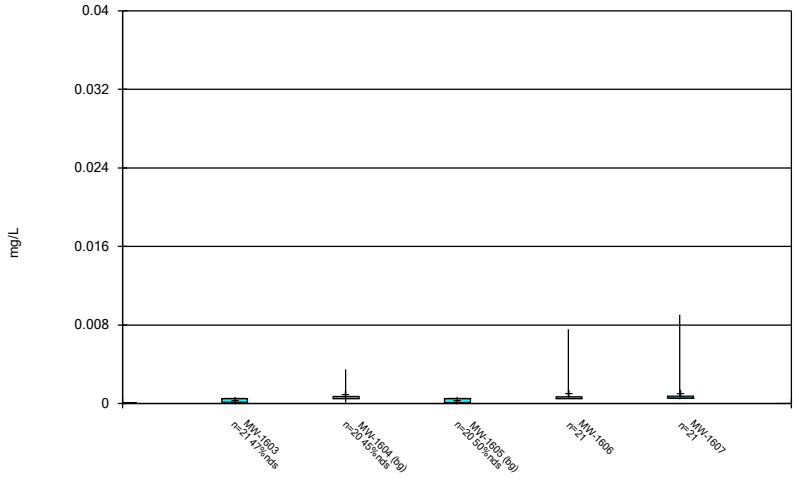
Box & Whiskers Plot



Constituent: Molybdenum Analysis Run 8/18/2022 11:37 PM View: AIV
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.35 . UG

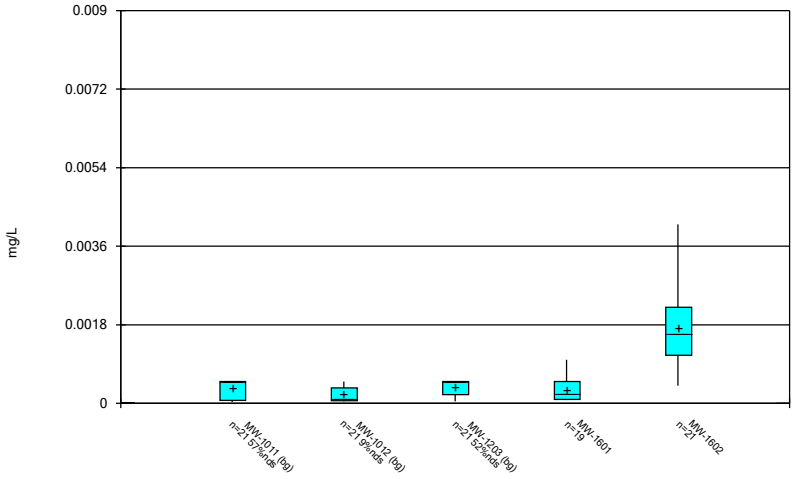
Box & Whiskers Plot



Constituent: Molybdenum Analysis Run 8/18/2022 11:37 PM View: AIV
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.35 . UG

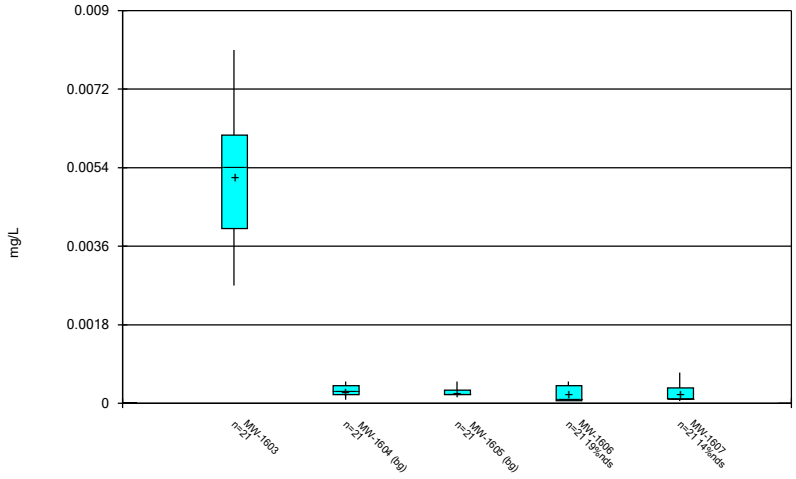
Box & Whiskers Plot



Constituent: Selenium Analysis Run 8/18/2022 11:37 PM View: AIV
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

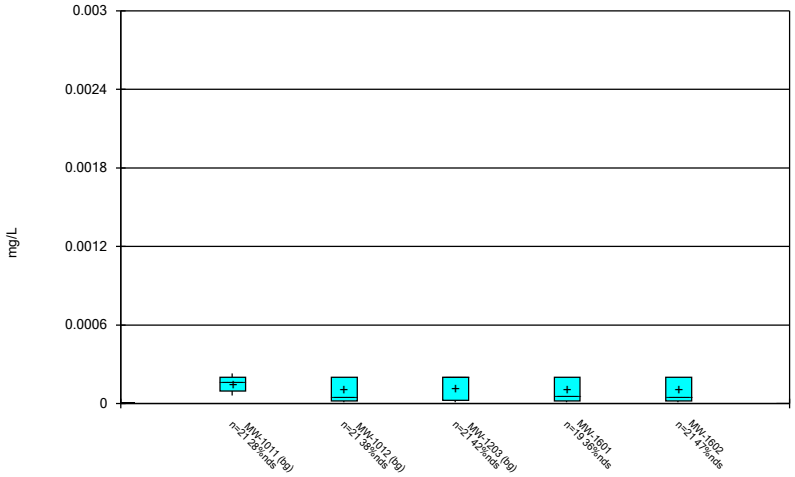
Sanitas™ v.9.6.35 . UG

Box & Whiskers Plot



Constituent: Selenium Analysis Run 8/18/2022 11:37 PM View: AIV
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

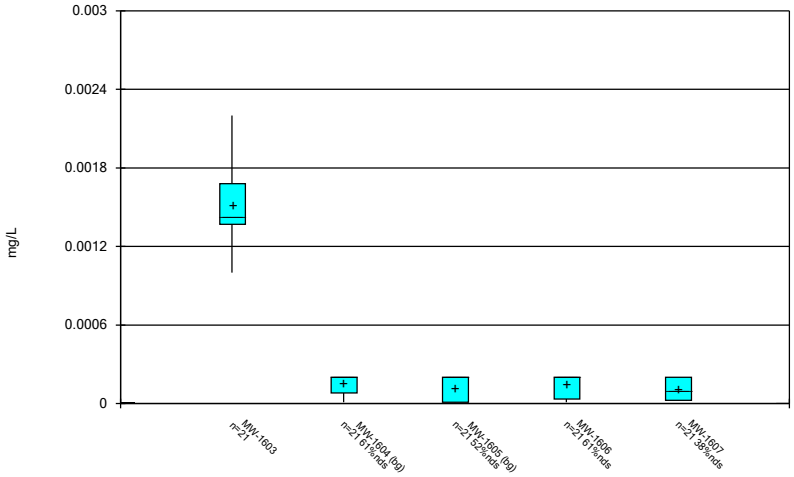
Box & Whiskers Plot



Constituent: Thallium Analysis Run 8/18/2022 11:37 PM View: AIV
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.35 . UG

Box & Whiskers Plot



Constituent: Thallium Analysis Run 8/18/2022 11:37 PM View: AIV
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

FIGURE C: OUTLIER SUMMARY

Outlier Summary

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP Printed 8/18/2022, 11:38 PM

	MW-1012 Chromium (mg/L)	MW-1203 Combined Radium 226 + 228 (pCi/L)	MW-1604 Combined Radium 226 + 228 (pCi/L)	MW-1605 Combined Radium 226 + 228 (pCi/L)	MW-1604 Molybdenum (mg/L)	MW-1605 Molybdenum (mg/L)
5/23/2017			6.707 (o)	6.077 (o)		
5/24/2017	0.00784 (o)					
6/21/2017			16.848 (o)	10.864 (o)		
7/12/2017					0.0159 (o)	0.0237 (o)
3/17/2020		7.524 (o)				

FIGURE D: TOLERANCE LIMITS

Upper Tolerance Limits

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP Printed 1/11/2022, 10:54 AM

Constituent	Well	Upper Lim.	Date	Observ.	Sig.	Bg N	%NDs	Transform	Alpha	Method
Antimony (mg/L)	n/a	0.0012	n/a	n/a	n/a	95	24.21	n/a	0.007651	NP Inter(normality)
Arsenic (mg/L)	n/a	0.0289	n/a	n/a	n/a	95	3.158	n/a	0.007651	NP Inter(normality)
Barium (mg/L)	n/a	0.1222	n/a	n/a	n/a	95	0	ln(x)	0.05	Inter
Beryllium (mg/L)	n/a	0.0001742	n/a	n/a	n/a	95	20	sqrt(x)	0.05	Inter
Cadmium (mg/L)	n/a	0.00014	n/a	n/a	n/a	95	29.47	n/a	0.007651	NP Inter(normality)
Chromium (mg/L)	n/a	0.00291	n/a	n/a	n/a	94	0	n/a	0.008054	NP Inter(normality)
Cobalt (mg/L)	n/a	0.004414	n/a	n/a	n/a	95	0	ln(x)	0.05	Inter
Combined Radium 226 + 228 (pCi/L)	n/a	4.488	n/a	n/a	n/a	90	0	sqrt(x)	0.05	Inter
Fluoride (mg/L)	n/a	0.85	n/a	n/a	n/a	99	15.15	n/a	0.006232	NP Inter(normality)
Lead (mg/L)	n/a	0.001347	n/a	n/a	n/a	95	6.316	ln(x)	0.05	Inter
Lithium (mg/L)	n/a	0.02	n/a	n/a	n/a	95	11.58	n/a	0.007651	NP Inter(normality)
Mercury (mg/L)	n/a	0.000013	n/a	n/a	n/a	95	85.26	n/a	0.007651	NP Inter(NDs)
Molybdenum (mg/L)	n/a	0.00348	n/a	n/a	n/a	93	27.96	n/a	0.008478	NP Inter(normality)
Selenium (mg/L)	n/a	0.0005	n/a	n/a	n/a	95	26.32	n/a	0.007651	NP Inter(normality)
Thallium (mg/L)	n/a	0.000229	n/a	n/a	n/a	95	47.37	n/a	0.007651	NP Inter(normality)

FIGURE E: GROUNDWATER PROTECTION STANDARDS

BIG SANDY FAP GWPS				
Constituent Name	**MCL**	**CCR-Rule**	**Background**	**GWPS**
Antimony, Total (mg/L)	0.006		0.0012	0.006
Arsenic, Total (mg/L)	0.01		0.029	0.029
Barium, Total (mg/L)	2		0.12	2
Beryllium, Total (mg/L)	0.004		0.00017	0.004
Cadmium, Total (mg/L)	0.005		0.00014	0.005
Chromium, Total (mg/L)	0.1		0.0029	0.1
Cobalt, Total (mg/L)	n/a	0.006	0.0044	0.006
Combined Radium, Total (pCi/L)	5		4.49	5
Fluoride, Total (mg/L)	4		0.85	4
Lead, Total (mg/L)	0.015		0.0013	0.015
Lithium, Total (mg/L)	n/a	0.04	0.02	0.04
Mercury, Total (mg/L)	0.002		0.000013	0.002
Molybdenum, Total (mg/L)	n/a	0.1	0.0035	0.1
Selenium, Total (mg/L)	0.05		0.0005	0.05
Thallium, Total (mg/L)	0.002		0.00023	0.002

**Grey cell indicates Background is higher than MCL or CCR-Rule Specified Level*

**GWPS = Groundwater Protection Standard*

**MCL = Maximum Contaminant Level*

**CCR = Coal Combustion Residual*

FIGURE F: CONFIDENCE INTERVALS

Confidence Interval Summary Table - Significant Results

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP Printed 8/23/2022, 8:46 AM

Constituent	Well	Upper Lim.	Lower Lim.	Compliance	Sig.	N	%NDs	Transform	Alpha	Method
Beryllium (mg/L)	**MW-1603**	**0.01975**	**0.01639**	**0.004**	**Yes**	**21**	**0**	**No**	**0.01**	**Param.**
Cobalt (mg/L)	**MW-1603**	**0.09393**	**0.08479**	**0.006**	**Yes**	**21**	**0**	**No**	**0.01**	**Param.**
Combined Radium 226 + 228 (pCi/L)	**MW-1603**	**8.036**	**5.124**	**5**	**Yes**	**21**	**0**	**x^(1/3)**	**0.01**	**Param.**
Lithium (mg/L)	**MW-1603**	**0.2197**	**0.1766**	**0.04**	**Yes**	**21**	**0**	**No**	**0.01**	**Param.**

Confidence Interval Summary Table - All Results

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP Printed 8/23/2022, 8:46 AM

Constituent	Well	Upper Lim.	Lower Lim.	Compliance	Sig.	N	%NDs	Transform	Alpha	Method
Antimony (mg/L)	MW-1601	0.0003341	0.0001179	0.006	No	19	0	ln(x)	0.01	Param.
Antimony (mg/L)	MW-1602	0.0001054	0.0000603	0.006	No	21	0	No	0.01	Param.
Antimony (mg/L)	MW-1603	0.0001	0.00004	0.006	No	21	71.43	No	0.01	NP (NDs)
Antimony (mg/L)	MW-1606	0.0001	0.00004	0.006	No	21	57.14	No	0.01	NP (NDs)
Antimony (mg/L)	MW-1607	0.0001	0.00002	0.006	No	21	14.29	No	0.01	NP (normality)
Arsenic (mg/L)	MW-1601	0.00518	0.00053	0.029	No	19	0	No	0.01	NP (normality)
Arsenic (mg/L)	MW-1602	0.001401	0.000642	0.029	No	21	0	x^(1/3)	0.01	Param.
Arsenic (mg/L)	MW-1603	0.001346	0.001065	0.029	No	21	0	No	0.01	Param.
Arsenic (mg/L)	MW-1606	0.001097	0.0009345	0.029	No	21	0	No	0.01	Param.
Arsenic (mg/L)	MW-1607	0.01887	0.01074	0.029	No	21	0	ln(x)	0.01	Param.
Barium (mg/L)	MW-1601	0.06998	0.0519	2	No	19	0	No	0.01	Param.
Barium (mg/L)	MW-1602	0.05743	0.05271	2	No	21	0	No	0.01	Param.
Barium (mg/L)	MW-1603	0.01322	0.01104	2	No	21	0	No	0.01	Param.
Barium (mg/L)	MW-1606	0.884	0.764	2	No	21	0	No	0.01	NP (normality)
Barium (mg/L)	MW-1607	0.03933	0.03032	2	No	21	0	No	0.01	Param.
Beryllium (mg/L)	MW-1601	0.00005	0.000009	0.004	No	19	42.11	No	0.01	NP (normality)
Beryllium (mg/L)	**MW-1603**	**0.01975**	**0.01639**	**0.004**	**Yes**	**21**	**0**	**No**	**0.01**	**Param.**
Beryllium (mg/L)	MW-1606	0.00005	0.00001	0.004	No	21	38.1	No	0.01	NP (normality)
Beryllium (mg/L)	MW-1607	0.00005	0.00001	0.004	No	21	28.57	No	0.01	NP (normality)
Cadmium (mg/L)	MW-1601	0.00002	0.000008	0.005	No	19	21.05	No	0.01	NP (normality)
Cadmium (mg/L)	MW-1602	0.00002	0.000009	0.005	No	21	52.38	No	0.01	NP (NDs)
Cadmium (mg/L)	MW-1603	0.0008377	0.0007409	0.005	No	21	0	No	0.01	Param.
Cadmium (mg/L)	MW-1606	0.00002	0.00001	0.005	No	21	76.19	No	0.01	NP (NDs)
Cadmium (mg/L)	MW-1607	0.00002	0.000009	0.005	No	21	66.67	No	0.01	NP (NDs)
Chromium (mg/L)	MW-1601	0.0005426	0.0003196	0.1	No	19	0	ln(x)	0.01	Param.
Chromium (mg/L)	MW-1602	0.0008159	0.0005352	0.1	No	21	0	No	0.01	Param.
Chromium (mg/L)	MW-1603	0.0008317	0.000623	0.1	No	21	0	No	0.01	Param.
Chromium (mg/L)	MW-1606	0.0008061	0.0002696	0.1	No	21	0	sqrt(x)	0.01	Param.
Chromium (mg/L)	MW-1607	0.0004568	0.0002817	0.1	No	21	0	sqrt(x)	0.01	Param.
Cobalt (mg/L)	MW-1601	0.001173	0.0004647	0.006	No	19	0	No	0.01	Param.
Cobalt (mg/L)	MW-1602	0.0000924	0.00002284	0.006	No	21	0	ln(x)	0.01	Param.
Cobalt (mg/L)	**MW-1603**	**0.09393**	**0.08479**	**0.006**	**Yes**	**21**	**0**	**No**	**0.01**	**Param.**
Cobalt (mg/L)	MW-1606	0.0003024	0.00009115	0.006	No	21	0	ln(x)	0.01	Param.
Cobalt (mg/L)	MW-1607	0.001426	0.001218	0.006	No	21	0	No	0.01	Param.
Combined Radium 226 + 228 (pCi/L)	MW-1601	1.73	1.02	5	No	19	0	sqrt(x)	0.01	Param.
Combined Radium 226 + 228 (pCi/L)	MW-1602	1.487	0.8491	5	No	21	0	No	0.01	Param.
Combined Radium 226 + 228 (pCi/L)	**MW-1603**	**8.036**	**5.124**	**5**	**Yes**	**21**	**0**	**x^(1/3)**	**0.01**	**Param.**
Combined Radium 226 + 228 (pCi/L)	MW-1606	3.378	2.686	5	No	21	0	No	0.01	Param.
Combined Radium 226 + 228 (pCi/L)	MW-1607	1.824	0.6632	5	No	21	0	sqrt(x)	0.01	Param.
Fluoride (mg/L)	MW-1601	0.2839	0.2031	4	No	20	0	No	0.01	Param.
Fluoride (mg/L)	MW-1602	0.1309	0.1004	4	No	22	0	sqrt(x)	0.01	Param.
Fluoride (mg/L)	MW-1603	1.008	0.818	4	No	23	0	No	0.01	Param.
Fluoride (mg/L)	MW-1606	0.2219	0.1926	4	No	22	0	No	0.01	Param.
Fluoride (mg/L)	MW-1607	0.07289	0.05983	4	No	22	0	No	0.01	Param.
Lead (mg/L)	MW-1601	0.000143	0.000037	0.015	No	19	15.79	No	0.01	NP (normality)
Lead (mg/L)	MW-1602	0.00008439	0.00003996	0.015	No	21	19.05	sqrt(x)	0.01	Param.
Lead (mg/L)	MW-1603	0.006158	0.004308	0.015	No	21	0	No	0.01	Param.
Lead (mg/L)	MW-1606	0.000341	0.00008	0.015	No	21	14.29	No	0.01	NP (normality)
Lead (mg/L)	MW-1607	0.000174	0.00007532	0.015	No	21	4.762	ln(x)	0.01	Param.
Lithium (mg/L)	MW-1601	0.03128	0.02037	0.04	No	19	5.263	No	0.01	Param.
Lithium (mg/L)	MW-1602	0.0101	0.006063	0.04	No	21	4.762	sqrt(x)	0.01	Param.
Lithium (mg/L)	**MW-1603**	**0.2197**	**0.1766**	**0.04**	**Yes**	**21**	**0**	**No**	**0.01**	**Param.**
Lithium (mg/L)	MW-1606	0.007928	0.003617	0.04	No	21	9.524	x^(1/3)	0.01	Param.
Lithium (mg/L)	MW-1607	0.004437	0.0006344	0.04	No	21	9.524	x^(1/3)	0.01	Param.
Mercury (mg/L)	MW-1601	0.000005	0.000005	0.002	No	19	94.74	No	0.01	NP (NDs)
Mercury (mg/L)	MW-1602	0.000005	0.000003	0.002	No	21	61.9	No	0.01	NP (NDs)
Mercury (mg/L)	MW-1603	0.000005	0.000003	0.002	No	21	76.19	No	0.01	NP (NDs)
Mercury (mg/L)	MW-1606	0.000005	0.000003	0.002	No	21	80.95	No	0.01	NP (NDs)
Mercury (mg/L)	MW-1607	0.000005	0.000004	0.002	No	21	90.48	No	0.01	NP (NDs)
Molybdenum (mg/L)	MW-1601	0.02416	0.01194	0.1	No	19	0	No	0.01	Param.
Molybdenum (mg/L)	MW-1602	0.0019	0.001206	0.1	No	21	0	ln(x)	0.01	Param.
Molybdenum (mg/L)	MW-1603	0.00025	0.00011	0.1	No	21	47.62	No	0.01	NP (normality)
Molybdenum (mg/L)	MW-1606	0.00068	0.0005	0.1	No	21	0	No	0.01	NP (normality)
Molybdenum (mg/L)	MW-1607	0.0008	0.00054	0.1	No	21	0	No	0.01	NP (normality)
Selenium (mg/L)	MW-1601	0.0003291	0.0001248	0.05	No	19	0	ln(x)	0.01	Param.
Selenium (mg/L)	MW-1602	0.002212	0.00124	0.05	No	21	0	No	0.01	Param.
Selenium (mg/L)	MW-1603	0.005892	0.004473	0.05	No	21	0	No	0.01	Param.
Selenium (mg/L)	MW-1606	0.0001179	0.00005563	0.05	No	21	19.05	ln(x)	0.01	Param.

Confidence Interval Summary Table - All Results

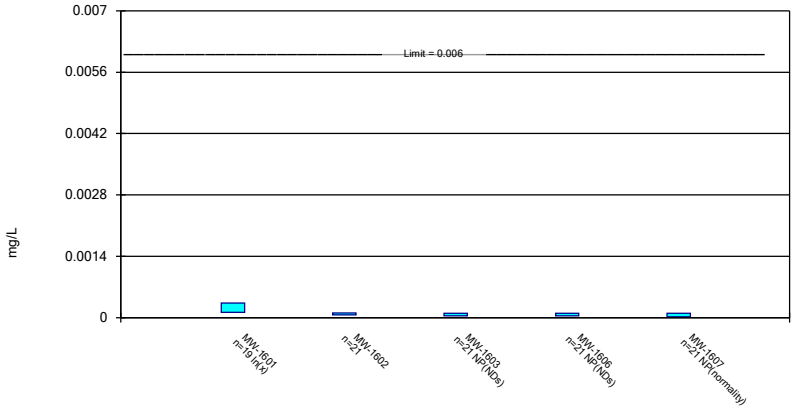
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP Printed 8/23/2022, 8:46 AM

Constituent	Well	Upper Lim.	Lower Lim.	Compliance	Sig.	N	%NDs	Transform	Alpha	Method
Selenium (mg/L)	MW-1607	0.00025	0.00009	0.05	No	21	14.29	No	0.01	NP (normality)
Thallium (mg/L)	MW-1601	0.0002	0.00002	0.002	No	19	36.84	No	0.01	NP (normality)
Thallium (mg/L)	MW-1602	0.0002	0.00002	0.002	No	21	47.62	No	0.01	NP (normality)
Thallium (mg/L)	MW-1603	0.001666	0.001367	0.002	No	21	0	No	0.01	Param.
Thallium (mg/L)	MW-1606	0.0002	0.00003	0.002	No	21	61.9	No	0.01	NP (NDs)
Thallium (mg/L)	MW-1607	0.0002	0.00003	0.002	No	21	38.1	No	0.01	NP (normality)

Sanitas™ v.9.6.35 . UG

Parametric and Non-Parametric (NP) Confidence Interval

Compliance Limit is not exceeded. Per-well alpha = 0.01. Normality Test: Shapiro Wilk, alpha based on n.



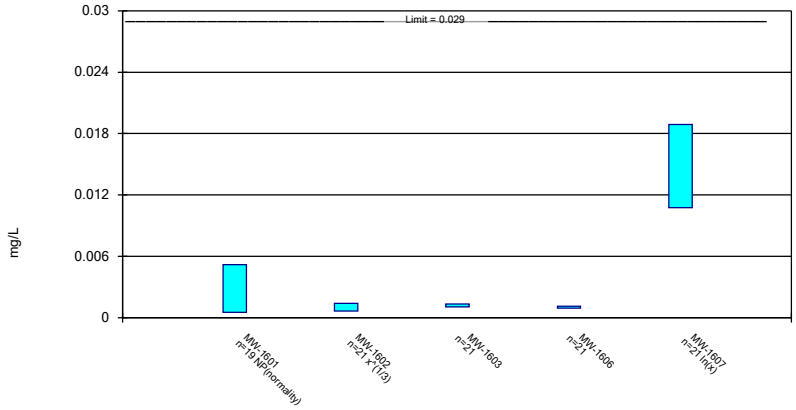
Constituent: Antimony Analysis Run 8/23/2022 8:45 AM View: AIV

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.35 . UG

Parametric and Non-Parametric (NP) Confidence Interval

Compliance Limit is not exceeded. Per-well alpha = 0.01. Normality Test: Shapiro Wilk, alpha based on n.



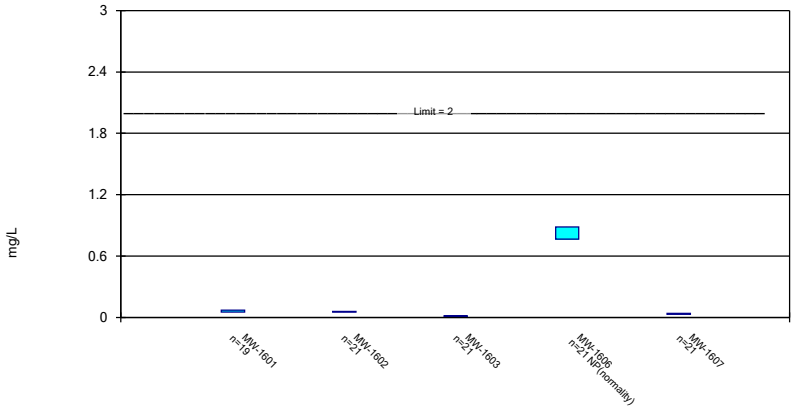
Constituent: Arsenic Analysis Run 8/23/2022 8:45 AM View: AIV

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.35 . UG

Parametric and Non-Parametric (NP) Confidence Interval

Compliance Limit is not exceeded. Per-well alpha = 0.01. Normality Test: Shapiro Wilk, alpha based on n.



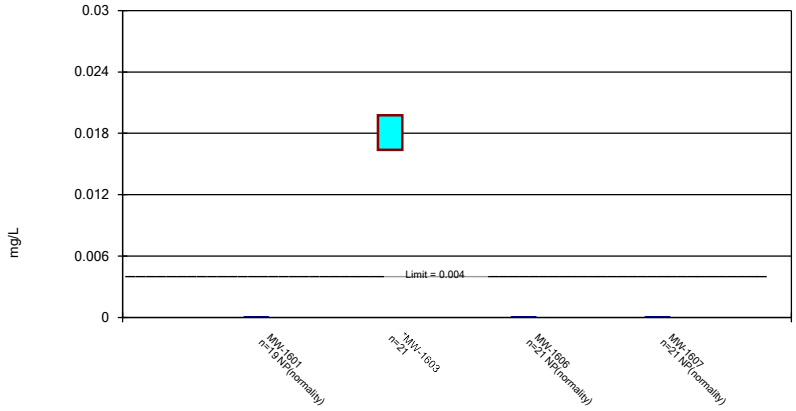
Constituent: Barium Analysis Run 8/23/2022 8:45 AM View: AIV

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.35 . UG

Parametric and Non-Parametric (NP) Confidence Interval

Compliance limit is exceeded.* Per-well alpha = 0.01. Normality Test: Shapiro Wilk, alpha based on n.



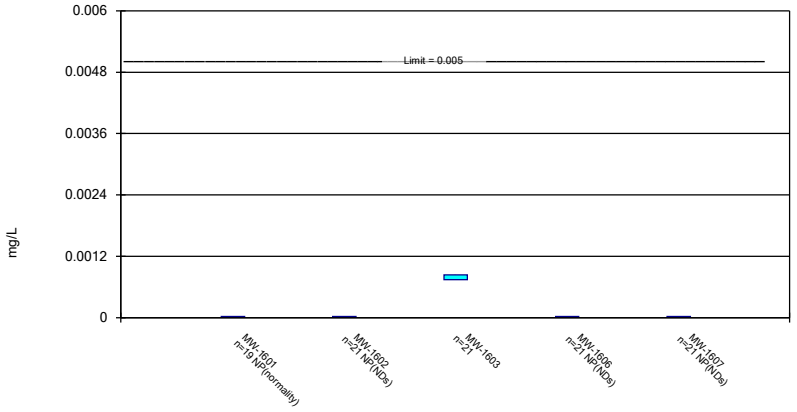
Constituent: Beryllium Analysis Run 8/23/2022 8:45 AM View: AIV

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.35 . UG

Parametric and Non-Parametric (NP) Confidence Interval

Compliance Limit is not exceeded. Per-well alpha = 0.01. Normality Test: Shapiro Wilk, alpha based on n.



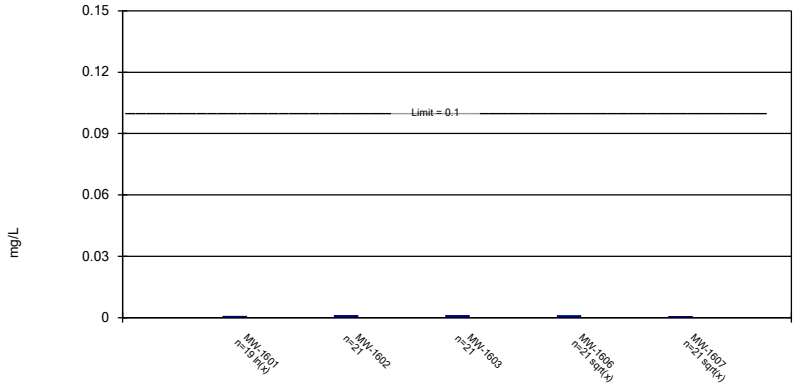
Constituent: Cadmium Analysis Run 8/23/2022 8:45 AM View: AIV

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.35 . UG

Parametric Confidence Interval

Compliance Limit is not exceeded. Per-well alpha = 0.01. Normality Test: Shapiro Wilk, alpha based on n.



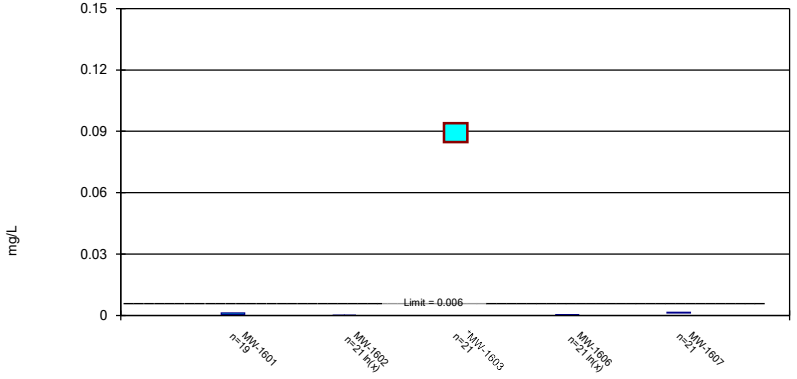
Constituent: Chromium Analysis Run 8/23/2022 8:45 AM View: AIV

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.35 . UG

Parametric Confidence Interval

Compliance limit is exceeded.* Per-well alpha = 0.01. Normality Test: Shapiro Wilk, alpha based on n.



Constituent: Cobalt Analysis Run 8/23/2022 8:45 AM View: AIV

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.35 . UG

Parametric Confidence Interval

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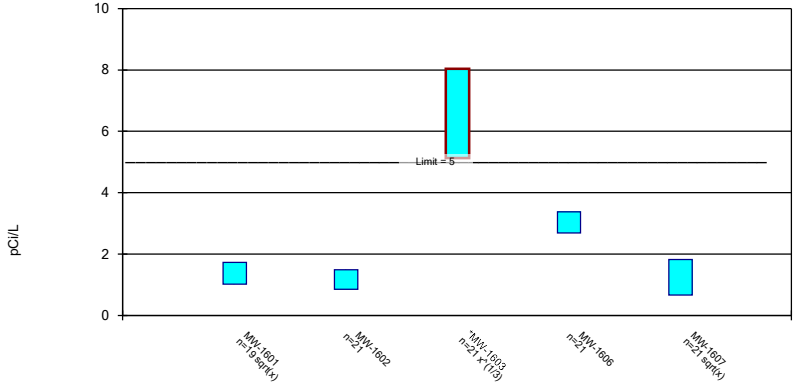

Constituent: Combined Radium 226 + 228 Analysis Run 8/23/2022 8:45 AM View: AIV

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.35 . UG

Parametric Confidence Interval

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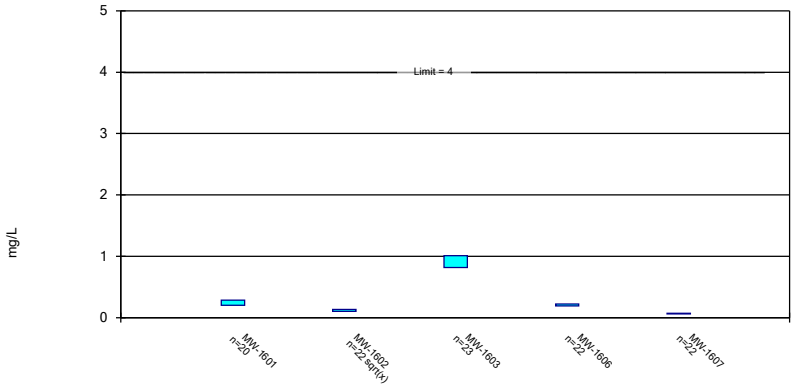
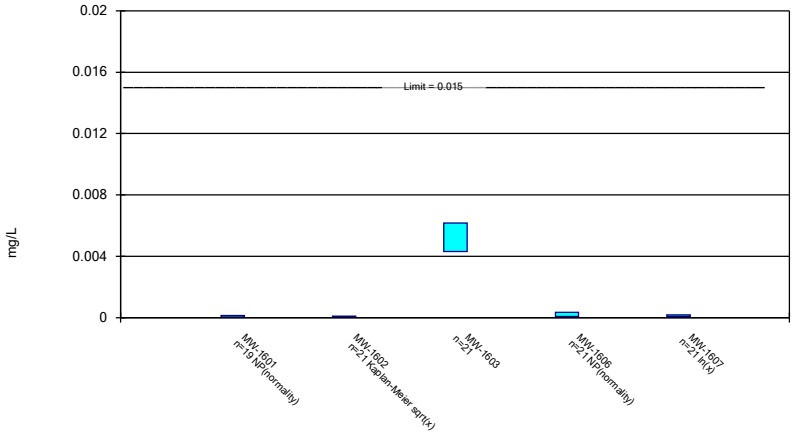


Constituent: Fluoride Analysis Run 8/23/2022 8:45 AM View: AIV
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.35 . UG

Parametric and Non-Parametric (NP) Confidence Interval

Compliance Limit is not exceeded. Per-well alpha = 0.01. Normality Test: Shapiro Wilk, alpha based on n.



