
**2023 Annual Groundwater Monitoring Report for
Retrofit Bottom Ash Pond (RBAP)
Cardinal Operating Company – Cardinal Plant
306 County Road 7E
Brilliant, Ohio**

January 30, 2024

Submitted to:

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Executive Summary

Cox-Colvin & Associates, Inc. (Cox-Colvin) has prepared this 2023 Annual Groundwater Monitoring Report (Report) for the Retrofit Bottom Ash Pond (RBAP), an existing coal combustion residual (CCR) unit at the Cardinal Plant in Brilliant, Ohio. This report has been prepared in accordance with §257.90(e) of the Federal Coal Combustion Residuals Rules (“CCR Rules”, 40 CFR Subpart D), which requires owners and/or operators of existing CCR landfills and surface impoundments to prepare a groundwater monitoring and corrective action report no later than January 31, annually. This report summarizes groundwater monitoring activities conducted pursuant to the CCR Rules from January 1, 2023, through December 31, 2023.

The groundwater monitoring system for the RBAP was established on March 8, 2022. The first detection monitoring sampling event was conducted on November 23, 2022.

To evaluate whether an SSI of an Appendix III constituent has occurred, sample results from the November 2022 and April 2023 sampling events were compared to previously established intrawell UPLs and LPLs. Statistically significant increases (SSIs)¹ above background levels were identified in each event for the constituents and well pairings below:

- Boron: MW-BAP-3, MW-BAP-1002, MW-BAP-1003
- Calcium: MW-BAP-1002, MW-BAP-1003
- Chloride: MW-BAP-3, MW-BAP-1002, MW-BAP-1003
- pH: MW-BAP-3
- Sulfate: MW-BAP-3, MW-BAP-1002, MW-BAP-1003
- Total Dissolved Solids (TDS): MW-BAP-3, MW-BAP-1001, MW-BAP-1003

In accordance with §257.94(e)(2) of the CCR Rule, Cox-Colvin completed alternative source demonstrations (ASD) to evaluate if sources other than the RBAP are responsible for the SSIs (Cox-Colvin 2023a, Cox-Colvin 2023b). The ASD Reports concluded that alternative sources include, but may not be limited to, the former BAP Complex and acidic drainage from former coal mines. Because the SSIs are attributable to sources other than the RBAP, the RBAP will remain in detection monitoring and not enter assessment monitoring.

¹ Unlike other monitored constituents that are compared to only a UPL, pH is compared to both a UPL and an LPL when evaluating potential SSIs. In this context, a statistically significant decrease (SSD) of pH values below the LPL is included as a potential “SSI” for consistency with the language and requirements of the CCR Rule.

1.0 Introduction

Cox-Colvin & Associates, Inc. (Cox-Colvin) has prepared this 2023 Annual Groundwater Monitoring Report for the Retrofit Bottom Ash Pond (RBAP) at the Cardinal Plant in Brilliant, Ohio (Figure 1-1, Site). This report has been prepared in accordance with §257.90(e) of the Federal Coal Combustion Residuals Rule (“CCR Rules”, 40 CFR Subpart D), which requires owners and/or operators of existing CCR landfills and surface impoundments to prepare a groundwater monitoring and corrective action report no later than January 31, annually. This report summarizes groundwater monitoring activities conducted pursuant to the CCR Rule from January 1, 2023, through December 31, 2023.

1.1 Site Summary

The Site is located one mile south of Brilliant, Ohio in Jefferson County and is operated by Cardinal Operating Company (Cardinal). Located along the Ohio River, the generating station consists of three coal-powered units with an 1,800-megawatt (MW) capacity. Units 1 and 2 began operation in 1967 and Unit 3 began operation in 1977. Each generating unit is equipped with an electrostatic precipitator (ESP) for removal of fly ash particulate matter, a selective catalytic reduction (SCR) system for removal of nitrogen oxide, and flue gas desulfurization (FGD) systems for removal of sulfur dioxide (Geosyntec 2016).

1.2 CCR Unit Description

The RBAP, previously referred to as the South Pond of the Bottom Ash Complex (BAC) in the historical BAP area (Figure 1-1), is situated along the Ohio River south of Cardinal Plant Unit 3 and receives bottom ash sluicing discharge. An excavator placed on an “island” or “peninsula” of deposited bottom ash in the center of the pond is used to dredge settled bottom ash from the pond for dewatering. Once dewatered, the ash is loaded onto trucks and either beneficially used as construction material or placed in the FAR I Solid Waste Landfill (RSW Landfill), a dry landfill disposal unit located north of the plant. Water is recirculated for bottom ash sluicing. There are no discharge facilities from the RBAP, except for a blowdown line to the Unit 3 FGD system to control the water level in the pond and to manage water quality (Sargent & Lundy 2021b).

The RBAP has a surface area of approximately 7 acres and a storage capacity of approximately 74 acre-feet. It is fitted with a CCR compliant liner in accordance with §257.102(k) and will operate as the sole CCR pond for management of Bottom Ash Transport Water. The liner system is composed of a geosynthetic clay over a graded and compacted native soil base in accordance with the CCR Rule permeability requirement and topped with a 60-mil textured HDPE geomembrane. The liner system is protected by additional geotextile and natural gravel.

The North Pond of the previous BAC is currently being retrofitted with a National Pollutant Discharge Elimination System (NPDES) liner to receive non-CCR low volume waste and stormwater runoff for discharge at a relocated Outfall 023. The work on the North Pond is on-going and is not part of the RBAP.

The RBAP and associated monitoring wells are shown in Figure 1-2.

1.3 Regional Physiographic Setting

The RBAP is located immediately west of the Ohio River. Regional geology is dominated by sedimentary bedrock units overlain by unconsolidated deposits (typically sand and gravel) associated with the Ohio River Valley in an area of Ohio which was unglaciated during the most recent ice age. Bedrock consists of interbedded shale, sandstone, coal, and limestone of the Pennsylvanian Age Conemaugh Formation.

The uppermost aquifer at the RBAP consists of fine to coarse sand and gravel below a silty clay, interbedded organic clay, and silt. Groundwater in the uppermost aquifer generally flows southeast towards the Ohio River (to which it is hydraulically connected) with hydraulic conductivity of monitoring wells ranging from 0.000233 to 0.288219 centimeters per second (cm/s) (Cox-Colvin 2022).

2.0 Groundwater Monitoring System

The RBAP's groundwater monitoring network was designed to comply with §257.91 of the CCR Rules. The groundwater monitoring network is used to monitor groundwater quality in the uppermost aquifer at the RBAP and is comprised of 1 upgradient background well (MW-BAP-1001) and 3 downgradient monitoring wells (MA-BAP-1002, MW-BAP-1003, and MW-BAP-3). The locations of these wells are shown in Figure 1-2.

No CCR monitoring wells were installed or decommissioned during 2023. Monitoring wells in the network were installed in 2015 and 2021, prior to establishment of the RBAP groundwater monitoring network.

3.0 Groundwater Monitoring Program

In accordance with §257.94 of the CCR Rules, detection monitoring at the RBAP was initiated in November 2022 in accordance with the established groundwater monitoring system for the RBAP (Cox-Colvin 2022).

3.1 Statistical Analysis Plan

Evaluation of analytical data is performed in accordance with the Statistical Analysis Plan (Geosyntec 2020), which describes a logic process regarding the statistical analysis of groundwater data collected in compliance with the CCR Rules. No revisions were made to the Statistical Analysis Plan during 2023.

3.2 Monitoring Frequency

In accordance with §257.94 of the CCR Rules, monitoring wells are sampled semi-annually for constituents listed in Appendix III of the CCR Rules.

There was no suspension of groundwater monitoring requirements at the RBAP under §257.90(g) of the CCR Rules.

4.0 Key Actions Completed

The sections below summarize key actions completed in 2023 with respect to CCR Rule groundwater monitoring and corrective actions at the RBAP.

4.1 Groundwater Elevation and Flow

Prior to sampling, a synoptic round of groundwater level measurements was collected from the compliance and background monitoring wells. Potentiometric surface maps based on groundwater elevations measured during detection monitoring events are presented in Figures 4-1 and 4-2. The potentiometric maps show that groundwater near the RBAP flows southeast towards the Ohio River. Groundwater flow rate calculations relative to the RBAP are summarized in Tables 4-1 and 4-2.

4.2 Groundwater Sampling

Table 4-3 contains a summary of groundwater samples collected for analysis in 2023 in association with CCR activities for the RBAP monitoring program. A total of 10 samples were collected in 2023. Analytical results are summarized in Tables 4-4.

4.3 Data Evaluation

Data evaluations performed in 2023 consisted of the following:

- Comparison of Fall 2022 monitoring data to background levels for Appendix III constituents
- Comparison of Spring 2023 monitoring data to background levels for Appendix III constituents

Comparison of Fall 2023 monitoring data to background levels for Appendix III constituents is ongoing and will be included in the 2024 annual report.

