Big Sandy Power Plant
Fly Ash Pond
Alternative Source Demonstration

The Big Sandy Fly Ash Pond initiated an assessment monitoring program in accordance with 40 CFR 257.95 on April 13, 2018. Groundwater protection standards (GWPS) were set in accordance with 257.95(d)(2) and a statistical evaluation of the assessment monitoring data was conducted. This statistical evaluation revealed an exceedance of the GWPS for beryllium, cobalt, and lithium at Monitoring Well MW-1603 on July 12, 2019. A successful alternative source demonstration (ASD) was completed per 257.95(g)(3), therefore, the Big Sandy Fly Ash Pond will remain in assessment monitoring. An alternative source demonstration is documentation that shows a source other than the CCR unit was responsible for causing the statistics to exceed the GWPS. The ASD document will explain the alternate cause of the GWPS exceedances. The successful ASD is attached.

Alternative Source Demonstration Addendum Report for Beryllium, Cobalt and Lithium

Big Sandy Fly Ash Pond
Louisa, Kentucky

Prepared for:

American Electric Power

Prepared by:

EHS Support

September 2019

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Acronyms

<	less than
µg/L	micrograms per liter
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
J	estimated concentration below the reporting level and greater than equal to the method detection limit
KGS	Kentucky Geological Survey
mg/L	milligrams per liter
msl	mean sea level
MDL	Method Detection Limit
mV	millivolts
MW	monitoring well
ORP	oxidation reduction potential
SSL	statistically significant levels
S.U.	standard units (pH)
U	not detected
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

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Licensing State

9/19/2019
Date

1 Introduction

EHS Support LLC ("EHS Support") was retained by American Electric Power, Kentucky Power Company ("AEP") in December 2018 to conduct an alternative source demonstration (ASD) investigation for beryllium, cobalt and lithium at the Big Sandy Fly Ash Pond (BSFAP) associated with the Big Sandy Power Plant located in Louisa, Kentucky (**Figure 1,** attached) (EHS Support, 2019). The ASD determined that groundwater in the vicinity of the BSFAP is not being impacted by coal combustion residual (CCR) constituents from the BSFAP, but rather the elevated beryllium, cobalt, and lithium concentrations that triggered the ASD assessment are due to the oxidation of coal seams that have been intersected by well location MW-1603.

Since the initial ASD was completed (incorporating data from September 2016 to October 2018), statistically significant levels (SSLs) of beryllium, cobalt, and lithium exceeding the groundwater protection standards have persisted through the subsequent March 2019 sampling event in one groundwater monitoring location, MW-1603. All other March 2019 groundwater quality results were below the level of statistical significance.

This ASD addendum for beryllium, cobalt and lithium in MW-1603 groundwater has been prepared per the requirements of the United States Environmental Protection Agency (USEPA) CCR Rule (40 Code of Federal Regulations [CFR] §257.95).

1.1 Objectives

The ASD investigation objective is to assess groundwater monitoring data collected in compliance with the CCR Rule as allowed under paragraph 40 CFR §257.95(g)(3)(ii) of the CCR Rule. This part of the rule allows AEP to determine whether the source(s) for SSLs of beryllium, cobalt, and lithium exceeding the groundwater protection standards reported from groundwater monitoring well MW-1603 are associated with the CCR unit, or 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 addendum for the BSFAP has been conducted to further evaluate potential alternate sources or reasons for the continuing SSLs of beryllium, cobalt, and lithium within monitoring well MW-1603.

A potential alternate source was previously established as evident in (EHS Support, 2019), based on the following lines of evidence:

- Lack of exceedances and increasing trends of primary indicators of CCR
- BSFAP water concentrations are lower than those of the corresponding constituent observed in groundwater
- Major ion chemistry does not indicate mixing between BSFAP water and groundwater.

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

1. Constituent that typically has high concentration in leachate, relative to background, such that it is expected to have elevated concentration in the event of a release
2. Constituent that is not reactive and has high mobility in groundwater such that it is expected to be at the leading edge of the plume, meaning that it will have elevated concentrations relative to background across the entire area of the plume.

As boron and sulfate are primary indicators for coal ash leachate (Electric Power Research Institute [“EPRI”], 2012) and have previously been evaluated, they have been re-evaluated herein as primary indicators for this ASD investigation. Other potential indicators that were evaluated in this ASD investigation include: chloride, potassium, sodium, fluoride, molybdenum, and bromide.

2 Project Background

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

To support this ASD, the following sections on the groundwater monitoring network and groundwater monitoring are included to provide context to the ASD investigation.

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 and the Quaternary alluvium. The Conemaugh Formation and Breathitt Group consists of sandstones, siltstones, shale, and coal that may grade laterally and vertically into one another. The overlying Quaternary alluvium deposits include sandy lean clay to silty sand and gravel at the bottom of the Horseford Creek valley and the floodplain of the 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 units, the recovery of these wells during pumping and development, and a potentiometric surface generally consistent with site topography and surface water elevations.

To assess the upper water-bearing aquifer, Geosyntec identified the groundwater monitoring network as consisting of 10 groundwater monitoring wells to provide detection monitoring in the uppermost aquifer (fractured bedrock and alluvium) (Geosyntec, 2016). Of these, six monitoring wells (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. The remaining three monitoring wells (MW-1601, MW-1602, and MW-1603) installed in bedrock are located downgradient of the BSFAP and used for compliance monitoring. Two monitoring wells (MW-1604 and MW-1605) screened in alluvium are used for background monitoring; while two other monitoring wells (MW-1606 and MW-1607), screened in alluvium and located below the Main Dam, are used for compliance monitoring.

As bedrock monitoring well MW-1603 is the focus of this ASD, the boring log (EHS Support, 2019) exhibits 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 bottom of the boring at 39.5 ft bgs) that are indicative of the upper portion of the Princess Formation (uppermost formation in the Breathitt

Group [Rice, C. and Hiett, J., 1994]). Within the screened interval (22 to 32 ft bgs), a description of the shale at a depth of 24 to 25 ft bgs was "intensely fractured, black, wet, nearly all organic matter; slight coaly texture." This elevation corresponds with the measurements by the Kentucky Geologic Society (KGS) of the elevation of the Princess Number 8 coal (EHS Support, 2019). A coal or "organic material" also was logged in three other monitoring wells (MW-1608, MW-1609, and MW-1610) in the network (**Table 2-1**) at the same approximate elevation between 630 and 650 feet that matches the KGS measurements. Three monitoring wells did not document any coal in this section (MW-1601, MW-1602, and MW-1611) and four monitoring wells were installed below this coal layer in the sedimentary sequence (MW-1604, MW-1605, MW-1606, and MW-1607).

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
Not logged = Boring log has no description of coal or "organics" in the interval between 632 to 650 ft msl
~ = Approximate
ft = feet
msl = mean sea level

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 that accurately represent the quality of background groundwater and groundwater passing the waste boundary of the BSFAP.

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, October 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 in accordance with 40 CFR §257.93, which was prepared, certified, and posted to AEP's CCR website in April 2017 in AEP's *Statistical Analysis Plan* (Geosyntec, January 2017). The statistical process was guided by USEPA's *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance* ("Unified Guidance", USEPA, 2009)
- Initiation of assessment monitoring sampling and analysis
- Completion of statistical data evaluation and determination of groundwater protection standards

Assessment monitoring for the BSFAP has been conducted on a semi-annual basis since April 2018. The groundwater data up until and including the March 2019 monitoring event has been used for this review. Specifically, beryllium, cobalt and lithium in well MW-1603 that were identified as continuing to exhibit a SSLs. Assessment monitoring data for well MW-1603 is provided in **Table 2-2** below.

Table 2-2 MW-1603 March 2019 Groundwater Quality

Analyte	Unit	Value
Antimony	µg/L	<0.2
Arsenic	µg/L	1.26
Barium	µg/L	12
Beryllium	µg/L	24.4
Boron	mg/L	0.05
Cadmium	µg/L	0.78
Calcium	mg/L	84.6
Chloride	mg/L	4.42
Chromium	µg/L	1
Cobalt	µg/L	87.9
Fluoride	mg/L	0.92
Lead	µg/L	4.28
Lithium	mg/L	0.209

Analyte	Unit	Value
Mercury	µg/L	<0.002
Molybdenum	µg/L	<4
pH	Std. Units	3.19
Residue, Filterable, TDS	mg/L	896
Selenium	µg/L	4
Sulfate	mg/L	709

< = less than
µg/L = micrograms per liter
J = estimated concentration
mg = milligrams per liter
TDS = total dissolved solids

3 Alternative Source Demonstration Requirements

3.1 Alternative Source Demonstration

Potential causes that may support the ASD may 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). This ASD for the BSFAP will be focused on assessing whether Type IV natural variations in groundwater could be the cause of statistically significant exceedances of beryllium, cobalt and lithium reported from groundwater monitoring well MW-1603.

Historical groundwater monitoring data for MW-1603 is provided as **Table 1**.

3.2 Water Monitoring Results

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

- Primary indicators (boron and sulfate) for potential BSFAP leachate impacts.
- Major ion concentrations (alkalinity, chloride, sulfate, calcium, magnesium, potassium, and sodium) in leachate and groundwater which 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 in groundwater is an indicator of the presence of suspended solids that may contribute to elevated concentrations of constituents monitored in unfiltered samples under the CCR Rule.
- pH in 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 all indicators of redox conditions. Changes in redox 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 [mV] at pH 7), sulfate can be reduced to form hydrogen sulfide or it can precipitate as iron sulfide, arsenic reduces to the 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 some 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 (coal ash) leachate affects in groundwater are boron and sulfate. In addition to these two constituents, chloride will also be a primary indicator for this ASD. Other potential indicators that have been evaluated include potassium, sodium, fluoride, molybdenum, and bromide.

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

EPRI (2012) describes three tiers of investigation for evaluation of water quality signatures to determine if elevated concentrations represent a release from a CCR facility. Conversely, these tools can also be used to evaluate whether or not sources other than CCR are contributing to groundwater quality degradation. The three tiers defined by EPRI (2012) are:

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

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

4.1 Groundwater Data Analysis

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, with data for the BSFAP water presented for comparison. All temporal plots have used the following color-coding system:

- Red – to indicate a concentration reported above the reporting limit
- Orange – to indicate a concentration reported below the reporting limit but above the method detection limit (denoted as estimated "J" values)
- Green – to indicate a concentration below the method detection limit (denoted as "U"); results below the method detection limit (MDL) were conservatively plotted as the MDL.