Constituent: Lead Analysis Run 8/23/2022 8:45 AM View: AIV
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.35 . UG

Parametric Confidence Interval

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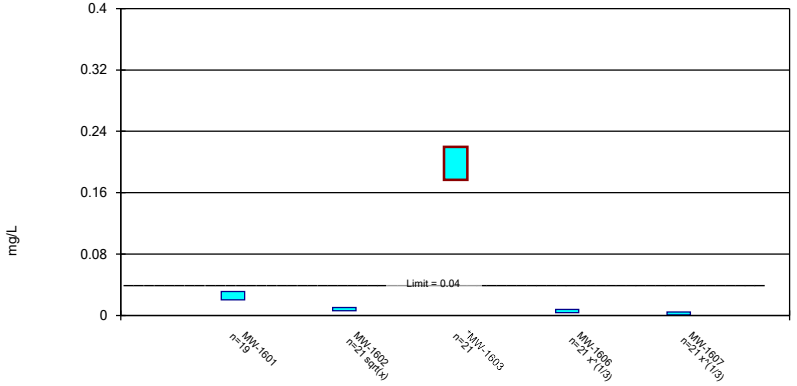

Constituent: Lithium Analysis Run 8/23/2022 8:45 AM View: AIV
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.35 . UG

Non-Parametric Confidence Interval

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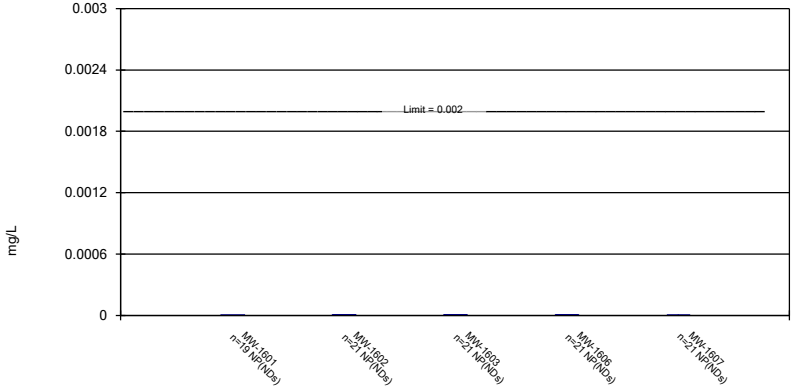
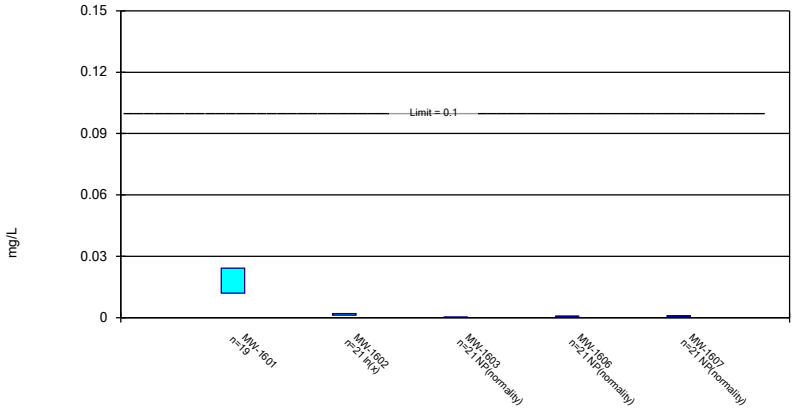


Constituent: Mercury Analysis Run 8/23/2022 8:45 AM View: AIV
Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.35 . UG

Parametric and Non-Parametric (NP) Confidence Interval

Compliance Limit is not exceeded. Per-well alpha = 0.01. Normality Test: Shapiro Wilk, alpha based on n.



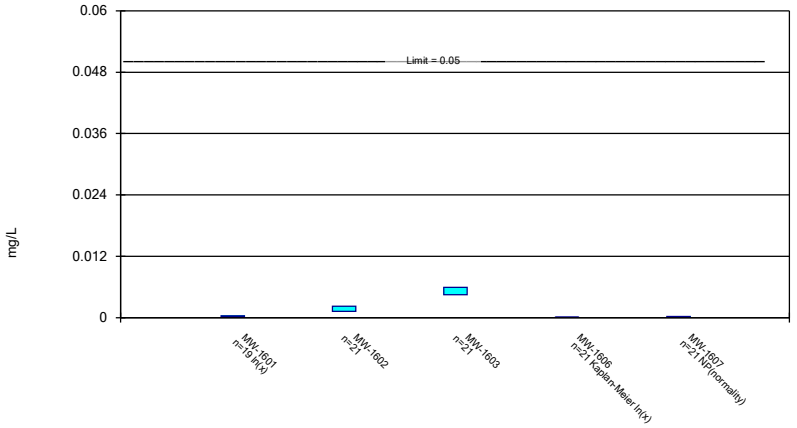
Constituent: Molybdenum Analysis Run 8/23/2022 8:45 AM View: AIV

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.35 . UG

Parametric and Non-Parametric (NP) Confidence Interval

Compliance Limit is not exceeded. Per-well alpha = 0.01. Normality Test: Shapiro Wilk, alpha based on n.



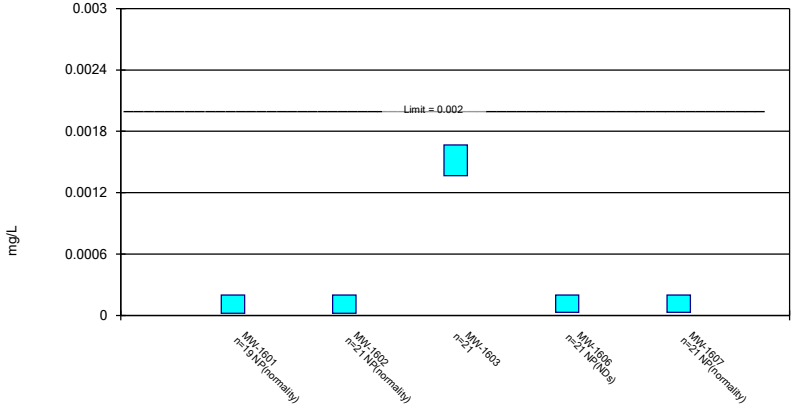
Constituent: Selenium Analysis Run 8/23/2022 8:45 AM View: AIV

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

Sanitas™ v.9.6.35 . UG

Parametric and Non-Parametric (NP) Confidence Interval

Compliance Limit is not exceeded. Per-well alpha = 0.01. Normality Test: Shapiro Wilk, alpha based on n.



Constituent: Thallium Analysis Run 8/23/2022 8:45 AM View: AIV

Big Sandy FAP Client: Geosyntec Data: Big Sandy FAP

APPENDIX 2
ALTERNATIVE SOURCE DEMONSTRATION REPORTS

Alternative Source Demonstration Addendum Report for the October 2021 Monitoring Data

Big Sandy Fly Ash Pond
Louisa, Kentucky

Prepared for:

American Electric Power

Prepared by:

EHS Support

March 2022

Table of Contents

List of In-Text Tables

List of Attached Tables

List of In-Text Figures

List of Attached Figures

List of Appendices

Acronyms

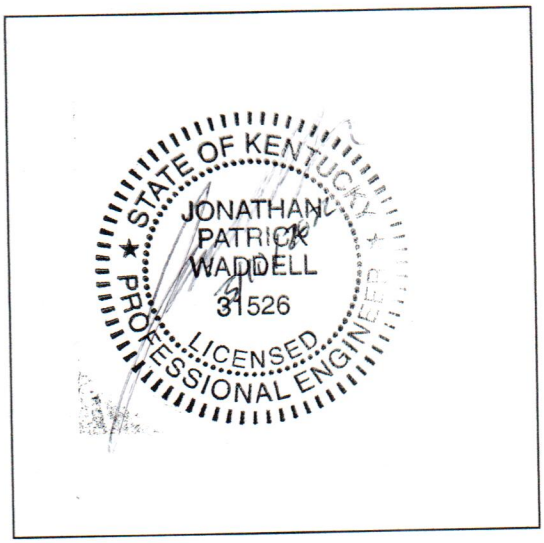
µg/L	micrograms per liter
AEP	American Electric Power
ASD	alternative source demonstration
bgs	below ground surface
BSFAP	Big Sandy Fly Ash Pond
CCR	coal combustion residual
CFR	Code of Federal Regulations
EPRI	Electric Power Research Institute
ft	foot/feet
GWPS	Groundwater Protection Standards
KGS	Kentucky Geological Survey
LCL	lower confidence level
MDL	method detection limit
mg/L	milligrams per liter
msl	mean sea level
NORM	naturally occurring radioactive materials
ORP	oxidation-reduction potential
pCi/L	picocuries per liter
ppm	parts per million
S.U.	standard units (pH)
SSL	statistically significant level
TDS	total dissolved solids
UCL	upper confidence level
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

Certification by Qualified Professional Engineer

I certify that the alternative source demonstration (ASD) conducted and presented within this report is accurate and appropriate for evaluating the groundwater monitoring data for the Big Sandy Fly Ash Pond Coal Combustion Residual (CCR) management area associated with the Big Sandy Power Plant located in Louisa, Kentucky. This ASD meets the requirements of the United States Environmental Protection Agency CCR Rule defined at 40 Code of Federal Regulations 257.95(g)(3)(ii).

Jonathan Patrick Waddell

Printed Name of Licensed Professional Engineer



Signature

31526

License Number

KY

Licensing State

3/10/2022

Date

1 Introduction

EHS Support LLC ("EHS Support") was retained by the American Electric Power (AEP) – Kentucky Power Company in December 2018 to conduct an alternative source demonstration (ASD) investigation for coal combustion residual (CCR) constituents in groundwater near the Big Sandy Fly Ash Pond (BSFAP or "Site"). The BSFAP is associated with the Big Sandy Power Plant located in Louisa, Kentucky (EHS Support, 2019a). The ASD determined that groundwater in the vicinity of the Site was not being impacted by CCR constituents from the BSFAP. The statistically significant levels (SSLs) of beryllium, cobalt, and lithium concentrations present in excess of the Groundwater Protection Standards (GWPS), which triggered the ASD investigation, were determined to be a result of the oxidation of coal seams that were intersected by the borehole and well screen for well MW-1603.

Since the initial ASD investigation was completed (incorporating data from September 2016 to October 2018), the following ASD investigations have been conducted:

- The second ASD investigation was conducted after the March 2019 groundwater monitoring data indicated continued SSLs of beryllium, cobalt, and lithium exceeding the GWPS at MW-1603 (EHS Support, 2019b).
- The third ASD investigation was conducted following continued detections of beryllium, cobalt, and lithium at SSLs above the GWPS in MW-1603 during the August 2019 sampling event (EHS Support, 2020). In addition, an SSL of radium 226 combined with radium 228 (hereafter radium 226/228) was measured above its GWPS for the first time in MW-1603 groundwater during the August 2019 sampling event (EHS Support, 2020).
- The fourth ASD investigation was conducted following continued detections of four constituents (beryllium, cobalt, lithium, and radium 226/228) at SSLs above the GWPS in MW-1603 in March and June 2020 (EHS Support, 2021a).
- The fifth ASD investigation was conducted following continued detections of three constituents (beryllium, cobalt, and lithium) at SSLs above the GWPS in MW-1603 in October 2020 (EHS Support, 2021b).
- The sixth ASD investigation was conducted following continued detections of three constituents (beryllium, cobalt, and lithium) at SSLs above the GWPS in MW-1603 in March and June 2021 (EHS Support, 2021c).

In October 2021, four constituents (beryllium, cobalt, lithium, and radium 226/228) were detected at SSLs above the GWPS in MW-1603, thus requiring the ASD addendum investigation presented in this report. This ASD addendum investigation has been prepared per the requirements of the United States Environmental Protection Agency (USEPA) CCR Rule (40 Code of Federal Regulations [CFR] §257.95). The concentrations of beryllium, cobalt, lithium, and radium 226/228 in MW-1603 groundwater were determined herein to result from Type IV natural variations in groundwater (ASD types are discussed in **Section 3.1**). This conclusion was reached by examining analytical results for compounds detected at SSLs in the context of the broader list of CCR constituents analyzed at the Site.

1.1 Objective

The objective of this ASD investigation is to assess groundwater monitoring data collected in compliance with the CCR Rule, as allowed under paragraph 40 CFR §257.95(g)(3)(ii). This part of the CCR Rule allows

AEP to determine whether the source(s) for SSLs of beryllium, cobalt, lithium, and radium 226/228 exceeding the GWPSs, as reported in groundwater monitoring well MW-1603, are associated with the CCR unit; or alternatively if the SSL resulted from an error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality.

1.2 Lines of Evidence

This ASD investigation for the BSFAP has been conducted to further evaluate potential alternate sources or reasons for the continued detection of SSLs of beryllium, cobalt, lithium, and radium 226/228 in groundwater samples from monitoring well MW-1603.

A potential alternate source was previously identified in prior ASD investigations (EHS Support, 2019a, 2019b, 2020, 2021a, 2021b, and 2021c), based on the following lines of evidence:

- A lack of exceedances and increasing trends of primary indicators of CCR.
- Constituent concentrations in BSFAP water are lower than those of the corresponding constituent observed in groundwater from MW-1603.
- Major ion chemistry was not indicative of mixing between BSFAP water and groundwater.
- Acidic groundwater in MW-1603 (pH 3 to 5.5 standard units [S.U.]) is not indicative of BSFAP water (pH 7.97).

For the purposes of this ASD addendum investigation, constituents were identified that would serve as a primary indicator for CCR. A primary indicator must meet **both** of the following criteria:

1. The constituent typically has a high concentration in CCR leachate, relative to background, such that it is expected to have an elevated concentration in the event of a release.
2. The constituent is unreactive and has high mobility in groundwater, such that it is expected to be at the leading edge of the plume. Consequently, the constituent will have elevated concentrations relative to background across the entire area of the plume.

As boron and sulfate are primary indicators for CCR (Electric Power Research Institute [EPRI], 2012) and have previously been evaluated, they have been re-evaluated herein as primary indicators for this ASD investigation. In addition, chloride is used as a primary indicator for this ASD. Other potential indicators that were evaluated in this ASD investigation include bromide, fluoride, molybdenum, potassium, and sodium.

2 Project Background

A detailed description of Site location, history, and geology was provided in the *Alternative Source Demonstration Report for Beryllium, Cobalt and Lithium, Big Sandy Fly Ash Pond, Louisa, Kentucky* (EHS Support, 2019a). Attached **Figure 1** and **Figure 2** show the Site layout and groundwater monitoring network, respectively.

To support and provide context to this ASD addendum investigation, **Section 2.1** and **Section 2.2** describe the groundwater monitoring network and groundwater monitoring activities.

2.1 Groundwater Monitoring Network Evaluation

On behalf of AEP, Geosyntec Consultants, Inc. ("Geosyntec") conducted an assessment of the groundwater monitoring network in the uppermost aquifer associated with the BSFAP (Geosyntec, 2016). Geosyntec determined that the hydrostratigraphy in the vicinity of the BSFAP is characterized by an interconnected water-bearing system comprised of Pennsylvanian-aged bedrock (of the Breathitt Group, Conemaugh Formation) and Quaternary alluvium. The Conemaugh Formation and Breathitt Group consist of sandstones, siltstones, shale, and coal that may grade laterally and vertically into one another. The overlying Quaternary alluvial deposits include sandy lean clay to silty sand and gravel at the bottom of the Horseford Creek valley and the floodplain of Blaine Creek. Based on these hydrogeologic conditions, Geosyntec defined the interconnected water-bearing system of the fractured bedrock and alluvium as the uppermost aquifer for the BSFAP CCR unit. This determination was based on the presence of groundwater in numerous monitoring wells screened in the water-bearing unit (fractured bedrock and alluvium), the recovery of these wells during pumping and development, and a potentiometric surface generally consistent with Site topography and surface water elevations.

Geosyntec defined the groundwater detection monitoring network as consisting of ten monitoring wells to assess the upper water-bearing aquifer (fractured bedrock and alluvium) (Geosyntec, 2016). Of these monitoring wells, six locations (MW-1011, MW-1012, MW-1203, MW-1601, MW-1602, and MW-1603) are screened in fractured sandstone and shale layers of the Breathitt formation. The remaining four monitoring wells (MW-1604 through MW-1607) are screened in the alluvium. The location of each groundwater monitoring well within the uppermost aquifer is shown in **Figure 2**.

Three of the monitoring wells (MW-1011, MW-1012, and MW-1203) screened in bedrock were installed on the hillside slopes upgradient of the BSFAP to support background monitoring. Three monitoring wells (MW-1601, MW-1602, and MW-1603) were installed in bedrock located downgradient of the BSFAP and used for compliance monitoring. Two monitoring wells (MW-1604 and MW-1605) side gradient of the BSFAP are screened in alluvium and are used for background monitoring. The remaining two monitoring wells (MW-1606 and MW-1607) are located south of the Main Dam (**Figure 1**). These locations are screened in the alluvium downgradient of the BSFAP and used for compliance monitoring.

Geosyntec determined that the groundwater monitoring well network described above meets the requirements of 40 CFR §257.91, as it consists of a sufficient number of wells installed at the appropriate locations and depths to yield groundwater samples from the uppermost aquifer. Thus, the current groundwater monitoring network accurately represents the quality of background groundwater and groundwater passing the waste boundary of the BSFAP.

As bedrock monitoring well MW-1603 is the focus of this ASD, the boring log was reviewed to assess the lithology that could impact groundwater chemistry (EHS Support, 2019a). The boring log descriptions show alternating sequences of yellowish-brown sandstones and bluish-gray to black shales beginning at 13 feet below ground surface (ft bgs) and extending to the total depth of the boring at 39.5 ft bgs. This lithologic description is indicative of the upper portion of the Princess Formation (uppermost formation in the Breathitt Group [Rice and Hiett, 1994]). Within the MW-1603 screened interval (22 to 32 ft bgs), the shale at a depth of 24 to 25 ft bgs was described as "intensely fractured, black, wet, nearly all organic matter; slight coaly texture." This depth (24 to 25 ft bgs) corresponds with the measurements by the Kentucky Geological Survey (KGS) of the elevation of the Princess Number 8 coal, which is present within the Princess Formation of the Breathitt Group (EHS Support, 2019a).

Coal or "organic material" was also visually identified on the MW-1608, MW-1609, and MW-1610 boring logs at the same approximate elevation, between 630 and 650 feet, that aligns with the KGS measurements (**Table 2-1**). No coal was documented in this section in three monitoring wells (MW-1601, MW-1602, and MW-1611). Four monitoring wells (MW-1604, MW-1605, MW-1606, and MW-1607) were installed stratigraphically below this coal layer.

Table 2-1 Screened Interval of Monitoring Wells

Well/Boring	Surface Elevation (ft msl)	Screened Interval (ft msl)	Coal or "Organics" Description at ~632-650 ft
MW-1601	713.8	646.8-636.8	No coal logged
MW-1602	711.6	632.1-622.1	No coal logged
MW-1603	673.2	651.2-641.2	Yes, at a depth of ~25 ft (Elevation of 648 ft)
MW-1604	553.1	513.1-503.1	---
MW-1605	554.4	538.9-528.9	---
MW-1606	551	513.1-503.1	---
MW-1607	542.2	518.7-508.7	---
MW-1608	716.2	606.6-596.6	Yes, at depths of ~74 ft (Elevation of 642 ft), ~ 75.3 to 76.6 ft (Elevation of 641 to 640 ft), and ~ 83.5 to 84 ft (Elevation of 633 to 632 ft)
MW-1609	~728	---	Yes, at a depth of ~79 ft (Elevation of 649 ft)
MW-1610	~716	---	Yes, at a depth of ~81 ft (Elevation of 635 ft)
MW-1611	~711	606-596	No coal logged

--- = Boring advanced below the coal interval
~ = Approximate
ft = feet
msl = mean sea level

2.2 Groundwater Monitoring

AEP has conducted groundwater monitoring of the uppermost aquifer to meet the requirements of the CCR Rules. Groundwater monitoring generally included the following activities:

- Collection of groundwater samples and analysis for Appendix III and Appendix IV constituents, as specified in 40 CFR §257.94 et seq. and AEP's Groundwater Sampling and Analysis Plan (AEP and EHS Support, 2016).
- Completion of validation tests for groundwater data, including tests for completeness, valid values, transcription errors, and consistent units.
- Establishment of background data for each Appendix III and Appendix IV constituent.
- Initiation of detection monitoring sampling and analysis.
- Evaluation of the groundwater data using a statistical process per 40 CFR §257.93, which was prepared, certified, and originally posted to AEP's CCR website in April 2017 in AEP's Statistical Analysis Plan (Geosyntec, 2017) and updated as Revision 1 in January 2021 (Geosyntec, 2021); the statistical process was guided by USEPA's Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance (USEPA, 2009).
- Initiation of assessment monitoring sampling and analysis.
- Completion of statistical data evaluation and determination of GWPS.

Assessment monitoring for the BSFAP has been conducted on a semi-annual basis since April 2018. The groundwater data collected through the October 2021 monitoring event have been used for this ASD addendum investigation. Historical groundwater monitoring data for MW-1603 is provided in **Table 1** (attached). The October 2021 groundwater data was evaluated, and no data usability issues were found (Geosyntec, 2021b). Assessment monitoring data for well MW-1603 in October 2021 is provided in **Table 2-2**.

Table 2-2 MW-1603 October 2021 Groundwater Quality

Analyte	Unit	October 2021 Value
Antimony	µg/L	< 0.02
Arsenic	µg/L	1.01
Barium	µg/L	17.1
Beryllium	µg/L	17.4
Boron	mg/L	0.054
Bromide	mg/L	0.03
Cadmium	µg/L	0.0931
Calcium	mg/L	93.1
Chloride	mg/L	3.93
Chromium	µg/L	0.59
Cobalt	µg/L	95.1
Fluoride	mg/L	0.96
Lead	µg/L	6.10
Lithium	mg/L	0.186
Mercury	µg/L	0.003

Analyte	Unit	October 2021 Value
Molybdenum	µg/L	< 0.1
pH	S.U.	3.23
Potassium	mg/L	4.6
Radium 226/228	pCi/L	10.51
Residue, Filterable, TDS	mg/L	1,040
Selenium	µg/L	4.26
Sodium	mg/L	24
Sulfate	mg/L	735
Thallium	µg/L	2.2

< = non detect at method detection limit (MDL)
µg/L = micrograms per liter
mg/L = milligrams per liter
NA = constituent not analyzed
pCi/L = picocuries per liter
S.U. = standard units
TDS = total dissolved solids

AEP submitted the October 2021 monitoring data to Groundwater Stats Consulting, LLC for statistical analysis. A GWPS was established for each of the Appendix IV parameters. Confidence intervals, including lower confidence levels (LCLs) and upper confidence levels (UCLs), were calculated for Appendix IV parameters at the compliance wells to assess whether Appendix IV parameters were present at an SSL above the GWPS. Based on this statistical analysis of the October 2021 data, the following SSLs were identified at the BSFAP in MW-1603 (no other monitoring well had constituents exceeding a GWPS):

- The LCL for beryllium exceeded the GWPS of 0.004 milligrams per liter (mg/L) at MW-1603 (0.0166 mg/L).
- The LCL for cobalt exceeded the GWPS of 0.006 mg/L at MW-1603 (0.0855 mg/L).
- The LCL for lithium exceeded the GWPS of 0.04 mg/L at MW-1603 (0.181 mg/L).
- The LCL for radium 226/228 exceeded the GWPS of 5.00 picocuries per liter (pCi/L) at MW-1603 (5.11 pCi/L).

3 Alternative Source Demonstration Requirements

Potential causes that may support an ASD include, but are not limited to, sampling causes (ASD Type I), laboratory causes (ASD Type II), statistical evaluation causes (ASD Type III), and/or natural variation causes (ASD Type IV).

3.1 Alternative Source Demonstration

This ASD for the BSFAP is focused on assessing whether Type IV natural variations in groundwater could be the cause of the SSLs of beryllium, cobalt, lithium, and radium 226/228 reported for groundwater collected from monitoring well MW-1603 during the October 2021 sampling.

Historical groundwater monitoring data for MW-1603 is provided in **Table 1** (attached).

3.2 Assessment of Groundwater Monitoring Results

The following constituents will typically provide the information required for a complete ASD:

- Primary indicators (boron and sulfate) are evaluated for potential BSFAP leachate.
- Major ion concentrations (alkalinity, chloride, sulfate, calcium, magnesium, potassium, and sodium) in leachate and groundwater are used to evaluate whether downgradient groundwater chemistry remains representative of background groundwater chemistry. Major ion chemistry can also be used to evaluate natural variability due to seasonal changes or other causes.
- Field turbidity of groundwater is used as an indicator of the presence of suspended solids that may contribute to elevated concentrations of constituents monitored in unfiltered samples under the CCR Rule.
- The pH of leachate and groundwater provides information on chemical reactions and potential mobility of constituents in groundwater.
- Dissolved oxygen, oxidation-reduction potential (ORP), iron, and manganese in groundwater are used as indicators of redox conditions. Redox changes can affect the chemical state and solubility of sulfate, in addition to trace elements including arsenic and selenium. For example, under strongly reduced conditions (ORP less than -200 millivolts at pH 7), sulfate can be reduced to form hydrogen sulfide, or it can precipitate as iron sulfide, arsenic reduces to more mobile arsenite species, and selenium reduces to the low-mobility selenite species.

Groundwater monitored at a CCR unit for compliance with the CCR Rule is a compilation of the history of all sources of water comingling at that particular monitoring well. Different sources may contribute to the presence and detection of the same constituents, making source identification challenging. The identification and use of water quality “signatures” can be used as a tool for deciphering the similarity between potential sources and the water quality at a specific monitoring point.

4 Alternative Source Demonstration Assessment

As stated within **Section 1.2**, the primary indicators for CCR leachate impacts to groundwater are boron and sulfate. In addition to these two constituents, chloride is also used as a primary indicator for this ASD. Other potential indicators that have been evaluated include bromide, fluoride, molybdenum, potassium, and sodium.

As identified in **Section 1.1**, SSLs of beryllium, cobalt, and lithium have been reported in groundwater samples above the GWPS from monitoring well MW-1603 in October 2021. The water quality signatures for well MW-1603 are discussed in **Section 4.3** and compared to the water quality of the BSFAP.

EPRI (2012) defines three tiers of investigation for evaluation of water quality signatures to determine if elevated concentrations represent a release from a CCR facility:

- Tier I: Trend Analysis and Statistics
- Tier II: Advanced Geochemical Evaluation Methods
- Tier III: Isotopic Analyses

Conversely, these tools can also be used to evaluate whether or not sources other than CCR are contributing to groundwater quality degradation.

The CCR Rule requires statistical analysis under assessment monitoring for the determination of SSLs above the GWPS. Many of the primary and potential indicator constituents listed for CCR (EPRI, 2017) are included in AEP's constituent list for the BSFAP groundwater monitoring programs, including primary constituents boron and sulfate. If there is an SSL without a corresponding increase in a primary indicator constituent (boron and usually sulfate for CCR), then this is a key line of evidence for an ASD.

4.1 Groundwater Data Analysis

Temporal plots are provided in **Section 4.1.1** through **Section 4.1.3** for monitoring well MW-1603 (**Figure 4-1** through **Figure 4-13**). Each of the plots uses the following color-coding system:

- Red – indicates a concentration reported above the reporting limit.
- Orange – indicates a concentration reported below the reporting limit but greater than the method detection limit (MDL) (denoted as estimated "J" values).
- Green – indicates a concentration not detected at or above the MDL (denoted as "U"); results were conservatively plotted as the MDL.

The BSFAP water signature from October 2017 is plotted as a constant concentration in **Figure 4-1** through **Figure 4-13** for comparison. It is probable that BSFAP water quality historically varied over time since the BSFAP accepted fly ash before 1970. However, the BSFAP ceased accepting fly ash in November 2015 and the surface water quality is anticipated to be more stable following this termination of relatively constant fly ash addition. Therefore, the October 19, 2017 data provides a reasonable representation of BSFAP surface water conditions. Shortly after the October 2017 sample collection, BSFAP closure work, including contouring of CCR in preparation for geomembrane cover installation, began near the surface water collection area and samples were no longer representative. Geomembrane installation was completed over the entire BSFAP in November 2020 and the BSFAP is now closed.

Groundwater constituents for well MW-1603 are plotted on the primary y-axis and BSFAP water constituents are plotted on the secondary y-axis due to the differences in concentration (**Figure 4-1** through **Figure 4-13**).

4.1.1 Primary Indicators

Temporal plots for primary indicators boron, sulfate, and chloride reported in groundwater monitoring well MW-1603 are provided in **Figure 4-1** to **Figure 4-3**, respectively (note the y-axis scales associated with the BSFAP data).