4.3.1 Background Levels

To evaluate whether an SSI of an Appendix III constituent has occurred, sample results from the November 2022 and April 2023 sampling events were compared to previously established intrawell UPLs and LPLs. Statistically significant increases (SSIs)² above background levels were identified³ in each event for the constituents and well pairings below:

- Boron: MW-BAP-3, MW-BAP-1002, MW-BAP-1003
- Calcium: MW-BAP-1002, MW-BAP-1003
- Chloride: MW-BAP-3, MW-BAP-1002, MW-BAP-1003
- pH: MW-BAP-3
- Sulfate: MW-BAP-3, MW-BAP-1002, MW-BAP-1003
- Total Dissolved Solids (TDS): MW-BAP-3, MW-BAP-1001, MW-BAP-1003

In accordance with §257.94(e)(2) of the CCR Rule, Cox-Colvin completed alternative source demonstrations (ASD) to evaluate if sources other than the RBAP are responsible for the SSIs (Cox-Colvin 2023a, Cox-Colvin 2023b). The ASD Reports concluded that alternative sources include, but may not be limited to, the former BAP Complex and acidic drainage from former coal mines. These conditions existed prior to implementation of the RBAP and, therefore, unrelated to RBAP operations, and that statistical evaluations of CCR constituents against baseline, as opposed to background, concentrations do not reveal evidence of a release from the RBAP. Copies of the ASD's for the November 2022 and April 2023 Sampling Events are presented as Appendices A and B.

Because the SSIs are attributable to sources other than the RBAP, the RBAP will remain in detection monitoring and not enter assessment monitoring.

4.3.2 Groundwater Protection Standards

Because no SSIs have been identified above background levels, the RBAP remains in detection monitoring. Unless an SSI is identified, there is no reason to anticipate SSLs of Appendix IV constituents above GWPSs.

4.4 Corrective Actions

In the absence of an identified release from the RBAP, no corrective actions or remedies were either necessary or performed during 2023.

5.0 Problems Encountered and Resolutions

No monitoring wells were gauged dry, abandoned, or added to the well network during 2023. All analytical data received were deemed to be of acceptable quality and no resampling was performed.

Two alternative source demonstrations under §257.94(e)(2) of the CCR Rules were performed during 2023.

6.0 Projected Key Activities

The following activities are projected for the RBAP:

- The 2023 Annual Groundwater Monitoring Report will be entered into the facility's operating record and posted to the public internet site.
- Two semi-annual groundwater detection monitoring program sampling events will be conducted, and the resulting data will be evaluated for SSIs over background levels.
- The RBAP's monitoring status will be confirmed following the SSI evaluation.
- The 2024 Annual Groundwater Monitoring Report will be prepared for submittal in January 2025.

7.0 References

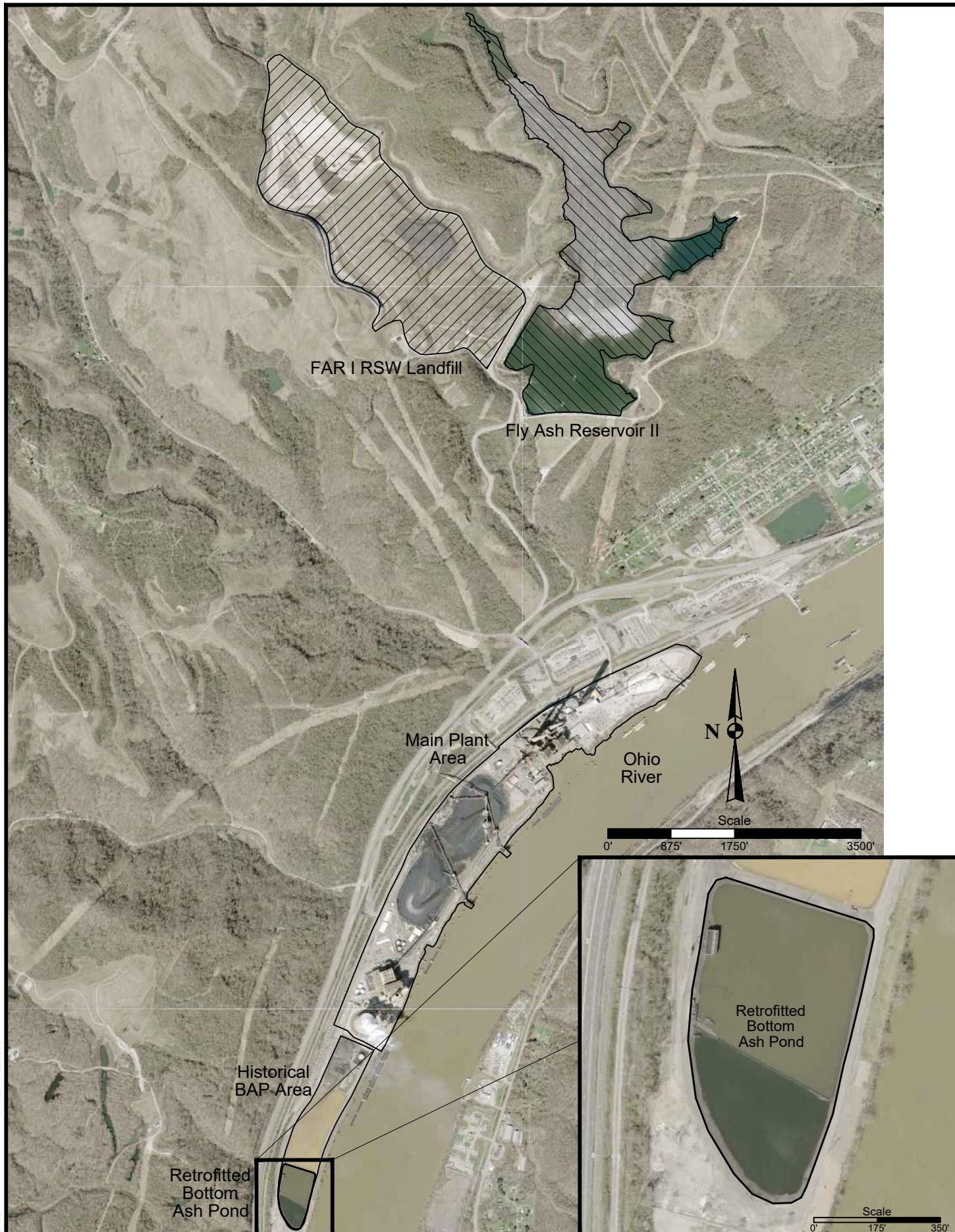
- Cox-Colvin. 2022. *Groundwater monitoring System for Retrofitted Bottom Ash Pond (BAP); Cardinal Operating Company - Cardinal Power Plant; 306 County Road 7E; Brilliant, Ohio*. Plain City, Ohio: Cox-Colvin & Associates, Inc.
- Cox-Colvin. 2023a. *RBAP Alternative Source Demonstration (ASD); Cardinal Operating Company - Cardinal Power Plant; 306 County Road 7E; Brilliant, Ohio. Plain City, Ohio: Cox-Colvin & Associates, Inc.* Plain City, Ohio: Cox-Colvin & Associates, Inc.
- Cox-Colvin. 2023b. *RBAP Alternative Source Demonstration (ASD); Cardinal Operating Company - Cardinal Power Plant; 306 County Road 7E; Brilliant, Ohio. Plain City, Ohio: Cox-Colvin & Associates, Inc.* Plain City, Ohio: Cox-Colvin & Associates, Inc.
- Geosyntec. 2016. *Groundwater Monitoring Network Evaluation; Cardinal Site - Bottom Ash Pond; Brilliant, Ohio (Geosyntec Project No. CHE8126L)*. Columbus, Ohio: Geosyntec Consultants.
- Geosyntec. 2020. *Statistical Analysis Plan; Cardinal Power Plant; Brilliant, Ohio (Revision 1)*. Columbus, Ohio: Geosyntec Consultants.
- Sargent & Lundy. 2021b. *Cardinal Power Plant Permit to Install Application Bottom Ash South Pond CCR Retrofit*.