The BSFAP water signature is plotted as a constant concentration in **Figure 4-1** to **Figure 4-12**. This sample was collected on October 19, 2017. As the BSFAP accepted fly ash prior to 1970, it is probable that BSFAP water quality has historically varied over time. However, since the BSFAP ceased accepting fly ash prior to 2016, the water quality is anticipated to be more stable; therefore, this October 2017 data provides a reasonable representation of current BSFAP conditions.

Groundwater quality for well MW-1603 is plotted on the primary y-axis and BSFAP water quality is plotted on the secondary y-axis, due to the differences in concentration between the groundwater quality in the vicinity of MW-1603 and the BSFAP water, as labelled in **Figure 4-1** to **Figure 4-12** below.

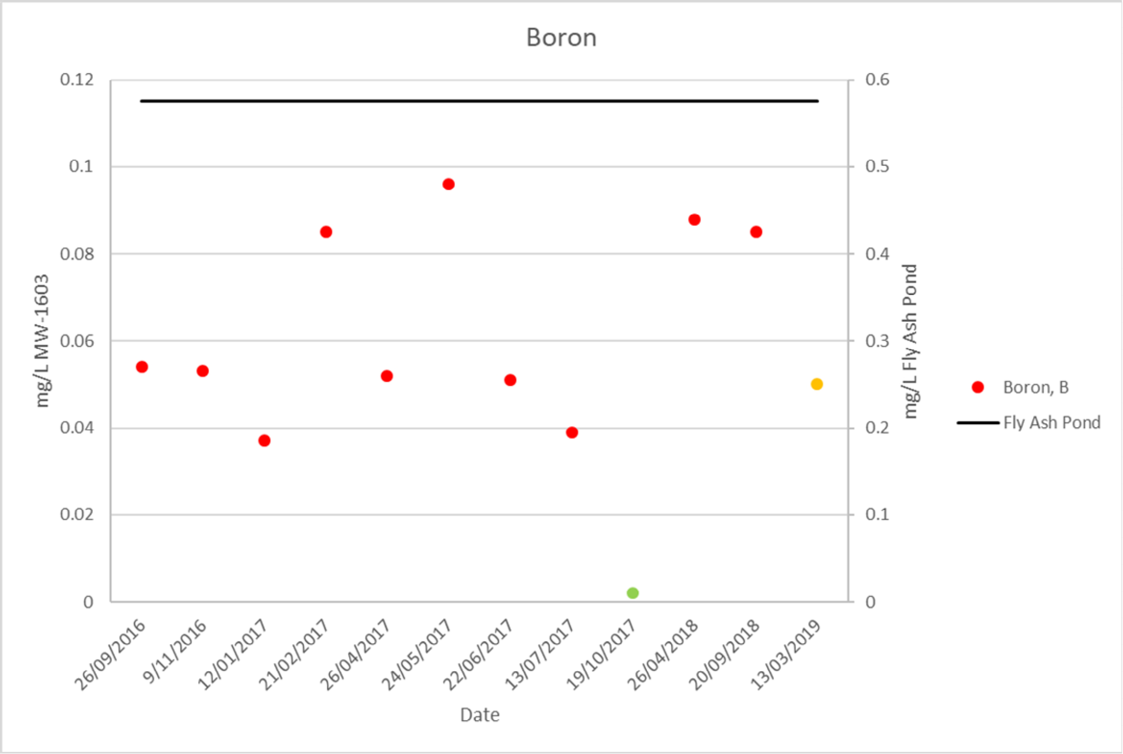

Figure 4-1 MW-1603 Boron concentrations

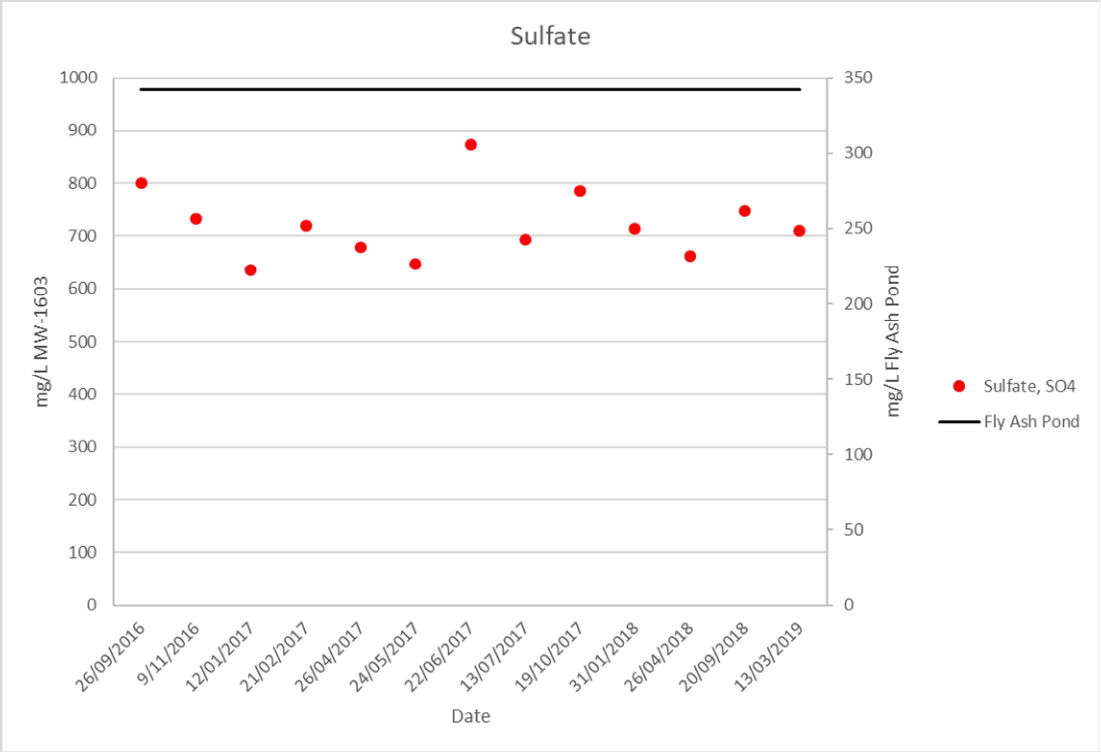

Figure 4-2 **MW-1603 Sulfate**

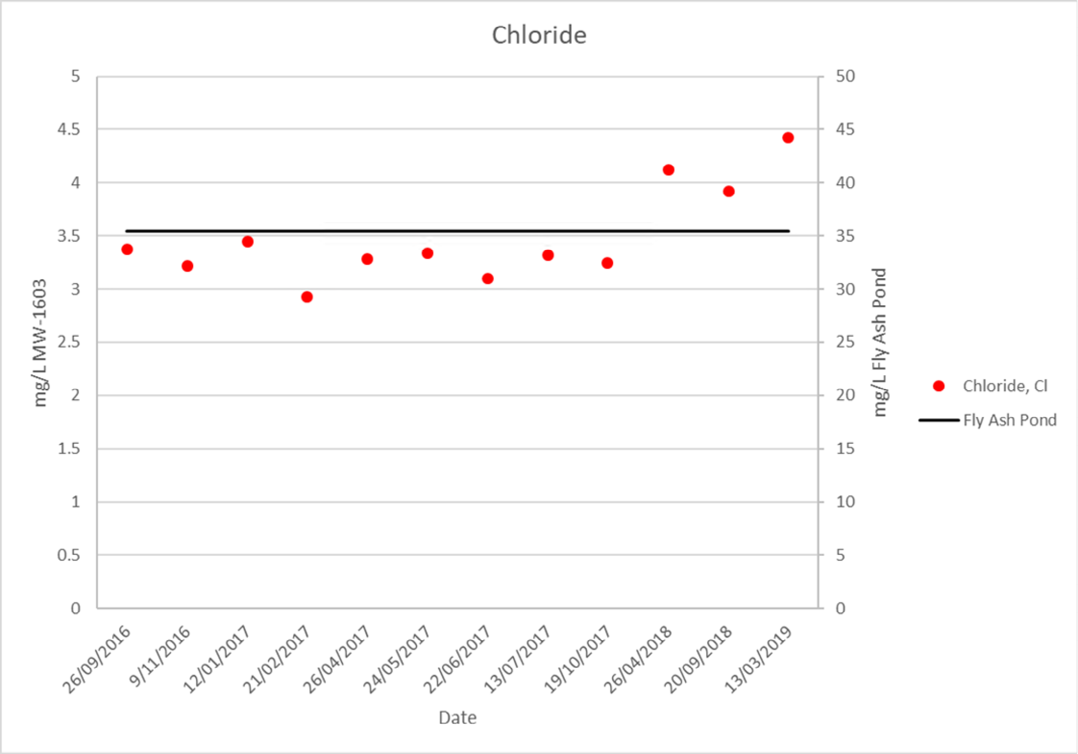

Figure 4-3 **MW-1603 Chloride**

Boron concentrations in MW-1603 have remained relatively constant, with some variability over the monitoring period (September 2016 through March 2019). Sulfate was initially reported as 801 mg/L in September 2016 and has shown a very slight decreasing trend during the monitoring period. Chloride concentrations in MW-1603 also remained relatively constant until April 2018, after which a slight increase is observed. Comparing the concentrations in groundwater to the BSFAP, boron and chloride are present at higher concentrations in the BSFAP than in groundwater, while sulfate is present at higher concentrations in groundwater than in the BSFAP.

In summary, there has been no observable changes in primary indicator concentrations since the last review in February 2019.

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, with data for the BSFAP water presented for comparison.