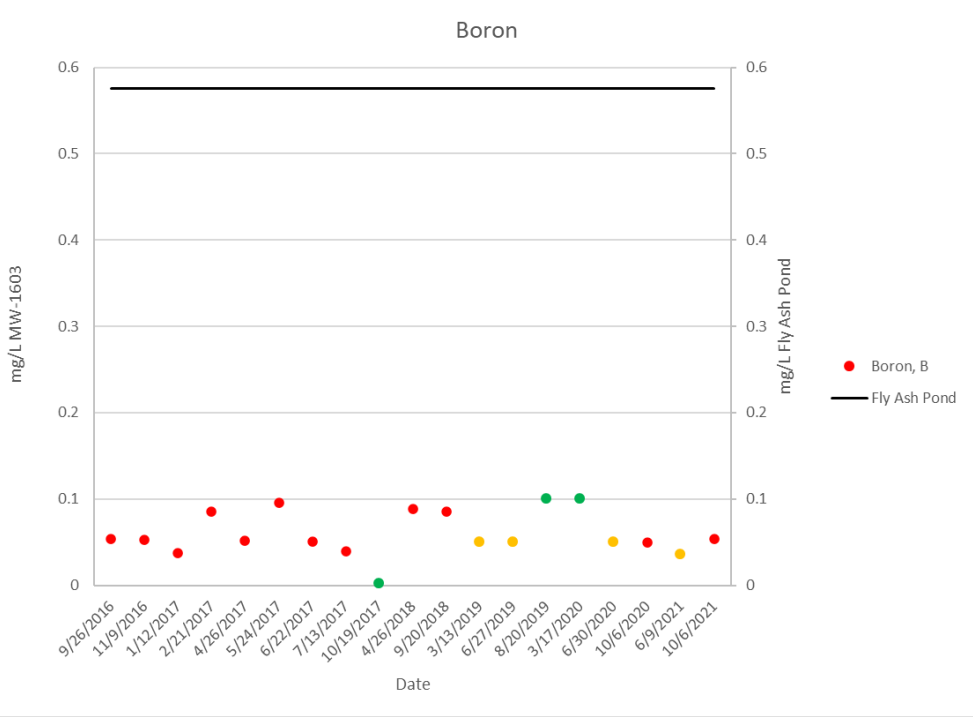


Figure 4-1 MW-1603 Boron Concentrations

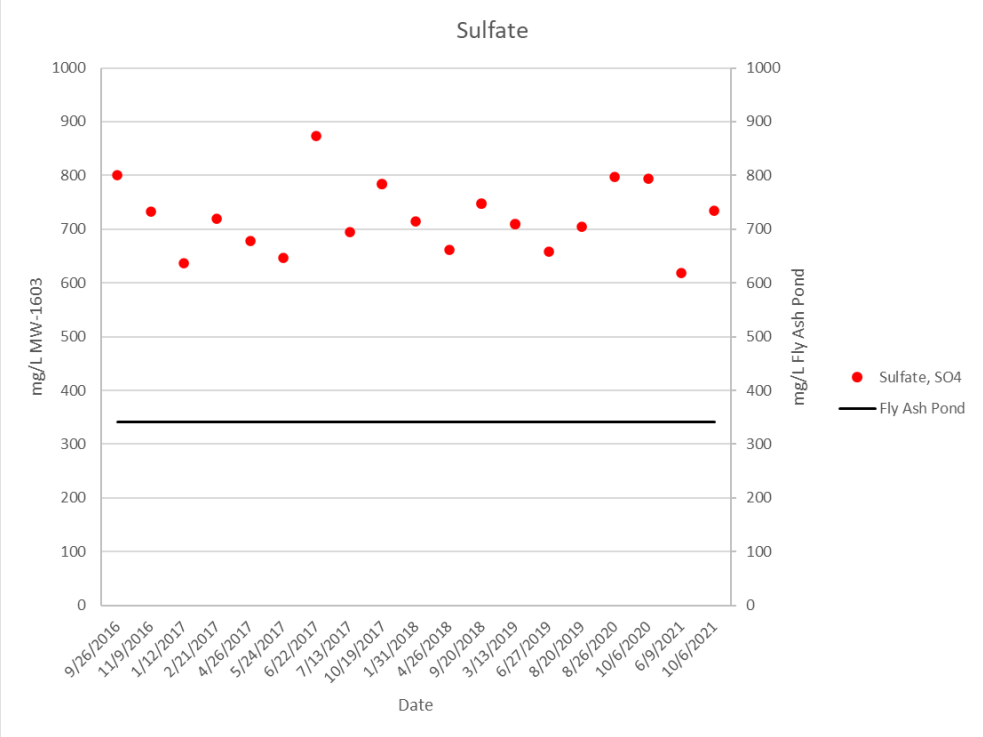


Figure 4-2 MW-1603 Sulfate Concentrations

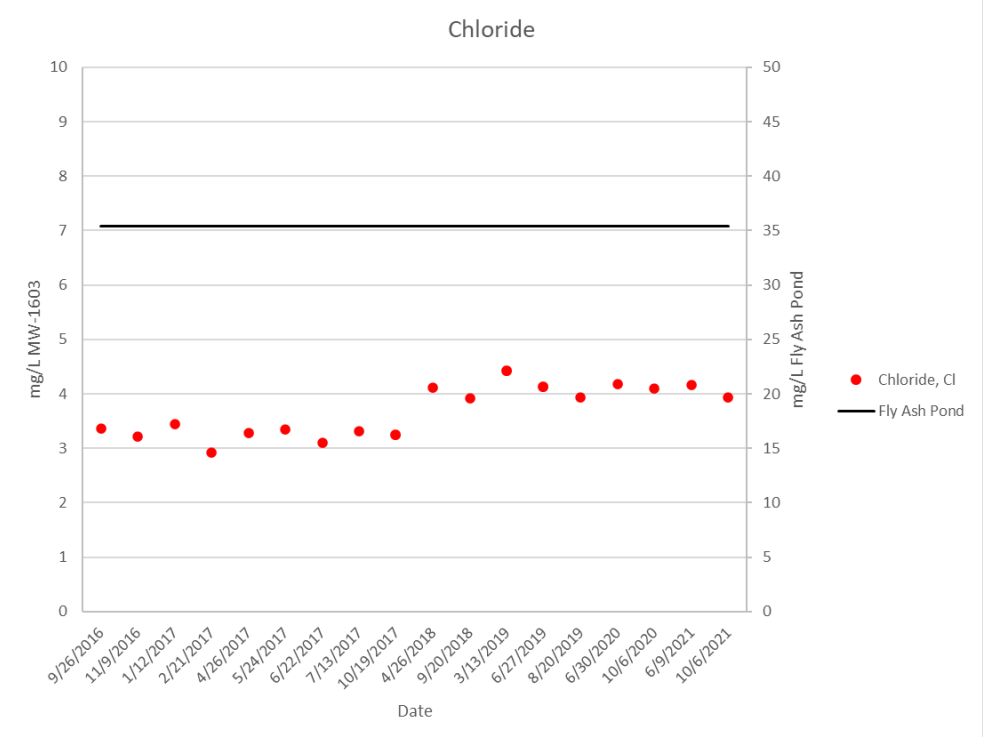


Figure 4-3 MW-1603 Chloride Concentrations

Boron and sulfate concentrations in MW-1603 have remained relatively stable, within the same order of magnitude, with minor variability over the monitoring period (September 2016 through October 2021). Chloride concentrations in MW-1603 remained relatively stable until April 2018, after which a slight increase is observed and is followed by stable concentrations. Given the overall very low chloride concentrations at MW-1603 (an order of magnitude lower than in the BSFAP), this slight apparent increase in chloride of approximately 1 mg/L is minimal and most likely reflects a change in sampling or analytical procedure. Boron and chloride in water from the BSFAP are present at higher concentrations than in groundwater at MW-1603, whereas sulfate is present at higher concentrations in groundwater at MW-1603 than in water from the BSFAP.

In summary, there were negligible changes in primary indicator concentrations since the last review in November 2021 (EHS Support, 2021c).

4.1.2 Potential Indicators

Temporal plots for potential indicators (bromide, fluoride, molybdenum, potassium, and sodium) reported in groundwater monitoring well MW-1603 are provided in **Figure 4-4** to **Figure 4-8**, respectively.

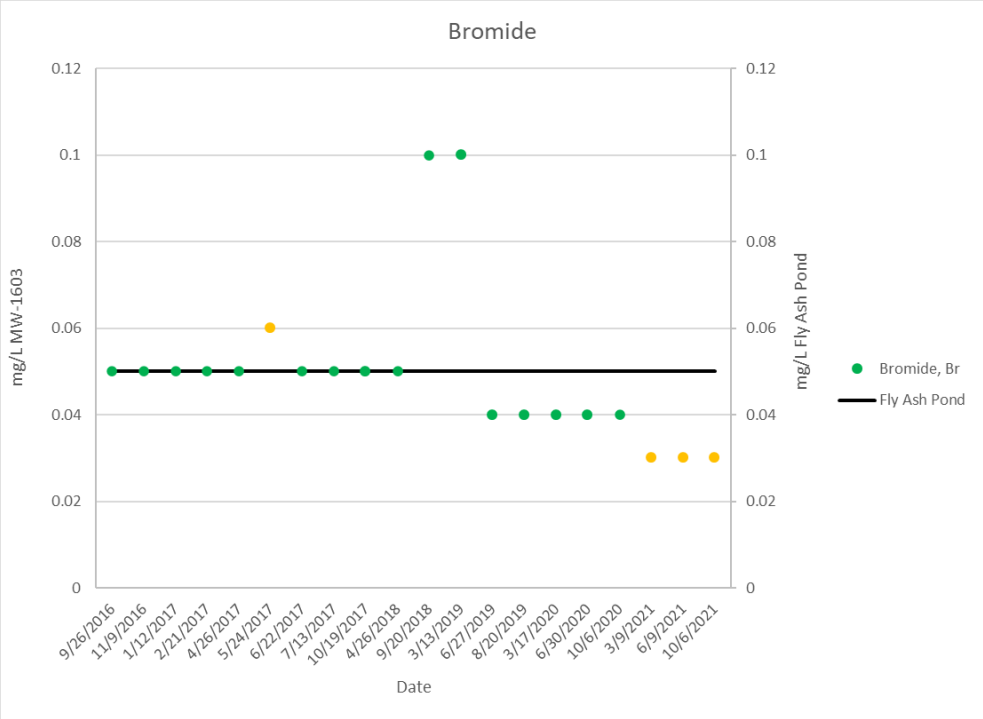


Figure 4-4 MW-1603 Bromide Concentrations[1]

[1] Bromide is below the reporting limit for BSFAP water; therefore, it is plotted at the MDL of 0.05 mg/L.

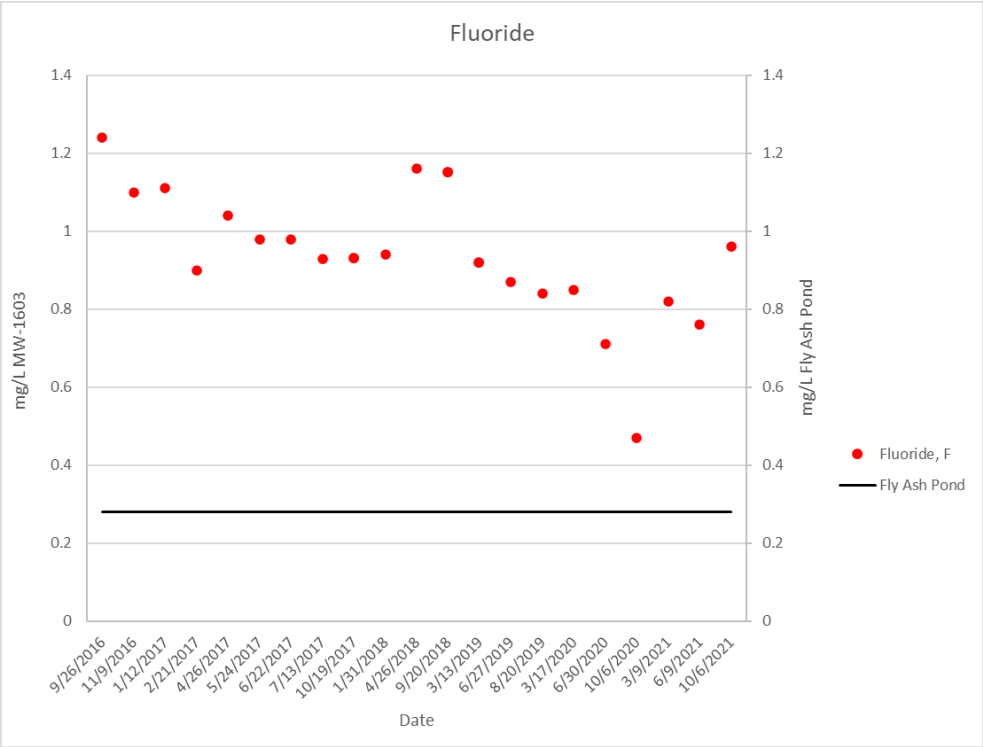


Figure 4-5 MW-1603 Fluoride Concentrations

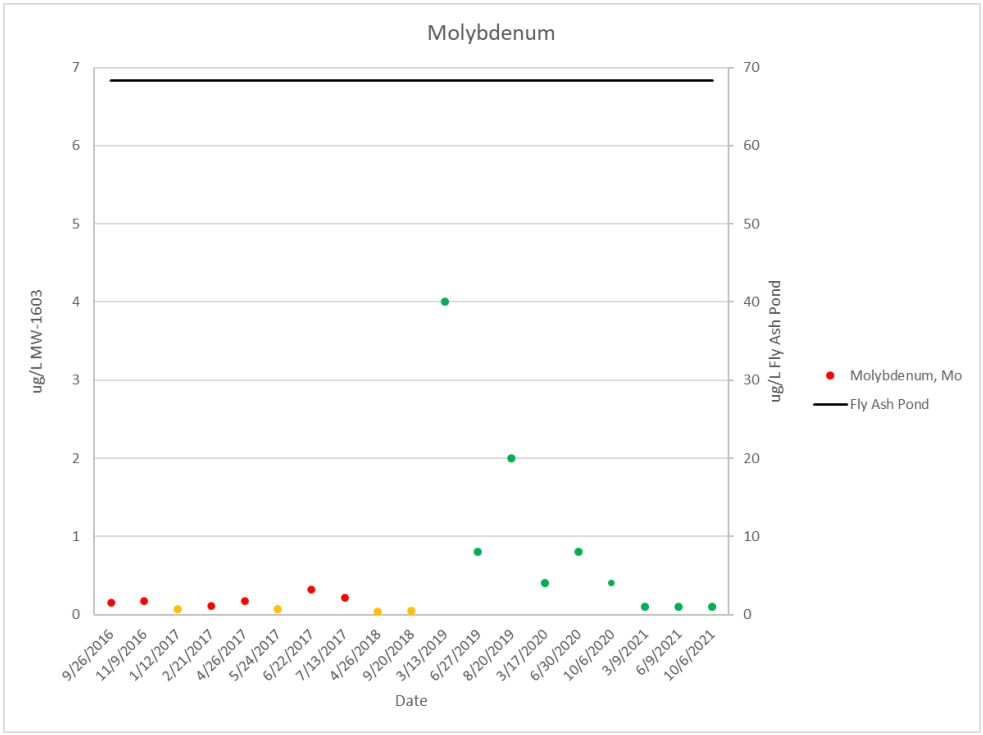


Figure 4-6 MW-1603 Molybdenum Concentrations

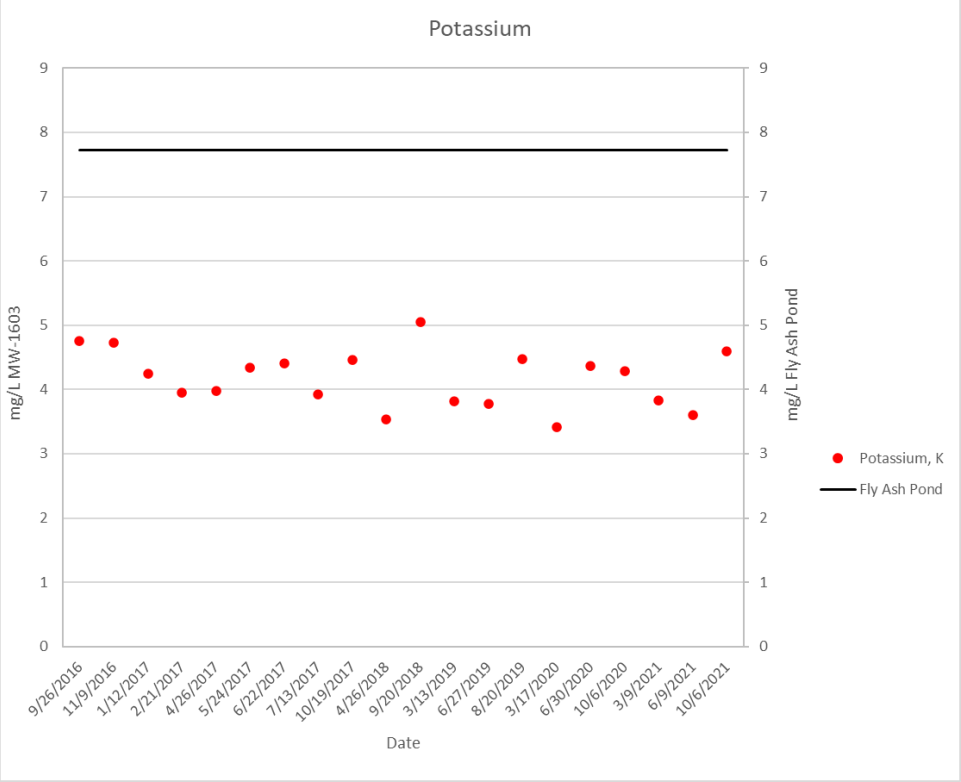


Figure 4-7 MW-1603 Potassium Concentrations

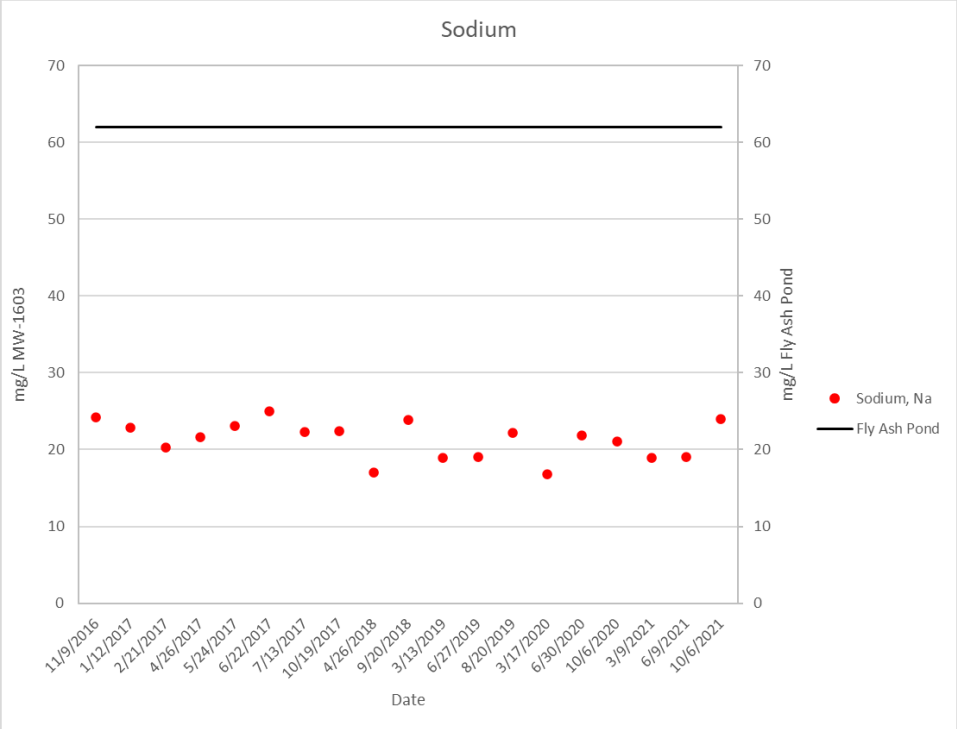


Figure 4-8 MW-1603 Sodium Concentrations

The following summarizes the data presented in **Figure 4-4** through **Figure 4-8**.

- Molybdenum, potassium, and sodium concentrations in groundwater from MW-1603 have consistently been lower than water from the BSFAP (**Figure 4-6**, **Figure 4-7**, **Figure 4-8** respectively).
- Molybdenum was last detected above the MDL in MW-1603 in September 2018 (**Figure 4-6**). The recent variation in molybdenum concentrations, as shown in green, is due to variable MDLs achieved in the laboratory analyses.
- Fluoride concentrations in groundwater from MW-1603 have consistently been higher than water from the BSFAP but have exhibited an overall declining concentration trend with time (**Figure 4-5**).
- Bromide concentrations in groundwater from MW-1603 have historically been below the MDL of 0.5 mg/L, except an estimated "J" value detection of 0.06 mg/L in May 2017. Estimated "J" value detections of 0.03 mg/L have been reported for bromide during the last three sampling events (March, June, and October 2021) due to lowering of the MDL (**Figure 4-4**).

A comparison of the pH of BSFAP water and groundwater from MW-1603 is provided in **Figure 4-9**. The figure illustrates the substantial difference in pH between the BSFAP water and groundwater of approximately three to five S.U. This is using the standard (logarithmic) pH scale which converts to a factor of 1,000 to 100,000 difference in the hydrogen ion concentration. The pH in MW-1603 is acidic with values generally between 3 and 4 standard pH units, whereas the BSFAP water is alkaline at a pH of approximately 8 S.U.

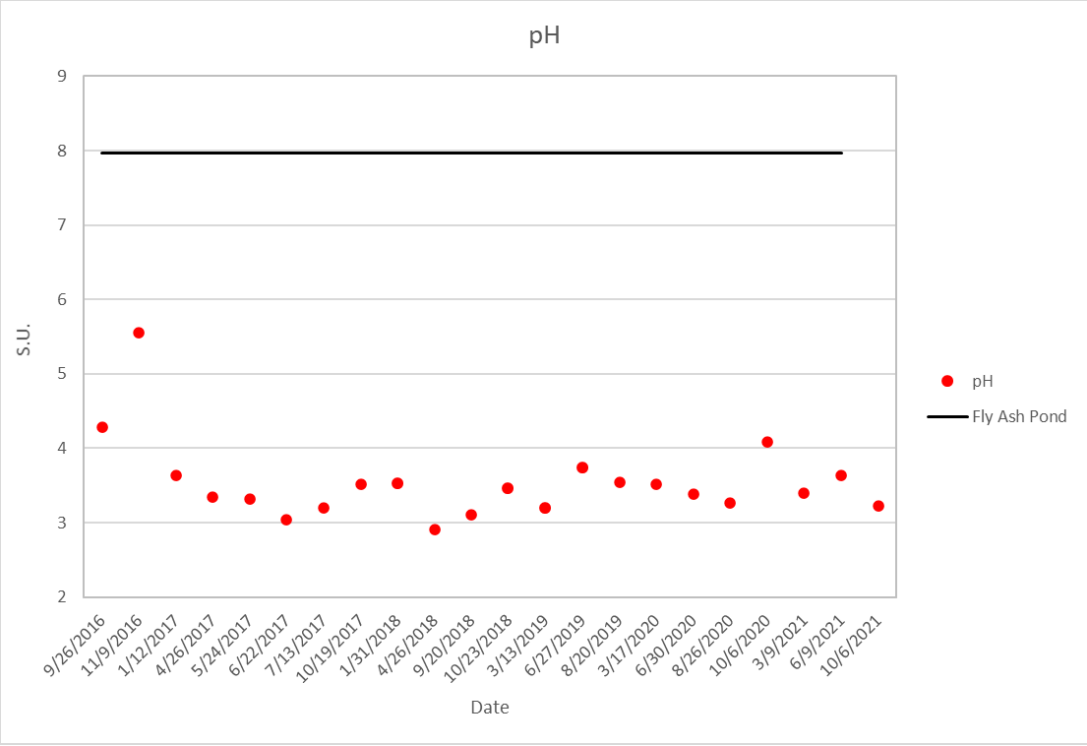


Figure 4-9 MW-1603 pH Values

In summary, there were negligible changes in potential indicator concentrations since the last review in November 2021 (EHS Support, 2021c).

4.1.3 ASD Constituent Trends

Temporal plots for the ASD constituents, beryllium, cobalt, lithium, and radium 226/228 reported in groundwater monitoring well MW-1603 are provided in **Figure 4-10** to **Figure 4-13**, respectively.

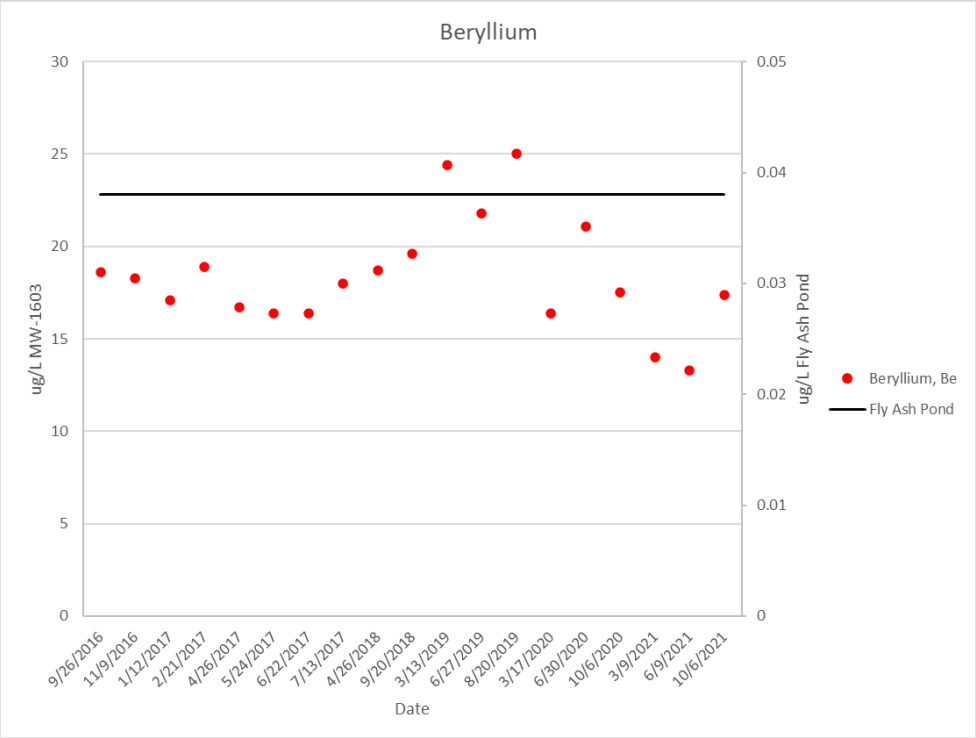


Figure 4-10 MW-1603 Beryllium Concentrations

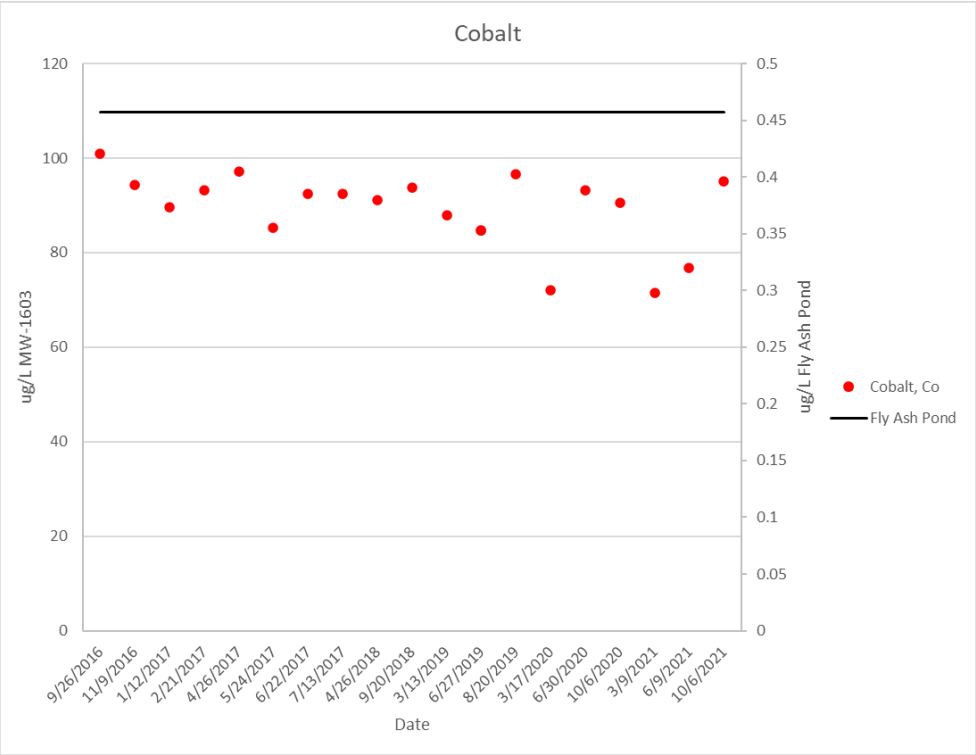


Figure 4-11 MW-1603 Cobalt Concentrations

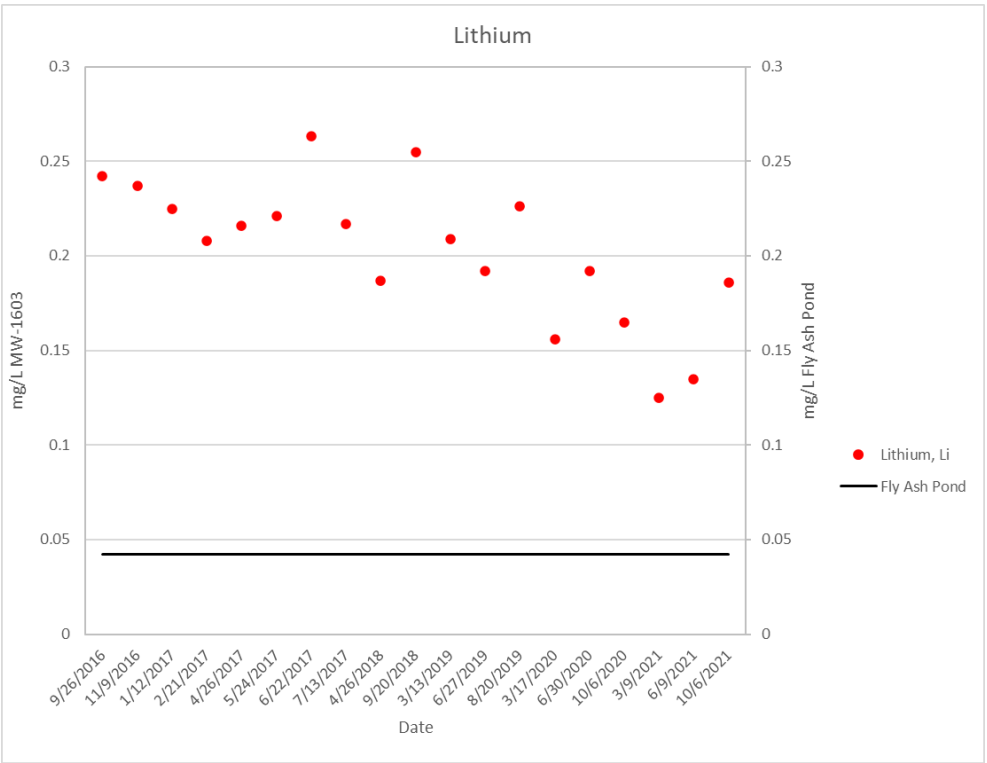


Figure 4-12 MW-1603 Lithium Concentrations

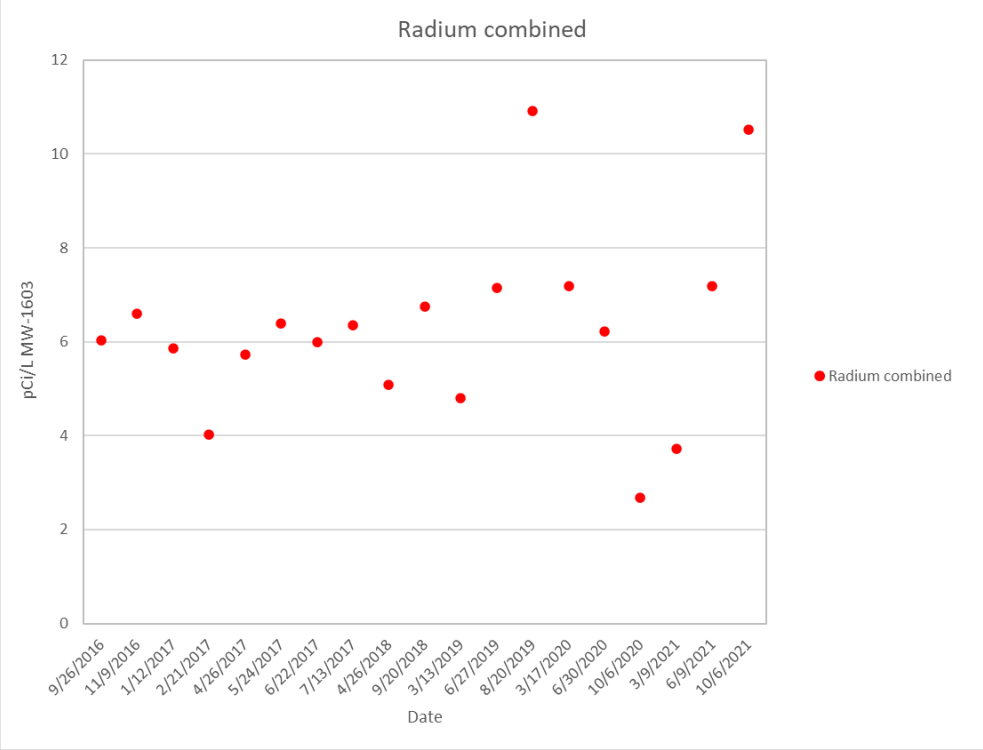


Figure 4-13 MW-1603 Radium 226/228 Concentrations

Beryllium, cobalt, and lithium concentrations are higher in groundwater from MW-1603 compared to BSFAP water (note the y-axis scales associated with **Figure 4-10** and **Figure 4-11**). This data indicates that the source of beryllium, cobalt, and lithium in groundwater at MW-1603 is not associated with the BSFAP.

Radium 226/228 concentrations in the BSFAP water are unknown, therefore, a comparison between the BSFAP water and MW-1603 groundwater cannot be made. However, radium 226/228 concentrations in MW-1603 are stable across most of the dataset, except for the result from August 2019 and the current result from October 2021. Both concentrations are considered anomalies which is supported by the outliers on the box and whisker plot of radium 226/228 on Figure A-12 of **Appendix A**.

4.1.4 Indicator Analysis Findings

Based on the temporal plots for primary indicators, potential indicators, and ASD constituents, it is considered unlikely that CCR constituents from the BSFAP are influencing the chemistry of surrounding groundwater. This is based on the primary indicator sulfate, potential indicators fluoride and bromide, and the ASD constituent's beryllium, cobalt, and lithium all being present at higher concentrations in surrounding groundwater in comparison to the BSFAP water (EHS Support, 2019a). As the concentrations of these constituents in surrounding groundwater are higher, it is unlikely that there is a concentration gradient extending from the BSFAP into groundwater. A key line of evidence that CCR constituents are not affecting groundwater at MW-1603 is the vastly different pH values between the locations. It is more likely that an alternate source is contributing to the higher concentrations observed in groundwater.

In summary, based on the analyses presented above, no trends in the MW-1603 groundwater dataset suggest that CCR constituents are migrating from the BSFAP into groundwater.

4.2 Tier I Evaluation - Statistical Evaluation

Statistical evaluations of analytes have been conducted previously (EHS Support, 2019a, 2019b, 2020, 2021a, 2021b, 2021c). The evaluations concluded that groundwater in the vicinity of MW-1603 is statistically the same as that which the United States Geological Survey (USGS) reported for regional background (Ruppert et al., 2000) for arsenic, boron, calcium, chloride, chromium, fluoride, molybdenum, potassium, sodium, and strontium.

The box plots from the earlier ASD investigation (EHS Support, 2019a) also show a difference between monitoring well MW-1603, BSFAP water, and/or the regional background for pH, alkalinity, barium, cobalt, lead, lithium, magnesium, selenium, and sulfate. No background values were provided by the USGS for beryllium, chromium, lead, lithium, molybdenum, and selenium.

Updated box and whisker plots for constituents reported in MW-1603 groundwater are provided in **Appendix A**. Plots for fluoride, pH, beryllium, cobalt, lithium, and radium 226/228 exhibit outliers which are calculated to be outside the range of distribution (Figure A-4, Figure A-8, Figure A-9, Figure A-10, Figure A-11, and Figure A-12 of **Appendix A**, respectively).