Figures

Figures

DATE: 10/28/2021

DWG NAME: Sitemap 3753



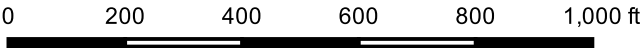


2020 aerial imagery from Ohio Statewide Imagery Program (OSIP)

Legend

- Retrofitted BAP
- ⊗ Monitor Well (Samples and Water Levels)
- ⊕ Monitor Well (Water Levels Only)

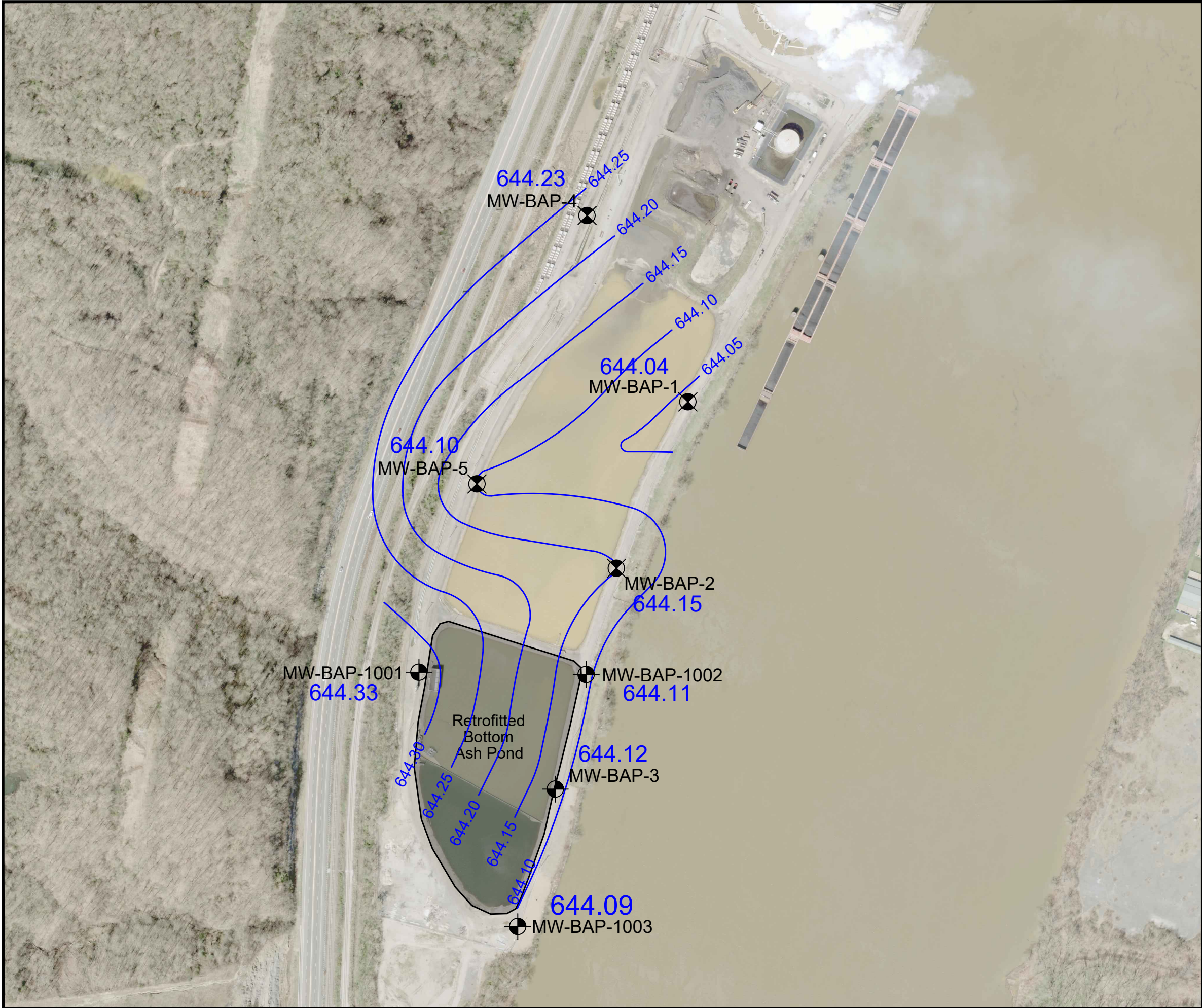
MW-BAP-1001 is upgradient and represents background conditions, while MW-BAP-1002, MW-BAP-3, and MW-BAP-1003 are downgradient monitoring wells.








Figure

1-2

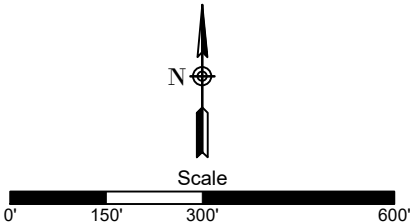
CCR Unit and Monitoring Wells,
Retrofitted Bottom Ash Pond,
Cardinal Plant,
Brilliant, Ohio



Legend

-  RBAP Monitor Well
-  Non-RBAP Monitor Well
-  644.05 Approximate Groundwater Elevation Contour
-  644.04 Groundwater Elevation on April 10, 2023
-  Retrofitted Bottom Ash Pond (RBAP)

Source of Aerial Photograph: Ohio Statewide Imagery Program, 2020.








Figure

4-1

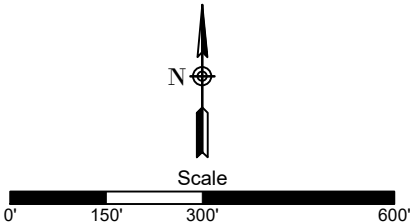
Potentiometric Surface Map - Uppermost Aquifer - April 10, 2023,
Retrofitted Bottom Ash Pond (RBAP),
Cardinal Plant,
Brilliant, Ohio



Legend

-  RBAP Monitor Well
-  Non-RBAP Monitor Well
-  644.76 Approximate Groundwater Elevation Contour
-  644.75 Groundwater Elevation on October 9, 2023
-  Retrofitted Bottom Ash Pond (RBAP)

Source of Aerial Photograph: Ohio Statewide Imagery Program, 2020.



Figure

4-2

Potentiometric Surface Map - Uppermost Aquifer - October 9, 2023,
Retrofitted Bottom Ash Pond (RBAP),
Cardinal Plant,
Brilliant, Ohio

Tables

Tables

Table 4-1. Groundwater Flow Calculations April 2023, Retrofit Bottom Ash Pond (RBAP), Cardinal Plant, Brilliant, Ohio

Program	Groundwater Zone	Well	Hyrdaulic Location	Depth to Water (ft)	Potentiometric Elevation (ft)	Gradient ¹ (ft/ft)	Hydraulic Conductivity ² (cm/sec)			Effective Porosity	Groundwater Velocity (ft/day)			Well Diameter ³ (in.)	Residence Time ⁴ (days)		
							Low	Representative	High		Low	Representative	High		Low	Representative	High
RBAP	RBAP	MW-BAP-1001	Upgradient	28.90	644.33	0.0004	0.0002	0.05	0.3	0.36	0.0006	0.16	0.94	8	0.71	4.23	1058
RBAP	RBPA	MW-BAP-1002	Downgradient	28.73	644.11	0.0007	0.0002	0.05	0.3	0.36	0.0011	0.28	1.65	8	0.40	2.42	605
RBAP	RBAP	MW-BAP-1003	Downgradient	28.54	644.09	0.0007	0.0002	0.05	0.3	0.36	0.0011	0.27	1.63	8	0.41	2.46	614
RBAP	RBAP	MW-BAP-3	Downgradient	28.93	644.12	0.0007	0.0002	0.05	0.3	0.36	0.0011	0.28	1.65	8	0.40	2.42	605

K:\CCA\PROJECTS\Buckeye_Power\Cardinal\BAP Retrofit\Annual Groundwater and Corrective Measures Report\2023\Tables\[Table 4-1 - April GW Flow RBAP.xlsx]Table 4-1

Measurements and calculations represent conditions on April 10, 2023.

¹ Hydraulic gradient was calculated from a potentiometric surface.

² Low and high conductivity values are from the 2022 Groundwater Monitoring Network Evaluation, with a representative value chosen within this range that is consistent with previous velocity calculations.

³ Well diameter represents the diameter of the borehole (sandpack).

⁴ Residence time is an estimation of how long it would take groundwater to travel a distance equivalent to the well diameter at the calculated velocity.

Table 4-2. Groundwater Flow Calculations October 2023, Retrofit Bottom Ash Pond (RBAP), Cardinal Plant, Brilliant, Ohio

Program	Groundwater Zone	Well	Hyrdaulic Location	Depth to Water (ft)	Potentiometric Elevation (ft)	Gradient ¹ (ft/ft)	Hydraulic Conductivity ² (cm/sec)			Effective Porosity	Groundwater Velocity (ft/day)			Well Diameter ³ (in.)	Residence Time ⁴ (days)		
							Low	Representative	High		Low	Representative	High		Low	Representative	High
RBAP	RBAP	MW-BAP-1001	Upgradient	28.41	644.82	0.0004	0.0002	0.05	0.3	0.36	0.0006	0.16	0.94	8	0.71	4.23	1058
RBAP	RBPA	MW-BAP-1002	Downgradient	28.15	644.69	0.0004	0.0002	0.05	0.3	0.36	0.0006	0.16	0.94	8	0.71	4.23	1058
RBAP	RBAP	MW-BAP-1003	Downgradient	27.99	644.64	0.0004	0.0002	0.05	0.3	0.36	0.0006	0.16	0.94	8	0.71	4.23	1058
RBAP	RBAP	MW-BAP-3	Downgradient	28.47	644.58	0.0005	0.0002	0.05	0.3	0.36	0.0008	0.20	1.18	8	0.56	3.39	847

K:\CCA\PROJECTS\Buckeye_Power\Cardinal\BAP Retrofit\Annual Groundwater and Corrective Measures Report\2023\Tables\[Table 4-2 - October GW Flow RBAP.xlsx]Table 4-1

Measurements and calculations represent conditions on October 9, 2023.