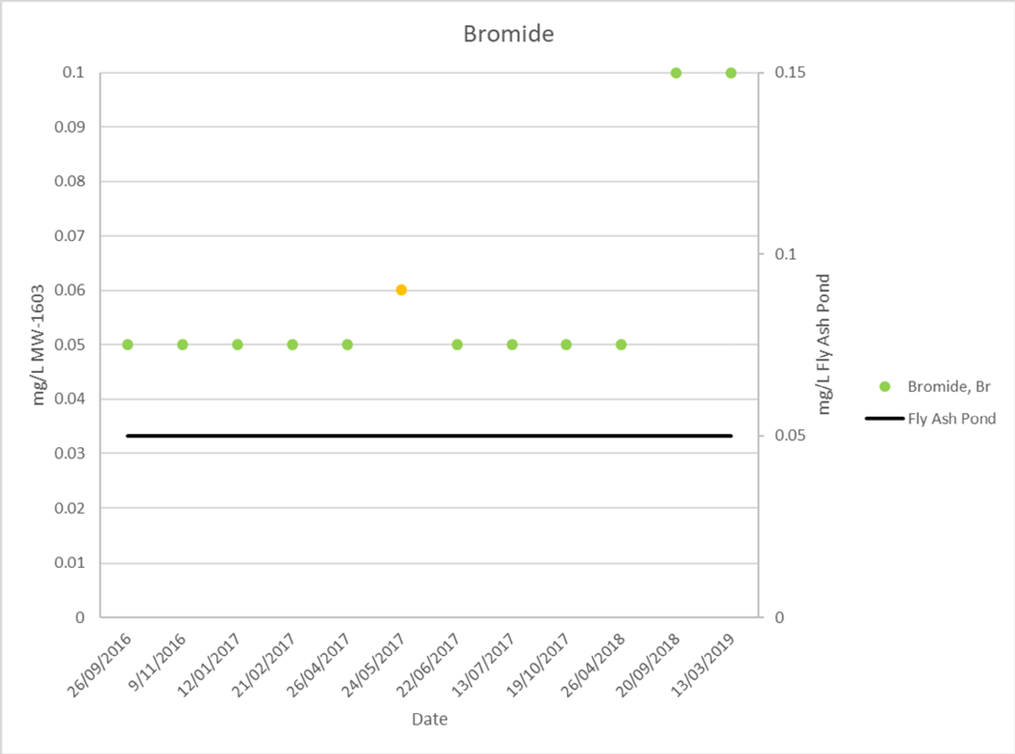

Figure 4-4 MW-1603 Bromide Concentrations[1]

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[1] Bromide is below the level of reporting for the BSFAP water, with a detection level of <0.05 mg/L.