It is likely that the acidic groundwater conditions identified at MW-1603, relative to regional background, are driving the observed SSLs. The geochemical conditions within well MW-1603, including a strongly acidic pH, low alkalinity, and high sulfate, are indicative of conditions similar to those observed at acid mine drainage sites. At MW-1603, the geochemical conditions have developed due to the presence of the sulfide-bearing Princess coal seams being intersected by the screened interval of the monitoring well (discussed in EHS Support, 2019a). The combination of the well installation and effects of well sampling has resulted in the development of aerobic and water-saturated conditions within the coal seams. These conditions have led to a lowering of the pH through oxidation of sulfides present in the coal which has subsequently enhanced rock dissolution. Enhanced host rock dissolution at MW-1603 is evident from the much higher total dissolved solids (TDS) values at this location in comparison to groundwater samples from the other Site wells, including water from the BSFAP.

In addition to an abundance of sulfides, rock and coal samples from the Princess Formation in Kentucky have been shown to contain parts per million (ppm) levels of beryllium, cobalt, and lithium (Hood et al., 2020), thereby, providing a viable source for the observed SSLs. Part per million concentrations of the radioactive elements thorium and uranium are also reported for the Princess coal (Gabbard, 1993; Hood et al., 2020), and radium is a typical decay product of thorium and uranium that is often detected at elevated levels in coal deposits (Zielinski and Finkelman, 1997).

Conditions that are associated with the highest radium concentrations in groundwater include (1) oxygen poor water, (2) acidic conditions (low pH), and high concentrations of dissolved solids (Szabo et al, 2012). Radium is removed from groundwater under shifts to oxidizing conditions by co-precipitation with barite and adsorption onto iron/manganese oxide precipitates. Radium is mobilized into groundwater following shifts to more reducing conditions where it is desorbed following reduction of iron and manganese (McMahon et al., 2019).

For context, studies have demonstrated that the pH of groundwater in contact with fly ash is maintained alkaline (pH 7 to 10) for decades due to buffering by reactions with carbonates and amorphous aluminum silicates in the fly ash (Twardowska et al., 2003). The BSFAP water is consistent with this range, with a pH of 7.97 S.U. Therefore, the acidic pH of groundwater identified at MW-1603 is compelling evidence that groundwater at this location has not mixed with, and is not representative of, water from the BSFAP.

4.3 Tier II Evaluation - Geochemical Evaluation

A simple analysis of primary and potential indicator constituents (as performed in **Section 4.1**) may not provide the lines of evidence required for a robust ASD investigation. It is recognized that naturally occurring indicator constituents and upgradient sources may have an additional influence on groundwater quality. Spatially across a site, groundwater quality may be observed to change due to chemical interactions with the aquifer matrix. EPRI (2012) recommended the use of more sophisticated methods for multiple parameters over multiple locations, such as ion ratios and ternary plots.

4.3.1 Ion Ratios

The development of ion ratios involves first selecting two non-competing, non-sorbing constituents (boron and chloride). The ratios of these constituents are then compared spatially across the Site and a judgment is made as to whether the hydraulically downgradient groundwater is similar to the background groundwater quality.

The calculation of ion ratios was conducted using median concentrations of the indicator species. The median concentrations of boron, chloride, and sulfate over the monitoring period (September 2016 through October 2021) are provided in **Table 4-1**. These three constituents were selected based on the EPRI (2017) recommended indicator species. Whereas bromide is also a recommended indicator species, it was not included in the assessment as it was non-detect in the BSFAP water, indicating its presence in groundwater was either naturally derived or from an off-site source. The median concentrations for sulfate, boron, and chloride show minimal change since January 2019.

Table 4-1 Median Concentrations of Boron, Chloride, and Sulfate

Location	Location ID	Median Concentrations September 2016 to October 2021		
		Boron (mg/L)	Chloride (mg/L)	Sulfate (mg/L)
Source	**Fly Ash Pond**	0.58	35.4	342
Downgradient	**MW-1603**	0.052 ± 0.025	3.685 ± 0.463	714 ± 67

mg/L = milligrams per liter

Ion ratios have been calculated using boron, chloride, and sulfate as recommended in EPRI (2017) and are provided in **Table 4-2**. The ion ratios show little change since the last evaluation in November 2021.

Table 4-2 Ion Ratios

Location	Location ID	Median Concentrations September 2016 to October 2021		
		Boron/Sulfate (x1000)	Boron/Chloride	Chloride/Sulfate
Source	**Fly Ash Pond**	1.68	0.002	0.10
Downgradient	**MW-1603**	0.07 ± 0.03	0.01 ± 0.01	0.005 ± 0.001

Based on the previous and current ion ratio analysis, the conclusion that MW-1603 is not impacted by CCR constituents from the BSFAP is unchanged.

4.3.2 Ternary Plots

Ternary plots are used to identify changes in major or minor ion distributions over time. A ternary plot using calcium, chloride, and sulfate measured in the vicinity of MW-1603 is provided in **Figure 4-14**. The close grouping of ratios from all events on the ternary plot shows that the major ion groundwater ratios have not changed during the five-year period of groundwater quality monitoring at well MW-1603 and that the ratios are distinct from the BSFAP.

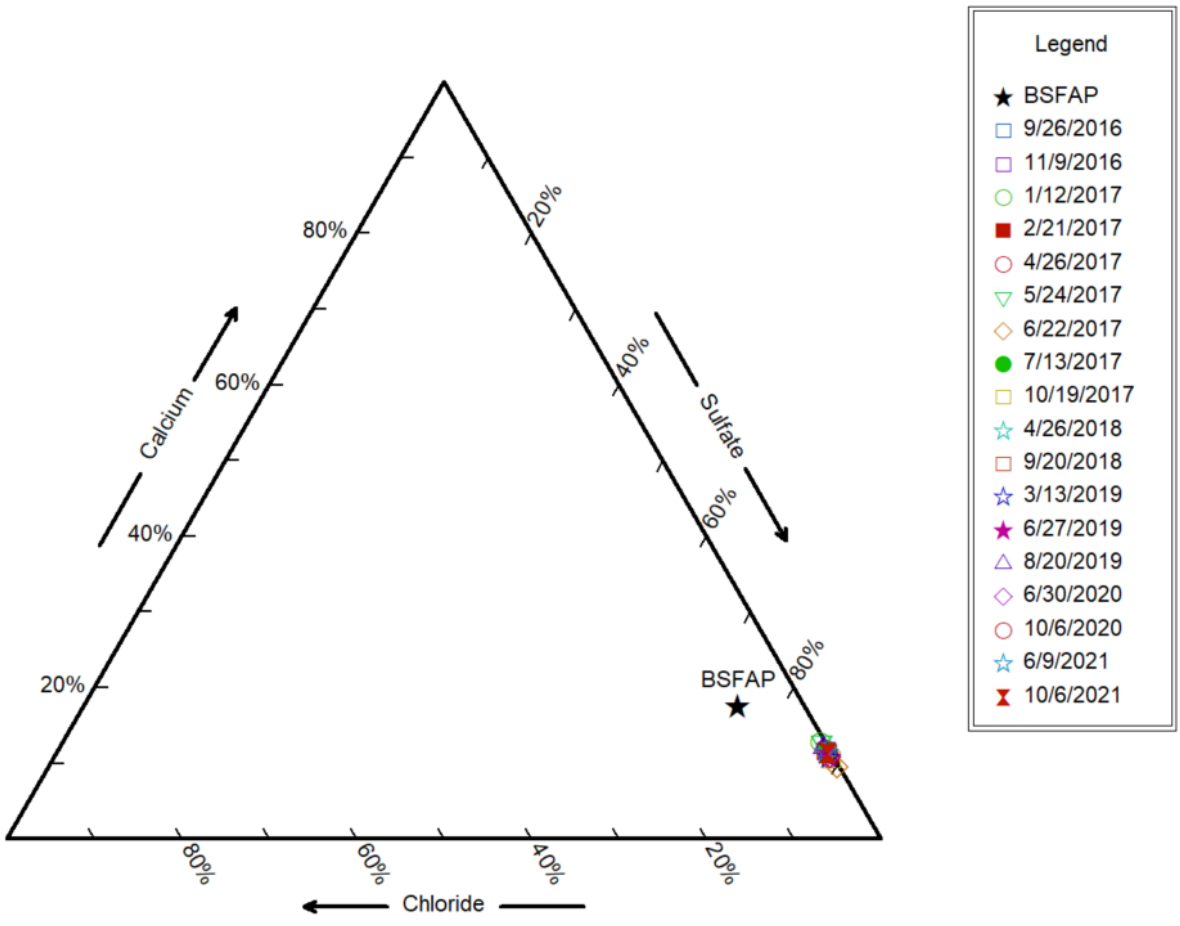


Figure 4-14 Ternary Plot MW-1603

4.3.3 Summary

In summary, based on the previous geochemical evaluations (EHS Support, 2021a, 2021b, 2021c) and the updated review presented in this ASD investigation, there is insufficient evidence to support the presence of CCR constituents (beryllium, cobalt, lithium, and radium 226/228), derived from the BSFAP, in groundwater sampled at MW-1603. The ternary plot does not support temporal changes of MW-1603 groundwater quality. The boron, chloride, and sulfate ion ratios remain relatively unchanged since September 2019. Therefore, it is unlikely that beryllium, cobalt, lithium, and radium 226/228 detected within MW-1603 groundwater are sourced from the BSFAP. It is likely that beryllium, cobalt, lithium, and radium 226/228 are sourced from the lithologies in which MW-1603 is screened across, primarily the Princess coal.

5 Summary and Conclusions

Using the EPRI (2017) guidance for ASD investigations, the conclusions based on the lines of evidence presented and discussed within **Section 3** and **Section 4** indicate that groundwater in the vicinity of the Site is not being impacted by CCR constituents from the BSFAP. The elevated beryllium, cobalt, lithium, and radium concentrations that triggered the ASD investigation are due to the oxidation of sulfide minerals present in coal seams that have been intersected by well MW-1603, including organic material within the screened interval that is identified as having "a slight coaly texture." This is supported by the visual evidence recorded during the logging of the core from this location (EHS Support, 2019a), the low pH reported in groundwater, and the subsequent mobilization and leaching of trace metals (beryllium, cobalt, and lithium) into groundwater by the elevated acidity.

Consistent with the August 2019, March 2020, and June 2020 sampling events, radium 226/228 detections have been reported for MW-1603 as an SSL in the October 2021 groundwater monitoring statistics. Radium is sourced from radioactive decay of naturally occurring radioactive materials (NORM), including uranium and thorium, which are present in the Princess coal at ppm levels. Therefore, the presence of radium 226/228 is likely due to elevated uranium and thorium in the coal seams that have been intersected at well location MW-1603. Natural variations in redox conditions likely cause sorption and desorption of radium to iron/manganese oxides that leads to fluctuation in the detections in groundwater. As a result of the installation, screening, and extraction of groundwater from MW-1603, radium 226/228 may now be considered a technologically enhanced NORM.

The higher pH in the BSFAP water and the corresponding lower concentrations of minor ions in the BSFAP also support the unlikely influence of the BSFAP on groundwater. Therefore, it is concluded that the elevated signatures of beryllium, cobalt, lithium, and radium 226/228 in MW-1603, as noted in the October 2021 groundwater monitoring data, are related to the dissolution of naturally occurring, coal seam-derived constituents within the shale layers of the Breathitt Group, as supported by the discussion of local and regional geology in **Section 2.1** and EHS Support (2019a).

In conclusion, this ASD addendum for the BSFAP has determined that Type IV natural variations in groundwater resulted in the SSLs of beryllium, cobalt, lithium, and radium 226/228 detected at MW-1603.

6 References

AEP and EHS Support. (2016). Groundwater Sampling and Analysis Plan. October.

EHS Support. (2019a). Alternative Source Demonstration Report for Beryllium, Cobalt and Lithium, Big Sandy Fly Ash Pond, Louisa, Kentucky. February.

EHS Support. (2019b). Alternative Source Demonstration Addendum Report for Beryllium, Cobalt and Lithium, Big Sandy Fly Ash Pond, Louisa, Kentucky. September.

EHS Support. (2020). Alternative Source Demonstration Addendum Report for 2019 Monitoring Data, Big Sandy Fly Ash Pond, Louisa, Kentucky. January.

EHS Support. (2021a). Alternative Source Demonstration Addendum Report for the March and June 2020 Monitoring Data, Big Sandy Fly Ash Pond, Louisa, Kentucky. January.

EHS Support. (2021b). Alternative Source Demonstration Addendum Report for the October 2020 Monitoring Data, Big Sandy Fly Ash Pond, Louisa, Kentucky. April.

EHS Support. (2021c). Alternative Source Demonstration Addendum Report for the March and June 2021 Monitoring Data, Big Sandy Fly Ash Pond, Louisa, Kentucky. November.

EPRI. (2012). Groundwater Quality Signatures for Assessing Potential Impacts from Coal Combustion Product Leachate. EPRI, Palo Alto, CA. 1017923.

EPRI. (2017). Guidelines for Development of Alternative Source Demonstrations at Coal Combustion Residual Sites. EPRI, Palo Alto, CA. 3002010920.

Gabbard, A. (1993) Coal Combustion: Nuclear Resource or Danger. Oak Ridge National Laboratory Review v.26, no. 3&4.

Geosyntec Consultants, Inc. (2016). Groundwater Monitoring Well Installation Report – Fly Ash Pond. October.

Geosyntec Consultants, Inc. (2017). Statistical Analysis Plan, Revision 0. January.

Geosyntec Consultants, Inc. (2021). Statistical Analysis Plan, Revision 1. January.

Geosyntec Consultant, Inc. (2021a) Statistical Analysis Summary. February.

Hood, M.M., Eble, C.F., Hower, J.C. and Dai, S. (2020). Geochemistry, petrology, and palynology of the Princess No. 3 coal, Greenup County, Kentucky. International Journal of Coal Science & Technology, pp.1-19.

McMahon, P.B., Vengosh, A., Davis, T.A., Landon, M.K., Tyne, R.L., Wright, M.T., Kulongoski, J.T., Hunt, A.G., Barry, P.H., Kondash, A.J. and Wang, Z., 2019. Occurrence and sources of radium in groundwater associated with oil fields in the southern San Joaquin Valley, California. Environmental Science & Technology, 53(16), pp.9398-9406.

Rice, C. and Hiett, J. (1994). Revised Correlation Chart of the Coal Beds, Coal Zones, and Key Stratigraphic Units in the Pennsylvanian Rocks of Eastern Kentucky, USGS Miscellaneous Field Studies Map MF-2275.

Ruppert, L., Tewalt, S., Wallack, R., Bragg, L., Brezinski, D., Carlton, R., Butler, D., and Calef, F. (2000). A Digital Resource Model of the Middle Pennsylvanian Upper Freeport Coal Bed Allegheny Group, Northern Appalachian Basin Coal Region. USGS Professional Paper 1625-C. 101 pages.

Szabo, Z., Fischer, J.M. and Hancock, T.C., 2012. Principal aquifers can contribute radium to sources of drinking water under certain geochemical conditions. US Department of the Interior, US Geological Survey.

Twardowska, I., Szczepanska, J. and Stefaniak, S. (2003). Occurrence and mobilization potential of trace elements from disposed coal combustion fly ash. In Chemistry of Trace Elements in Fly Ash (pp. 13-24). Springer, Boston, MA.

USEPA. (2009). Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance. March.

Zielinski, R.A. and Finkelman, R.B. (1997). Radioactive elements in coal and fly ash: abundance, forms, and environmental significance (No. 163-97). US Geological Survey.

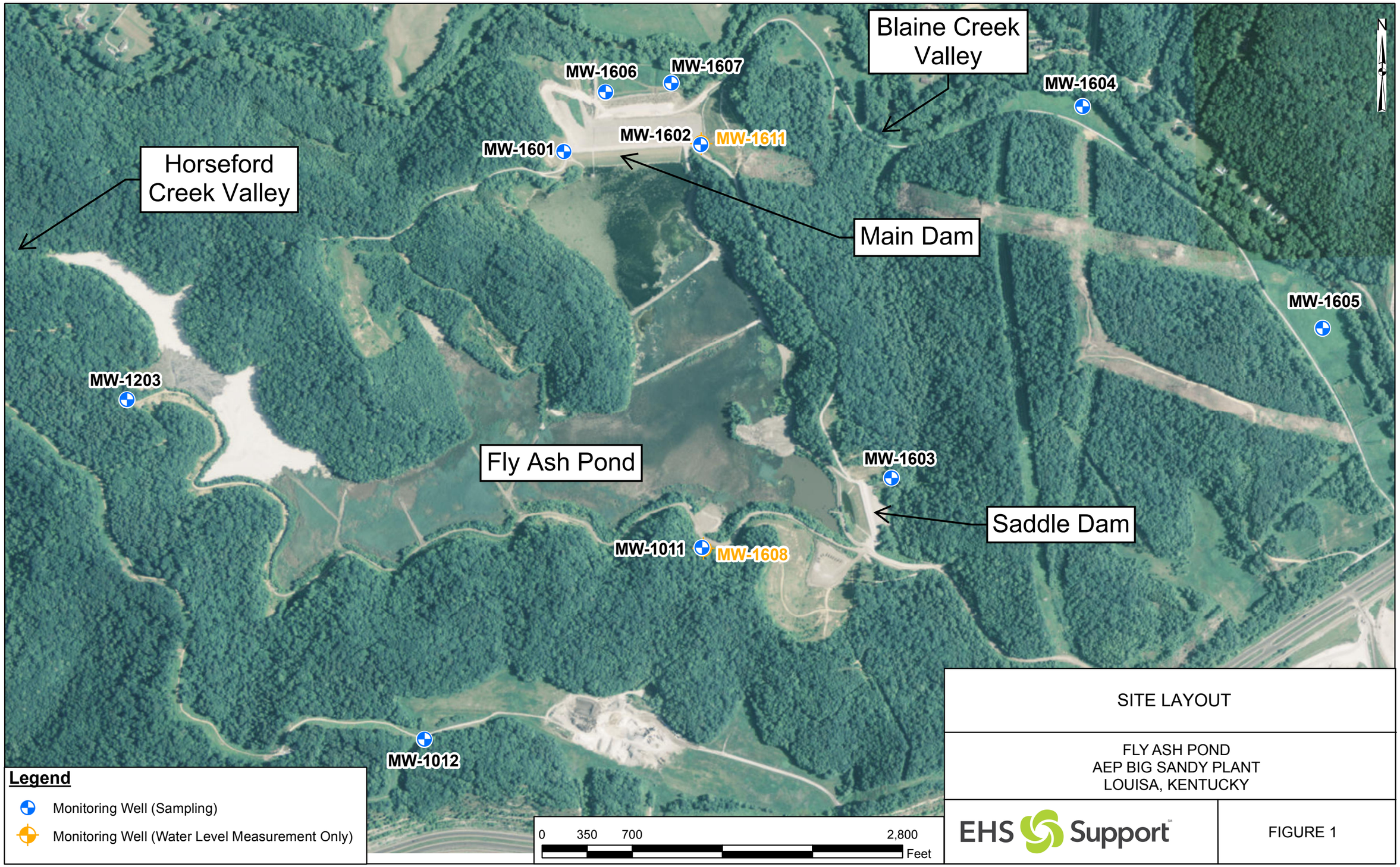
Tables

Table 1
MW-1603 Historical Groundwater Data September 2016 to October 2021
Big Sandy Fly Ash Pond Groundwater Monitoring,
American Electric Power, Kentucky Power Company,
Louisa, Kentucky

Analytes	Units	9/26/2016	11/9/2016	1/12/2017	2/21/2017	4/26/2017	5/24/2017	6/22/2017	7/13/2017	10/19/2017	1/31/2018	4/26/2018	9/20/2018	10/23/2018	3/13/2019	6/27/2019	8/20/2019	3/17/2020	6/30/2020	8/26/2020	10/6/2020	3/9/2021	6/9/2021	10/6/2021
Antimony, Sb	µg/L	0.01 J	< 0.01	< 0.01	< 0.01	0.01 J	< 0.01	< 0.01	< 0.01	NA	NA	0.04 J	0.02 J	NA	< 0.2	< 0.04	< 0.1	< 0.02	< 0.04	NA	< 0.02	< 0.02	0.04 J	< 0.02
Arsenic, As	µg/L	1.51	1.19	1.4	1.26	1.3	1.34	1.29	0.89	NA	NA	1.6	1.4	NA	1.26	1.36	1.39	0.83	1.12	NA	1.12	0.84	0.69	1.01
Barium, Ba	µg/L	13.4	15.4	11.4	10.3	12.4	11.5	11.4	11.3	NA	NA	10.5	11.4	NA	12	11	13.6	9.92	12.2	NA	14.6	10.1	13.1	17.1
Beryllium, Be	µg/L	18.6	18.3	17.1	18.9	16.7	16.4	16.4	18	NA	NA	18.7	19.6	NA	24.4	21.8	25	16.4	21.1	NA	17.5	14	13.3	17.4 M
Boron, B	mg/L	0.054	0.053	0.037	0.085	0.052	0.096	0.051	0.039	< 0.002	NA	0.088	0.085	NA	0.05 J	0.05 J	< 0.1	< 0.1	0.05 J	NA	0.05	NA	0.036 J	0.054
Bromide	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.06 J	< 0.05	< 0.05	< 0.05	NA	< 0.05	< 0.1	NA	< 0.1	< 0.04	< 0.04	< 0.04	< 0.04	NA	< 0.04	0.03 J	0.03 J	0.03 J
Cadmium, Cd	µg/L	0.84	0.93	0.79	0.75	0.87	0.77	0.86	0.8	NA	NA	0.74	0.83	NA	0.78	0.7	0.89	0.64	0.85	NA	0.87	0.62	0.709	0.0931
Calcium, Ca	mg/L	105	94.7	92.7	91.9	90.5	93.9	90.6	90.2	91	82.2	83.6	97.5	NA	84.6	83.3	95.8	NA	96.6	NA	94.5	NA	79	93.1
Chloride, Cl	mg/L	3.37	3.22	3.45	2.93	3.28	3.34	3.1	3.32	3.24	NA	4.12	3.92	NA	4.42	4.13	3.93	NA	4.18	NA	4.1	NA	4.16	3.93
Chromium, Cr	µg/L	1.1	1.12	0.731	0.771	0.829	0.62	0.821	0.485	NA	NA	0.771	0.713	NA	1 J	0.618	0.8	0.56	0.694	NA	0.743	0.659	0.51	0.59
Cobalt, Co	µg/L	101	94.4	89.6	93.2	97.1	85.3	92.4	92.5	NA	NA	91.1	93.8	NA	87.9	84.7	96.6	72	93.2	NA	90.5	71.4	76.8	95.1 M
Comb. Radium 226/228	pCi/L	6.04	6.6	5.86	4.03	5.72	6.4	6	6.36	NA	NA	5.09	6.75	NA	4.8	7.149	10.92	7.19	6.22	NA	2.681	3.73	7.18	10.51 B
Fluoride, F	mg/L	1.24	1.1	1.11	0.9	1.04	0.98	0.98	0.93	0.93	0.94	1.16	1.15	NA	0.92	0.87	0.84	0.85	0.71	NA	0.47	0.82	0.76	0.96
Lead, Pb	µg/L	9.75	8.18	6.11	6.3	6.41	4.96	6.47	3.72	NA	NA	5.27	4.39	NA	4.28	3.68	4.17	3.95	4.67	NA	4.85	3.37	3.39	6.1
Lithium, Li	mg/L	0.242	0.237	0.225	0.208	0.216	0.221	0.263	0.217	NA	NA	0.187	0.255	NA	0.209	0.192	0.226	0.156	0.192	NA	0.165	0.125	0.135	0.186 M
Mercury, Hg	µg/L	< 0.002	< 0.002	< 0.002	< 0.002	0.002 J	< 0.002	< 0.002	< 0.002	NA	NA	< 0.002	NA	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	NA	< 0.002	0.002 J	0.002 J	0.003 J
Molybdenum, Mo	µg/L	0.15	0.17	0.06 J	0.11	0.18	0.07 J	0.32	0.22	NA	NA	0.03 J	0.04 J	NA	< 4	< 0.8	< 2	< 0.4	< 0.8	NA	< 0.4	< 0.1	< 0.1	<0.1
pH	S.U.	4.29	5.56	3.64	4.51	3.34	3.32	3.04	3.20	3.52	3.52	2.91	3.10	3.46	3.19	3.73	3.54	3.52	3.38	3.27	4.09	3.4	3.64	3.23
Potassium, K	mg/L	4.76	4.73	4.25	3.95	3.98	4.34	4.41	3.92	4.46	NA	3.53	5.05	NA	3.81	3.78	4.48	3.42	4.36	NA	4.29	3.83	3.6	4.6
Residue, Filterable, TDS	mg/L	1,060	1,010	948	1,020	994	936	1,040	1,000	962	915	926	974	NA	896	954	1,010	NA	NA	1,040	1,020	NA	880	1040
Selenium, Se	µg/L	5.4	4.8	5.6	4.9	6.1	6.3	6.1	2.7	NA	NA	8.1	6.3	NA	4	4.9	5.6	4	6.2	NA	5.8	3.9	3.3	4.26
Sodium, Na	mg/L	NA	24.2	22.9	20.3	21.6	23.1	25	22.3	22.4	NA	17	23.9	NA	18.9	19.1	22.2	16.8	21.9	NA	21.1	18.9	19	24
Sulfate, SO_4	mg/L	801	733	636	720	678	646	873	694	784	714	661	747	NA	709	658	704	NA	NA	798	794	NA	618	735
Thallium, Tl	µg/L	1.29	1.55	1.39	1.2	1.41	1.35	1.43	1.43	NA	NA	1.39	1.7	NA	1 J	1.4	2 J	1.34	1.57	NA	1.82	1.39	1.62	2.2

Notes:
< = not detected at or above the method detection limit
µg/L = Micrograms per liter
B = Analyte detected in a blank sample
J = Estimated value. Analyte detected at a level less than the reporting limit but greater than the method detection limit.
M = the associated MS or MSD recovery was outside acceptance limits.
mg/L = Milligrams per liter
MS = Matrix spike
MSD = Matrix spike duplicate
NA = Not analyzed
pCi/L = Picocuries per liter
S.U. = Standard Units
TDS = Total Dissolved Solids

Figures

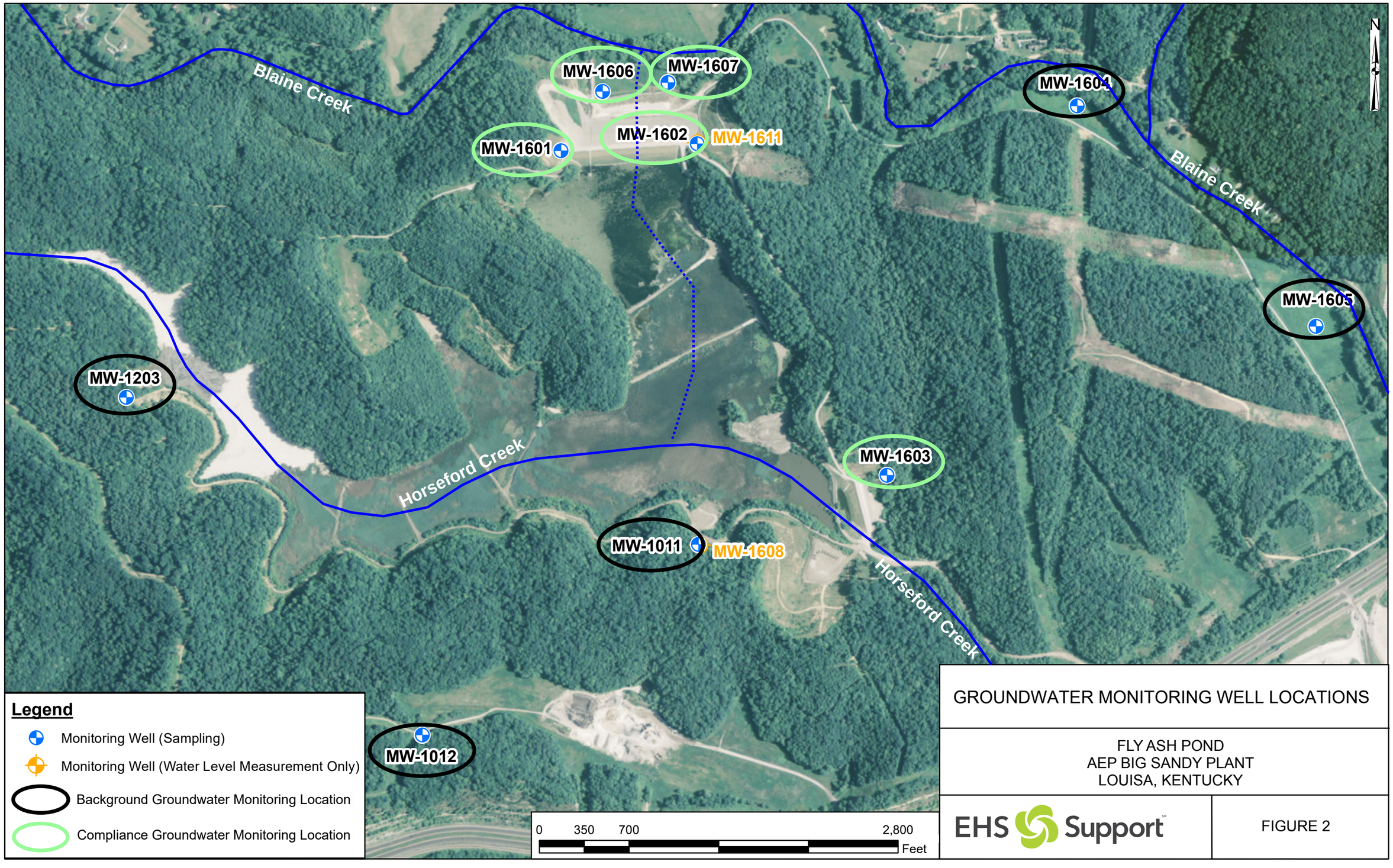


SITE LAYOUT

FLY ASH POND
AEP BIG SANDY PLANT
LOUISA, KENTUCKY

EHS Support℠

FIGURE 1



Legend

- Monitoring Well (Sampling)
- Monitoring Well (Water Level Measurement Only)
- Background Groundwater Monitoring Location
- Compliance Groundwater Monitoring Location