¹ Hydraulic gradient was calculated from a potentiometric surface.

² Low and high conductivity values are from the 2022 Groundwater Monitoring Network Evaluation, with a representative value chosen within this range that is consistent with previous velocity calculations.

³ Well diameter represents the diameter of the borehole (sandpack).

⁴ Residence time is an estimation of how long it would take groundwater to travel a distance equivalent to the well diameter at the calculated velocity.

Table 4-3. Summary of CCR Groundwater Samples, Retrofit Bottom ash Pond (RBAP), Cardinal Plant, Brilliant, Ohio

Well Name	Type of Well	Sample Date	Constituents Analyzed	Purpose
MW-BAP-3	Downgradient	4/20/2023	Appendix III	Detection Monitoring Program
MW-BAP-3	Downgradient	10/18/2023	Appendix III	Detection Monitoring Program
MW-BAP-3	Downgradient	10/18/2023	Appendix III	Detection Monitoring Program (Duplicate)
MW-BAP-1001	Background	4/21/2023	Appendix III	Detection Monitoring Program
MW-BAP-1001	Background	10/18/2023	Appendix III	Detection Monitoring Program
MW-BAP-1002	Downgradient	4/21/2023	Appendix III	Detection Monitoring Program
MW-BAP-1002	Downgradient	10/18/2023	Appendix III	Detection Monitoring Program
MW-BAP-1003	Downgradient	4/20/2023	Appendix III	Detection Monitoring Program
MW-BAP-1003	Downgradient	4/20/2023	Appendix III	Detection Monitoring Program (Duplicate)
MW-BAP-1003	Downgradient	10/18/2023	Appendix III	Detection Monitoring Program

K:\CCA\PROJECTS\Buckeye_Power\Cardinal\BAP Retrofit\Annual Groundwater and Corrective Measures Report\2023\Tables\[Table 4-3 - Sample Summary RBAP.xlsx]Sample Summary

Table 4-4. Sampling Data, Retrofit Bottom Ash Pond (RBAP), Cardinal Plant, Brilliant, Ohio

Well Name		MW-BAP-1001	MW-BAP-1001	MW-BAP-1002	MW-BAP-1002	MW-BAP-1003	MW-BAP-1003	MW-BAP-1003	MW-BAP-3	MW-BAP-3	MW-BAP-3
Well Type		Background	Background	Downgradient	Downgradient	Downgradient	Downgradient	Downgradient	Downgradient	Downgradient	Downgradient
Sample Name		MW-BAP-1001	MW-BAP-1001	MW-BAP-1002	MW-BAP-1002	MW-BAP-1003	MW-BAP-1003 Dup	MW-BAP-1003	MW-BAP-3	MW-BAP-3	MW-BAP-3 DUP
Sample Date		4/21/2023	10/18/2023	4/21/2023	10/18/2023	4/20/2023	4/20/2023	10/18/2023	4/20/2023	10/18/2023	10/18/2023
Laboratory	Concentration	Pace Analytical	Pace Analytical	Pace Analytical	Pace Analytical	Pace Analytical	Pace Analytical	Pace Analytical	Pace Analytical	Pace Analytical	Pace Analytical
Lab ID	Units	50342943001	50357062001	50342943002	50357062002	50342943004	50342943005	50357062003	50342943003	50356927003	50356927004
APPENDIX III CONSTITUENTS											
Boron	MG/L	0.0322	0.03	3.26	2.91	0.766	1.95	0.84	1.92	2.12	2.12
Calcium	MG/L	86	87.6	100	95.8	107	108	102	81.4	82.8	81.9
Chloride	MG/L	6.4	5.9	69.2	63	62.4	63.5	59.5	65.8	63.4	63.6
Fluoride	MG/L	0.17	0.15	0.11	0.12	0.12	0.12	0.1	0.098	0.09	0.09
Sulfate	MG/L	34.3	31.9	55.9	82.1	47.9	47.6	49	183	170	168
Total Dissolved Solids	MG/L	325	319	475	451	502	502	461	492	492	489
pH	SU	7.19	7.29	6.91	6.88	7.16	NA	7.12	6.9	6.57	NA

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Bold = Detected
NA = Not Analyzed

Appendix A

Alternative Source Demonstration (ASD) for the
Retrofit Bottom Ash Pond (RBAP) – May 2023

**Alternative Source Demonstration (ASD) for the
Retrofit Bottom Ash Pond (RBAP)
Federal CCR Rule
Cardinal Operating Company – Cardinal Power Plant
306 County Road 7E
Brilliant, Ohio**

May 25, 2023

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**Alternative Source Demonstration (ASD) for the
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306 County Road 7E
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May 25, 2023

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Brilliant, Ohio 43913

Submitted by:



Nate Wanner, CPG
Senior Scientist



Nick Petruzzi, PE
Principal Engineer



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1.0 Introduction

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 was conducted in November 2022 at the Retrofit BAP (RBAP), a CCR unit at the Cardinal Power Plant located in Brilliant, Ohio. As the RBAP CCR unit was only recently created, to replace the former Bottom Ash Pond (BAP) Complex, the November 2022 groundwater sampling event is the first monitoring event to be conducted following the initial determination of background concentrations.

Statistical analyses were performed following semi-annual groundwater sampling to evaluate whether the concentrations of any constituent represent a statistically significant increase (SSI) – i.e., exceeding recently established background upper prediction limits (UPLs) defined in accordance with §257.93(f)(3) of the CCR Rule. The analyses were conducted in accordance with the Statistical Analysis Plan (StAP) (Geosyntec 2020). SSIs above background levels were identified.

The purpose of this technical memorandum is to document the completion of an alternative source demonstration (ASD) in accordance with §257.94(e)(2) of the CCR Rule. This ASD demonstrates that sources other than the RBAP are responsible for the SSIs. These sources include, but may not be limited to, the former BAP Complex and acidic drainage from former coal mines. Because the SSIs are attributable to sources other than the RBAP, it will remain in detection monitoring and not enter assessment monitoring.

1.1 Statistically Significant Increases (SSIs)

SSIs above background levels were identified for the constituents and well pairings below. These SSIs were identified on March 9, 2023 (Cox-Colvin 2023).

- Boron: MW-BAP-3, MW-BAP-1002, MW-BAP-1003
- Calcium: MW-BAP-1002, MW-BAP-1003
- Chloride: MW-BAP-3, MW-BAP-1002, MW-BAP-1003
- pH¹: MW-BAP-3
- Sulfate: MW-BAP-3, MW-BAP-1002, MW-BAP-1003
- Total Dissolved Solids (TDS): MW-BAP-3, MW-BAP-1001, MW-BAP-1003

¹ Unlike other monitored constituents that are compared to only a UPL, pH is compared to both a UPL and an LPL when evaluating potential SSIs. In this context, a statistically significant decrease (SSD) of pH values below the lower prediction limit (LPL) is included as a potential "SSI" for consistency with the language and requirements of the CCR Rule.

1.2 CCR Rule Requirements

CCR Rule §257.94(e)(2) states that:

The owner or operator may demonstrate that a source other than the CCR unit caused the statistically significant increase over background levels for a constituent or that the statistically significant increase resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality. The owner or operator must complete the written demonstration within 90 days of detecting a statistically significant increase over background levels to include obtaining a certification from a qualified professional engineer or approval from the Participating State Director or approval from EPA where EPA is the permitting authority verifying the accuracy of the information in the report. If a successful demonstration is completed within the 90-day period, the owner or operator of the CCR unit may continue with a detection monitoring program under this section. If a successful demonstration is not completed within the 90-day period, the owner or operator of the CCR unit must initiate an assessment monitoring program as required under § 257.95. The owner or operator must also include the demonstration in the annual groundwater monitoring and corrective action report required by § 257.90(e), in addition to the certification by a qualified professional engineer or approval from the Participating State Director or approval from EPA where EPA is the permitting authority.

1.3 RBAP Construction and Operational History

The Bottom Ash Complex at the Cardinal Plant consists of a South Pond and a North Pond, located at the southern end of the plant and directly west of the Ohio River. The Cardinal Operating Company elected to retrofit the pond complex by segregating it into two separate ponds designed to manage CCR wastes and Low Volume Waste, respectively. The South Pond ceased receiving waste streams and initiated retrofit in August 2021 by excavating the deposited ash and relining with a CCR compliant liner (Buckeye Power, Inc. 2021).

On March 27, 2022, the Cardinal Operating Company completed the retrofit activities for the South Pond of the Bottom Ash Complex (Sargent & Lundy 2022). The retrofit activities were completed in accordance with the written retrofit plan (Sargent & Lundy 2020) and the requirements of 40 CFR 257.102(k). Upon completion of the retrofit, the South Pond's name was changed from the former Recirculation Pond to the Retrofit Bottom Ash Pond.