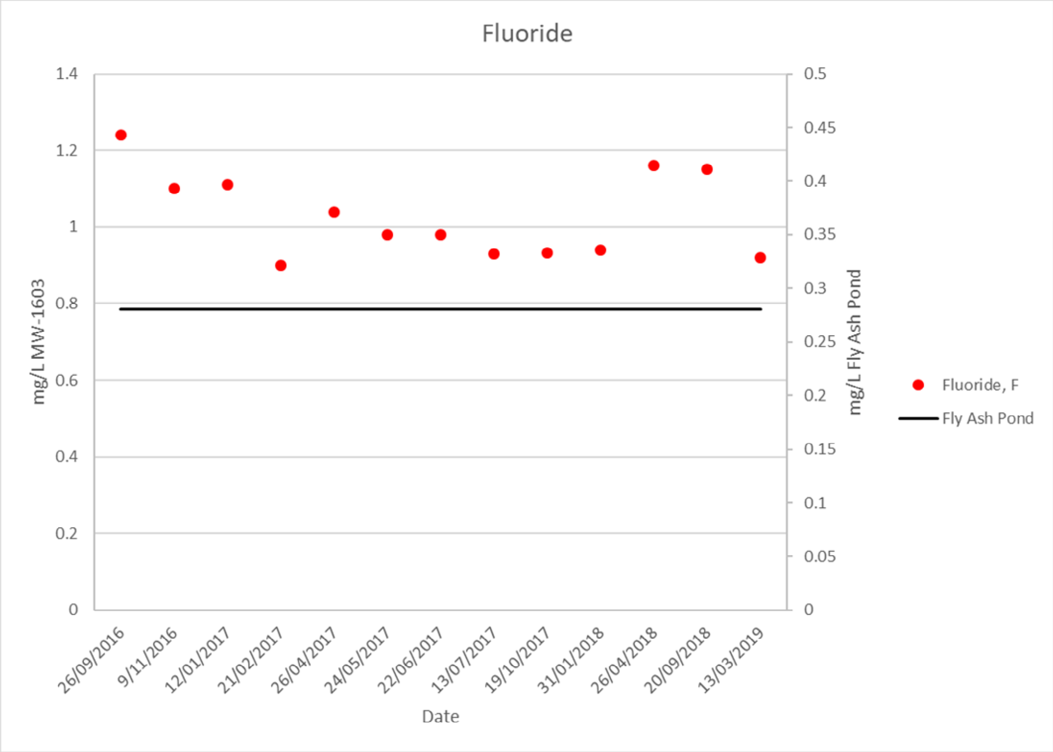

Figure 4-5 MW-1603 Fluoride Concentrations

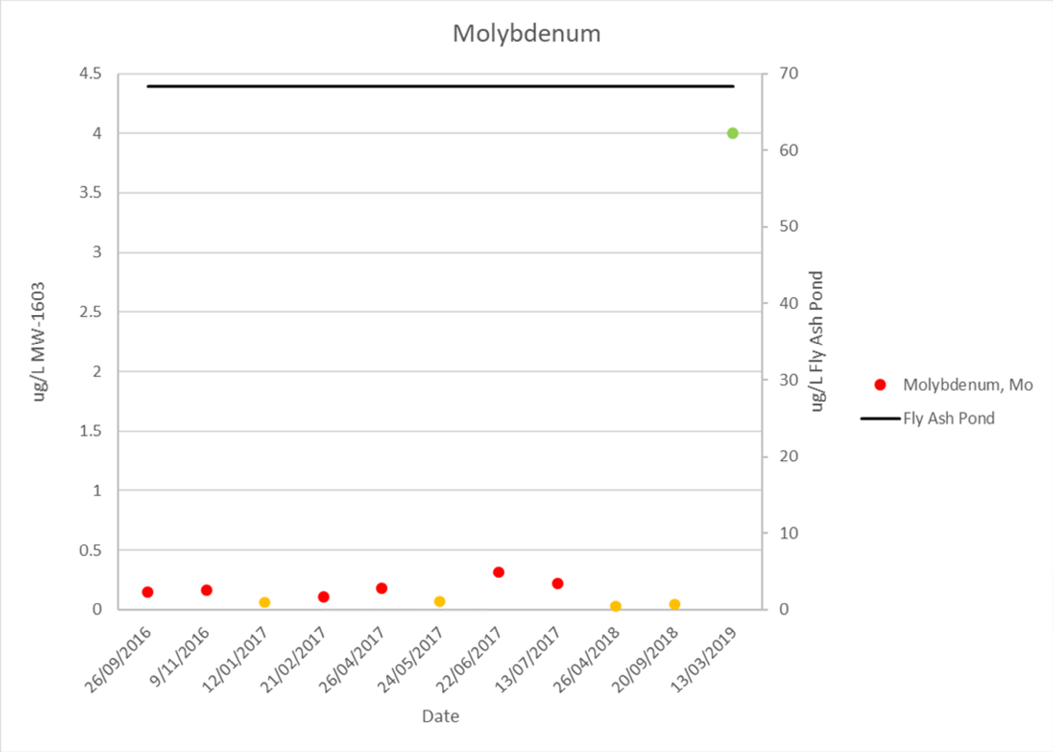

Figure 4-6 MW-1603 Molybdenum Concentrations

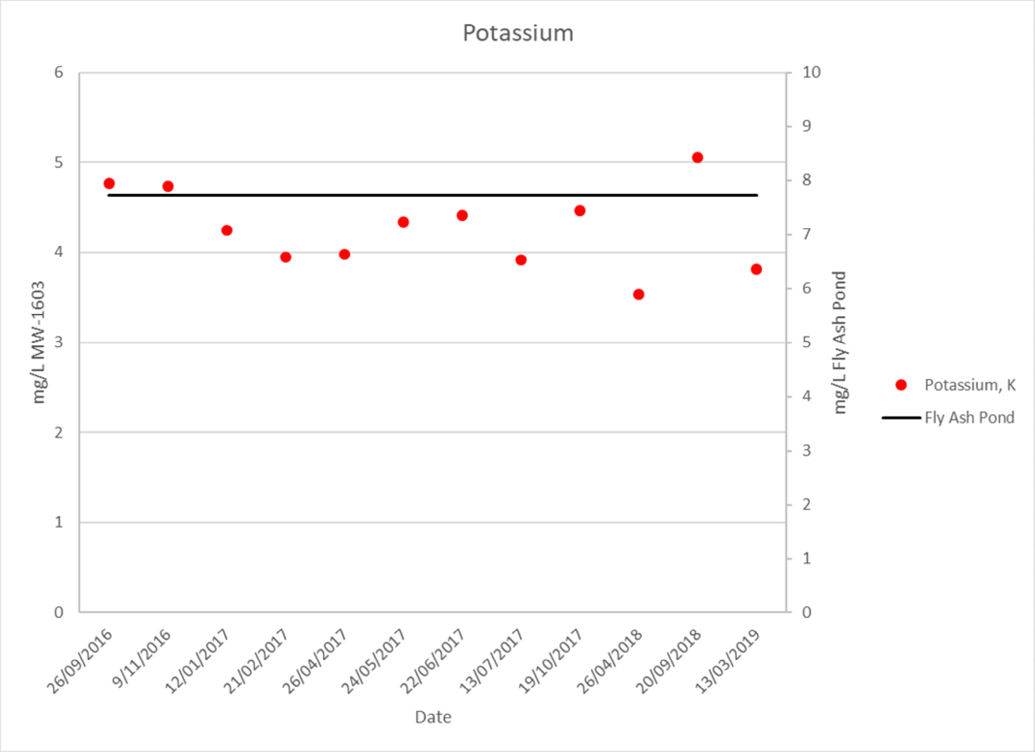

Figure 4-7 **MW-1603 Potassium Concentrations**

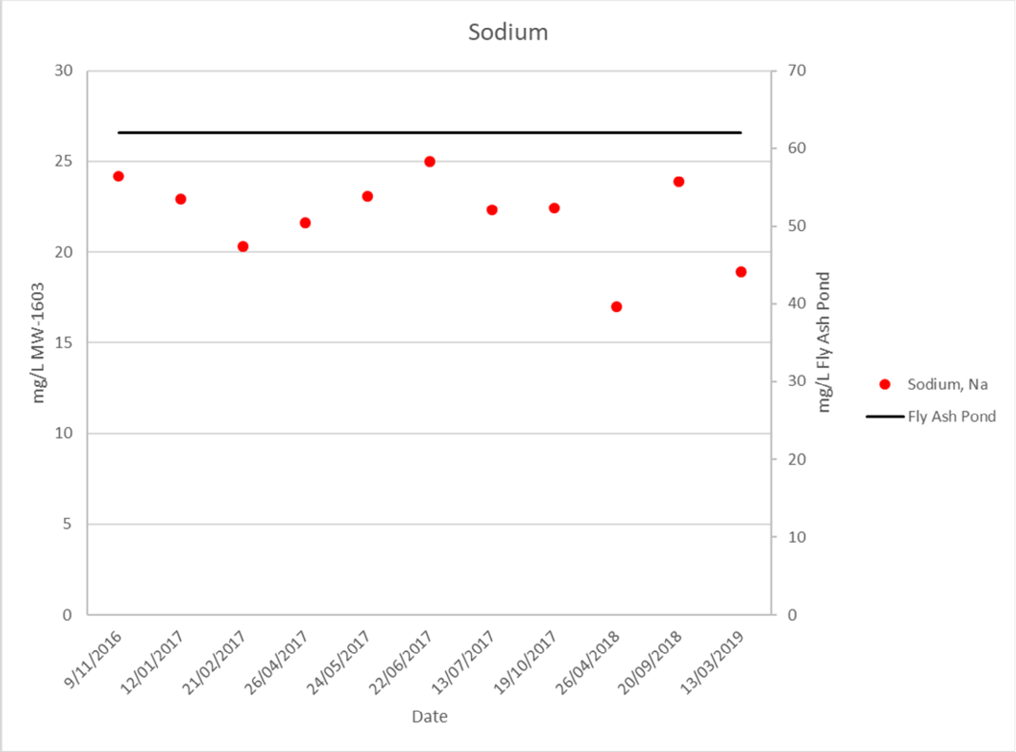

Figure 4-8 **MW-1603 Sodium Concentrations**

Molybdenum, potassium, and sodium are present in the groundwater in the vicinity of MW-1603 at concentrations below the concentrations reported within the BSFAP. Fluoride and bromide groundwater concentrations are more elevated than those within the BSFAP.

The comparison of pH between the BSFAP and MW-1603 is provided in **Figure 4-9** below. This illustrates the significant difference in pH between the pond water and groundwater, between approximately three to five standard units. This is using the standard pH scale which is logarithmic and converts to a difference of 1,000 to 100,000 units on an arithmetic scale.

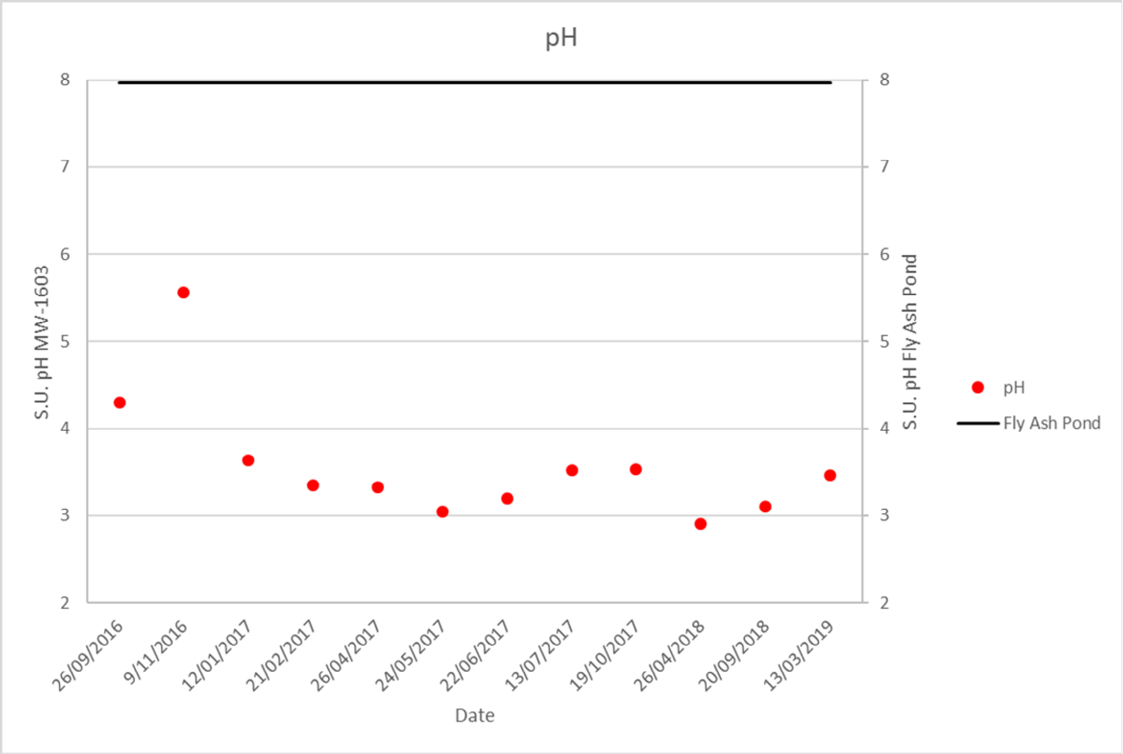

Figure 4-9 MW-1603 pH values

In summary, there has been no observable changes in primary indicator concentrations since the last review in February 2019.

4.1.3 ASD Constituent Trends

Temporal plots for the ASD constituents, beryllium, cobalt, and lithium reported in groundwater monitoring well MW-1603, are provided in **Figure 4-10** to **Figure 4-12** below, with data for the BSFAP water presented for comparison.