GROUNDWATER MONITORING WELL LOCATIONS

FLY ASH POND
AEP BIG SANDY PLANT
LOUISA, KENTUCKY

EHS Support

FIGURE 2

Appendix A Box Plots

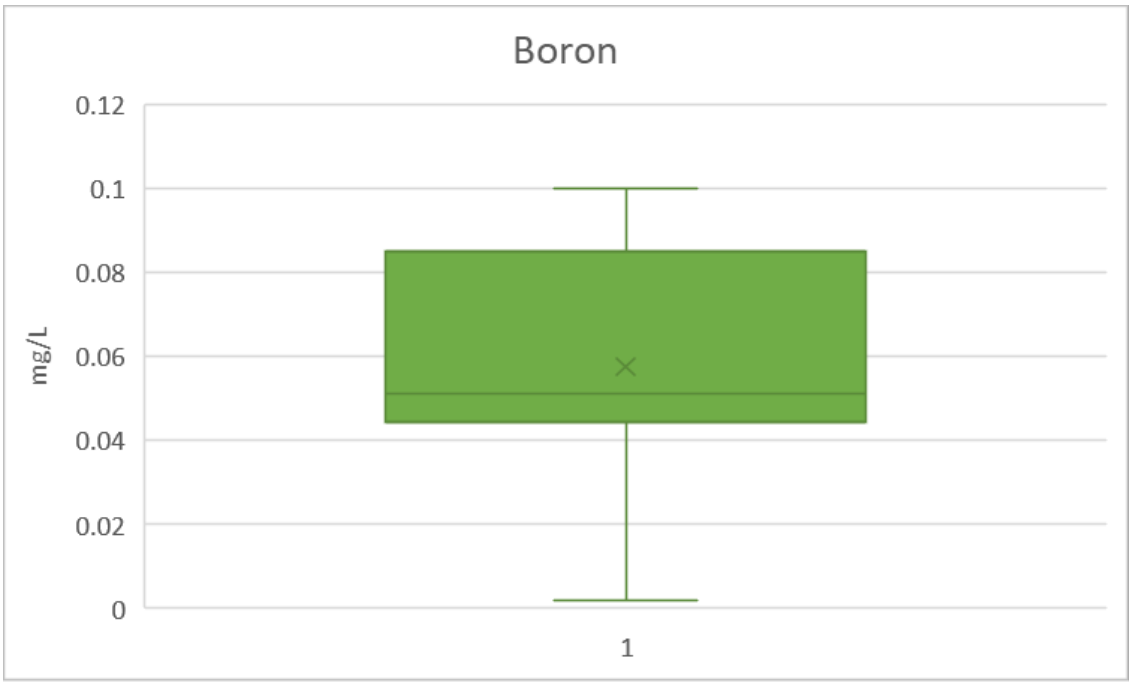


Figure A-1 Boron Box Plot

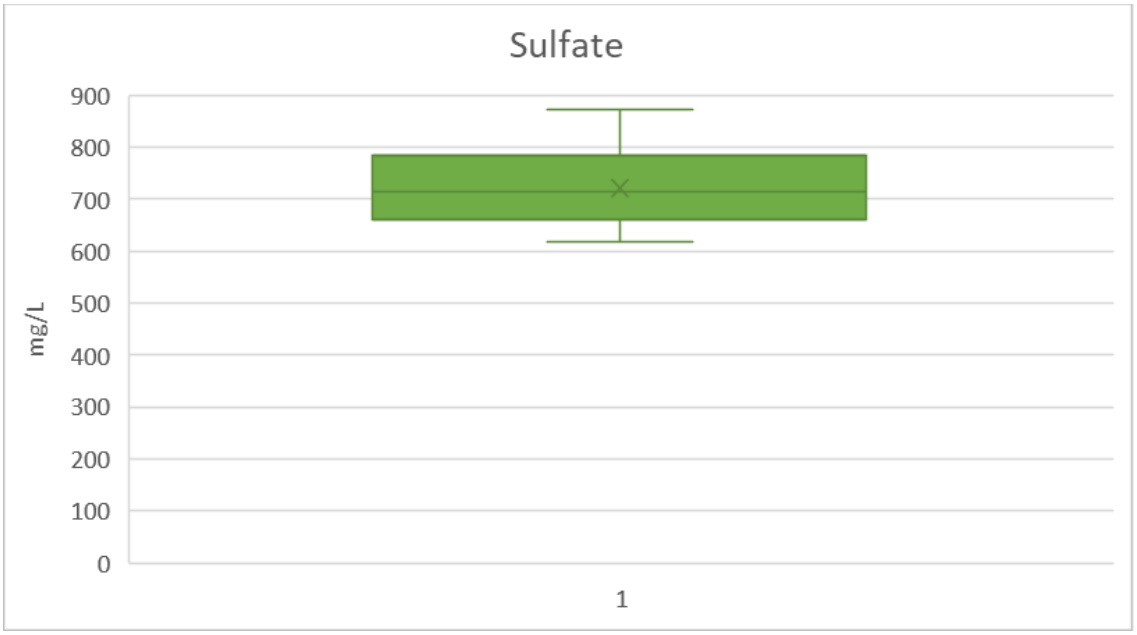


Figure A-2 Sulfate Box Plot

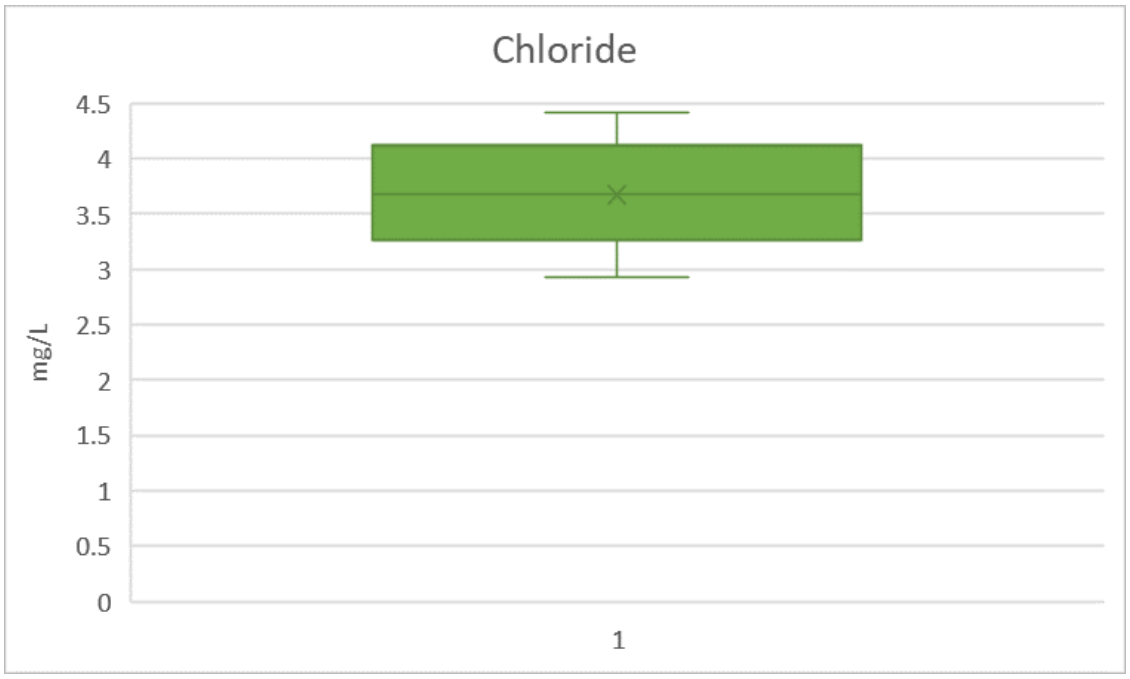


Figure A-3 Chloride Box Plot

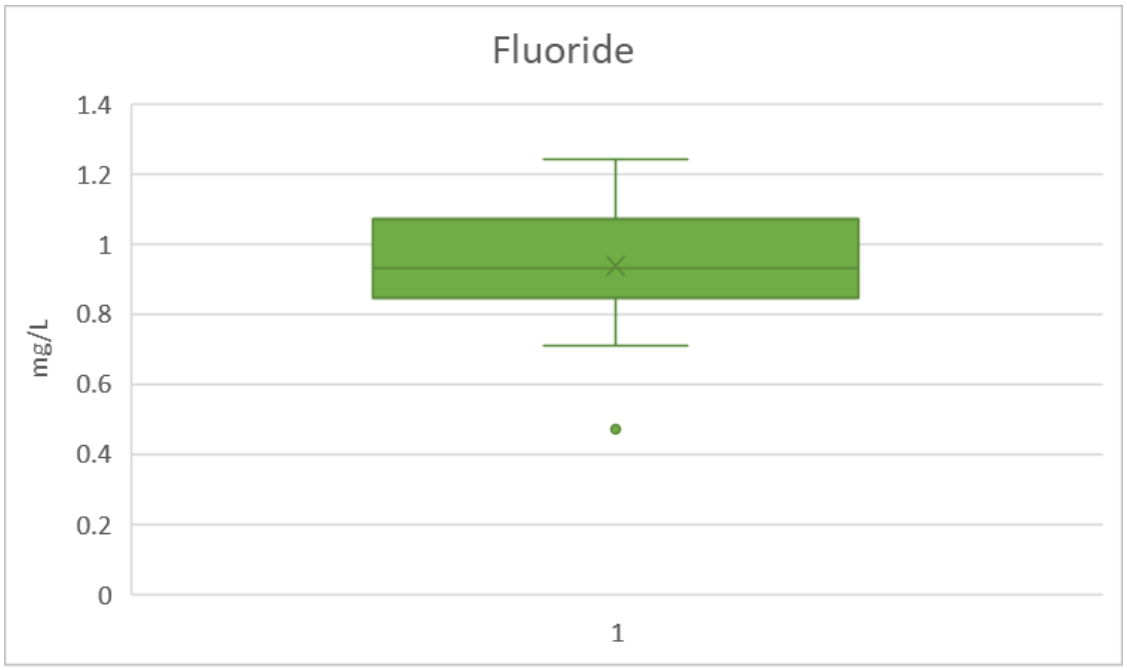


Figure A-4 Fluoride Box Plot

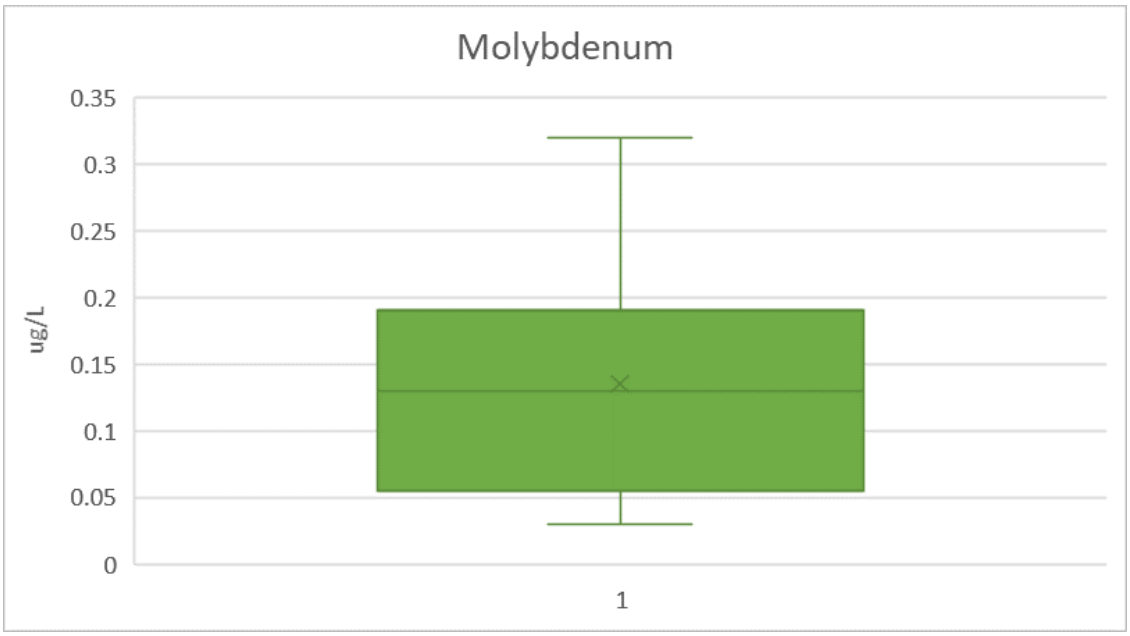


Figure A-5 Molybdenum Box Plot

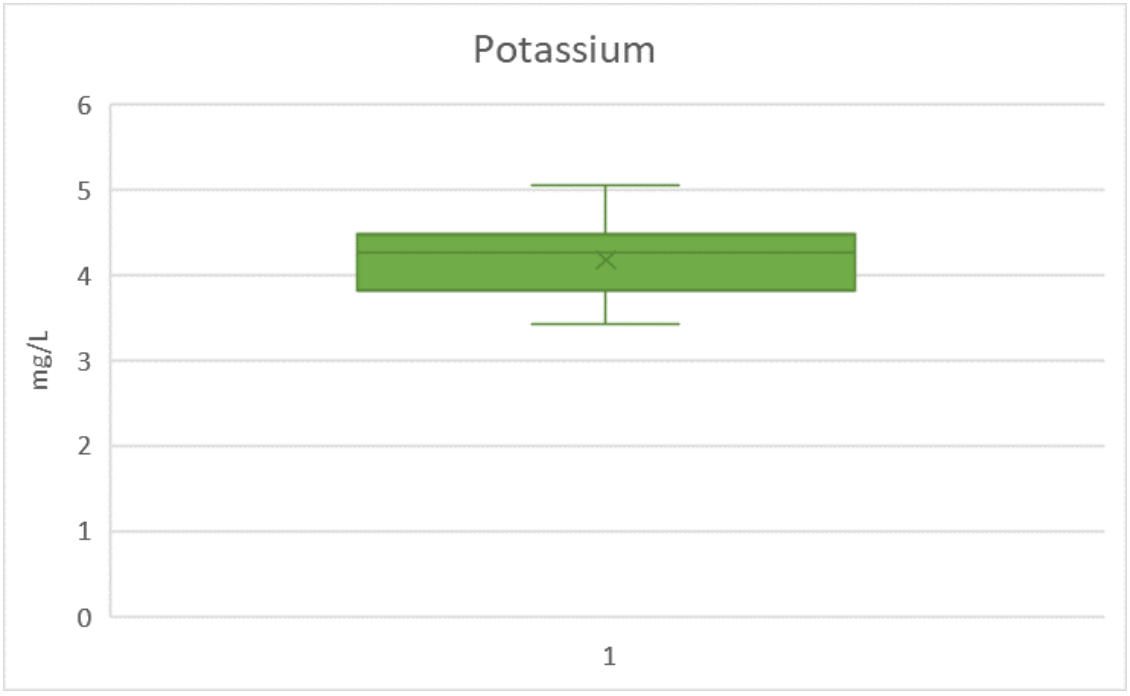


Figure A-6 Potassium Box Plot

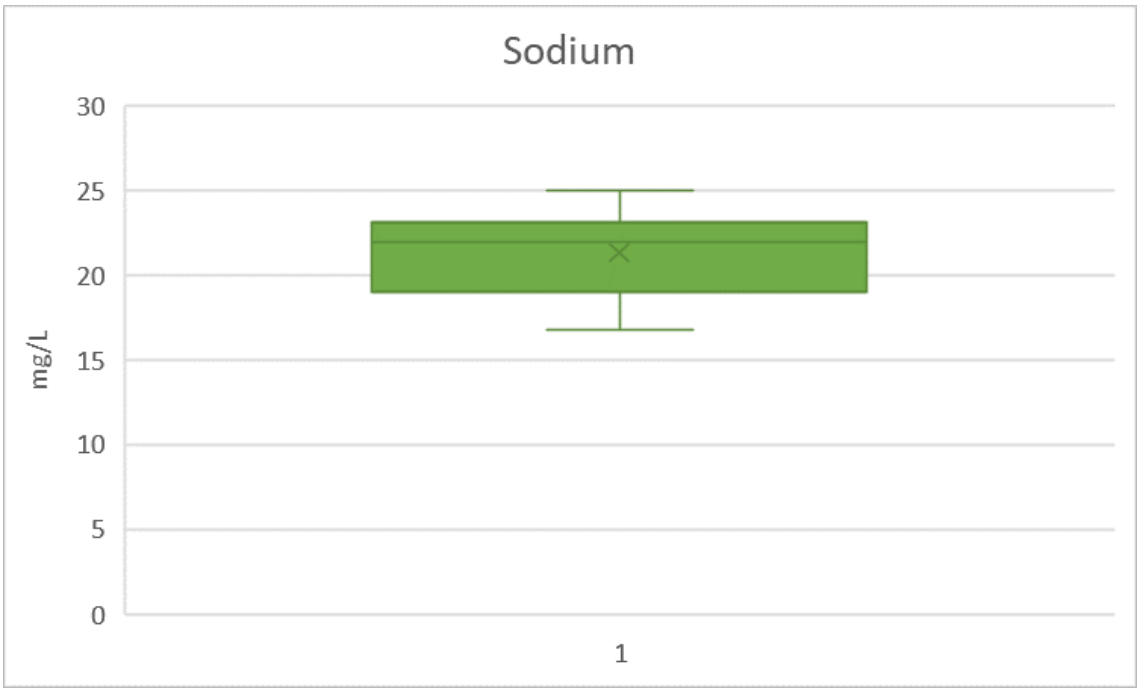


Figure A-7 Sodium Box Plot

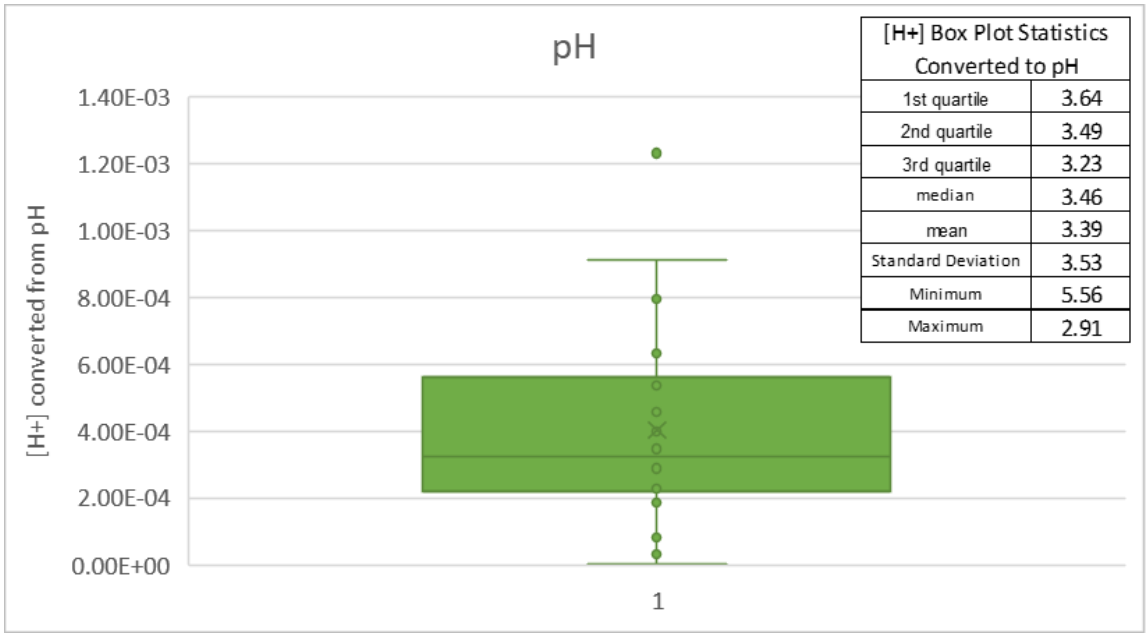


Figure A-8 pH Box Plot

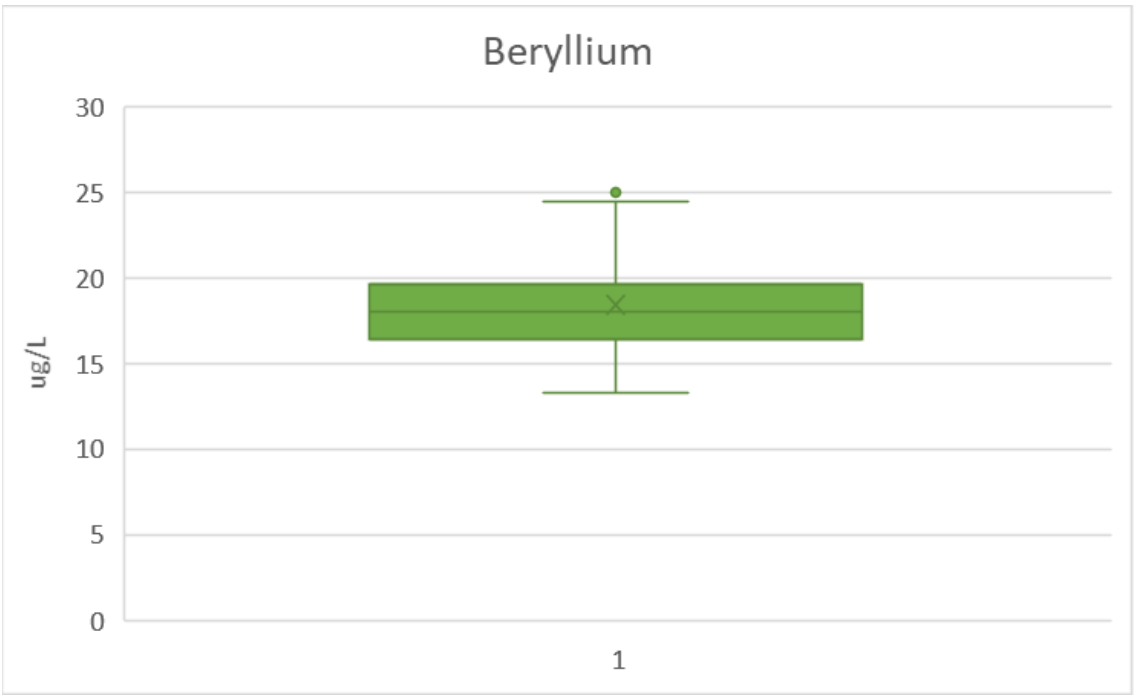


Figure A-9 Beryllium Box Plot

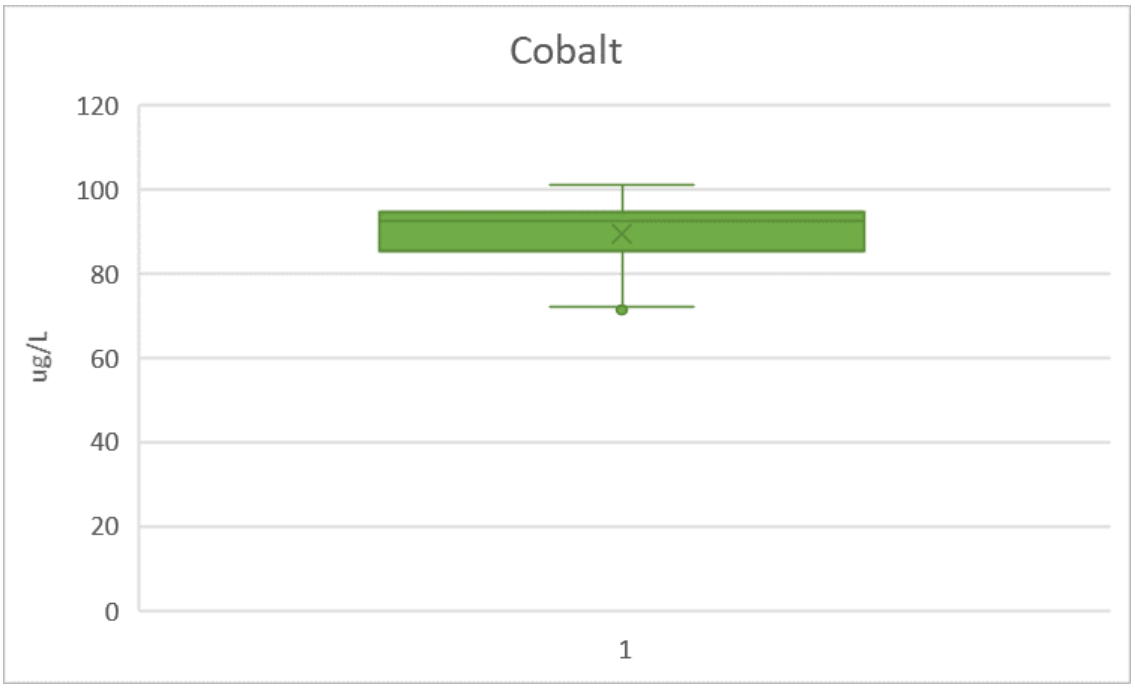


Figure A-10 Cobalt Box Plot

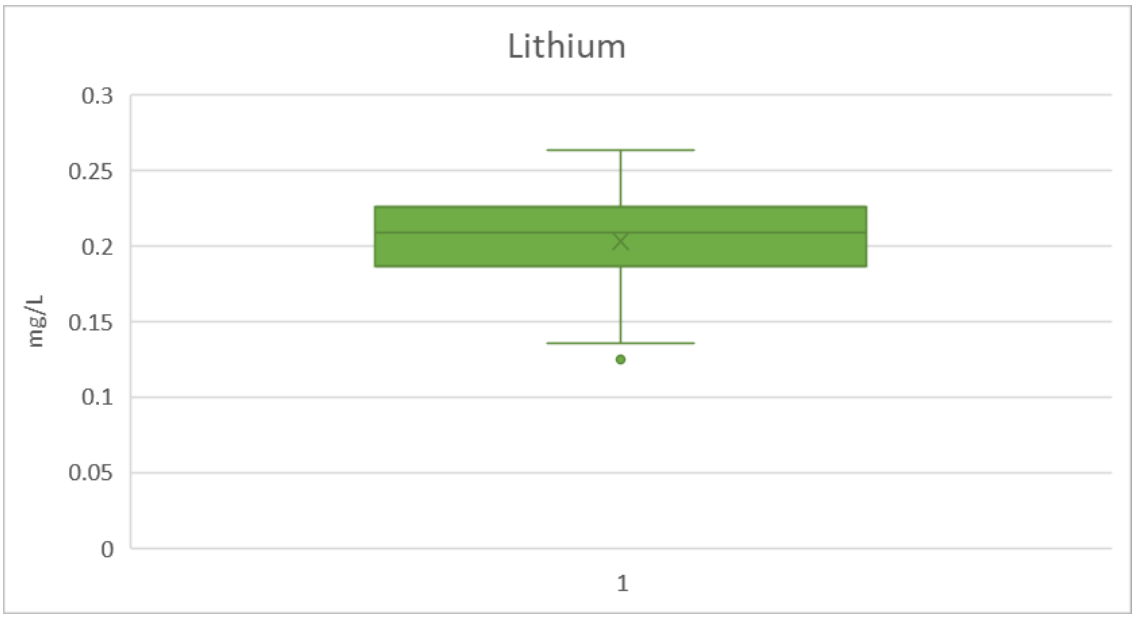


Figure A-11 Lithium Box Plot

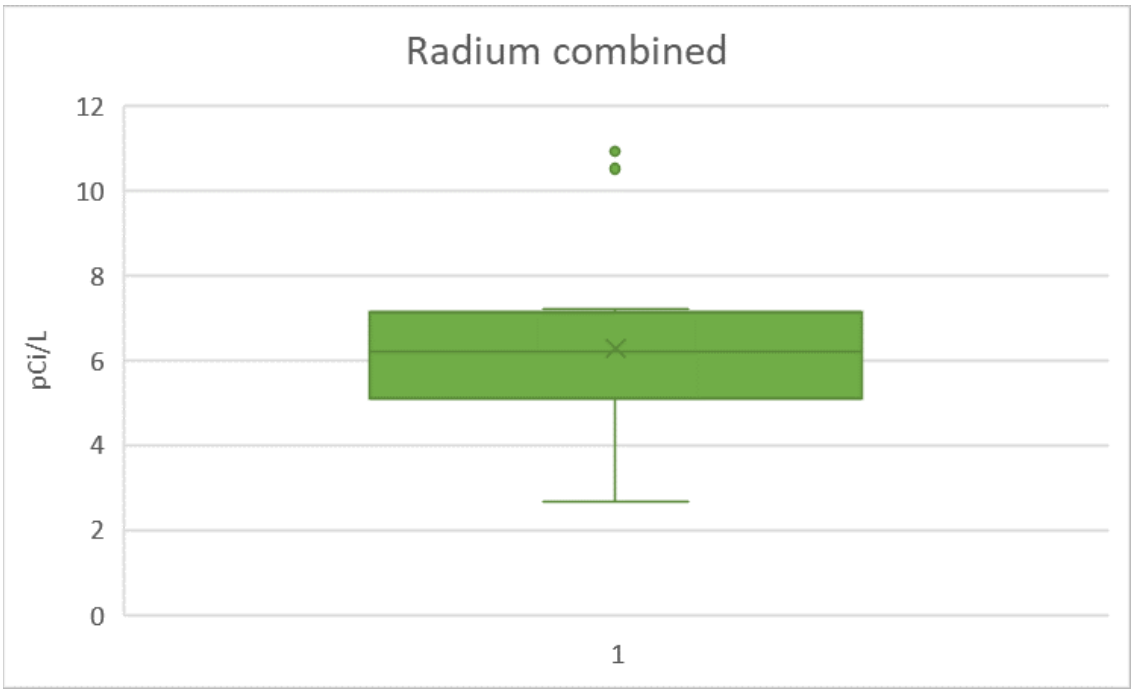


Figure A-12 Radium 226/228 Box Plot

Alternative Source Demonstration Addendum Report for the March and June 2022 Monitoring Data

Closed Big Sandy Fly Ash Pond
Louisa, Kentucky

Prepared for:

American Electric Power

Prepared by:

EHS Support

December 2022

Table of Contents

List of In-Text Tables

List of Attached Tables

List of In-Text Figures

List of Attached Figures

List of Appendices

Acronyms

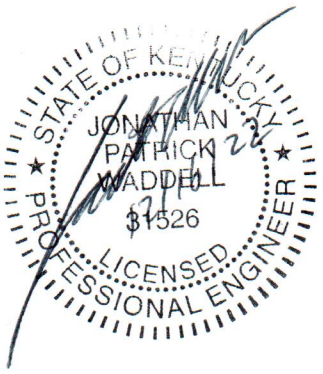
µg/L	micrograms per liter
AEP	American Electric Power
ASD	alternative source demonstration
bgs	below ground surface
BSFAP	Big Sandy Fly Ash Pond
CCR	coal combustion residual
CFR	Code of Federal Regulations
EPRI	Electric Power Research Institute
ft	foot/feet
GWPS	Groundwater Protection Standards
KGS	Kentucky Geological Survey
LCL	lower confidence level
MDL	method detection limit
mg/L	milligrams per liter
msl	mean sea level
NORM	naturally occurring radioactive materials
ORP	oxidation-reduction potential
pCi/L	picocuries per liter
ppm	parts per million
S.U.	standard units (pH)
SSL	statistically significant level
TDS	total dissolved solids
UCL	upper confidence level
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

Certification by Qualified Professional Engineer

I certify that the alternative source demonstration (ASD) conducted and presented within this report is accurate and appropriate for evaluating the groundwater monitoring data for the Closed Big Sandy Fly Ash Pond Coal Combustion Residual (CCR) management area associated with the Big Sandy Power Plant located in Louisa, Kentucky. This ASD meets the requirements of the United States Environmental Protection Agency CCR Rule defined at 40 Code of Federal Regulations 257.95(g)(3)(ii).

Jonathan Patrick Waddell

Printed Name of Licensed Professional Engineer



Signature

31526	KY	12/16/22
License Number	Licensing State	Date

1 Introduction

EHS Support LLC ("EHS Support") was retained by the American Electric Power (AEP) – Kentucky Power Company in December 2018 to conduct an alternative source demonstration (ASD) investigation for coal combustion residual (CCR) constituents in groundwater near the Big Sandy Fly Ash Pond (BSFAP or "Site"). The BSFAP is associated with the Big Sandy Power Plant located in Louisa, Kentucky (EHS Support, 2019a). The BSFAP was closed between September 2015 and November 2020 incorporating a cover system including a geomembrane. The ASD determined that groundwater in the vicinity of the Site was not being impacted by CCR constituents from the BSFAP. The statistically significant levels (SSLs) of beryllium, cobalt, and lithium concentrations present in excess of the Groundwater Protection Standards (GWPS), which triggered the ASD investigation, were determined to be a result of the oxidation of coal seams that were intersected by the borehole and well screen for well MW-1603.

Since the initial ASD investigation was completed (incorporating data from September 2016 to October 2018), the following ASD investigations have been conducted:

- An ASD investigation was conducted after the March 2019 groundwater monitoring data indicated continued SSLs of beryllium, cobalt, and lithium exceeding the GWPS at MW-1603 (EHS Support, 2019b).
- An ASD investigation was conducted following continued detections of beryllium, cobalt, and lithium at SSLs above the GWPS in MW-1603 during the August 2019 sampling event (EHS Support, 2020). In addition, an SSL of radium 226 combined with radium 228 (hereafter radium 226/228) was measured above its GWPS for the first time in MW-1603 groundwater during the August 2019 sampling event (EHS Support, 2020).
- An ASD investigation was conducted following continued detections of four constituents (beryllium, cobalt, lithium, and radium 226/228) at SSLs above the GWPS in MW-1603 in March and June 2020 (EHS Support, 2021a).
- An ASD investigation was conducted following continued detections of three constituents (beryllium, cobalt, and lithium) at SSLs above the GWPS in MW-1603 in October 2020 (EHS Support, 2021b).
- An ASD investigation was conducted following continued detections of three constituents (beryllium, cobalt, and lithium) at SSLs above the GWPS in MW-1603 in March and June 2021 (EHS Support, 2021c).
- An ASD investigation was conducted following continued detections of three constituents (beryllium, cobalt, and lithium) and the fourth constituent radium 226/228 at SSLs above the GWPS in MW-1603 in October 2021 (EHS Support, 2022).

In March and June 2022, four constituents (beryllium, cobalt, lithium, and radium 226/228) were detected at SSLs above the GWPS in MW-1603, thus requiring the ASD investigation presented in this report. This ASD investigation has been prepared per the requirements of the United States Environmental Protection Agency (USEPA) CCR Rule (40 Code of Federal Regulations [CFR] §257.95). The concentrations of beryllium, cobalt, lithium, and radium 226/228 in MW-1603 groundwater were determined herein to result from Type IV natural variations in groundwater (ASD types are discussed in **Section 3.1**). This conclusion was reached by examining analytical results for compounds detected at SSLs in the context of the broader list of CCR constituents analyzed at the Site.

1.1 Objective

The objective of this ASD investigation is to assess groundwater monitoring data collected in compliance with the CCR Rule, as allowed under paragraph 40 CFR §257.95(g)(3)(ii). This part of the CCR Rule allows AEP to determine whether the source(s) for SSLs of beryllium, cobalt, lithium, and radium 226/228 exceeding the GWPSs, as reported in groundwater monitoring well MW-1603, are associated with the CCR unit; or alternatively if the SSL resulted from an error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality.

1.2 Lines of Evidence

This ASD investigation for the BSFAP has been conducted to further evaluate potential alternate sources or reasons for the continued detection of SSLs of beryllium, cobalt, lithium, and radium 226/228 in groundwater samples from monitoring well MW-1603.

A potential alternate source was previously identified in prior ASD investigations (EHS Support, 2019a, 2019b, 2020, 2021a, 2021b, 2021c, 2022), based on the following lines of evidence:

- A lack of exceedances and increasing trends of primary indicators of CCR.
- Constituent concentrations in BSFAP water are lower than those of the corresponding constituent observed in groundwater from MW-1603.
- Major ion chemistry was not indicative of mixing between BSFAP water and groundwater.
- Acidic groundwater in MW-1603 (pH 3 to 5.5 standard units [S.U.]) is not indicative of BSFAP water (pH 7.97).

For the purposes of this ASD addendum investigation, constituents were identified that would serve as a primary indicator for CCR. A primary indicator must meet **both** of the following criteria:

1. The constituent typically has a high concentration in CCR leachate, relative to background, such that it is expected to have an elevated concentration in the event of a release.
2. The constituent is unreactive and has high mobility in groundwater, such that it is expected to be at the leading edge of the plume. Consequently, the constituent will have elevated concentrations relative to background across the entire area of the plume.

As boron and sulfate are primary indicators for CCR (Electric Power Research Institute [EPRI], 2012) and have previously been evaluated, they have been re-evaluated herein as primary indicators for this ASD investigation. In addition, chloride is used as a primary indicator for this ASD. Other potential indicators that were evaluated in this ASD investigation include bromide, fluoride, molybdenum, potassium, and sodium.

2 Project Background

A detailed description of the Site location, history, and geology was provided in the *Alternative Source Demonstration Report for Beryllium, Cobalt and Lithium, Big Sandy Fly Ash Pond, Louisa, Kentucky* (EHS Support, 2019a). Attached **Figure 1** and **Figure 2** show the Site layout and groundwater monitoring network, respectively.