The adjacent North Pond ceased receiving waste streams and initiated retrofit in accordance with the North Pond Closure Plan on March 24, 2023, and work is still on going.

2.0 Background Determinations

Background concentrations were initially established in October 2022 using background data collected from June 2021 to May 2022 at MW-BAP-1001. Interwell UPLs were calculated for Appendix III constituents based upon a one-of-two sampling plan with seven constituents analyzed twice per year at three downgradient (compliance) wells. Additionally, a lower prediction limit (LPL) was calculated for pH (Cox-Colvin 2022).

While the established prediction limits accurately represent *background* conditions at background monitoring well MW-BAP-1001, they are not representative of *baseline* conditions (conditions when RBAP began operation) at compliance monitoring wells MW-BAP-3, MW-BAP-1002, and MW-BAP-1003. This is a result of natural variation in groundwater quality and the presence of sources other than the RBAP CCR Unit, as discussed below.

The disparity between background and baseline conditions was recognized prior to statistical evaluation of the November 2022 sampling event data, but CCR Rules do not provide for consideration of baseline conditions during background determination. Baseline conditions are instead considered in this ASD.

2.1 Natural Variation in Groundwater Quality

CCR Rule §257.91(a)(1) requires that a groundwater monitoring system “accurately represent the quality of background groundwater that has not been affected by leakage from a CCR unit.” It is preferred to use data from background monitoring wells placed immediately upgradient of the CCR unit and in geologic materials identical to those at downgradient compliance wells. However, site conditions and operational history limit the ability to do so at the RBAP.

The uppermost aquifer at the RBAP consists of unconsolidated materials overlying a sandstone bedrock. The sandstone bedrock was encountered at 51 feet below ground surface (bgs) at MW-BAP-1001 on the west side of the RBAP. This bedrock surface slopes downward towards the Ohio River to the east and is estimated to be at least 30 feet deeper on the east side of the RBAP than it is at MW-BAP-1001.

MW-BAP-1001 is screened primarily in alluvial lean clay, silty sand, and silty sand clay overlying the sandstone bedrock. Some organic matter is also present. In contrast, MW-BAP-3, MW-BAP-1002, and MW-BAP-1003 are fully screened in glacial outwash and alluvial deposits consisting of sand and gravel materials. The difference in grain sizes and organic content are likely to result in different natural groundwater chemistry (e.g., spatial variation).

Sand and gravel materials that are more consistent with the downgradient wells are likely to be encountered at locations east of MW-BAP-1001. However, MW-BAP-1001 is already at the western bank of the RBAP, and a background well farther to the east would not be fully upgradient of the RBAP. Such well placement would also require the RBAP liner to be punctured.

CCR Rule §257.91(a)(1) allows that “a determination of background quality may include sampling of wells that are not hydraulically upgradient of the CCR management area where [...] sampling at other wells will provide an indication of background groundwater quality that is as representative or more representative than that provided by the upgradient wells.”

Based off neighboring monitor wells and borings, sand and gravel materials similar to those encountered at RBAP compliance wells are expected to be present north of the RBAP. Hydrogeology and measured flow directions in the area indicate the area would not be affected by the RBAP. However, the materials lie primarily beneath the North Pond that was historically part of the former BAP Complex that processed CCR prior to the retrofit. SSIs of CCR Appendix III constituents were previously identified for the former BAP Complex, which entered into assessment monitoring in August 2018.

Placement of background monitoring wells immediately to the north of the RBAP is not possible because CCR Rule §257.91(a)(1) requires that background groundwater not be “affected by leakage from a CCR unit.” The CCR Rule does not provide consideration as to whether the currently monitored CCR unit (e.g., RBAP), or a separate CCR unit (e.g., former BAP Complex), caused impact. As a result, upgradient locations adjacent to the RBAP where geologic materials are likely similar to those at RBAP compliance wells cannot presently be used to determine background concentrations.

The groundwater quality at background well MW-BAP-1001 is expected to have natural variations relative to groundwater quality at compliance wells. However, it is at present the best location to establish background quality in accordance with the CCR Rule due to the unique layout of the RBAP relative to underlying geology and historical operations in the area.

2.2 Statistical Evaluations

When significant spatial variation is present between monitoring wells, EPA statistical guidance states that it is preferable to use intrawell statistical tests that compare historical and recent data at a single well, as opposed to interwell tests that compare concentrations between wells (EPA 2009, Section 6.3.2). However, CCR Rule §257.93(d) requires that background groundwater quality be established “in a hydraulically upgradient or background well(s)”. Because of this requirement, use of intrawell statistical tests is not used to identify SSIs above background concentrations during RBAP detection monitoring. Instead, detection monitoring data is compared to interwell UPLs in compliance with the StAP and CCR Rule §257.93(f)(3).

3.0 Other Potential Sources

As discussed in Section 1.3, the RBAP is constructed atop the southern portion of the former BAP Complex. In accordance with §257.95 of the CCR Rules, assessment monitoring at the former BAP Complex was initiated in August 2018 after an SSI over groundwater background levels was first detected (nearly five years prior to RBAP operation). Although SSIs above background were identified for the former BAP Complex, no statistically significant levels (SSLs) above groundwater protection standards (GWPSs) have been identified for the former BAP Complex. As such, no corrective actions are necessary.

SSIs above background levels have been identified at the former BAP Complex groundwater monitoring network for boron, chloride, fluoride, pH, sulfate, and TDS. Although an SSI was not identified for calcium, the calcium UPL for the former BAP Complex monitoring program is higher (233 mg/L) than it is for the RBAP monitoring program (90 mg/L). This is because the background concentrations are based upon different background wells (the former BAP Complex covers a larger area) and natural variations exist in groundwater quality (Section 2.1).

On March 24, 2023, the North Pond ceased receiving waste streams and closure was initiated. As specified in §257.102(c) of the CCR Rules, closure activities at the BAP will be complete when all CCR has been removed and groundwater monitoring concentrations do not exceed GWPS. Groundwater contamination related to the former BAP Complex will remain, although there is no reason to expect groundwater concentrations to increase above GWPS following removal of all CCR material. With time, groundwater concentrations are expected to attenuate to background levels.

Additionally, many constituents of concern in CCR monitoring are also associated with acid mine drainage (AMD) related to coal mining. The area surrounding the facility has been extensively mined historically (Figure 2). The historical coal mining was performed at elevations higher than the RBAP, and AMD is expected to affect groundwater quality in shallow aquifers throughout the region.

4.0 Source Evaluation

As detailed in previous sections, groundwater monitoring of the RBAP is complicated by the following:

1. Unconsolidated materials at the background monitoring well (silts, clays, and silty sand) differ from sand/gravel materials at the compliance wells and are, therefore, likely to have differing natural chemistry.
2. Immediately adjacent locations to the north of the RBAP are expected to have similar sand/gravel materials as those found at compliance wells; however, these locations are impacted from another CCR unit and are not presently suitable as background well locations.
3. The RBAP is located in an area formerly occupied by the southern portion of the former BAP Complex. CCR monitoring detected SSIs above background concentrations at the former BAP Complex prior to construction and operation of the RBAP.
4. The northern portion of the former BAP Complex, adjacent to the RBAP, ceased receiving CCR in March 2023 (after the November 2022 sampling event for which SSIs were observed at the RBAP). Furthermore, closure activities in the northern portion of the former BAP Complex are still underway and not all CCR materials have been removed. These operations and materials, that are separate from the RBAP, could affect groundwater quality.
5. During detection monitoring, the CCR Rule requires evaluation of SSIs above background levels, as opposed to baseline conditions at the time a CCR unit began operating.

Although there is no provision in the CCR Rule to establish background concentrations based on baseline conditions, §257.94(e)(2) allows that “the owner or operator may demonstrate that a source other than the CCR unit caused the statistically significant increase over background levels for a constituent or that the statistically significant increase resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality.”

No errors in sampling, analysis, or statistical evaluation have been identified. However, the former BAP Complex CCR unit is known to have resulted in SSIs in groundwater beneath the present-day RBAP, even before the RBAP went into operation.

Because groundwater contamination is present from sources other than the RBAP, and the newly constructed RBAP has a CCR-compliant liner, it is highly unlikely that SSIs are a result of releases from the RBAP. However, it is prudent to confirm that no release from the RBAP contributed to SSIs. Such a demonstration is best performed using intrawell

statistical tests to compare groundwater conditions at each compliance well prior to RBAP operation to groundwater conditions during RBAP operation, as described below.

4.1 Statistical Methodology

CCR Rule §257.93(f)(4) allows the use of control charts as a valid statistical method to evaluate groundwater monitoring data. EPA's "Unified Guidance" introduces control charts as follows (EPA 2009, Section 20.1):

As a well-established statistical methodology, there are many kinds of control charts. Historically, control charts have been put to great use in quality engineering and manufacturing, but have more recently been adapted for use in groundwater monitoring. The specific control chart recommended in the Unified Guidance is known as a combined Shewhart-CUSUM control chart (Lucas, 1982). It is a 'combined' chart because it simultaneously utilizes two separate control chart evaluation procedures. The Shewhart portion is almost identical to a prediction limit in that compliance measurements are individually compared against a background limit. The cumulative sum [CUSUM] portion sequentially analyzes each new measurement with prior compliance data. Both portions are used to assess the similarity of compliance data to background in detection monitoring.