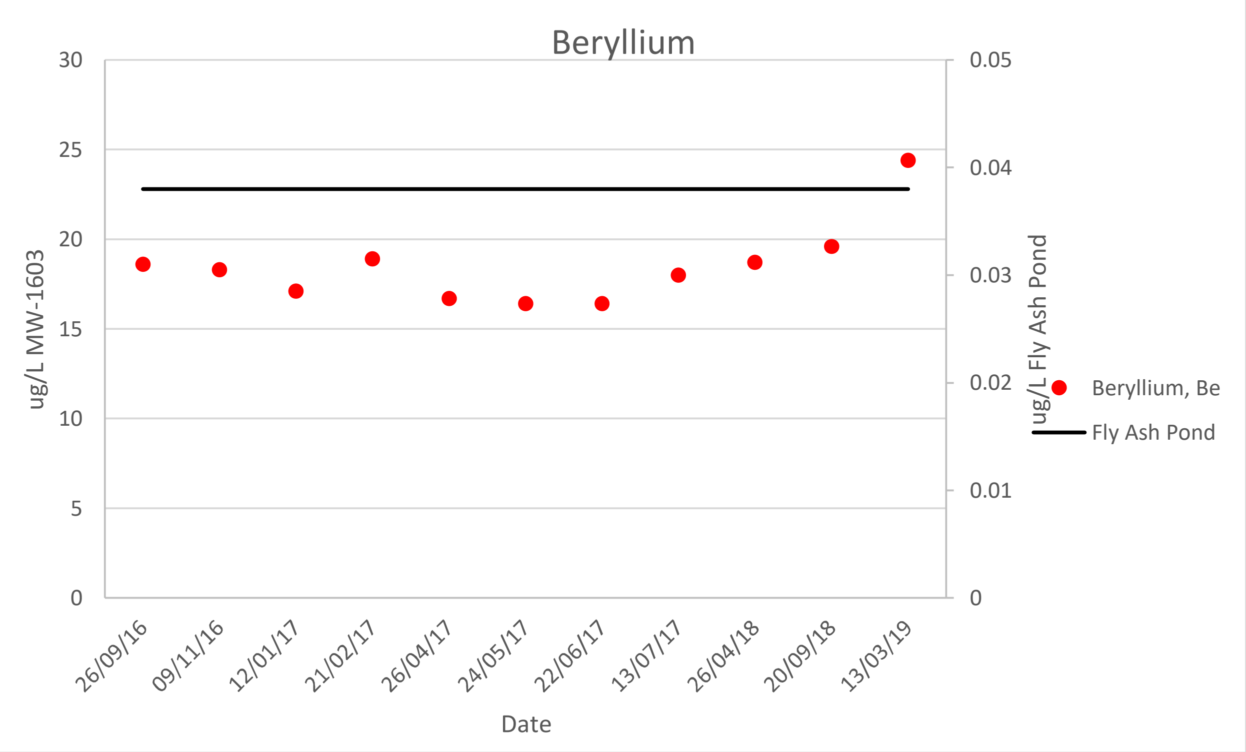

Figure 4-10 MW-1603 Beryllium Concentrations

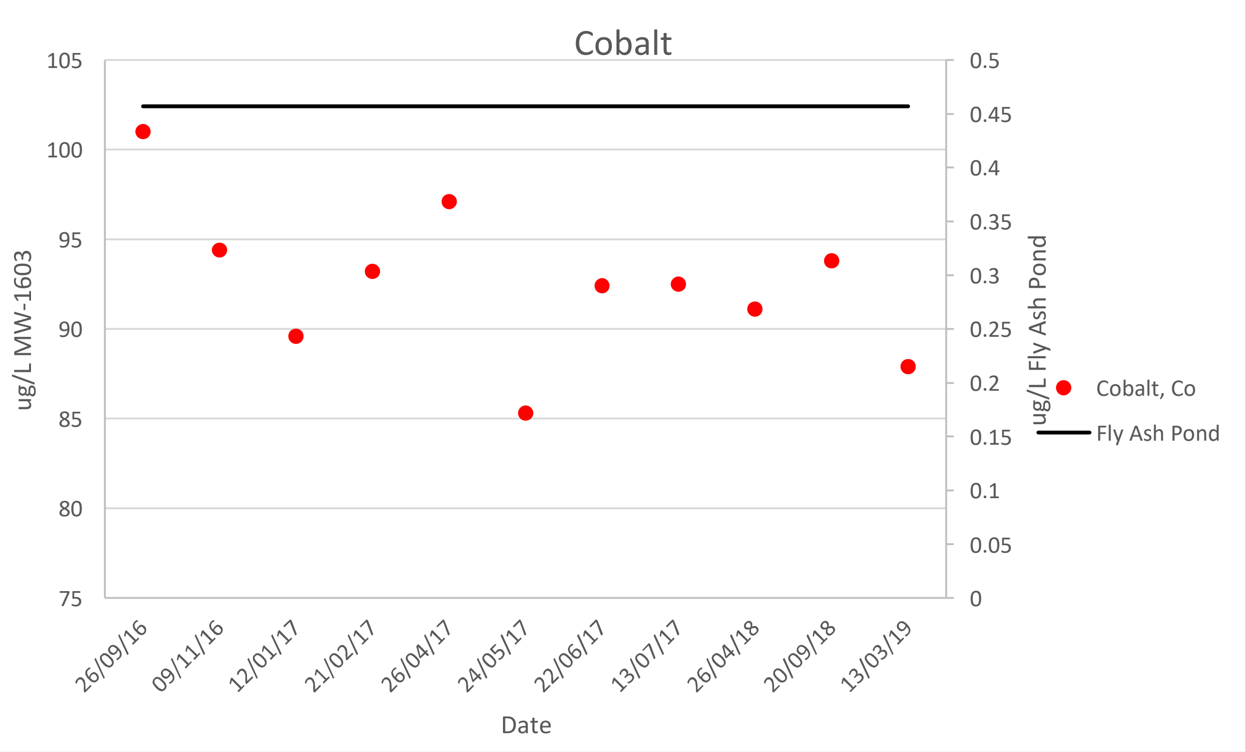

Figure 4-11 MW-1603 Cobalt Concentrations

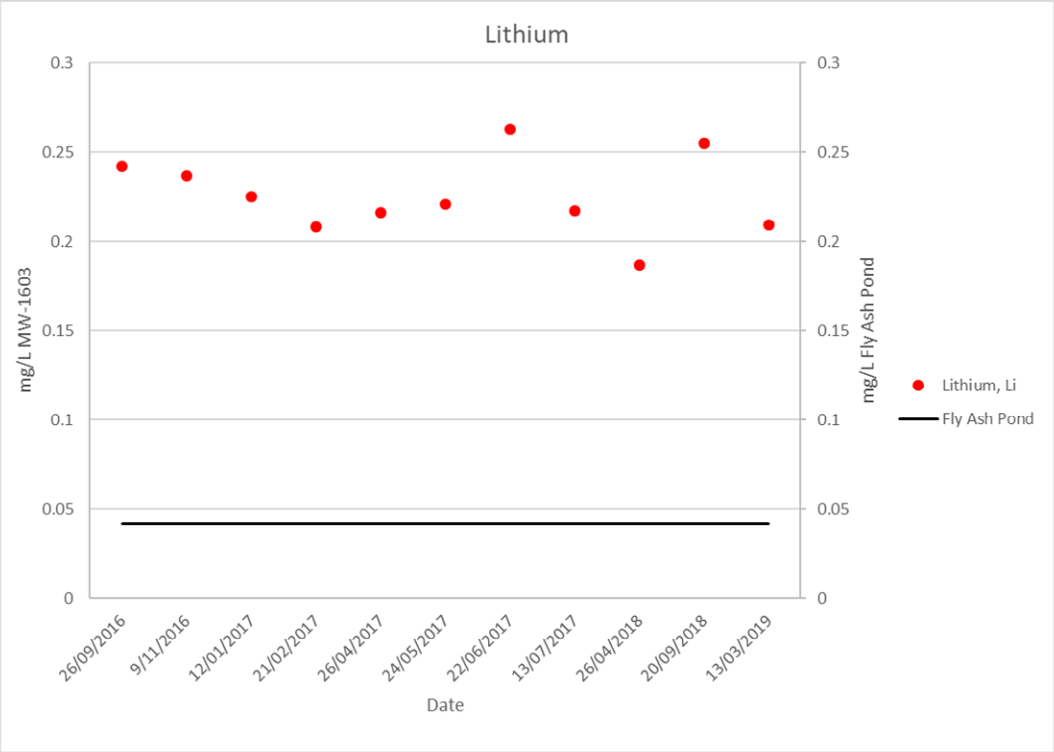

Figure 4-12 **MW-1603 Lithium Concentrations**

Beryllium, cobalt, and lithium are more elevated in MW-1603 groundwater in comparison to BSFAP water indicating the source of beryllium, cobalt, and lithium is not likely associated with the BSFAP.

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 water chemistry in 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 groundwater compared to the BSFAP water. As the concentrations of these constituents in groundwater are higher, it is unlikely that there is a concentration gradient extending from the BSFAP into groundwater. It is more likely that an alternate source in groundwater is contributing to the higher concentrations observed in groundwater.

In summary, there are no trends within MW-1603 groundwater data to suggest CCR constituents are migrating from the BSFAP into groundwater based on the analyses presented above.

4.2 Tier I Evaluation - Statistical Evaluation

A statistical evaluation of analytes has been conducted previously (EHS Support, 2019). The evaluation concluded that groundwater in the vicinity of MW-1603 is statistically the same as the United States Geologic Survey (USGS) reported regional background (Ruppert et al., 2000) in regard to arsenic, boron, calcium, chloride, chromium, fluoride, molybdenum, potassium, sodium, and strontium. The box plots from the earlier ASD investigation also show a difference between well MW-1603, BSFAP water and/or the regional background for pH, alkalinity, barium, cobalt, lead, lithium, magnesium, selenium, and sulfate. For beryllium, chromium, lead, lithium, molybdenum, and selenium no background values were provided by the USGS.

Updated box and whisker plots for constituents reported in MW-1603 groundwater are provided in **Appendix AFigures A-1 through A-11**. Plots for molybdenum, sodium, beryllium, and pH exhibit outliers which are calculated to be outside the range of distribution. A summary of data distribution statistics for MW-1603 is provided in **Appendix B - Table B-1**.

It is likely that the acidic pH conditions, low alkalinity and high sulfate conditions at MW-1603 relative to regional background are driving dissolution of metals. These geochemical conditions within well MW-1603, which are similar to acid mine drainage, are due to the presence of the Princess Coal Seams (discussed in EHS Support, 2019) being intersected by the screened interval of this monitoring well. The combination of the well installation and sampling is allowing the saturated conditions within the coal seams to become aerobic which results in a lowering of pH and increase in metal solubility.

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. 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 more sophisticated methods that can be used for multiple parameters over multiple locations. These include ion ratios and ternary plots.

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 median concentrations of boron, chloride, and sulfate are provided in **Table 4-1**. These three constituents were selected based on the recommended indicator species in EPRI (2017). Bromide was not included within the assessment, as bromide was non-detect in the BSFAP water indicating its presence in groundwater was either naturally derived or from an off-site source. The median concentration for sulfate indicates a minor increase, and median concentrations for boron and chloride show no change since January 2019.

As discussed above, the groundwater quality reported from well MW-1603 is unlikely to be influenced by the BSFAP.

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

		Median Concentrations 2016 to 2019		
	Location ID	**Boron**	**Chloride**	**Sulfate**
Location	**Units**	**mg/L**	**mg/L**	**mg/L**
Source	**Fly Ash Pond**	0.58	35.4	342
Downgradient	**MW-1603**	0.05 ±0.02	3 ±0.4	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 no change since the last evaluation in February 2019.

Table 4-2 Ion Ratios

		Median Concentrations 2016 to 2019		
Location	**Location ID**	**Boron/Sulfate (x1000)**	**Boron/Chloride**	**Chloride/Sulfate**
Source	**Fly Ash Pond**	1.68	0.002	0.10
Downgradient	**MW-1603**	0.07 ±0.03	0.02 ±0.01	0.005 ±0.001

Based on the previous evaluation of ion ratio analysis, the conclusion that it does not appear likely that MW-1603 has been impacted by CCR constituents from the BSFAP is unchanged.

Ternary plots can be 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 4-13**.

The ternary plot shows that the major ion groundwater ratios have not changed during the period of groundwater quality monitoring at well MW-1603, as all the event ratios are grouped closely together.

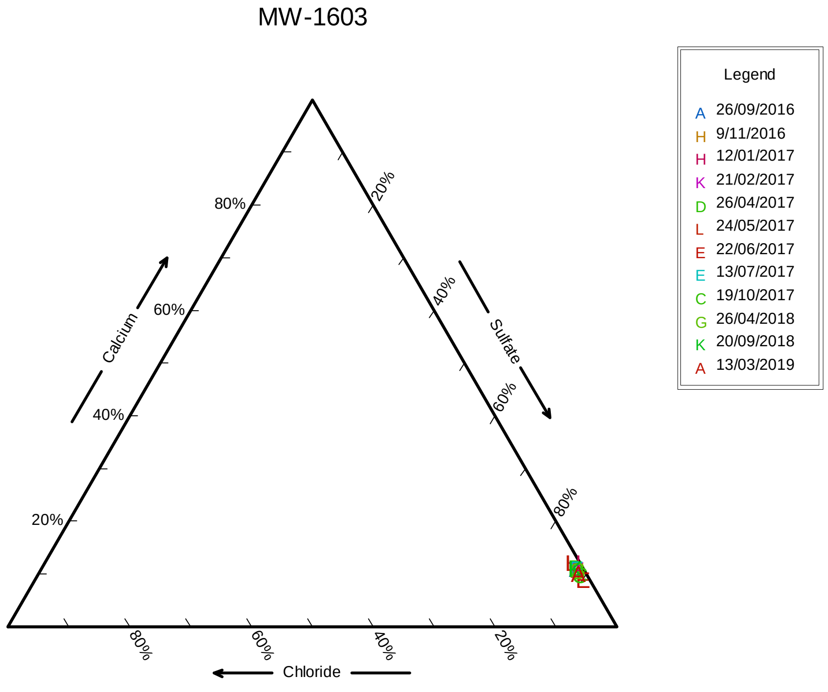

Figure 4-13 Ternary Plot MW-1603

In summary, based on the previous geochemical evaluation and the updated review presented in this ASD addendum there is insufficient evidence to support the presence of CCR constituents (principally beryllium, cobalt and lithium), as derived from the BSFAP, in groundwater sampled at MW-1603. The ternary plot does not support temporal changes of MW-1603 groundwater quality. The ion ratios of boron, chloride, and sulfate remain unchanged since February 2019. Therefore, it is highly unlikely that beryllium, cobalt, and lithium detected within MW-1603 groundwater is sourced from the BSFAP. It is much more likely that beryllium, cobalt, and lithium are characteristic of the lithologies in which this monitoring well is screened across, which includes the Princess Coal Seams.

5 Summary and Conclusions

Using the EPRI (2017) guidance for ASD, the conclusions that are based on the lines of evidence presented and discussed within **Sections 3** and **4** indicate that groundwater in the vicinity of the BSFAP is not being impacted by CCR constituents from the BSFAP. The elevated beryllium, cobalt, and lithium concentrations that triggered the ASD assessment are due to the oxidation of coal seams that have been intersected by well location MW-1603. This is supported by the visual evidence during the logging of core characteristics at this location (refer to EHS Support, 2019), the low pH reported in groundwater, and the subsequent likely dissolution and mobility of metalliferous species (beryllium, cobalt, and lithium) by the elevated acidity.