To support and provide context to this ASD addendum investigation, **Section 2.1** and **Section 2.2** describe the groundwater monitoring network and groundwater monitoring activities.

2.1 Groundwater Monitoring Network Evaluation

On behalf of AEP, Geosyntec Consultants, Inc. ("Geosyntec") conducted an assessment of the groundwater monitoring network in the uppermost aquifer associated with the BSFAP (Geosyntec, 2016). Geosyntec determined that the hydrostratigraphy in the vicinity of the BSFAP is characterized by an interconnected water-bearing system comprised of Pennsylvanian-aged bedrock (of the Breathitt Group, Conemaugh Formation) and Quaternary alluvium. The Conemaugh Formation and Breathitt Group consist of sandstones, siltstones, shale, and coal that may grade laterally and vertically into one another. The overlying Quaternary alluvial deposits include sandy lean clay to silty sand and gravel at the bottom of the Horseford Creek valley and the floodplain of Blaine Creek. Based on these hydrogeologic conditions, Geosyntec defined the interconnected water-bearing system of the fractured bedrock and alluvium as the uppermost aquifer for the BSFAP CCR unit. This determination was based on the presence of groundwater in numerous monitoring wells screened in the water-bearing unit (fractured bedrock and alluvium), the recovery of these wells during pumping and development, and a potentiometric surface generally consistent with Site topography and surface water elevations.

Geosyntec defined the groundwater detection monitoring network as consisting of ten monitoring wells used to assess the upper water-bearing aquifer (fractured bedrock and alluvium) (Geosyntec, 2016). Of these monitoring wells, six locations (MW-1011, MW-1012, MW-1203, MW-1601, MW-1602, and MW-1603) are screened in fractured sandstone and shale layers of the Breathitt formation. The remaining four monitoring wells (MW-1604 through MW-1607) are screened in the alluvium. The location of each groundwater monitoring well within the uppermost aquifer is shown in **Figure 2**.

Three of the monitoring wells (MW-1011, MW-1012, and MW-1203) screened in bedrock were installed on the hillside slopes upgradient of the BSFAP to support background monitoring. Three monitoring wells (MW-1601, MW-1602, and MW-1603) were installed in bedrock located downgradient of the BSFAP and are used for compliance monitoring. Two monitoring wells (MW-1604 and MW-1605) side gradient of the BSFAP are screened in alluvium and are used for background monitoring. The remaining two monitoring wells (MW-1606 and MW-1607) are located south of the Main Dam (**Figure 1**). These locations are screened in the alluvium downgradient of the BSFAP and are used for compliance monitoring.

Geosyntec determined that the groundwater monitoring well network described above meets the requirements of 40 CFR §257.91, as it consists of a sufficient number of wells installed at the appropriate locations and depths to yield groundwater samples from the uppermost aquifer. Thus, the

current groundwater monitoring network accurately represents the quality of background groundwater and groundwater passing the waste boundary of the BSFAP.

As bedrock monitoring well MW-1603 is the focus of this ASD, the boring log was reviewed to assess the lithology that could impact groundwater chemistry (EHS Support, 2019a). The boring log descriptions show alternating sequences of yellowish-brown sandstones and bluish-gray to black shales beginning at 13 feet below ground surface (ft bgs) and extending to the total depth of the boring at 39.5 ft bgs. This lithologic description is indicative of the upper portion of the Princess Formation (uppermost formation in the Breathitt Group [Rice and Hiett, 1994]). Within the MW-1603 screened interval (22 to 32 ft bgs), the shale at a depth of 24 to 25 ft bgs was described as "intensely fractured, black, wet, nearly all organic matter; slight coaly texture." This depth (24 to 25 ft bgs) corresponds with the measurements by the Kentucky Geological Survey (KGS) of the elevation of the Princess Number 8 coal, which is present within the Princess Formation of the Breathitt Group (EHS Support, 2019a).

Coal or "organic material" was also visually identified on the MW-1608, MW-1609, and MW-1610 boring logs at the same approximate elevation, between 630 and 650 feet, and align with the KGS measurements (**Table 2-1**). No coal was documented in this section in three monitoring wells (MW-1601, MW-1602, and MW-1611). Four monitoring wells (MW-1604, MW-1605, MW-1606, and MW-1607) were installed stratigraphically below this coal layer.

Table 2-1 Screened Interval of Monitoring Wells

Well/Boring	Surface Elevation (ft msl)	Screened Interval (ft msl)	Coal or "Organics" Description at ~632-650 ft
MW-1601	713.8	646.8-636.8	No coal logged
MW-1602	711.6	632.1-622.1	No coal logged
MW-1603	673.2	651.2-641.2	Yes, at a depth of ~25 ft (Elevation of 648 ft)
MW-1604	553.1	513.1-503.1	---
MW-1605	554.4	538.9-528.9	---
MW-1606	551	513.1-503.1	---
MW-1607	542.2	518.7-508.7	---
MW-1608	716.2	606.6-596.6	Yes, at depths of ~74 ft (Elevation of 642 ft), ~ 75.3 to 76.6 ft (Elevation of 641 to 640 ft), and ~ 83.5 to 84 ft (Elevation of 633 to 632 ft)
MW-1609	~728	---	Yes, at a depth of ~79 ft (Elevation of 649 ft)
MW-1610	~716	---	Yes, at a depth of ~81 ft (Elevation of 635 ft)
MW-1611	~711	606-596	No coal logged

--- = Boring advanced below the coal interval
~ = Approximate
ft = feet
msl = mean sea level

2.2 Groundwater Monitoring

AEP has conducted groundwater monitoring of the uppermost aquifer to meet the requirements of the CCR Rules. Groundwater monitoring generally included the following activities:

- Collection of groundwater samples and analysis for Appendix III and Appendix IV constituents, as specified in 40 CFR §257.94 et seq. and AEP's Groundwater Sampling and Analysis Plan (AEP and EHS Support, 2016).
- Completion of validation tests for groundwater data, including tests for completeness, valid values, transcription errors, and consistent units.
- Establishment of background data for each Appendix III and Appendix IV constituent.
- Initiation of detection monitoring sampling and analysis.
- Evaluation of the groundwater data using a statistical process per 40 CFR §257.93, which was prepared, certified, and originally posted to AEP's CCR website in April 2017 in AEP's Statistical Analysis Plan (Geosyntec, 2017) and updated as Revision 1 in January 2021 (Geosyntec, 2021); the statistical process was guided by USEPA's Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance (USEPA, 2009).
- Initiation of assessment monitoring sampling and analysis.
- Completion of statistical data evaluation and determination of GWPS.

Assessment monitoring for the BSFAP has been conducted on a semi-annual basis since April 2018. The groundwater data collected through the June 2022 monitoring event have been used for this ASD addendum investigation. Historical groundwater monitoring data for MW-1603 is provided in **Table 1** (attached). The March and June 2022 groundwater data was evaluated, and no data usability issues were found (Geosyntec, 2022). Assessment monitoring data for well MW-1603 in March and June 2022 is provided in **Table 2-2**.

Table 2-2 MW-1603 March and June 2022 Groundwater Quality

Analyte	Unit	March 2022 Value	June 2022 Value
Antimony	µg/L	<0.02	<0.10
Arsenic	µg/L	0.96	1.55
Barium	µg/L	13.3	8.77
Beryllium	µg/L	14.9	15.0
Boron	mg/L	NA	0.071
Bromide	mg/L	0.05 J	<0.10
Cadmium	µg/L	0.69	0.734
Calcium	mg/L	NA	94.4
Chloride	mg/L	NA	4.07
Chromium	µg/L	0.36	0.78
Cobalt	µg/L	79.7	98.3
Fluoride	mg/L	0.65	0.69

Analyte	Unit	March 2022 Value	June 2022 Value
Lead	µg/L	3.37	6.5
Lithium	mg/L	0.151	0.153
Mercury	µg/L	<0.002	<0.005
Molybdenum	µg/L	<0.1	<0.5
pH	S.U.	3.10	4.87
Potassium	mg/L	3.51	3.28
Radium 226/228	pCi/L	17.94	6.22
Residue, Filterable, TDS	mg/L	NA	970
Selenium	µg/L	4.01	6.56
Sodium	mg/L	19.7	20.4
Sulfate	mg/L	NA	675
Thallium	µg/L	1.66	1.71

< = non detect at method detection limit (MDL)
µg/L = micrograms per liter
J = Concentration estimated. Analyte was detected between the method detection limit and the reporting limit.
mg/L = milligrams per liter
NA = constituent not analyzed
pCi/L = picocuries per liter
S.U. = standard units
TDS = total dissolved solids

AEP submitted the March and June 2022 monitoring data to Groundwater Stats Consulting, LLC for statistical analysis. A GWPS was established for each of the Appendix IV parameters. Confidence intervals, including lower confidence levels (LCLs) and upper confidence levels (UCLs), were calculated for Appendix IV parameters at the compliance wells to assess whether Appendix IV parameters were present at an SSL above the GWPS. Based on this statistical analysis of March and June 2022, the following SSLs were identified at the BSFAP in MW-1603 (no other monitoring well had constituents exceeding a GWPS):

- The LCL for beryllium exceeded the GWPS of 0.004 milligrams per liter (mg/L) at MW-1603 (0.0164 mg/L).
- The LCL for cobalt exceeded the GWPS of 0.006 mg/L at MW-1603 (0.0848 mg/L).
- The LCL for lithium exceeded the GWPS of 0.04 mg/L at MW-1603 (0.177 mg/L).
- The LCL for radium 226/228 exceeded the GWPS of 5.00 picocuries per liter (pCi/L) at MW-1603 (5.12 pCi/L).

3 Alternative Source Demonstration Requirements

Potential causes that may support an ASD include, but are not limited to, sampling causes (ASD Type I), laboratory causes (ASD Type II), statistical evaluation causes (ASD Type III), and/or natural variation causes (ASD Type IV).

3.1 Alternative Source Demonstration

This ASD for the BSFAP is focused on assessing whether Type IV natural variations in groundwater could be the cause of the SSLs of beryllium, cobalt, lithium, and radium 226/228 reported for groundwater collected from monitoring well MW-1603 during the March and June 2022 sampling.

Historical groundwater monitoring data for MW-1603 is provided in **Table 1** (attached).

3.2 Assessment of Groundwater Monitoring Results

The following constituents will typically provide the information required for a complete ASD:

- Primary indicators (boron and sulfate) are evaluated for potential BSFAP leachate.
- Major ion concentrations (alkalinity, chloride, sulfate, calcium, magnesium, potassium, and sodium) in leachate and groundwater are used to evaluate whether downgradient groundwater chemistry remains representative of background groundwater chemistry. Major ion chemistry can also be used to evaluate natural variability due to seasonal changes or other causes.
- Field turbidity of groundwater is used as an indicator of the presence of suspended solids that may contribute to elevated concentrations of constituents monitored in unfiltered samples under the CCR Rule.
- The pH of leachate and groundwater provides information on chemical reactions and potential mobility of constituents in groundwater.
- Dissolved oxygen, oxidation-reduction potential (ORP), iron, and manganese in groundwater are used as indicators of redox conditions. Redox changes can affect the chemical state and solubility of sulfate, in addition to trace elements including arsenic and selenium. For example, under strongly reduced conditions (ORP less than -200 millivolts at pH 7), sulfate can be reduced to form hydrogen sulfide, or it can precipitate as iron sulfide, arsenic reduces to more mobile arsenite species, and selenium reduces to the low-mobility selenite species.

Groundwater monitored at a CCR unit for compliance with the CCR Rule is a compilation of the history of all sources of water comingling at that particular monitoring well. Different sources may contribute to the presence and detection of the same constituents, making source identification challenging. The identification and use of water quality “signatures” can be used as a tool for deciphering the similarity between potential sources and the water quality at a specific monitoring point.

4 Alternative Source Demonstration Assessment

As stated in **Section 1.2**, the primary indicators for CCR leachate impacts to groundwater are boron and sulfate. In addition to these two constituents, chloride is also used as a primary indicator for this ASD. Other potential indicators that have been evaluated include bromide, fluoride, molybdenum, potassium, and sodium.

As identified in **Section 1.1**, SSLs of beryllium, cobalt, lithium, and radium 226/228 have been reported in groundwater samples above the GWPS from monitoring well MW-1603 in March and June 2022. The water quality signatures for well MW-1603 are discussed in **Section 4.3** and compared to the water quality of the BSFAP.

EPRI (2012) defines three tiers of investigation for evaluation of water quality signatures to determine if elevated concentrations represent a release from a CCR facility:

- Tier I: Trend Analysis and Statistics
- Tier II: Advanced Geochemical Evaluation Methods
- Tier III: Isotopic Analyses

Conversely, these tools can also be used to evaluate whether or not sources other than CCR are contributing to groundwater quality degradation.

The CCR Rule requires statistical analysis under assessment monitoring for the determination of SSLs above the GWPS. Many of the primary and potential indicator constituents listed for CCR (EPRI, 2022) are included in AEP's constituent list for the BSFAP groundwater monitoring programs, including primary constituents boron and sulfate. If there is an SSL without a corresponding increase in a primary indicator constituent (boron and usually sulfate for CCR), then this is a key line of evidence for an ASD.

4.1 Groundwater Data Analysis

Temporal plots are provided in **Section 4.1.1** through **Section 4.1.3** for monitoring well MW-1603 (**Figure 4-1** through **Figure 4-12**). Each of the plots uses the following color-coding system:

- Red – indicates a concentration reported above the reporting limit.
- Orange – indicates a concentration reported below the reporting limit but greater than the method detection limit (MDL) (denoted as estimated "J" values).
- Green – indicates a concentration not detected at or above the MDL (denoted as "U"); results were conservatively plotted as the MDL.

The BSFAP surface water signature from October 2017 is plotted as a constant concentration in **Figure 4-1** through **Figure 4-12** as a proxy for BSFAP pore water for comparison to downgradient groundwater concentrations. It is probable that BSFAP water quality historically varied over time since the BSFAP accepted fly ash before 1970. However, the BSFAP ceased accepting fly ash in November 2015 and the surface water quality is anticipated to be more stable following this termination of relatively constant fly ash addition. Therefore, the October 19, 2017 data provides a reasonable representation of the BSFAP surface water conditions. Shortly after the October 2017 sample collection, BSFAP closure work, including contouring of CCR in preparation for geomembrane cover installation, began near the surface water collection area and samples were no longer representative of porewater conditions after this

time. Geomembrane installation was completed over the entire BSFAP in November 2020 and the BSFAP is now closed.

Groundwater constituents for well MW-1603 are plotted on the primary y-axis and BSFAP water constituents are plotted on the secondary y-axis due to the differences in concentration (**Figure 4-1** through **Figure 4-12**).

4.1.1 Primary Indicators

Temporal plots for primary indicators boron, sulfate, and chloride reported in groundwater monitoring well MW-1603 are provided in **Figure 4-1** to **Figure 4-3**, respectively (note the y-axis scales associated with the BSFAP water data).

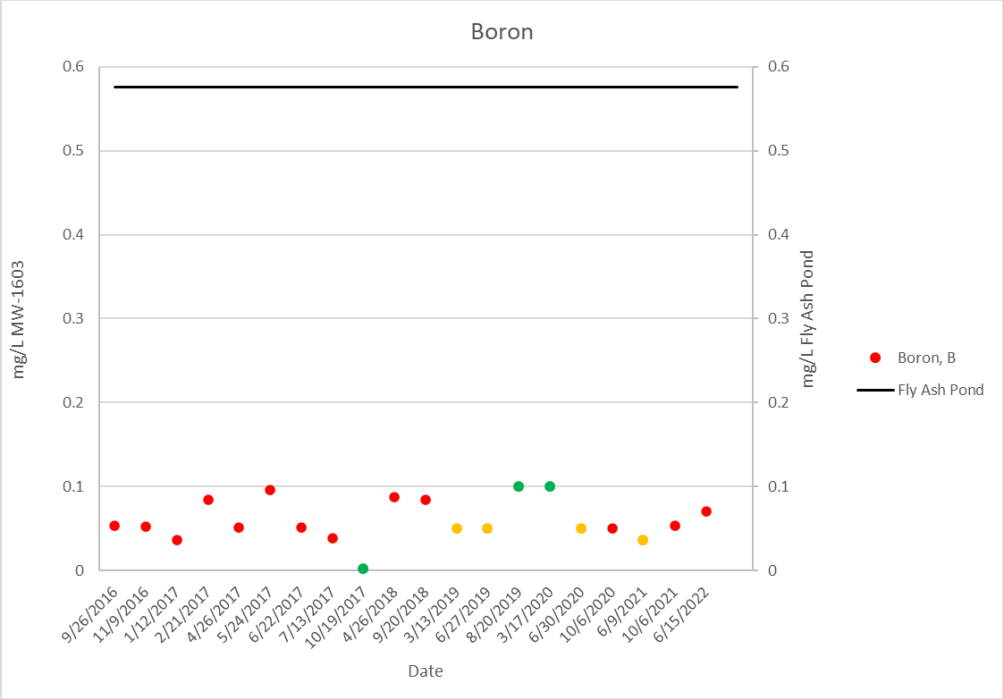


Figure 4-1 MW-1603 Boron Concentrations

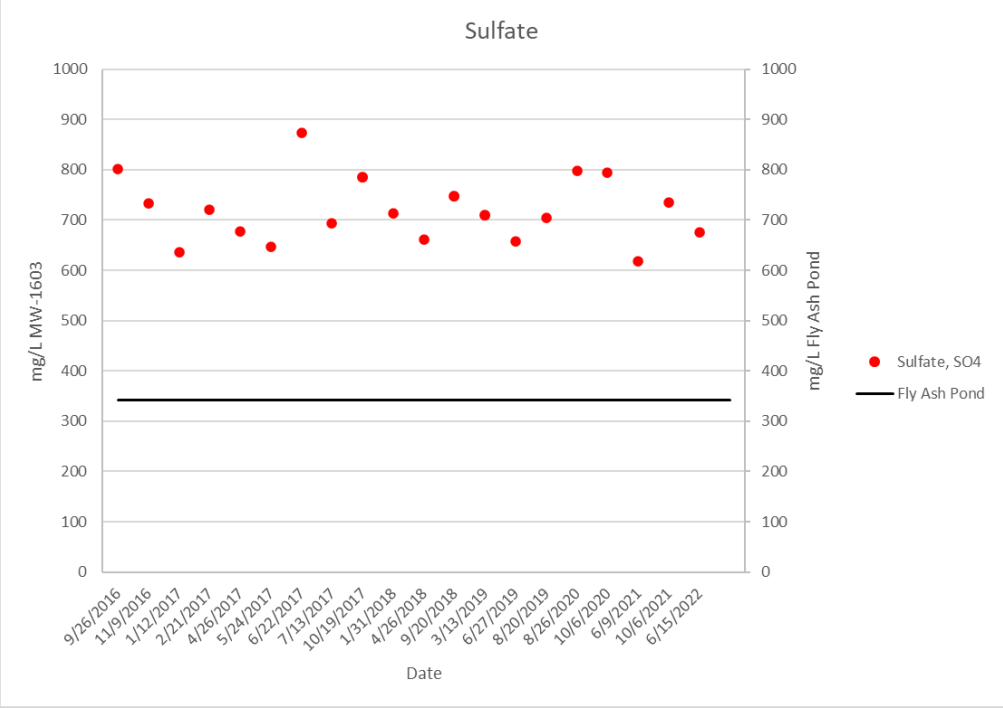


Figure 4-2 MW-1603 Sulfate Concentrations

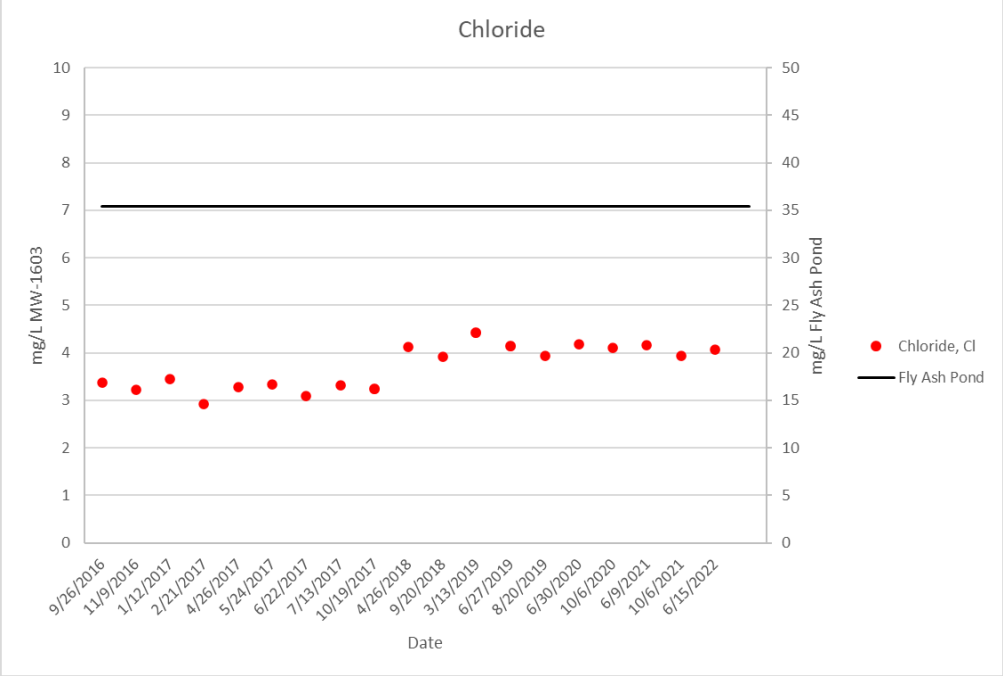


Figure 4-3 MW-1603 Chloride Concentrations

Boron and sulfate concentrations in MW-1603 have remained relatively stable, within the same order of magnitude, with minor variability over the monitoring period (September 2016 through June 2022). Chloride concentrations in MW-1603 remained relatively stable until April 2018, after which a slight

increase is observed followed by stable concentrations. Given the overall very low chloride concentrations at MW-1603 (an order of magnitude lower than in the BSFAP), this slight apparent increase in chloride of approximately 1 mg/L is minimal and most likely reflects a change in sampling or analytical procedure. Boron and chloride in water from the BSFAP are present at higher concentrations than in groundwater at MW-1603, whereas sulfate is present at higher concentrations in groundwater at MW-1603 than in water from the BSFAP.

In summary, there were negligible changes in primary indicator concentrations since the last review of the October 2021 monitoring data (EHS Support, 2022).

4.1.2 Potential Indicators

Temporal plots for potential indicators (bromide, fluoride, molybdenum, potassium, and sodium) reported in groundwater monitoring well MW-1603 are provided in **Figure 4-4** to **Figure 4-8**, respectively.

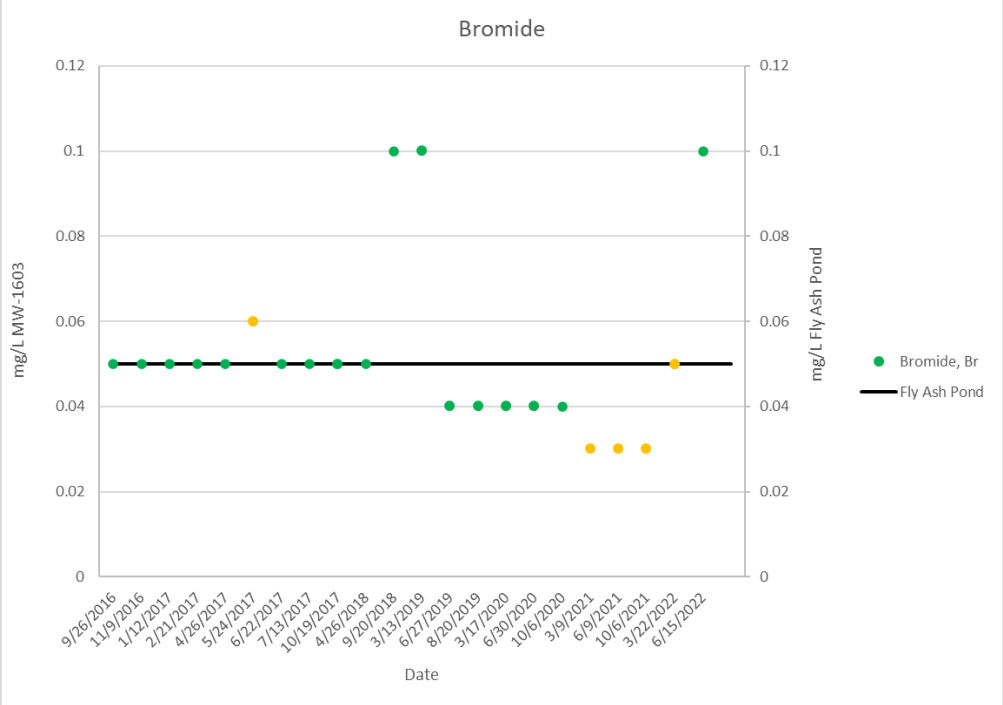


Figure 4-4 MW-1603 Bromide Concentrations[1]

[1] Bromide is below the reporting limit for BSFAP water; therefore, it is plotted at the MDL of 0.05 mg/L.

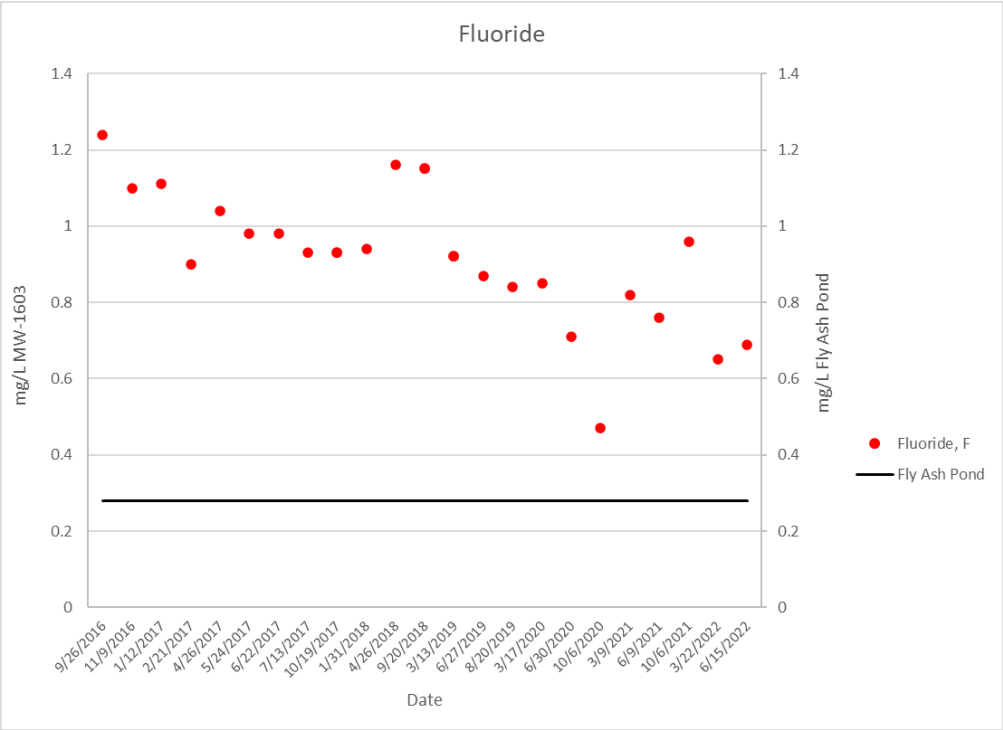


Figure 4-5 MW-1603 Fluoride Concentrations

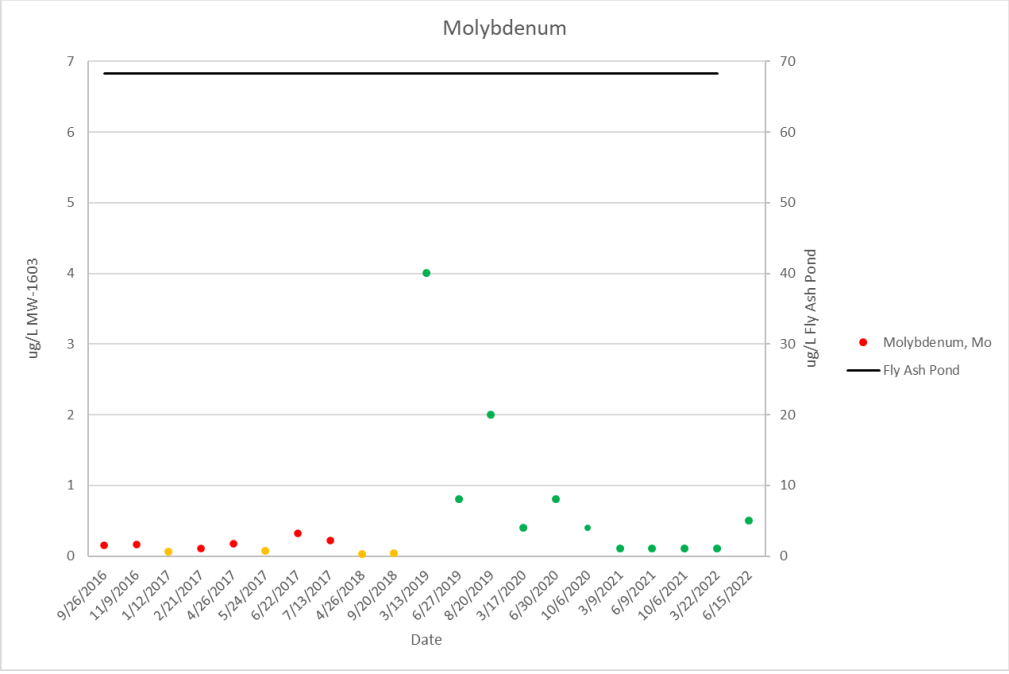


Figure 4-6 MW-1603 Molybdenum Concentrations

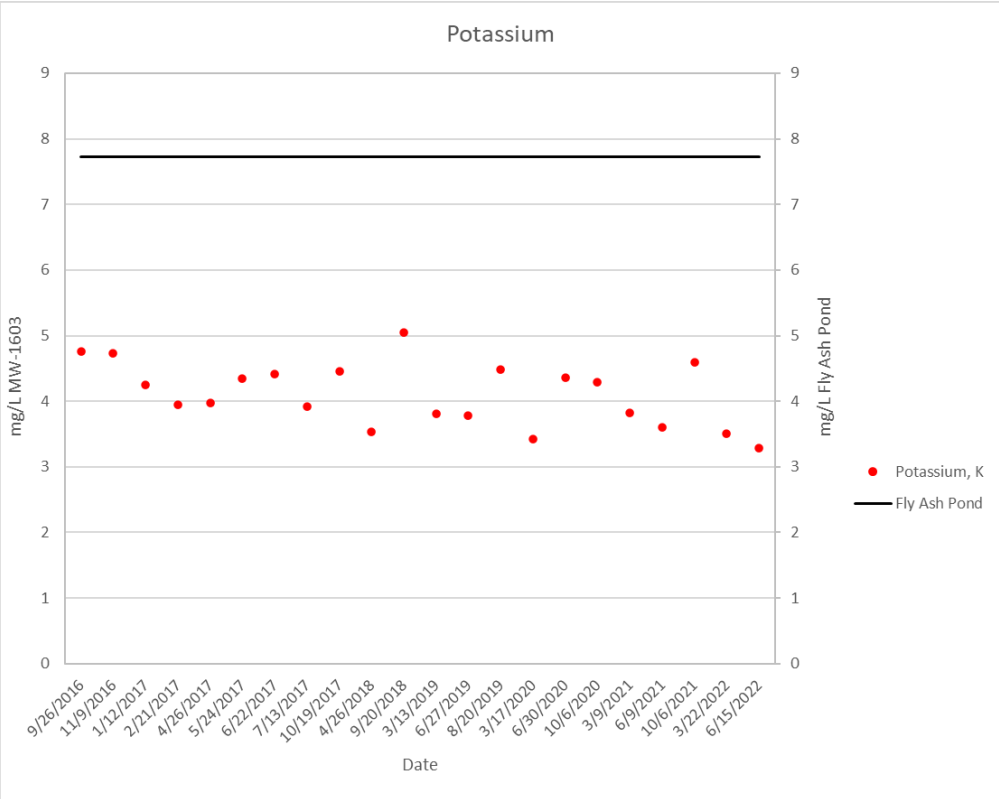


Figure 4-7 MW-1603 Potassium Concentrations

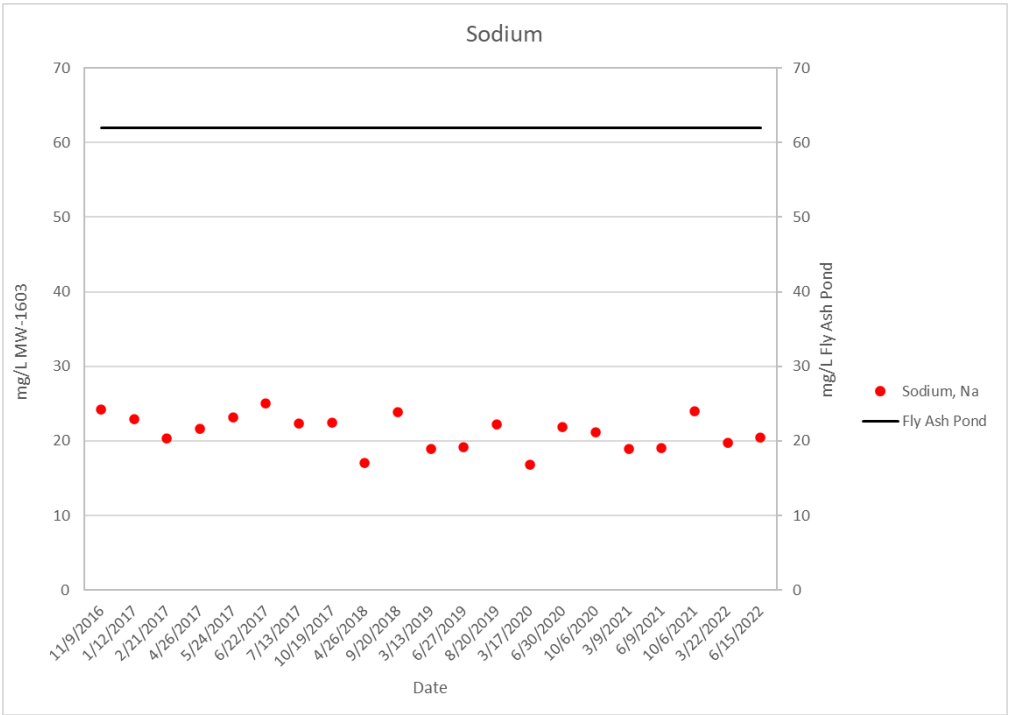


Figure 4-8 MW-1603 Sodium Concentrations

The following summarizes the data presented in **Figure 4-4** through **Figure 4-8**.