The Shewhart-CUSUM control chart works as follows. Appropriate background data are first collected from the specific compliance well for intrawell comparisons or from separate background wells for interwell tests. The baseline parameters for the chart, estimates of the mean and standard deviation, are obtained from these background data. These baseline measurements characterize the expected background concentrations at compliance wells.

As future compliance observations are collected, the baseline parameters are used to standardize the newly gathered data. After these measurements are standardized and plotted, a control chart is declared out-of-control if future concentrations exceed the baseline control limit. This is indicated on the control chart when either the Shewhart or CUSUM plot traces begins to exceed a control limit. The limit is based on the rationale that if the well remains uncontaminated as it was during the baseline period, new standardized observations should not deviate substantially from the baseline mean. If a release occurs, the standardized values will deviate significantly from baseline and tend to exceed the control limit. The historical baseline parameters then no longer accurately represent current well concentration levels.

Shewhart-CUSUM control charts are an effective way to evaluate not only whether current groundwater quality differs from pre-RBAP groundwater quality, but also whether there are "drifts" in concentrations over time. If the RBAP is contributing to SSIs, then

concentrations following its implementation are expected to be higher than those prior its implementation, and to also increase over time. Conversely, removal of all CCR material associated with the former BAP Complex is expected to result in decreasing concentrations of CCR constituents over time (although other factors may be involved).

4.2 Statistical Evaluation

SanitasTM statistical software was used to prepare control charts for well/constituent pairs exhibiting an SSI above background, as listed in Section 1.1.

The baseline data set for this evaluation consists of data from eight sampling events performed from June 2021 until implementation of the RBAP on March 27, 2022. The post-construction “compliance” data set consists of compliance well data from four sampling events performed from March 31, 2022, until November 2022. This baseline data set differs from the background data set comprised of data from MW-BAP-1001.

Results of the evaluation can be found in Appendix A. No SSIs above baseline conditions were identified, except for sulfate at MW-BAP-1003.

4.3 Sulfate

A sulfate concentration of 55.7 mg/L at MW-BAP-1003 in November 2022 was higher than the previous 11 sampling events where concentrations ranged from 25.3 to 37.5 mg/L. A resample has not been collected.

Figure 1 shows sulfate concentrations over time and their relative location to the RBAP. Groundwater flow is generally south, consistent with river flow. Sulfate concentrations in groundwater are highest in areas that are upgradient (north) of the RBAP. The highest sulfate concentrations associated with the former BAP complex monitoring were in upgradient background wells associated with the former BAP Complex (MW-BAP-4 and MW-BAP -5), where concentrations were significantly higher than those in the ash pond water itself. In fact, sulfate concentrations at MW-BAP-1003 are lower than all other wells included in both former BAP Complex and RBAP CCR monitoring except MW-BAP-1001.

Based upon the lower concentration of sulfate at MW-BAP-1003 and the distribution of sulfate throughout the area, the source is unrelated to RBAP operations. Presuming that the November 2022 sulfate concentration at MW-BAP-1003 was not anomalous and would be confirmed as an SSI if resampled, it is most likely related to upgradient sources. These sources may include acid mine drainage from historical coal mining activities west and northwest of the RBAP (Figure 2).

Future increases in sulfate concentrations at the RBAP compliance wells are possible. This is because construction of impermeable liners throughout the former BAP can result in less infiltration, and thus less dilution, of sulfate concentrations originating upgradient.

5.0 Conclusion

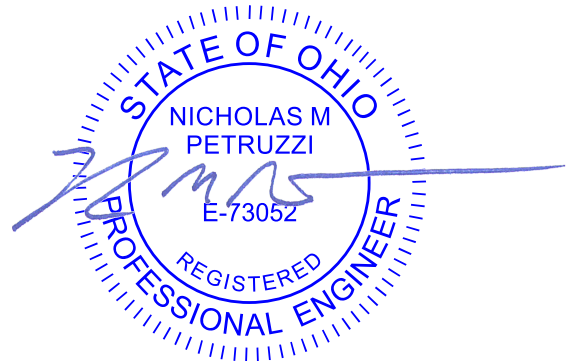
SSIs above background conditions have been detected at the RBAP. However, these SSIs are due to conditions that existed prior to implementation of the RBAP and, therefore, unrelated to RBAP operations.

Statistical evaluations of CCR constituents against baseline, as opposed to background, concentrations do not reveal evidence of a release from the RBAP.

6.0 Professional Engineer Certification

The undersigned Professional Engineer registered in the State of Ohio is familiar with the requirements of 40 CFR part 257, subpart D and has visited and examined the facility. The undersigned Registered Engineer attests that, to the best of his knowledge, the RBAP ASD has been prepared in accordance with good engineering practice, including the requirements of §257.94(e)(2).

Nick M. Petruzzi, PE, CPG
Principal Engineer
Registration No. E-73052 (Ohio)
Cox-Colvin & Associates, Inc.