The elevated pH in the BSFAP water and the corresponding lower concentrations of minor ions in BSFAP also support the unlikely influence of the BSFAP on groundwater. Therefore, it is concluded that the elevated signatures of beryllium, cobalt, and lithium in MW-1603 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 (2019).

6 References

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Figures

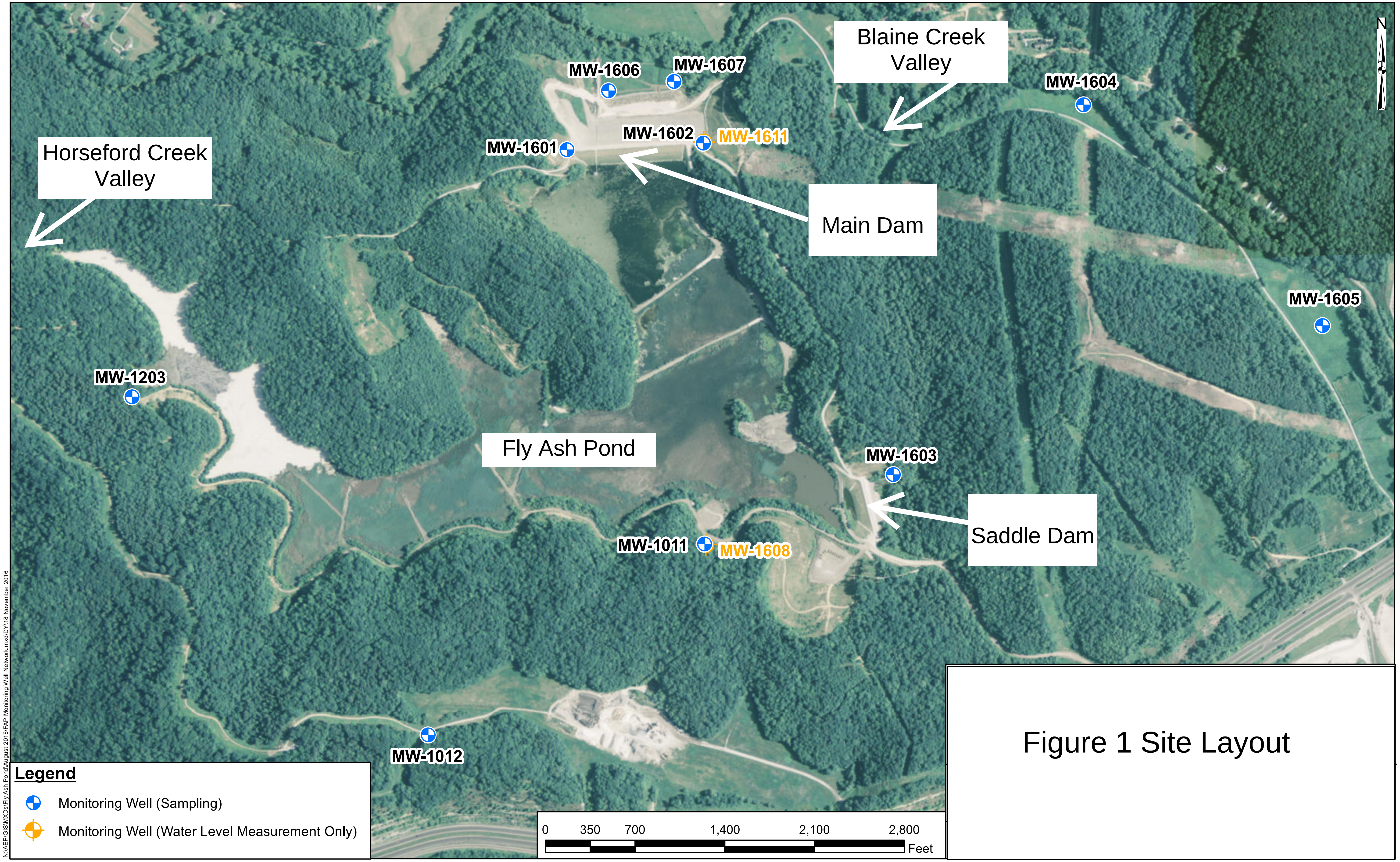

Figure 1 Site Layout

N:\AEP\GIS\MXDs\Fly Ash Pond\August 2016\FAP Monitoring Well Network.mxd\DY\18 November 2016

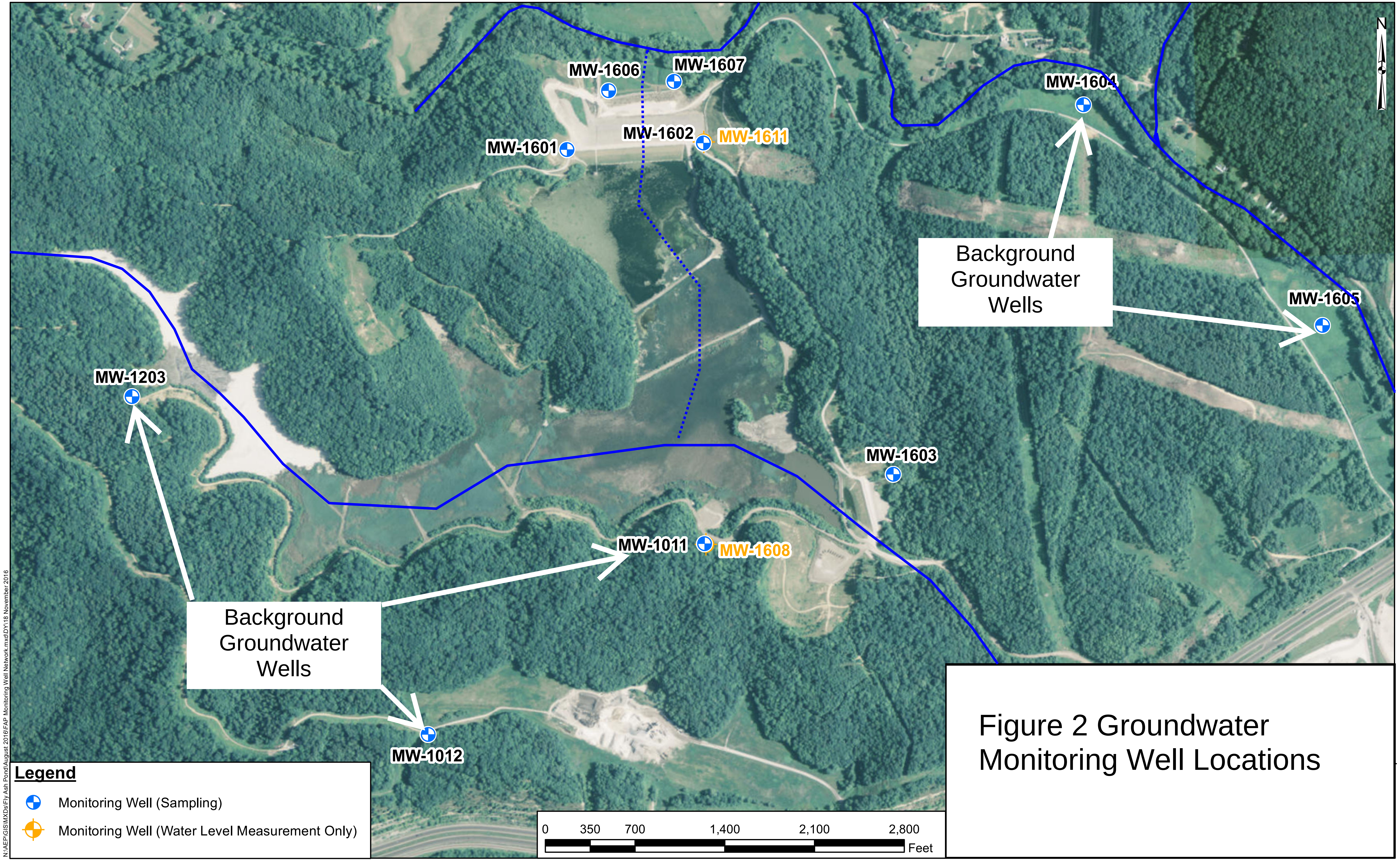

Figure 2 Groundwater Monitoring Well Locations

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Tables

Table 1
MW-1603 Historical Groundwater Data 2016 to 2019
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
Antimony, Sb	ug/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
Arsenic, As	ug/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
Barium, Ba	ug/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
Beryllium, Be	ug/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
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
Cadmium, Cd	ug/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
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
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
Chromium, Cr	ug/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
Cobalt, Co	ug/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
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
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
Lead, Pb	ug/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
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
Mercury, Hg	ug/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
Molybdenum, Mo	ug/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
pH	S.U.	4.29	5.56	3.64	3.34	3.32	3.04	3.20	3.52	NA	3.52	2.91	3.10	3.46	3.19
Residue, Filterable, TDS	mg/L	1060	1010	948	1020	994	936	1040	1000	962	915	926	974	NA	896
Selenium, Se	ug/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
Sulfate, SO4	mg/L	801	733	636	720	678	646	873	694	784	714	661	747	NA	709
Thallium, Tl	ug/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

Notes:

J - Estimated value. Analyte detected at a level less than the reporting limit and greater than or equal to the method detection limit.