- Molybdenum, potassium, and sodium concentrations in groundwater from MW-1603 have consistently been lower than water from the BSFAP (**Figure 4-6**, **Figure 4-7**, and **Figure 4-8** respectively)
- Molybdenum was last detected above the MDL in MW-1603 in September 2018 (**Figure 4-6**). The recent variation in molybdenum concentrations, as shown in green, is due to variable MDLs achieved in the laboratory analyses.
- Fluoride concentrations in groundwater from MW-1603 have consistently been higher than water from the BSFAP but have exhibited an overall declining concentration trend with time (**Figure 4-5**).
- Bromide concentrations in groundwater from MW-1603 have historically been non-detect below the MDL of 0.5 mg/L, except an estimated "J" value detection of 0.06 mg/L in May 2017. Estimated "J" value detections of 0.03 mg/L have been reported for bromide during four out of the last five sampling events (March, June, and October 2021, and March 2022) due to lowering of the MDL (**Figure 4-4**). Bromide was not detected in June 2022 likely due to the MDL being raised to 0.10 mg/L.

A comparison of the pH of BSFAP water and groundwater from MW-1603 is provided in **Figure 4-9**. The figure illustrates the substantial difference in pH between the BSFAP water and groundwater of approximately three to five S.U. This is using the standard (logarithmic) pH scale which converts to a factor of 1,000 to 100,000 difference in the hydrogen ion concentration. The pH in MW-1603 is acidic with values generally between 3 and 4 S.U., whereas the BSFAP water is alkaline at a pH of approximately 8 S.U.

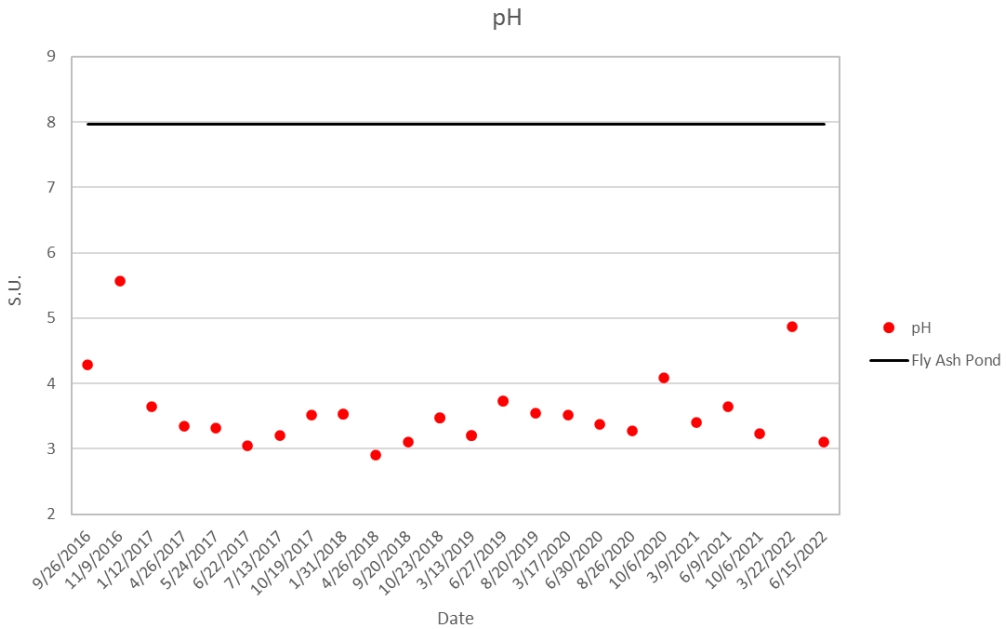


Figure 4-9 MW-1603 pH Values

In summary, there were negligible changes in potential indicator concentrations since the last review of the October 2021 monitoring data (EHS Support, 2022).

4.1.3 ASD Constituent Trends

Temporal plots for the ASD constituents, beryllium, cobalt, lithium, and radium 226/228 reported in groundwater monitoring well MW-1603 are provided in **Figure 4-10** to **Figure 4-12**, respectively.

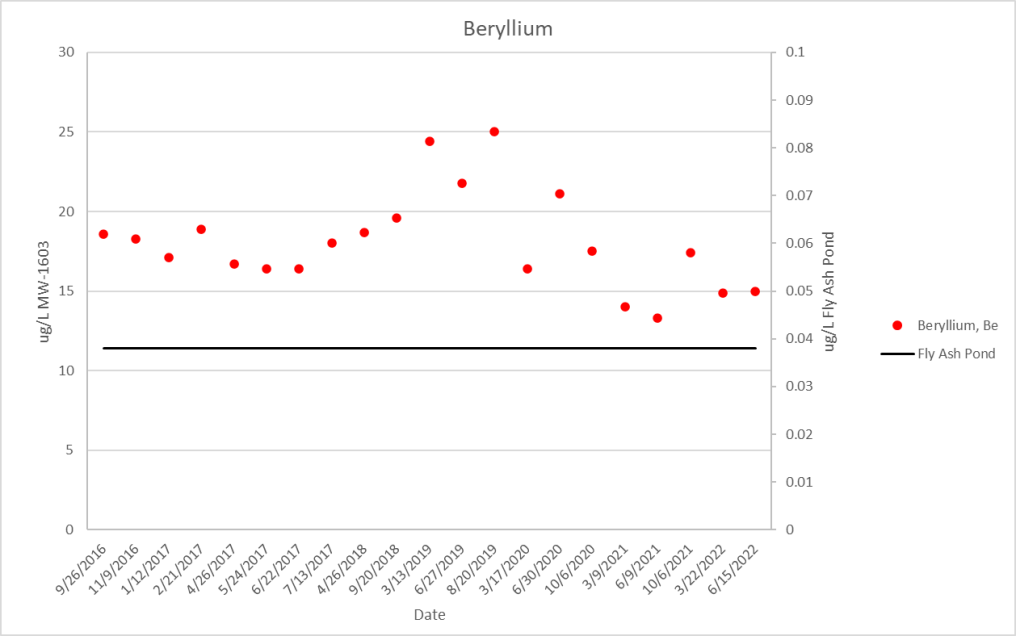


Figure 4-10 MW-1603 Beryllium Concentrations

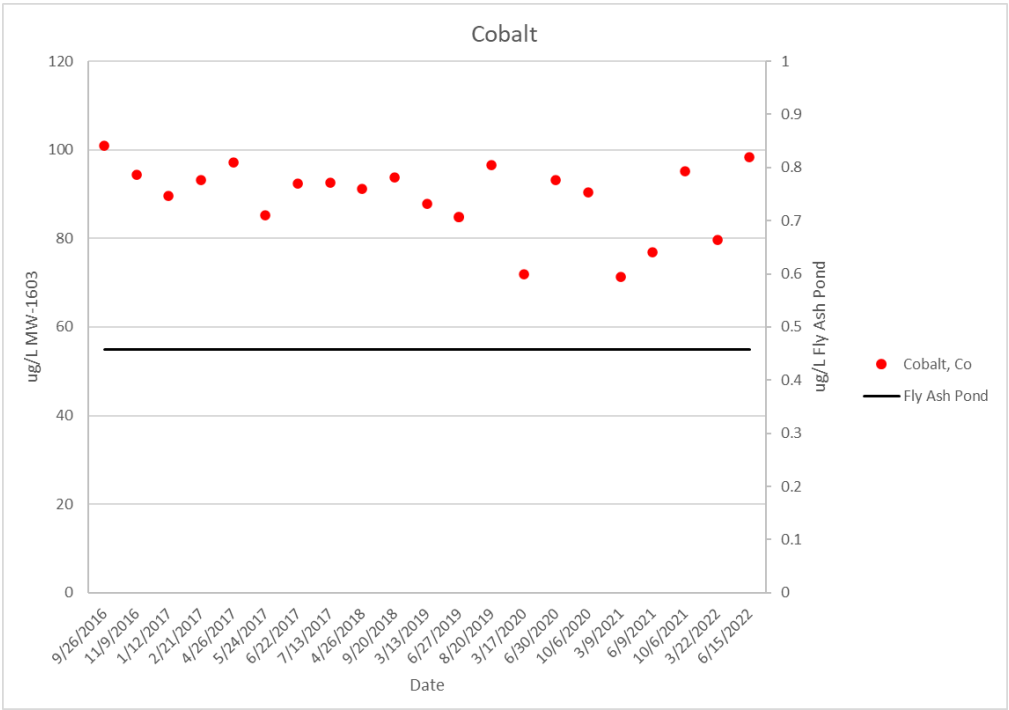


Figure 4-11 MW-1603 Cobalt Concentrations

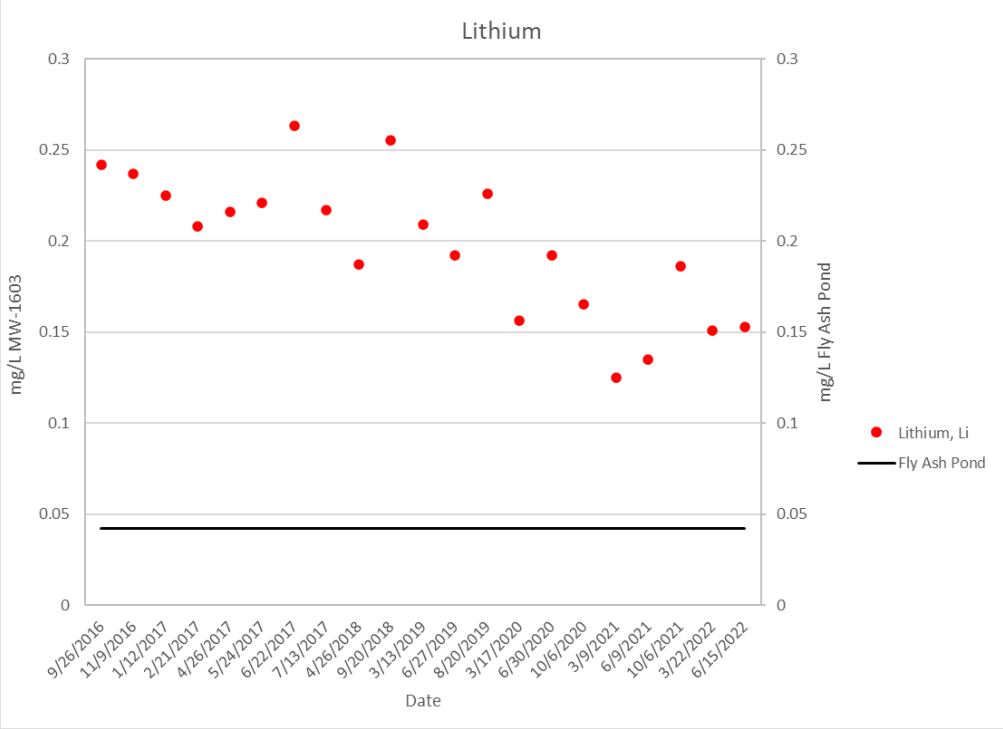


Figure 4-12 MW-1603 Lithium Concentrations

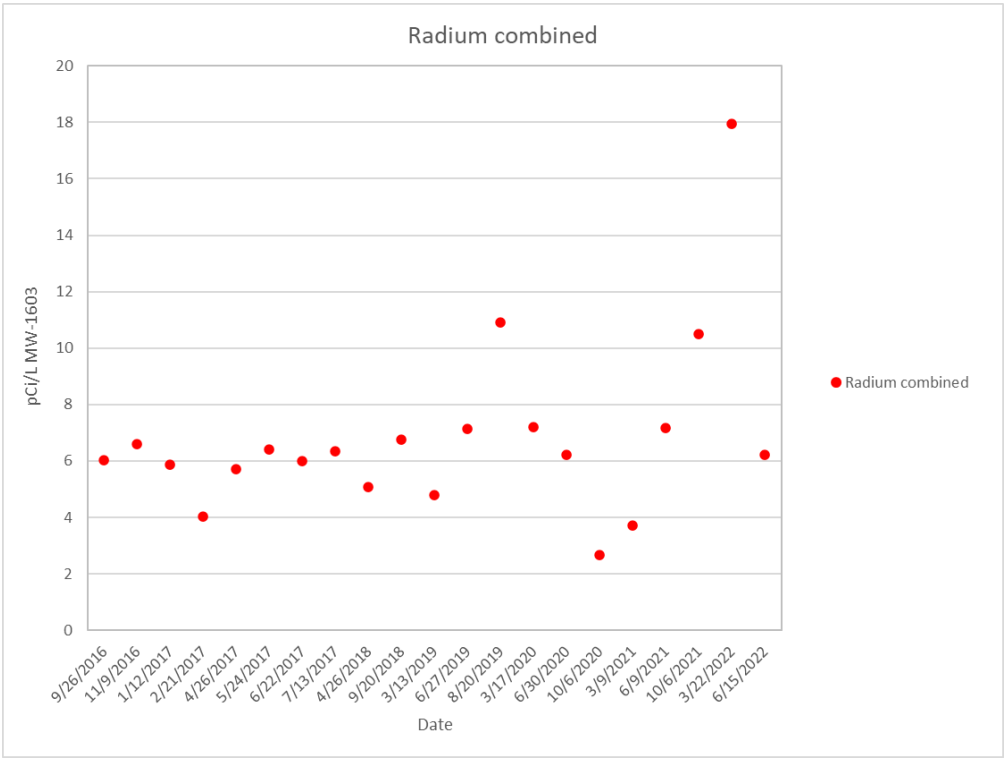


Figure 4-13 MW-1603 Radium 226/228 Concentrations

Beryllium, cobalt, and lithium concentrations are higher in groundwater from MW-1603 compared to BSFAP water (note the y-axis scales associated with **Figure 4-10** and **Figure 4-11**). This data indicates that the source of beryllium, cobalt, and lithium in groundwater at MW-1603 is not associated with the BSFAP.

Radium 226/228 concentrations in the BSFAP water are unknown, therefore, a comparison between the BSFAP water and MW-1603 groundwater cannot be made. However, radium 226/228 concentrations in MW-1603 are stable across most of the dataset, except for the results from August 2019, October 2020, October 2021, and March 2022. These concentrations are considered anomalies which is supported by the outliers on the box and whisker plot of radium 226/228 on Figure A-12 of **Appendix A**.

4.1.4 Indicator Analysis Findings

Based on the temporal plots for primary indicators, potential indicators, and ASD constituents, it is considered unlikely that CCR constituents from the BSFAP are influencing the chemistry of groundwater at MW-1603. This is based on the primary indicator sulfate, potential indicators fluoride and bromide, and the ASD constituent's beryllium, cobalt, and lithium all being present at higher concentrations in MW-1603 groundwater in comparison to the BSFAP water (EHS Support, 2019a). As the concentrations of these constituents in MW-1603 groundwater are higher, it is unlikely that there is a concentration gradient extending from the BSFAP to groundwater at that location. A key line of evidence that CCR constituents are not affecting groundwater at MW-1603 is the vastly different pH values between the locations. It is more likely that an alternate source is contributing to the higher concentrations observed in groundwater.

In summary, based on the analyses presented above, no trends in the MW-1603 groundwater dataset suggest that CCR constituents are migrating from the BSFAP into groundwater.

4.2 Tier I Evaluation - Statistical Evaluation

Statistical evaluations of analytes in groundwater at MW-1603 have been conducted previously (EHS Support, 2019a, 2019b, 2020, 2021a, 2021b, 2021c, 2022). The evaluations concluded that groundwater in the vicinity of MW-1603 is statistically the same as that which the United States Geological Survey (USGS) reported for regional background (Ruppert et al., 2000) for arsenic, boron, calcium, chloride, chromium, fluoride, molybdenum, potassium, sodium, and strontium.

The box plots from the earlier ASD investigation (EHS Support, 2019a) also show a difference between monitoring well MW-1603, BSFAP water, and/or the regional background for pH, alkalinity, barium, cobalt, lead, lithium, magnesium, selenium, and sulfate. No background values were provided by the USGS for beryllium, chromium, lead, lithium, molybdenum, and selenium.

Updated box and whisker plots for constituents reported in MW-1603 groundwater are provided in **Appendix A**. Plots for fluoride, pH, beryllium, cobalt, lithium, and radium 226/228 exhibit outliers which are calculated to be outside the range of distribution (Figure A-4, Figure A-8, Figure A-9, Figure A-10, Figure A-11, and Figure A-12 of **Appendix A**, respectively).

It is likely that the acidic groundwater conditions identified at MW-1603, relative to regional background, are driving the observed SSLs. The geochemical conditions within well MW-1603, including a strongly acidic pH, low alkalinity, and high sulfate, are indicative of conditions similar to those observed at acid mine drainage sites. At MW-1603, the geochemical conditions have developed due to the presence of the sulfide-bearing Princess coal seams being intersected by the screened interval of the monitoring well (discussed in EHS Support, 2019a). The combination of the well installation and effects of well sampling has resulted in the development of aerobic and water-saturated conditions within the coal seams. These conditions have led to a lowering of the pH through oxidation of sulfides present in the coal which has subsequently enhanced rock dissolution. Enhanced host rock dissolution at MW-1603 is evident from the much higher total dissolved solids (TDS) values at this location in comparison to groundwater samples from the other Site wells, including water from the BSFAP.

In addition to an abundance of sulfides, rock and coal samples from the Princess Formation in Kentucky have been shown to contain parts per million (ppm) levels of beryllium, cobalt, and lithium (Hood et al., 2020), thereby, providing a viable source for the observed SSLs. Part per million concentrations of the radioactive elements thorium and uranium are also reported for the Princess coal (Gabbard, 1993; Hood et al., 2020), and radium is a typical decay product of thorium and uranium that is often detected at elevated levels in coal deposits (Zielinski and Finkelman, 1997).

Conditions that are associated with the highest radium concentrations in groundwater include (1) oxygen poor water, (2) acidic conditions (low pH), and high concentrations of dissolved solids (Szabo et al, 2012). Radium is removed from groundwater under shifts to oxidizing conditions by co-precipitation with barite and adsorption onto iron/manganese oxide precipitates. Radium is mobilized into groundwater following shifts to more reducing conditions where it is desorbed following reduction of iron and manganese (McMahon et al., 2019).

For context, studies have demonstrated that the pH of groundwater in contact with fly ash is maintained alkaline (pH 7 to 10) for decades due to buffering by reactions with carbonates and amorphous aluminum silicates in the fly ash (Twardowska et al., 2003). The BSFAP water is consistent with this range, with a pH of 7.97 S.U. Therefore, the acidic pH of groundwater identified at MW-1603 is compelling evidence that groundwater at this location has not mixed with, and is not representative of, water from the BSFAP.

4.3 Tier II Evaluation - Geochemical Evaluation

A simple analysis of primary and potential indicator constituents (as performed in **Section 4.1**) may not provide the lines of evidence required for a robust ASD investigation. It is recognized that naturally occurring indicator constituents and upgradient sources may have an additional influence on groundwater quality. Spatially across a site, groundwater quality may be observed to change due to chemical interactions with the aquifer matrix. EPRI (2012) recommended the use of more sophisticated methods for multiple parameters over multiple locations, such as ion ratios and ternary plots.

4.3.1 Ion Ratios

The development of ion ratios involves first selecting two non-competing, non-sorbing constituents (boron and chloride). The ratios of these constituents are then compared spatially across the Site and a

judgment is made as to whether the hydraulically downgradient groundwater is similar to the background groundwater quality.

The calculation of ion ratios was conducted using median concentrations of the indicator species. The median concentrations of boron, chloride, and sulfate over the monitoring period (September 2016 through June 2022) are provided in **Table 4-1**. These three constituents were selected based on the EPRI (2017) recommended indicator species. Whereas bromide is also a recommended indicator species, it was not included in the assessment as it was non-detect in the BSFAP water, indicating its presence in groundwater was either naturally derived or from an off-site source. The median concentrations for sulfate, boron, and chloride show minimal change since January 2019.

Table 4-1 Median Concentrations of Boron, Chloride, and Sulfate

Location	Location ID	Median Concentrations September 2016 to June 2022		
		Boron (mg/L)	Chloride (mg/L)	Sulfate (mg/L)
Source	**Fly Ash Pond**	0.58	35.4	342
Downgradient	**MW-1603**	0.053 ± 0.025	3.92 ± 0.46	712 ± 66

mg/L = milligrams per liter

Ion ratios have been calculated using boron, chloride, and sulfate as recommended in EPRI (2017) and are provided in **Table 4-2**. The ion ratios show little change since the last evaluation of the October 2021 monitoring data (EHS Support, 2022).

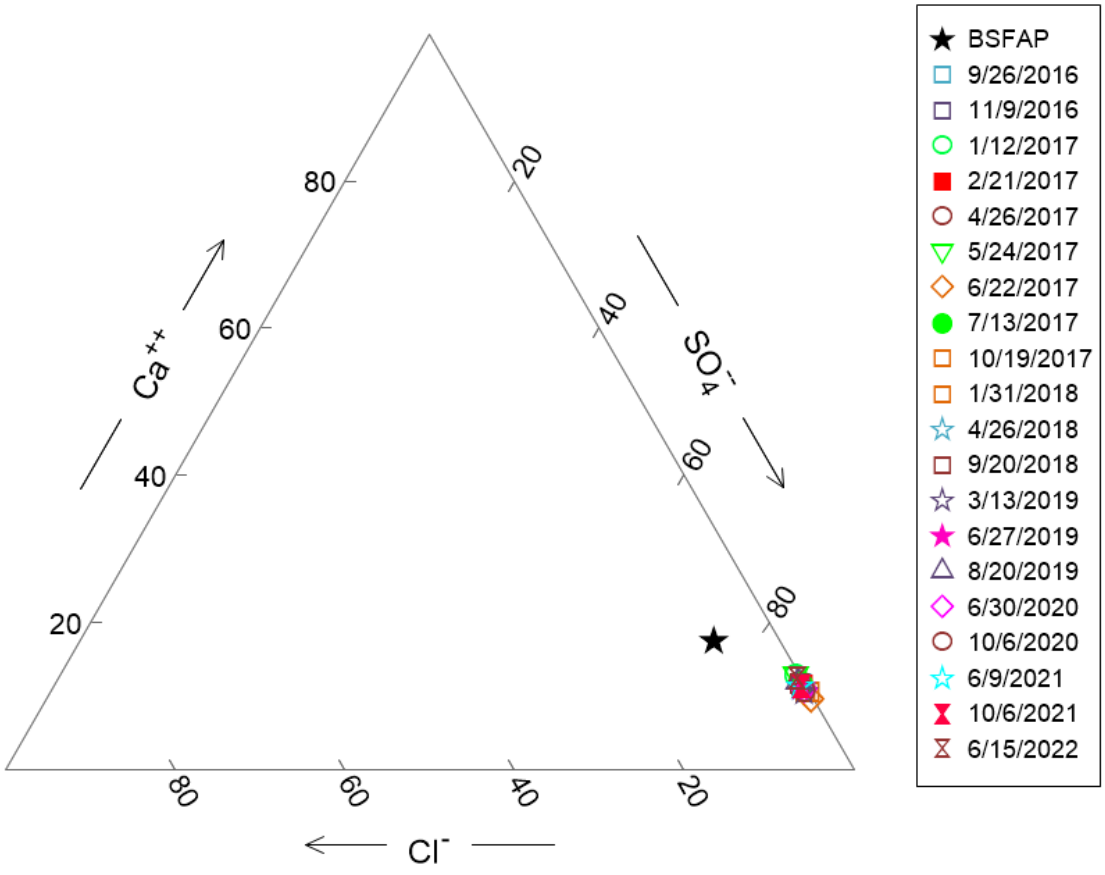
Table 4-2 Ion Ratios

Location	Location ID	Median Concentrations September 2016 to June 2022		
		Boron/Sulfate (x1000)	Boron/Chloride	Chloride/Sulfate
Source	**Fly Ash Pond**	1.68	0.002	0.10
Downgradient	**MW-1603**	0.071 ± 0.039	0.016 ± 0.007	0.0052 ± 0.001

Based on the previous and current ion ratio analysis, the conclusion that MW-1603 is not impacted by CCR constituents from the BSFAP is unchanged.

4.3.2 Ternary Plots

Ternary plots are used to identify changes in major or minor ion distributions over time. A ternary plot using calcium, chloride, and sulfate measured in the vicinity of MW-1603 is provided in **Figure 4-14**. The close grouping of ratios from all events on the ternary plot shows that the major ion groundwater ratios have not changed during the five-year period of groundwater quality monitoring at well MW-1603 and that the ratios are distinct from the BSFAP.



Notes:
Ca^{++} = calcium
SO_4^{--} = sulfate
Cl^- = chloride

Figure 4-14 Ternary Plot MW-1603

4.3.3 Summary

In summary, based on the previous geochemical evaluations (EHS Support, 2019a, 2019b, 2020, 2021a, 2021b, 2021c, 2022) and the updated review presented in this ASD investigation, there is insufficient evidence to support the presence of CCR constituents (beryllium, cobalt, lithium, and radium 226/228), derived from the BSFAP, in groundwater sampled at MW-1603. The ternary plot does not support temporal changes of MW-1603 groundwater quality. The boron, chloride, and sulfate ion ratios remain relatively unchanged since September 2019. Therefore, it is unlikely that beryllium, cobalt, lithium, and radium 226/228 detected within MW-1603 groundwater are sourced from the BSFAP. It is likely that beryllium, cobalt, lithium, and radium 226/228 are sourced from the lithologies in which MW-1603 is screened across, primarily the Princess coal.

5 Summary and Conclusions

Using the EPRI (2017) guidance for ASD investigations, the conclusions based on the lines of evidence presented and discussed within **Section 3** and **Section 4** indicate that groundwater in the vicinity of the Site is not being impacted by CCR constituents from the BSFAP. The elevated beryllium, cobalt, lithium, and radium 226/228 concentrations that triggered the ASD investigation are due to the oxidation of sulfide minerals present in coal seams that have been intersected by well MW-1603, including organic material within the screened interval that is identified as having "a slight coaly texture." This is supported by the visual evidence recorded during the logging of the core from this location (EHS Support, 2019a), the low pH reported in groundwater, and the subsequent mobilization and leaching of trace metals (beryllium, cobalt, and lithium) into groundwater by the elevated acidity.

Consistent with the August 2019, March 2020, June 2020, and October 2021 sampling events, radium 226/228 detections have been reported for MW-1603 as an SSL in the March and June 2022 groundwater monitoring statistics. Radium is sourced from radioactive decay of naturally occurring radioactive materials (NORM), including uranium and thorium, which are present in the Princess coal at ppm levels. Therefore, the presence of radium 226/228 is likely due to elevated uranium and thorium in the coal seams that have been intersected at well location MW-1603. Natural variations in redox conditions likely cause sorption and desorption of radium to iron/manganese oxides that leads to fluctuation in the detections in groundwater. As a result of the installation, screening, and extraction of groundwater from MW-1603, radium 226/228 may now be considered a technologically enhanced NORM.

The higher pH in the BSFAP water and the corresponding lower concentrations of minor ions in the BSFAP also support the unlikely influence of the BSFAP on groundwater. Therefore, it is concluded that the elevated signatures of beryllium, cobalt, lithium, and radium 226/228 in MW-1603, as noted in the March and June 2022 groundwater monitoring data, are related to the dissolution of naturally occurring, coal seam-derived constituents within the shale layers of the Breathitt Group, as supported by the discussion of local and regional geology in **Section 2.1** and EHS Support (2019a).

In conclusion, this ASD addendum for the BSFAP has determined that Type IV natural variations in groundwater resulted in the SSLs of beryllium, cobalt, lithium, and radium 226/228 detected at MW-1603.

6 References

AEP and EHS Support. (2016). Groundwater Sampling and Analysis Plan. October.

EHS Support. (2019a). Alternative Source Demonstration Report for Beryllium, Cobalt and Lithium, Big Sandy Fly Ash Pond, Louisa, Kentucky. February.

EHS Support. (2019b). Alternative Source Demonstration Addendum Report for Beryllium, Cobalt and Lithium, Big Sandy Fly Ash Pond, Louisa, Kentucky. September.

EHS Support. (2020). Alternative Source Demonstration Addendum Report for 2019 Monitoring Data, Big Sandy Fly Ash Pond, Louisa, Kentucky. January.

EHS Support. (2021a). Alternative Source Demonstration Addendum Report for the March and June 2020 Monitoring Data, Big Sandy Fly Ash Pond, Louisa, Kentucky. January.

EHS Support. (2021b). Alternative Source Demonstration Addendum Report for the October 2020 Monitoring Data, Big Sandy Fly Ash Pond, Louisa, Kentucky. April.

EHS Support. (2021c). Alternative Source Demonstration Addendum Report for the March and June 2021 Monitoring Data, Big Sandy Fly Ash Pond, Louisa, Kentucky. November.

EHS Support. (2022). Alternative Source Demonstration Addendum Report for the October 2021 Monitoring Data, Big Sandy Fly Ash Pond, Louisa, Kentucky. March.

EPRI. (2012). Groundwater Quality Signatures for Assessing Potential Impacts from Coal Combustion Product Leachate. EPRI, Palo Alto, CA. 1017923.

EPRI. (2017). Guidelines for Development of Alternative Source Demonstrations at Coal Combustion Residual Sites. EPRI, Palo Alto, CA. 3002010920.

EPRI. (2022). Guidelines for Development of Alternative Source Demonstrations at Coal Combustion Residual Sites. EPRI, Palo Alto, CA. 3002010920.

Gabbard, A. (1993) Coal Combustion: Nuclear Resource or Danger. Oak Ridge National Laboratory Review v.26, no. 3&4.

Geosyntec Consultants, Inc. (2016). Groundwater Monitoring Well Installation Report – Fly Ash Pond. October.

Geosyntec Consultants, Inc. (2017). Statistical Analysis Plan, Revision 0. January.

Geosyntec Consultants, Inc. (2021). Statistical Analysis Plan, Revision 1. January.

Geosyntec Consultant, Inc. (2021a) Statistical Analysis Summary. February.

Hood, M.M., Eble, C.F., Hower, J.C. and Dai, S. (2020). Geochemistry, petrology, and palynology of the Princess No. 3 coal, Greenup County, Kentucky. International Journal of Coal Science & Technology, pp.1-19.

McMahon, P.B., Vengosh, A., Davis, T.A., Landon, M.K., Tyne, R.L., Wright, M.T., Kulongoski, J.T., Hunt, A.G., Barry, P.H., Kondash, A.J. and Wang, Z., 2019. Occurrence and sources of radium in groundwater associated with oil fields in the southern San Joaquin Valley, California. Environmental Science & Technology, 53(16), pp.9398-9406.

Rice, C. and Hiett, J. (1994). Revised Correlation Chart of the Coal Beds, Coal Zones, and Key Stratigraphic Units in the Pennsylvanian Rocks of Eastern Kentucky, USGS Miscellaneous Field Studies Map MF-2275.

Ruppert, L., Tewalt, S., Wallack, R., Bragg, L., Brezinski, D., Carlton, R., Butler, D., and Calef, F. (2000). A Digital Resource Model of the Middle Pennsylvanian Upper Freeport Coal Bed Allegheny Group, Northern Appalachian Basin Coal Region. USGS Professional Paper 1625-C. 101 pages.

Szabo, Z., Fischer, J.M. and Hancock, T.C., 2012. Principal aquifers can contribute radium to sources of drinking water under certain geochemical conditions. US Department of the Interior, US Geological Survey.

Twardowska, I., Szczepanska, J. and Stefaniak, S. (2003). Occurrence and mobilization potential of trace elements from disposed coal combustion fly ash. In Chemistry of Trace Elements in Fly Ash (pp. 13-24). Springer, Boston, MA.

USEPA. (2009). Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance. March.

Zielinski, R.A. and Finkelman, R.B. (1997). Radioactive elements in coal and fly ash: abundance, forms, and environmental significance (No. 163-97). US Geological Survey.