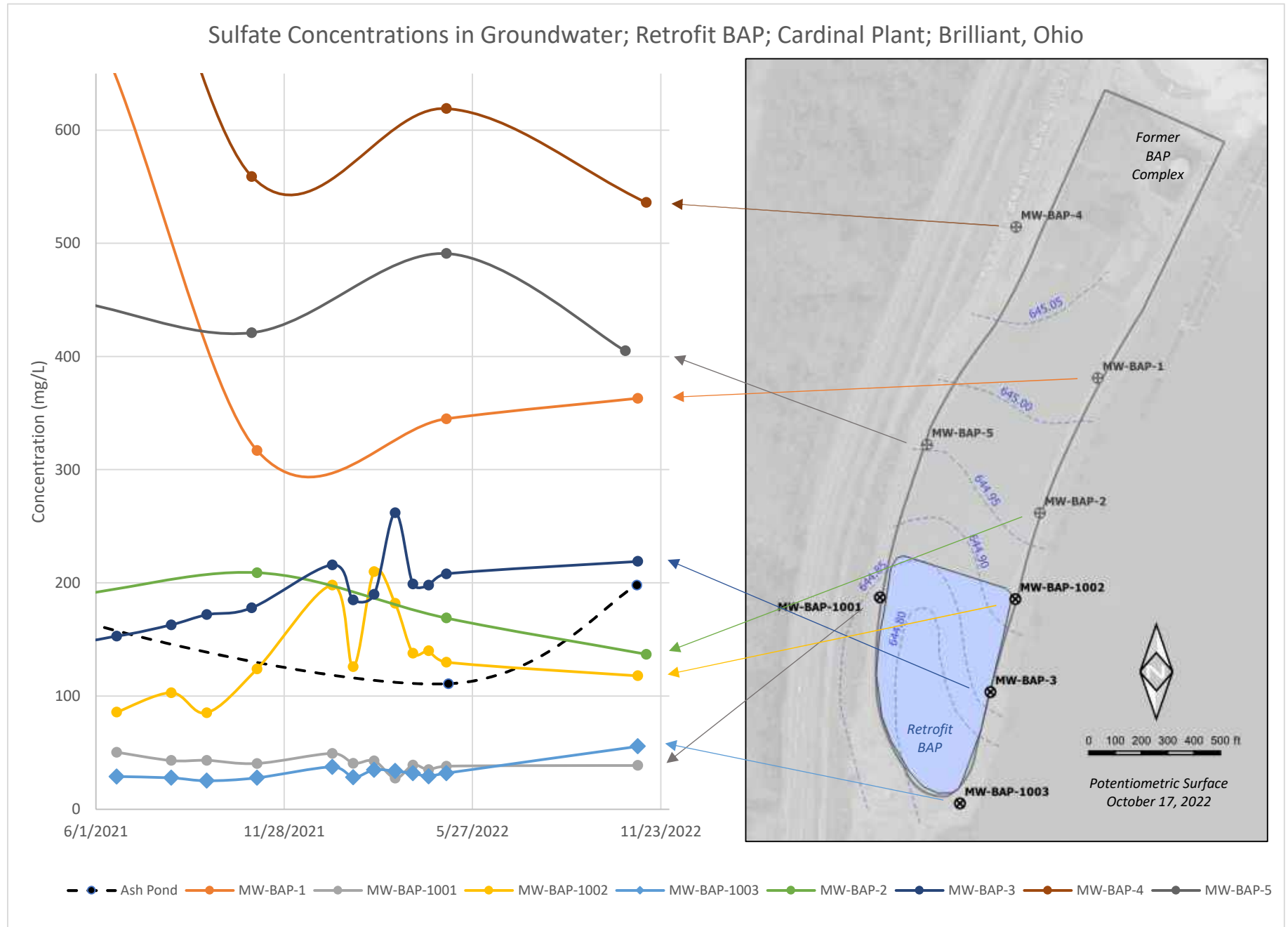


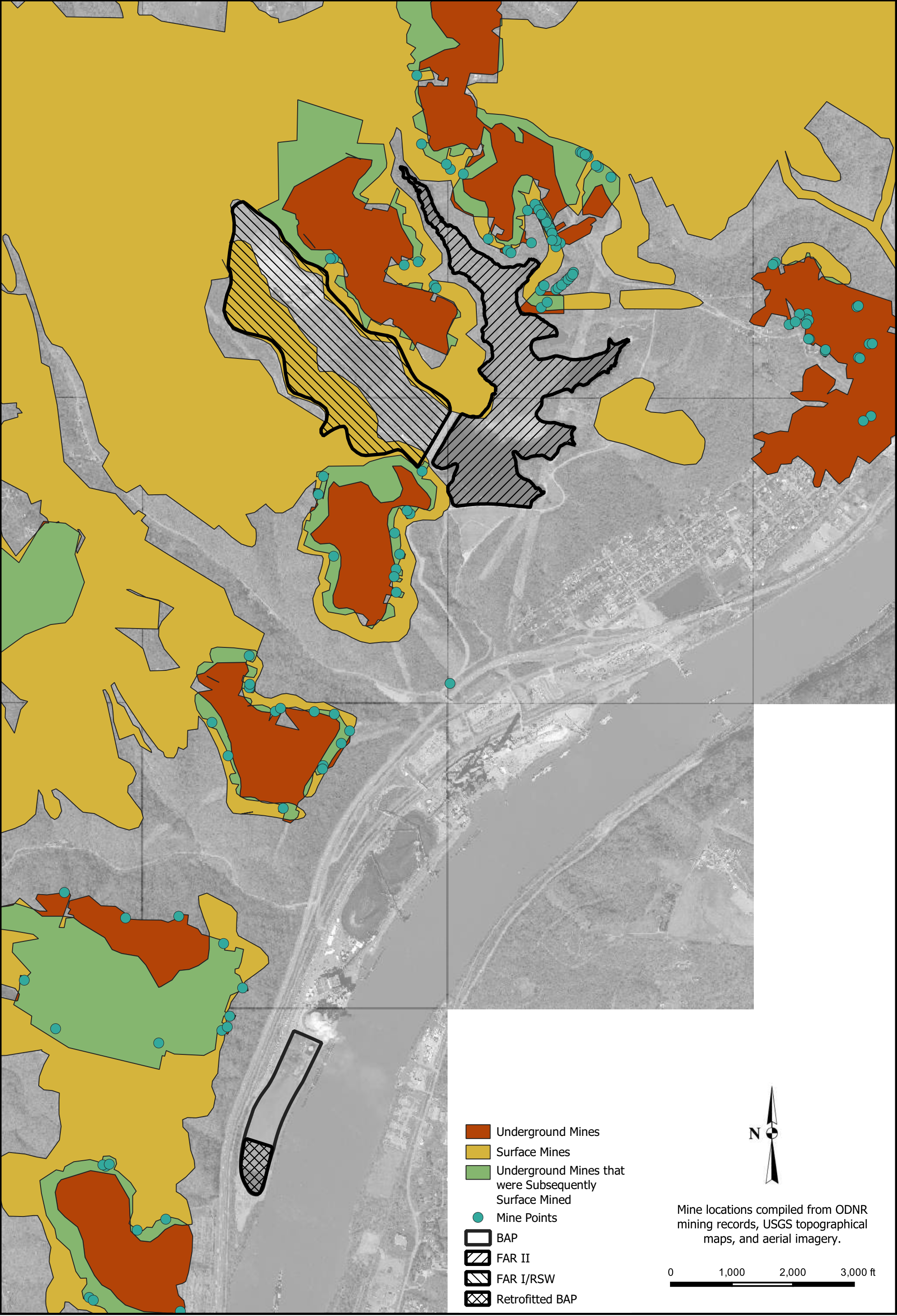
7.0 References

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https://pvt.buckeyepower.com/private/ccr/2021/Bottom%20Ash%20Pond/Notice%20of%20Intent%20to%20Retrofit%20South%20BAP_082021.pdf.
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https://pvt.buckeyepower.com/private/ccr/2022/BAP/Retrofit%20Completion_S.Pond.pdf.