< - not detected at or above the method detection limit

S.U. – Standard Units

TDS – Total Dissolved Solids

ug/L – Micrograms per liter

mg/L – Milligrams per liter

pCi/L – Picocuries per liter

NA – Not analyzed

Appendix A Box Plots

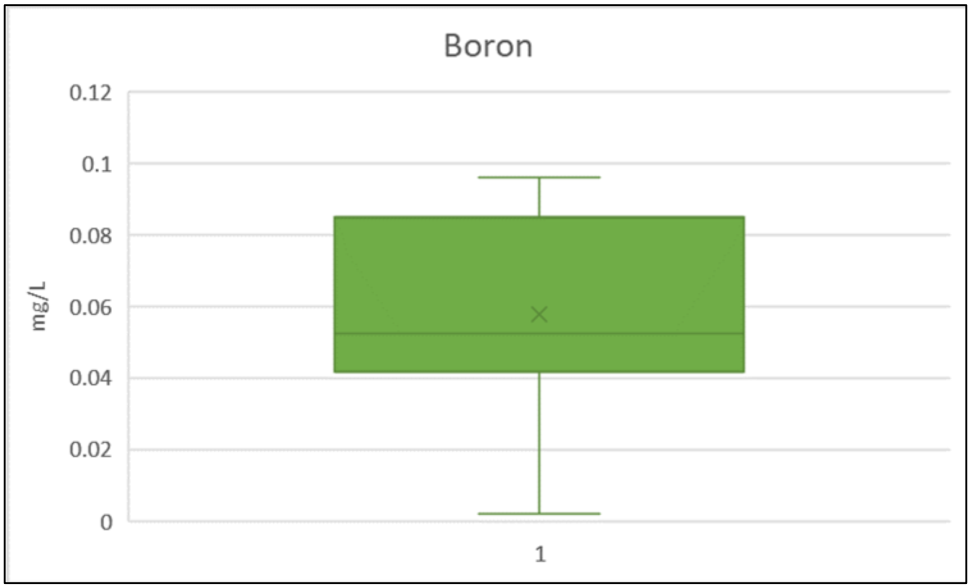

Figure A-1 Boron Box Plot

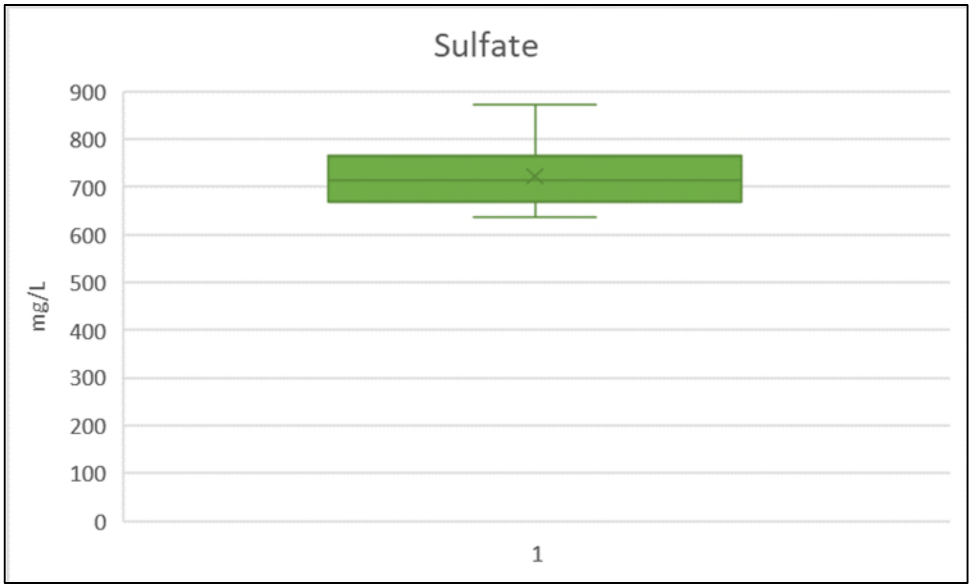

Figure A-2 Sulfate Box Plot

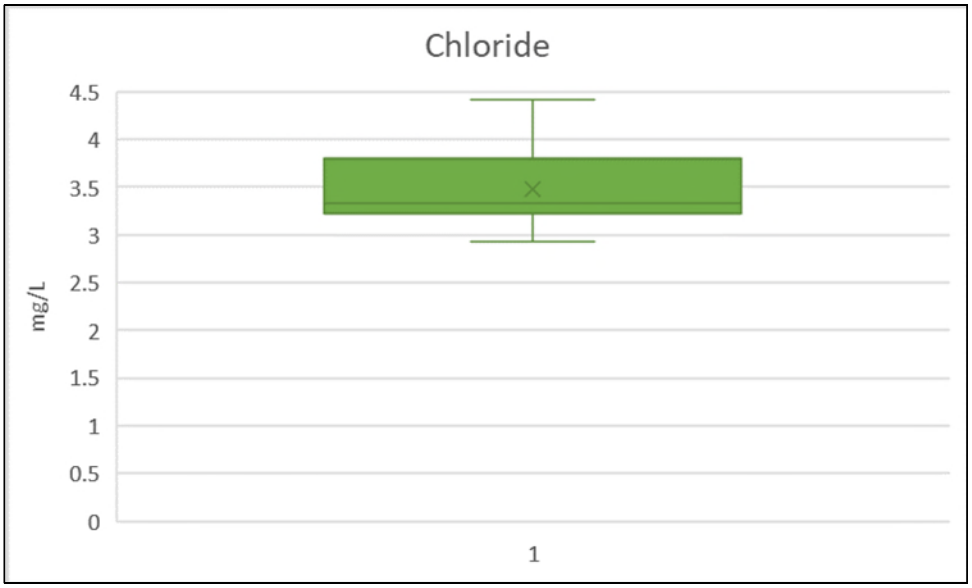

Figure A-3 Chloride Box Plot

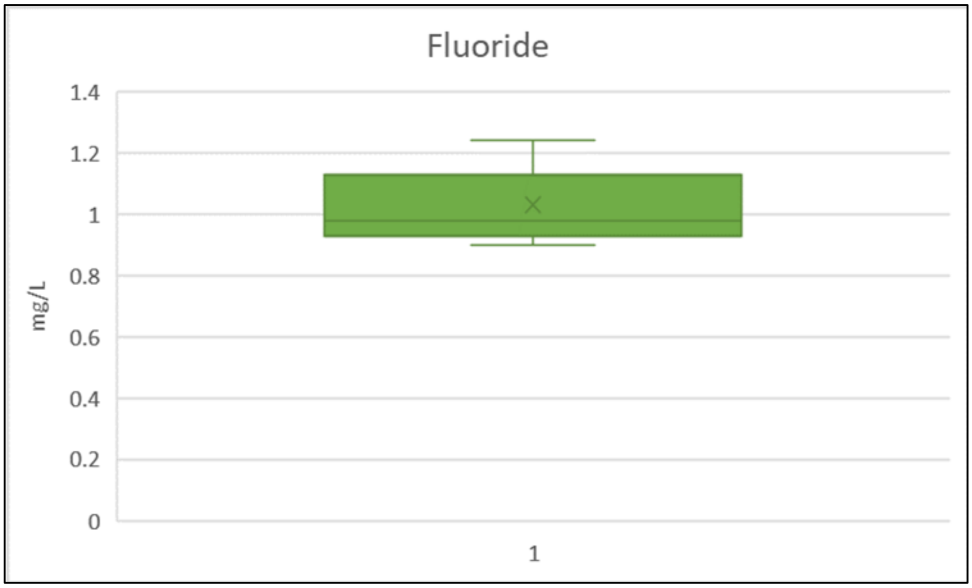

Figure A-4 Fluoride Box Plot

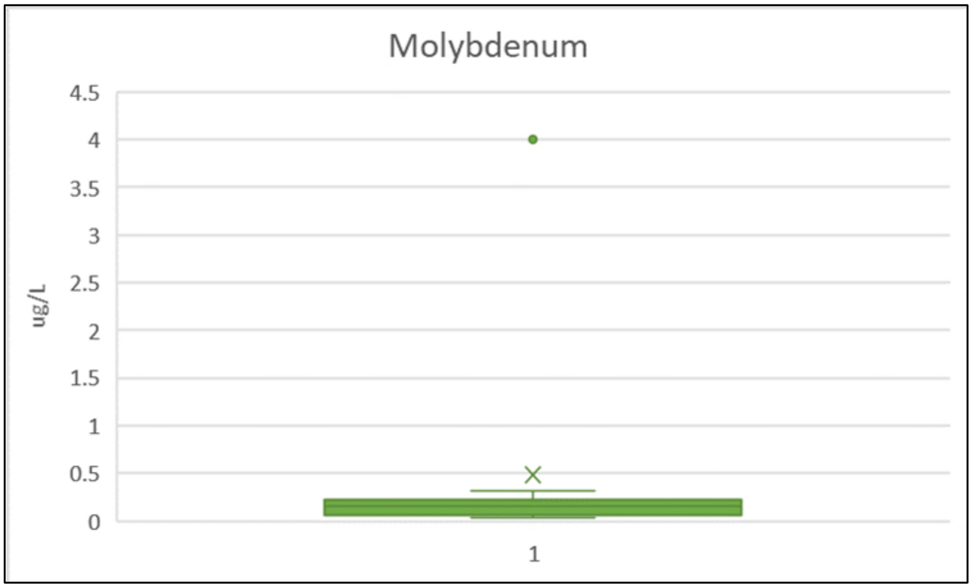

Figure A-5 Molybdenum Box Plot

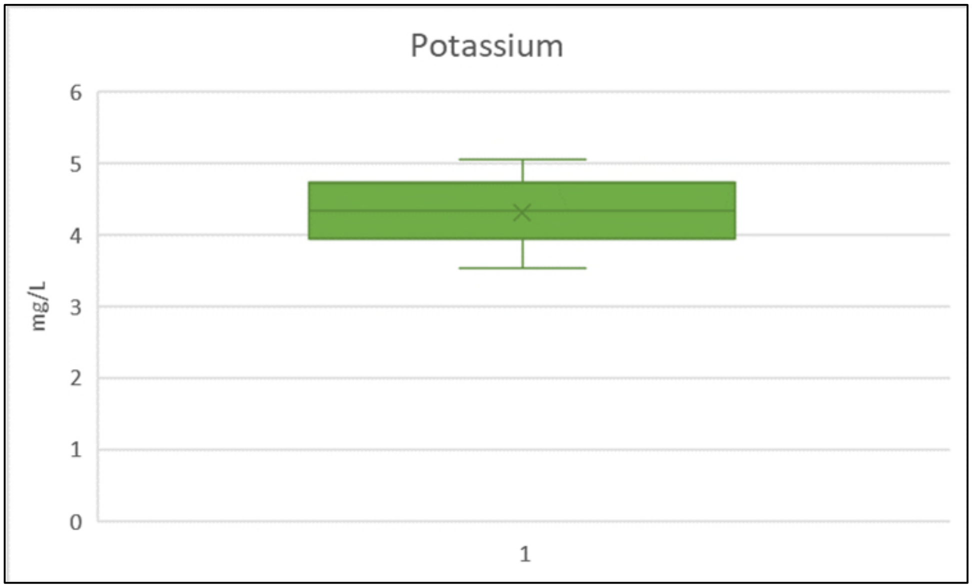

Figure A-6 Potassium Box Plot

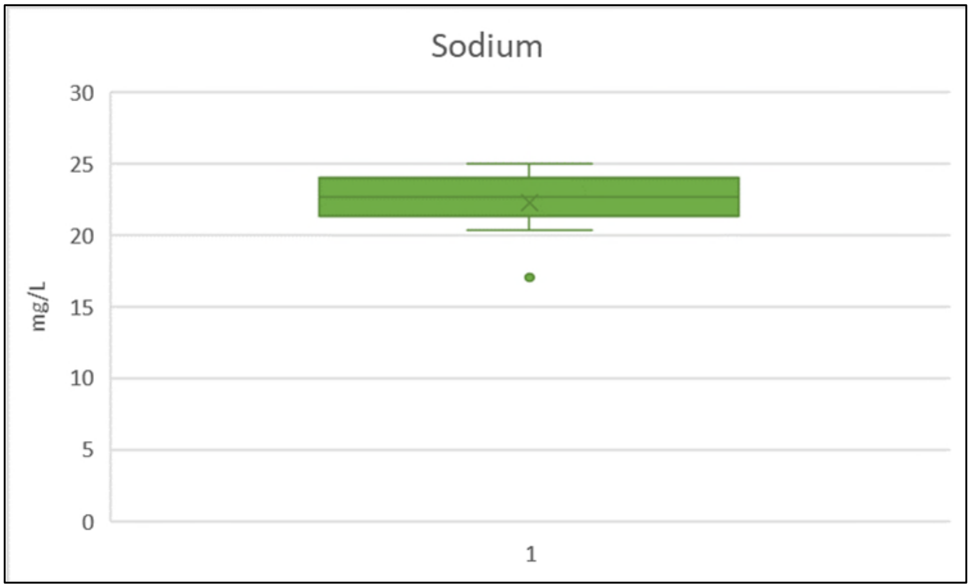

Figure A-7 Sodium Box Plot

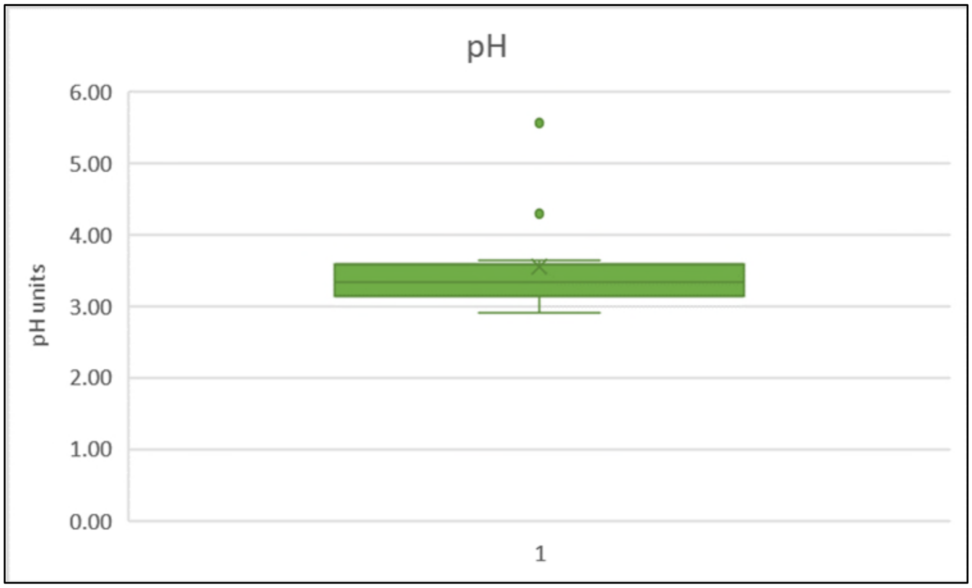

Figure A-8 pH Box Plot

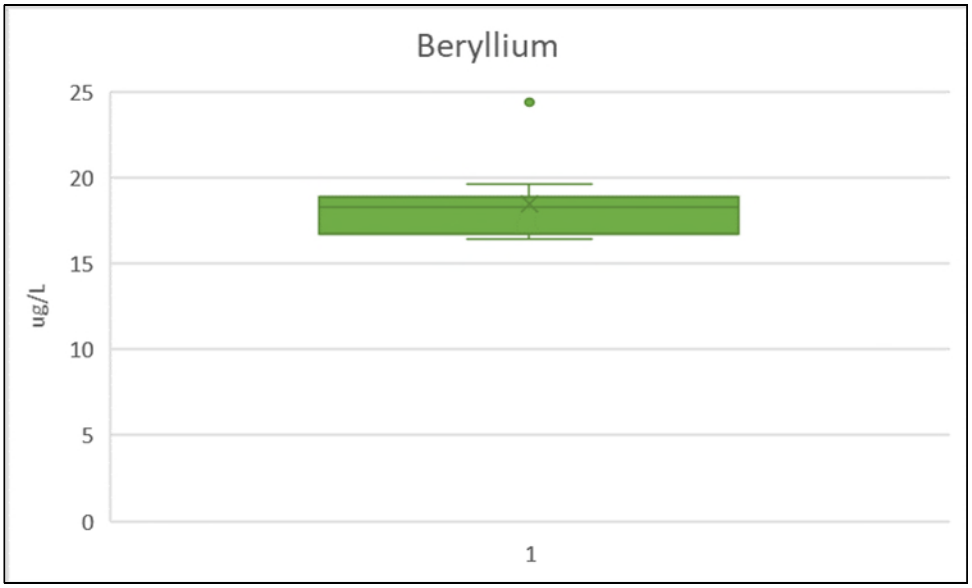

Figure A-9 **Beryllium Box Plot**

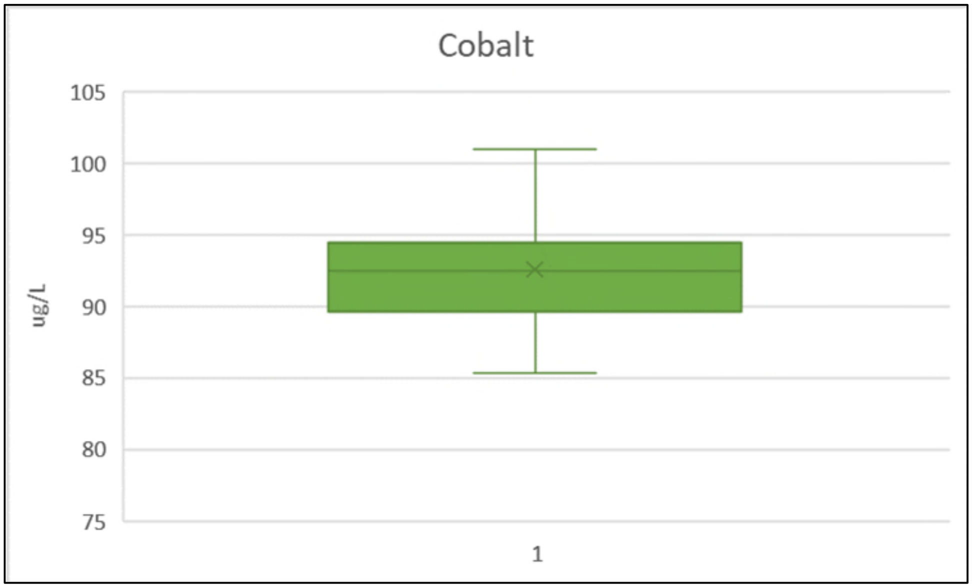