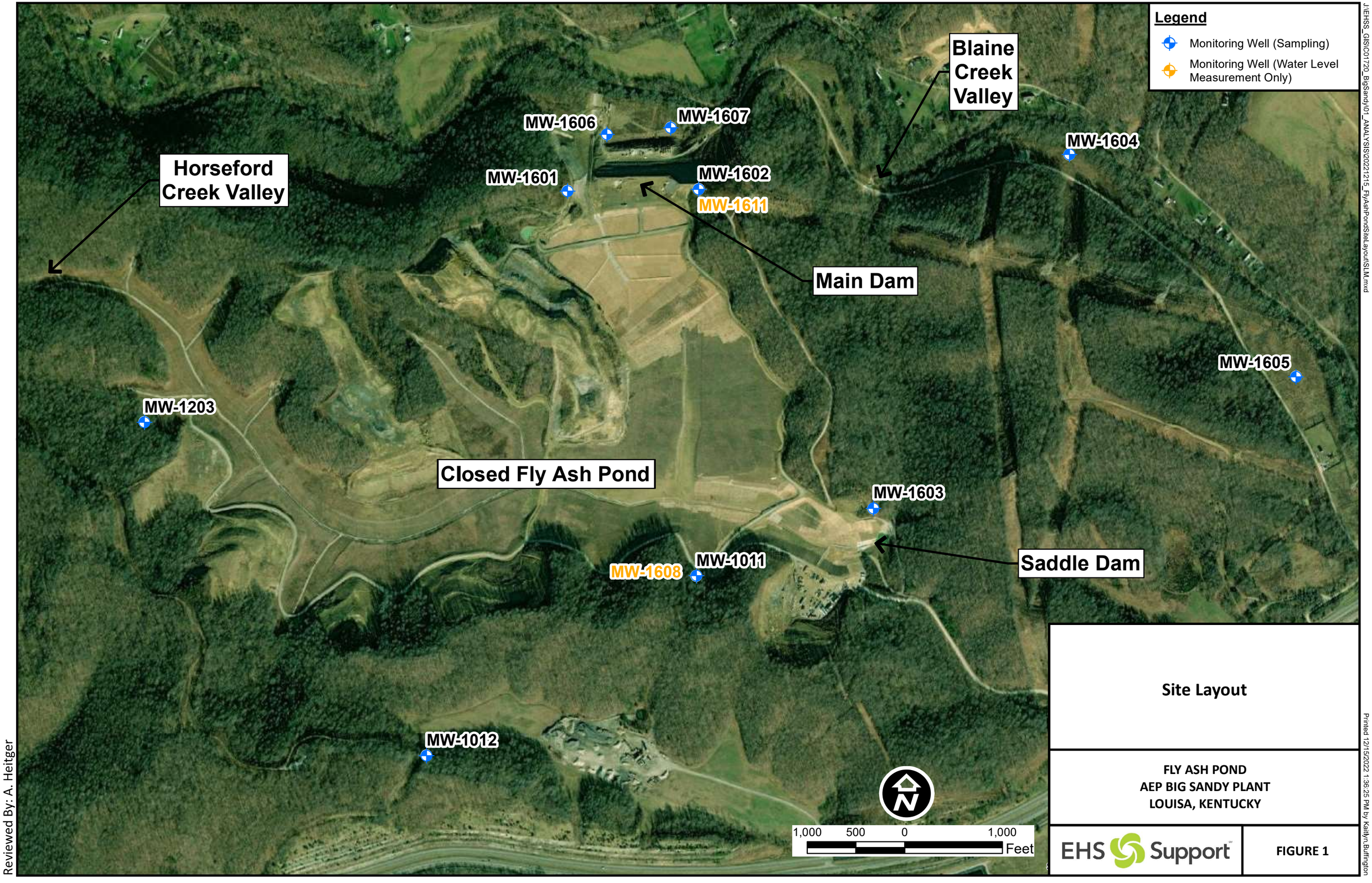
Tables

Table 1
MW-1603 Historical Groundwater Data September 2016 to June 2022
Big Sandy Fly Ash Pond Groundwater Monitoring,
American Electric Power, Kentucky Power Company,
Louisa, Kentucky

Analytes	Units	9/26/2016	11/9/2016	1/12/2017	2/21/2017	4/26/2017	5/24/2017	6/22/2017	7/13/2017	10/19/2017	1/31/2018	4/26/2018	9/20/2018	10/23/2018	3/13/2019	6/27/2019	8/20/2019	3/17/2020	6/30/2020	8/26/2020	10/6/2020	3/9/2021	6/9/2021	10/6/2021	3/22/2022	6/15/2022
Antimony, Sb	µg/L	0.01 J	< 0.01	< 0.01	< 0.01	0.01 J	< 0.01	< 0.01	< 0.01	NA	NA	0.04 J	0.02 J	NA	< 0.2	< 0.04	< 0.1	< 0.02	< 0.04	NA	< 0.02	< 0.02	0.04 J	< 0.02	<0.02	<0.10
Arsenic, As	µg/L	1.51	1.19	1.4	1.26	1.3	1.34	1.29	0.89	NA	NA	1.6	1.4	NA	1.26	1.36	1.39	0.83	1.12	NA	1.12	0.84	0.69	1.01	0.96	1.55
Barium, Ba	µg/L	13.4	15.4	11.4	10.3	12.4	11.5	11.4	11.3	NA	NA	10.5	11.4	NA	12	11	13.6	9.92	12.2	NA	14.6	10.1	13.1	17.1	13.3	8.77
Beryllium, Be	µg/L	18.6	18.3	17.1	18.9	16.7	16.4	16.4	18	NA	NA	18.7	19.6	NA	24.4	21.8	25	16.4	21.1	NA	17.5	14	13.3	17.4 M	14.9	15
Boron, B	mg/L	0.054	0.053	0.037	0.085	0.052	0.096	0.051	0.039	< 0.002	NA	0.088	0.085	NA	0.05 J	0.05 J	< 0.1	< 0.1	0.05 J	NA	2.681	NA	0.036 J	0.054	NA	0.071
Bromide	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.06 J	< 0.05	< 0.05	< 0.05	NA	< 0.05	< 0.1	NA	< 0.1	< 0.04	< 0.04	< 0.04	< 0.04	NA	< 0.04	0.03 J	0.03 J	0.03 J	0.05 J	<0.10
Cadmium, Cd	µg/L	0.84	0.93	0.79	0.75	0.87	0.77	0.86	0.8	NA	NA	0.74	0.83	NA	0.78	0.7	0.89	0.64	0.85	NA	17.5	0.62	0.709	0.0931	0.69	0.734
Calcium, Ca	mg/L	105	94.7	92.7	91.9	90.5	93.9	90.6	90.2	91	82.2	83.6	97.5	NA	84.6	83.3	95.8	NA	96.6	NA	17.4	NA	79	93.1	NA	94.4
Chloride, Cl	mg/L	3.37	3.22	3.45	2.93	3.28	3.34	3.1	3.32	3.24	NA	4.12	3.92	NA	4.42	4.13	3.93	NA	4.18	NA	4.09	NA	4.16	3.93	NA	4.07
Chromium, Cr	µg/L	1.1	1.12	0.731	0.771	0.829	0.62	0.821	0.485	NA	NA	0.771	0.713	NA	1 J	0.618	0.8	0.56	0.694	NA	0.05	0.659	0.51	0.59	0.36	0.78
Cobalt, Co	µg/L	101	94.4	89.6	93.2	97.1	85.3	92.4	92.5	NA	NA	91.1	93.8	NA	87.9	84.7	96.6	72	93.2	NA	0.04	71.4	76.8	95.1 M	79.7	98.3
Comb. Radium 226/228	pCi/L	6.04	6.6	5.86	4.03	5.72	6.4	6	6.36	NA	NA	5.09	6.75	NA	4.8	7.149	10.92	7.19	6.22	NA	794	3.73	7.18	10.51 B	17.94	6.22
Fluoride, F	mg/L	1.24	1.1	1.11	0.9	1.04	0.98	0.98	0.93	0.93	0.94	1.16	1.15	NA	0.92	0.87	0.84	0.85	0.71	NA	4.29	0.82	0.76	0.96	0.65	0.69
Lead, Pb	µg/L	9.75	8.18	6.11	6.3	6.41	4.96	6.47	3.72	NA	NA	5.27	4.39	NA	4.28	3.68	4.17	3.95	4.67	NA	0.87	3.37	3.39	6.1	3.37	6.5
Lithium, Li	mg/L	0.242	0.237	0.225	0.208	0.216	0.221	0.263	0.217	NA	NA	0.187	0.255	NA	0.209	0.192	0.226	0.156	0.192	NA	2.06	0.125	0.135	0.186 M	0.151	0.153
Mercury, Hg	µg/L	< 0.002	< 0.002	< 0.002	< 0.002	0.002 J	< 0.002	< 0.002	< 0.002	NA	NA	< 0.002	NA	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	NA	< 0.002	0.002 J	0.002 J	0.003 J	< 0.002	<0.005
Molybdenum, Mo	µg/L	0.15	0.17	0.06 J	0.11	0.18	0.07 J	0.32	0.22	NA	NA	0.03 J	0.04 J	NA	< 4	< 0.8	< 2	< 0.4	< 0.8	NA	< 0.4	< 0.1	< 0.1	<0.1	<0.1	<0.5
pH	S.U.	4.29	5.56	3.64	4.51	3.34	3.32	3.04	3.20	3.52	3.52	2.91	3.10	3.46	3.19	3.73	3.54	3.52	3.38	3.27	4.09	3.4	3.64	3.23	3.1	4.87
Potassium, K	mg/L	4.76	4.73	4.25	3.95	3.98	4.34	4.41	3.92	4.46	NA	3.53	5.05	NA	3.81	3.78	4.48	3.42	4.36	NA	4.85	3.83	3.6	4.6	3.51	3.28
Residue, Filterable, TDS	mg/L	1,060	1,010	948	1,020	994	936	1,040	1,000	962	915	926	974	NA	896	954	1,010	NA	NA	1,040	1,020	NA	880	1,040	NA	970
Selenium, Se	µg/L	5.4	4.8	5.6	4.9	6.1	6.3	6.1	2.7	NA	NA	8.1	6.3	NA	4	4.9	5.6	4	6.2	NA	0.743	3.9	3.3	4.26	4.01	6.56
Sodium, Na	mg/L	NA	24.2	22.9	20.3	21.6	23.1	25	22.3	22.4	NA	17	23.9	NA	18.9	19.1	22.2	16.8	21.9	NA	0.165	18.9	19	24	19.7	20.4
Sulfate, SO_4	mg/L	801	733	636	720	678	646	873	694	784	714	661	747	NA	709	658	704	NA	NA	798	5.8	NA	618	735	NA	675
Thallium, Tl	µg/L	1.29	1.55	1.39	1.2	1.41	1.35	1.43	1.43	NA	NA	1.39	1.7	NA	1 J	1.4	2 J	1.34	1.57	NA	90.5	1.39	1.62	2.2	1.66	1.71

Notes:
< = not detected at or above the method detection limit
µg/L = Micrograms per liter
B = Analyte detected in a blank sample
J = Estimated value. Analyte detected at a level less than the reporting limit but greater than the method detection limit.
M = the associated MS or MSD recovery was outside acceptance limits.
mg/L = Milligrams per liter
MS = Matrix spike
MSD = Matrix spike duplicate
NA = Not analyzed
pCi/L = Picocuries per liter
S.U. = Standard Units
TDS = Total Dissolved Solids

Figures



Site Layout

FLY ASH POND
AEP BIG SANDY PLANT
LOUISA, KENTUCKY

EHS Support

FIGURE 1

Reviewed By: A. Heitger

J:\EHSS_GIS\CC0172O_BigSandy\01_ANALYSIS\20221215_FlyAshPondSiteLayoutSLM.mxd

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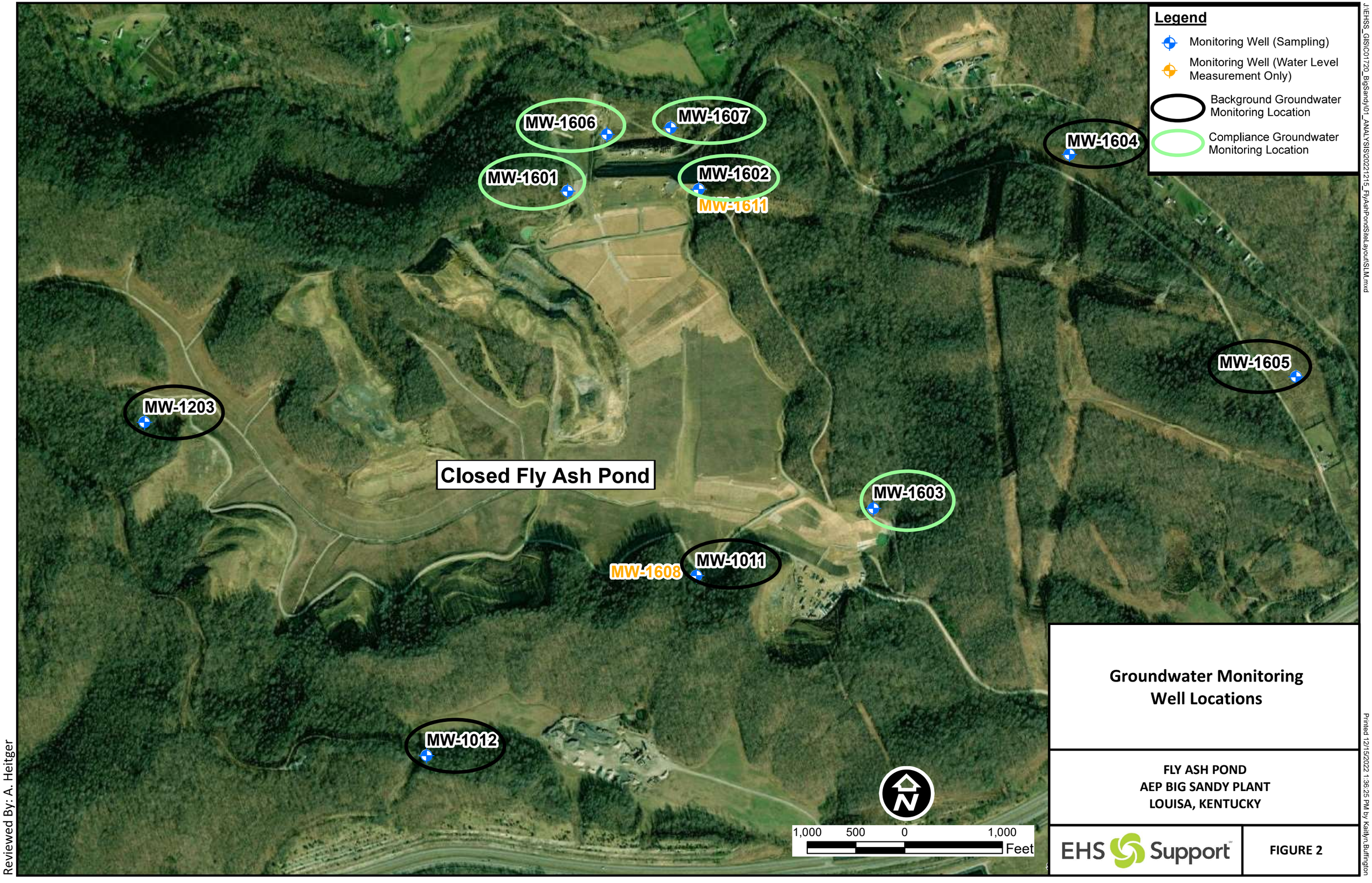

Groundwater Monitoring Well Locations

FLY ASH POND
AEP BIG SANDY PLANT
LOUISA, KENTUCKY

EHS Support

FIGURE 2

Reviewed By: A. Heitger

J:\EHSS_GIS\CI01720_BigSandy\01_ANALYSIS\20221215_FlyAshPondSiteLayoutSLM.mxd

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Appendix A MW-1603 Box Plots

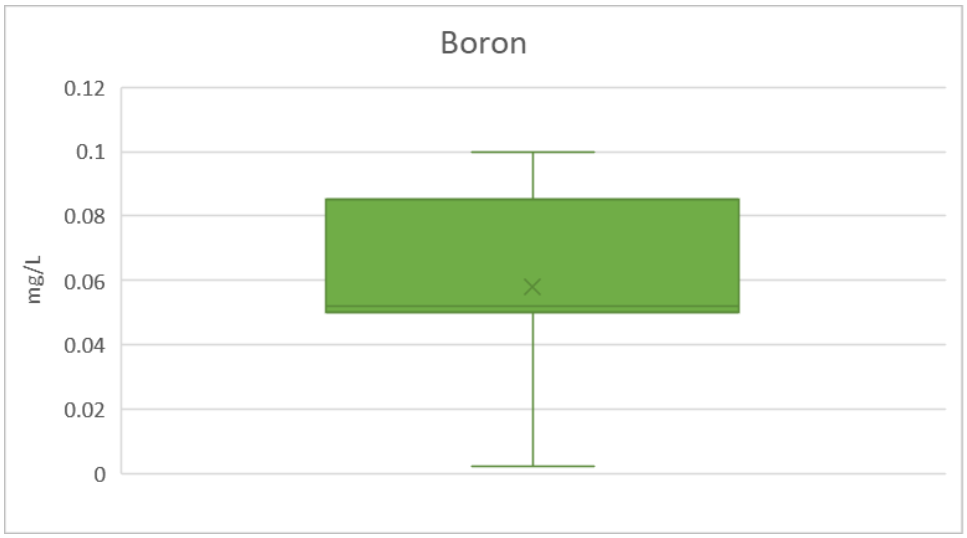

Figure A-1 Boron Box Plot

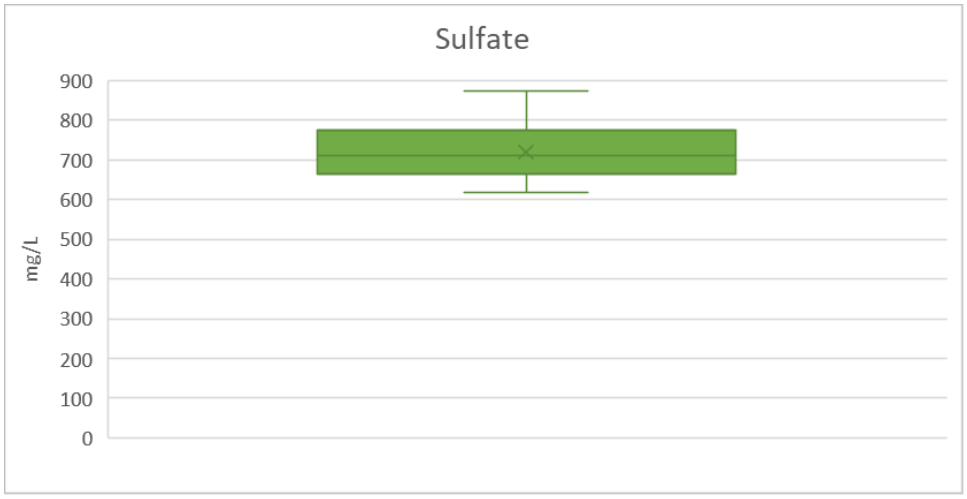

Figure A-2 Sulfate Box Plot

Figure A-3 Chloride Box Plot

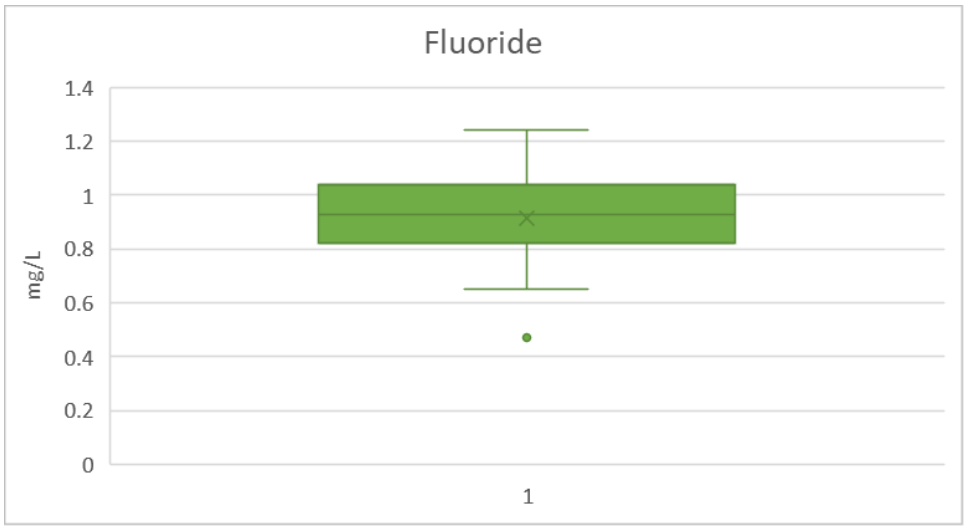

Figure A-4 Fluoride Box Plot

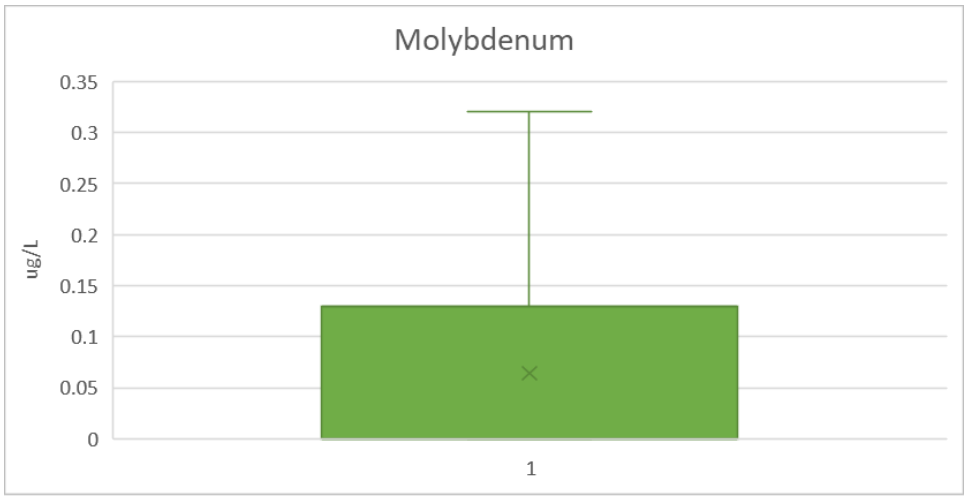

Figure A-5 Molybdenum Box Plot

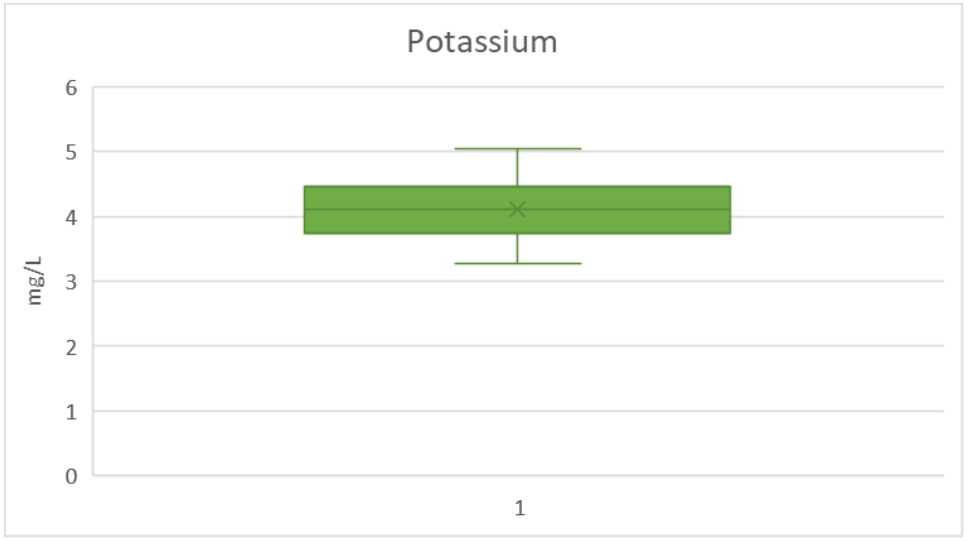

Figure A-6 Potassium Box Plot

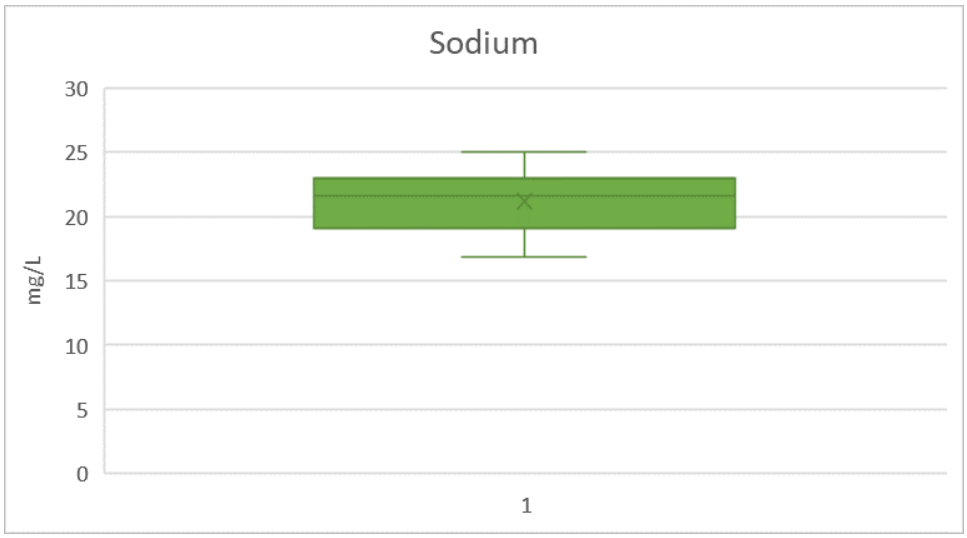

Figure A-7 Sodium Box Plot

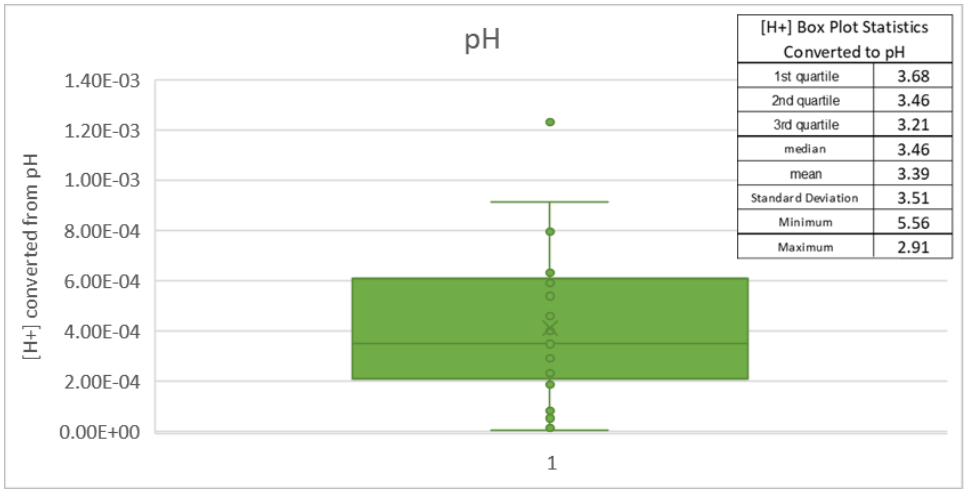

Figure A-8 pH Box Plot

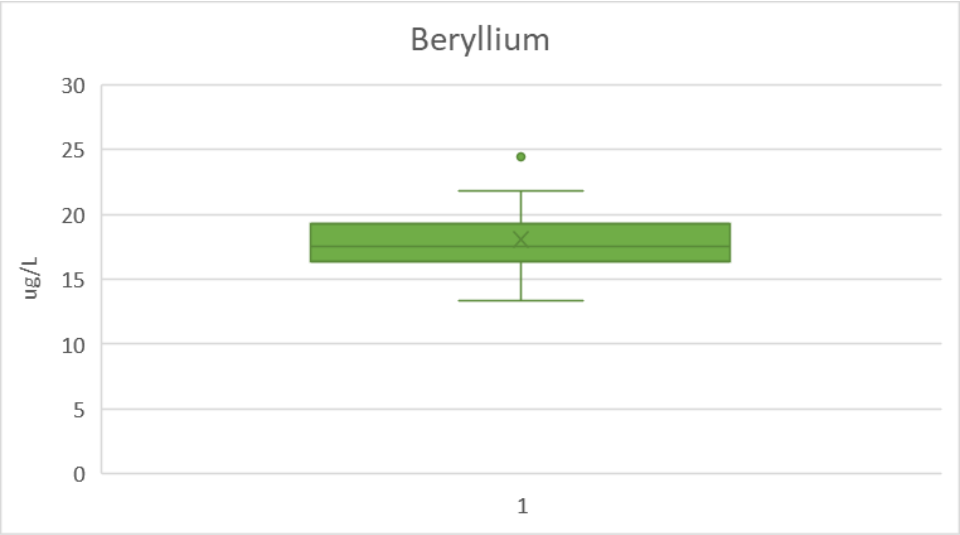

Figure A-9 Beryllium Box Plot

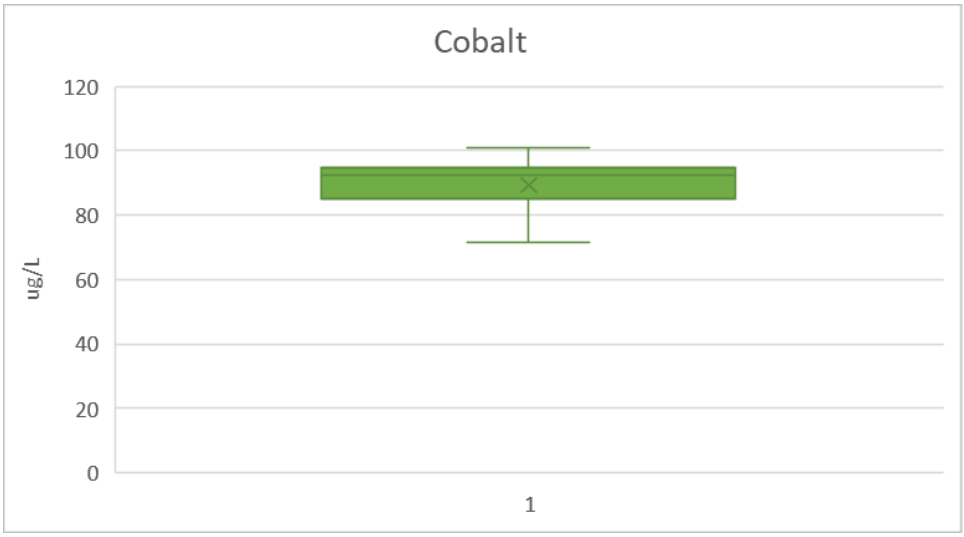

Figure A-10 Cobalt Box Plot

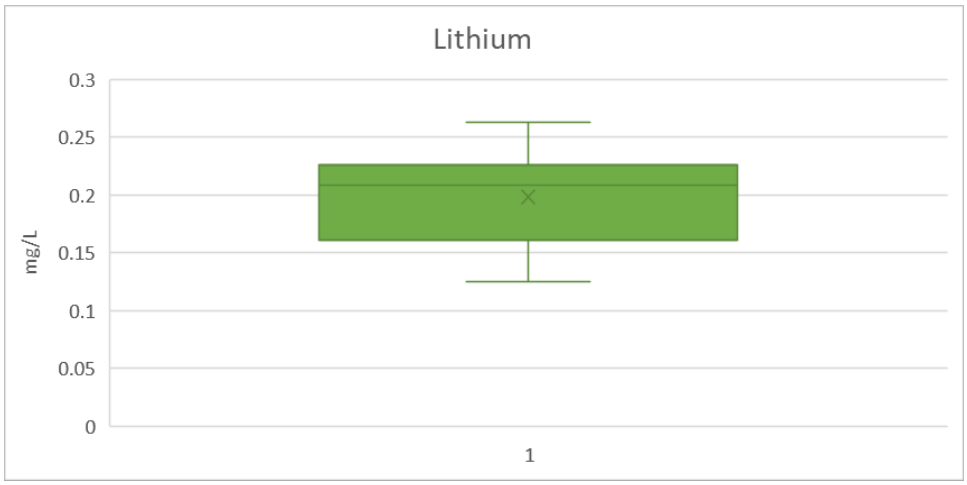

Figure A-11 Lithium Box Plot

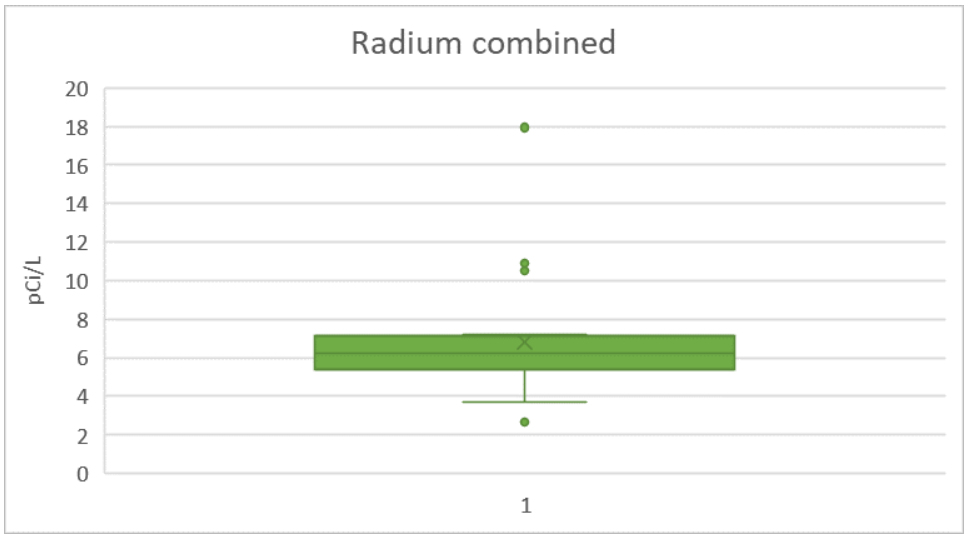

Figure A-12 Radium 226/228 Box Plot