Figure A-10 **Cobalt Box Plot**

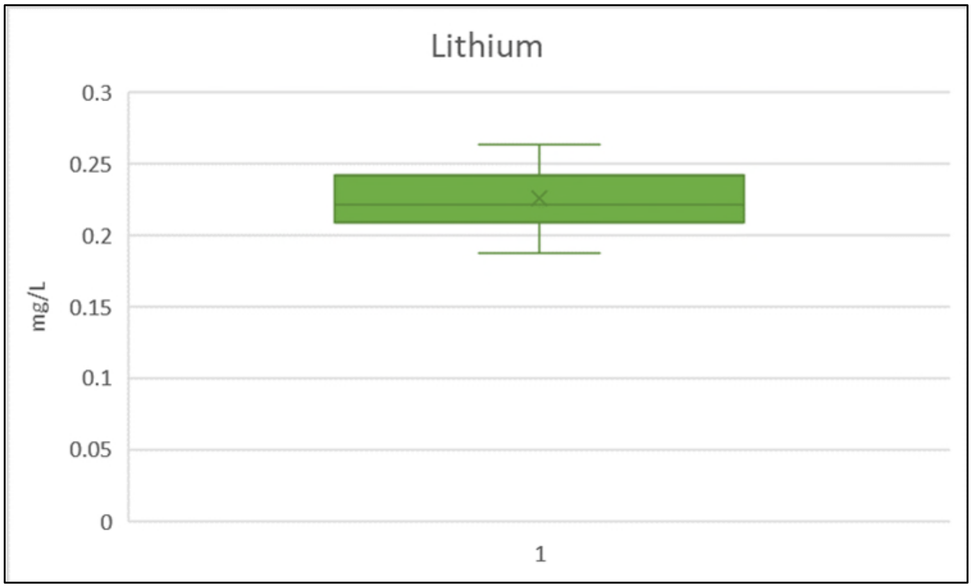

Figure A-11 Lithium Box Plot

Appendix B Data Distribution Summary

Table B-1 Data distribution Summary MW-1603

Parameter	Boron	Sulfate	Chloride	Fluoride	Molybdenum	Potassium	Sodium	pH	Beryllium	Cobalt	Lithium
	mg/L	mg/L	mg/L	mg/L	µg/L	mg/L	mg/L	S.U.	µg/L	µg/L	mg/L
1st quartile	0.042	670	3.23	0.93	0.06	3.95	21.28	3.15	16.7	89.6	0.209
2nd quartile	0.053	714	3.33	0.98	0.15	4.34	22.65	3.34	18.3	92.5	0.221
3rd quartile	0.085	766	3.80	1.13	0.22	4.73	23.98	3.58	18.9	94.4	0.242
Median	0.053	714	3.33	0.98	0.15	4.34	22.65	3.34	18.3	92.5	0.221
Mean	0.058	723	3.48	1.03	0.49	4.31	22.27	4.50	18.5	92.6	0.225
Standard deviation	0.027	67	0.44	0.11	1.17	0.44	2.29	0.70	2.2	4.3	0.022
Minimum	0.002	636	2.93	0.90	0.03	3.53	17.00	2.91	16.4	85.3	0.187
Maximum	0.096	873	4.42	1.24	4.00	5.05	25.00	5.56	24.4	101.0	0.263

µg/L = micrograms per liter
mg/L = milligrams per liter