Figures

Figure 1





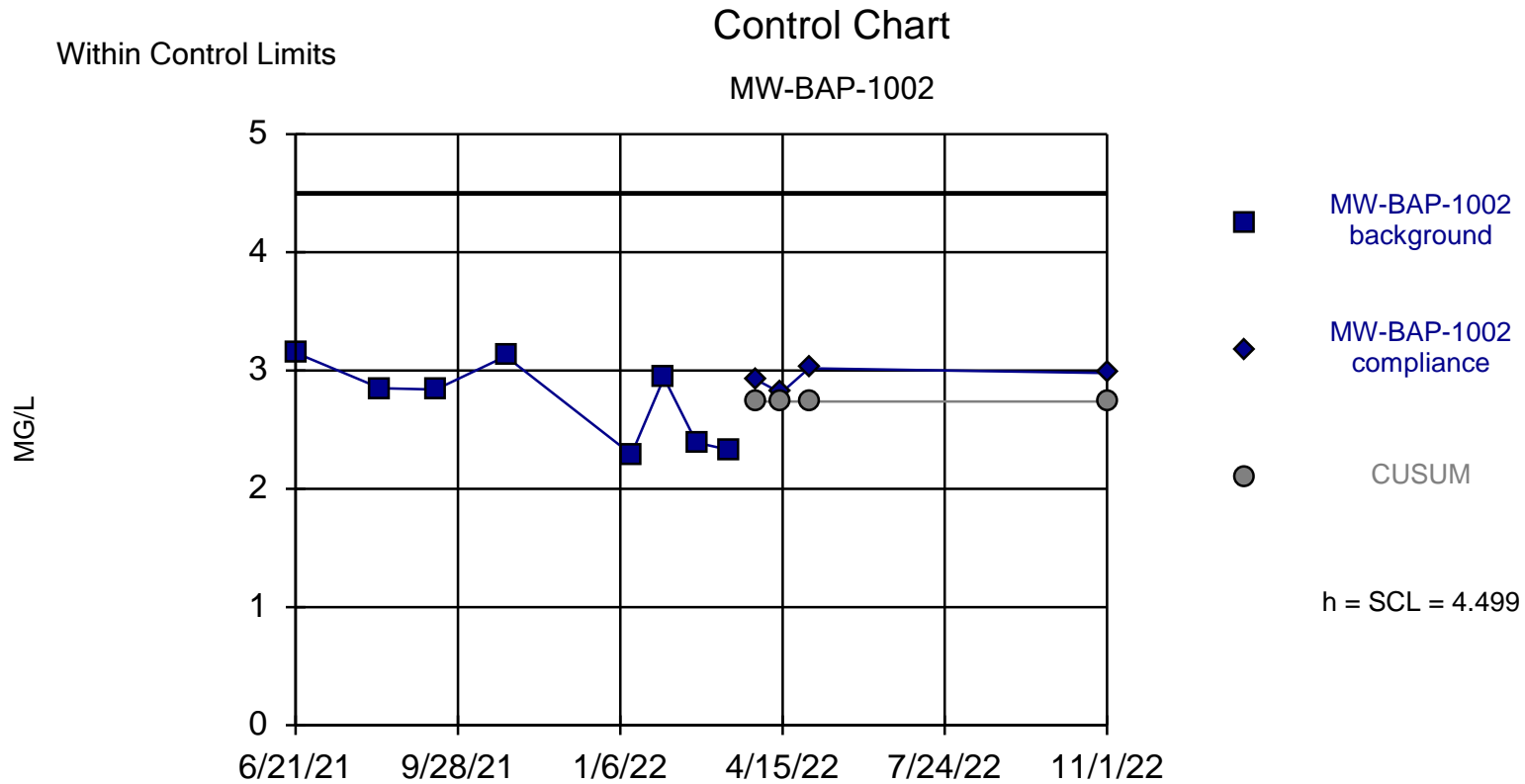
Appendix A

Control Charts

Shewhart-Cusum Control Chart / Rank Sum

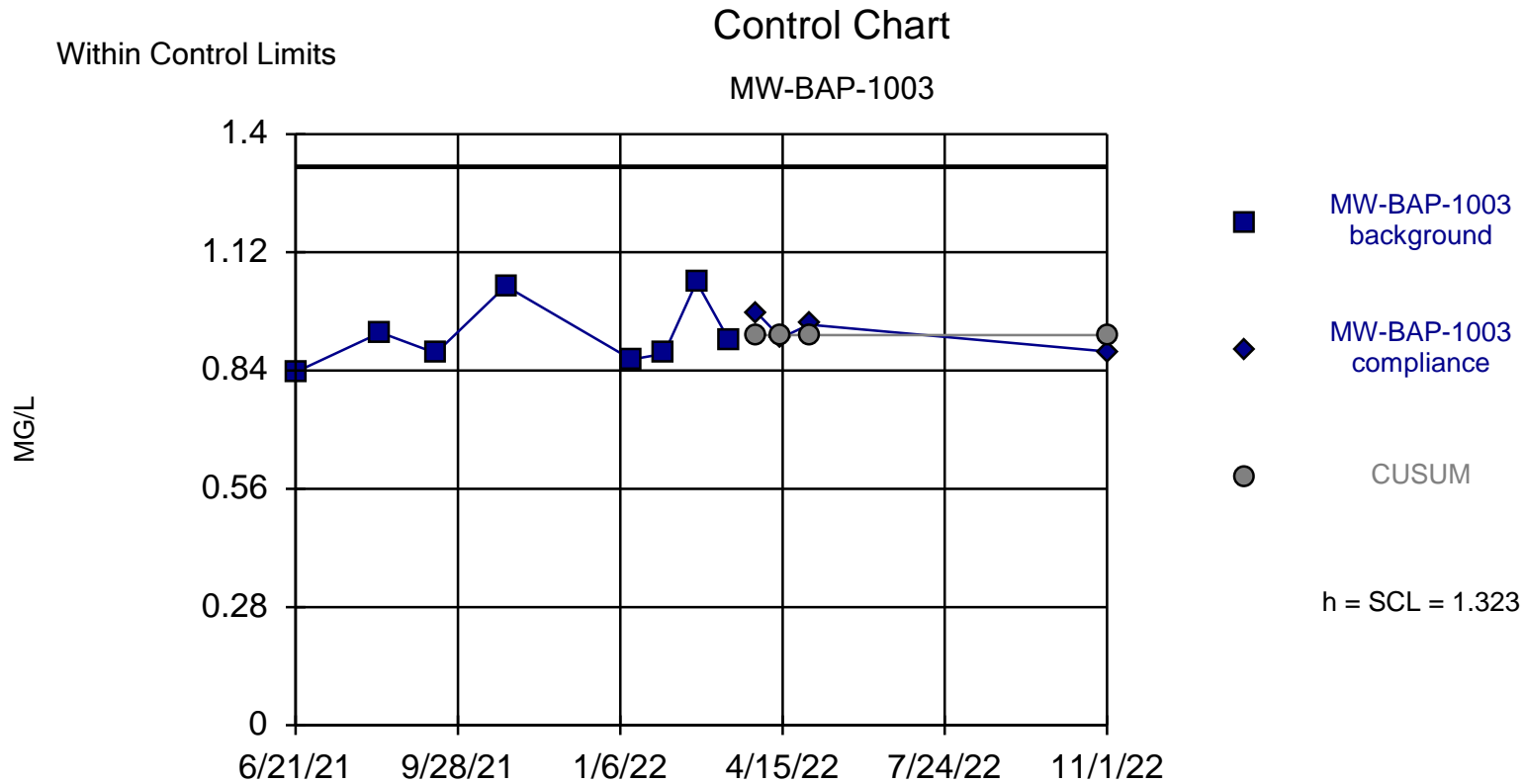
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<u>Constituent</u>	<u>Well</u>	<u>Sig.</u>	<u>N</u>	<u>%NDs</u>	<u>Transform</u>	<u>Method</u>
Boron (MG/L)	MW-BAP-1002	No	8	0	No	Param Intra
Boron (MG/L)	MW-BAP-1003	No	8	0	No	Param Intra
Boron (MG/L)	MW-BAP-3	No	8	0	No	Param Intra
Calcium (MG/L)	MW-BAP-1002	No	8	0	No	Param Intra
Calcium (MG/L)	MW-BAP-1003	No	8	0	No	Param Intra
Chloride (MG/L)	MW-BAP-1002	No	8	0	No	Param Intra
Chloride (MG/L)	MW-BAP-1003	No	8	0	No	Param Intra
Chloride (MG/L)	MW-BAP-3	No	8	0	No	NP Intra PL (normality)
Fluoride (MG/L)	MW-BAP-1002	No	8	0	No	Param Intra
Fluoride (MG/L)	MW-BAP-1003	No	8	0	No	Param Intra
Fluoride (MG/L)	MW-BAP-3	No	8	0	No	Param Intra
pH (SU)	MW-BAP-3	No	8	0	No	Param Intra
Sulfate (MG/L)	MW-BAP-1002	No	8	0	No	Param Intra
Sulfate (MG/L)	MW-BAP-1003	Yes	8	0	No	Param Intra
Sulfate (MG/L)	MW-BAP-3	No	8	0	No	Param Intra
Total Dissolved Solids (MG/L)	MW-BAP-1002	No	8	0	No	Param Intra
Total Dissolved Solids (MG/L)	MW-BAP-1003	No	8	0	No	Param Intra
Total Dissolved Solids (MG/L)	MW-BAP-3	No	8	0	No	Param Intra



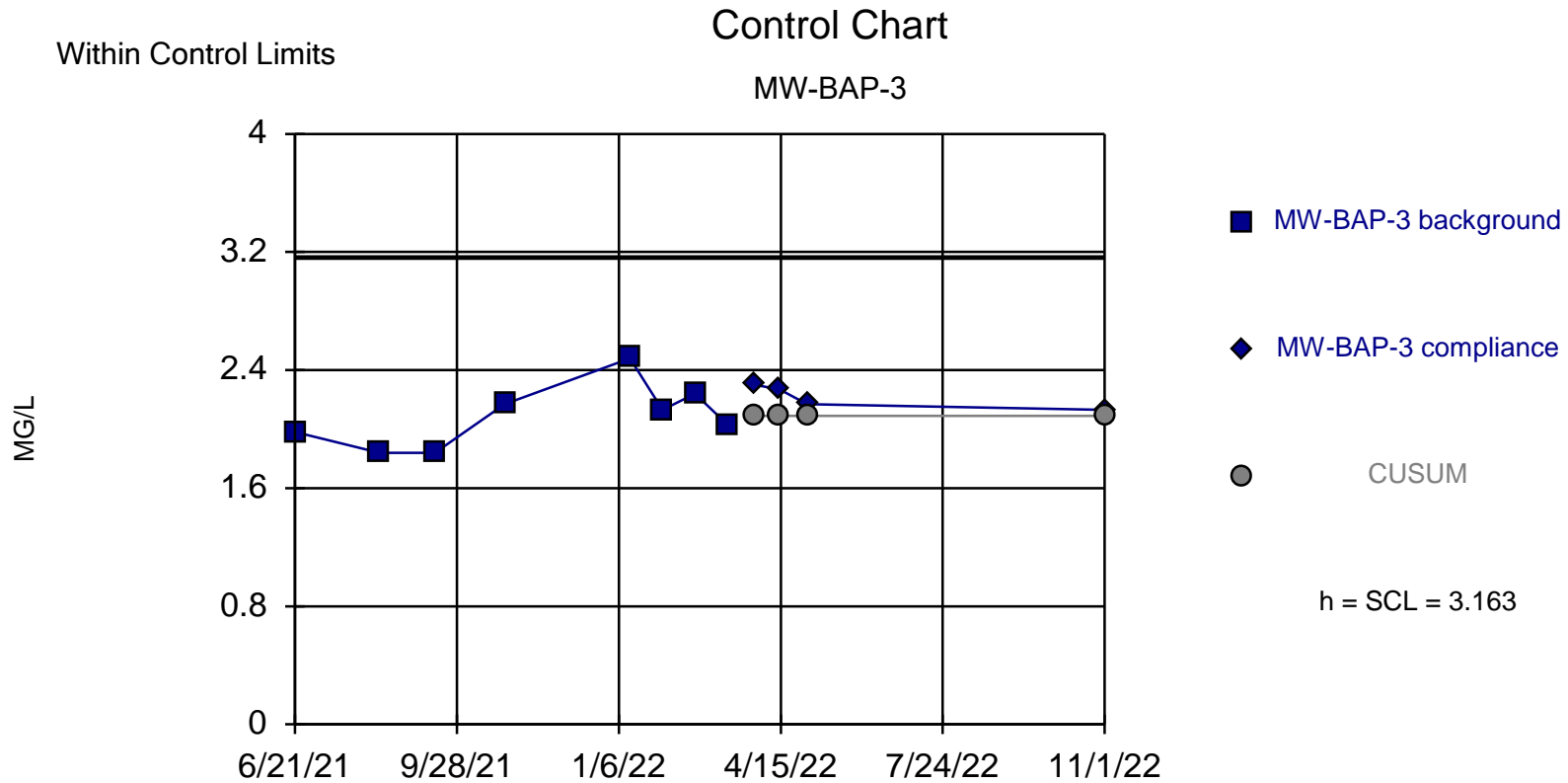
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Cardinal Facility Client: Cox-Colvin Data: stats_data_rbap



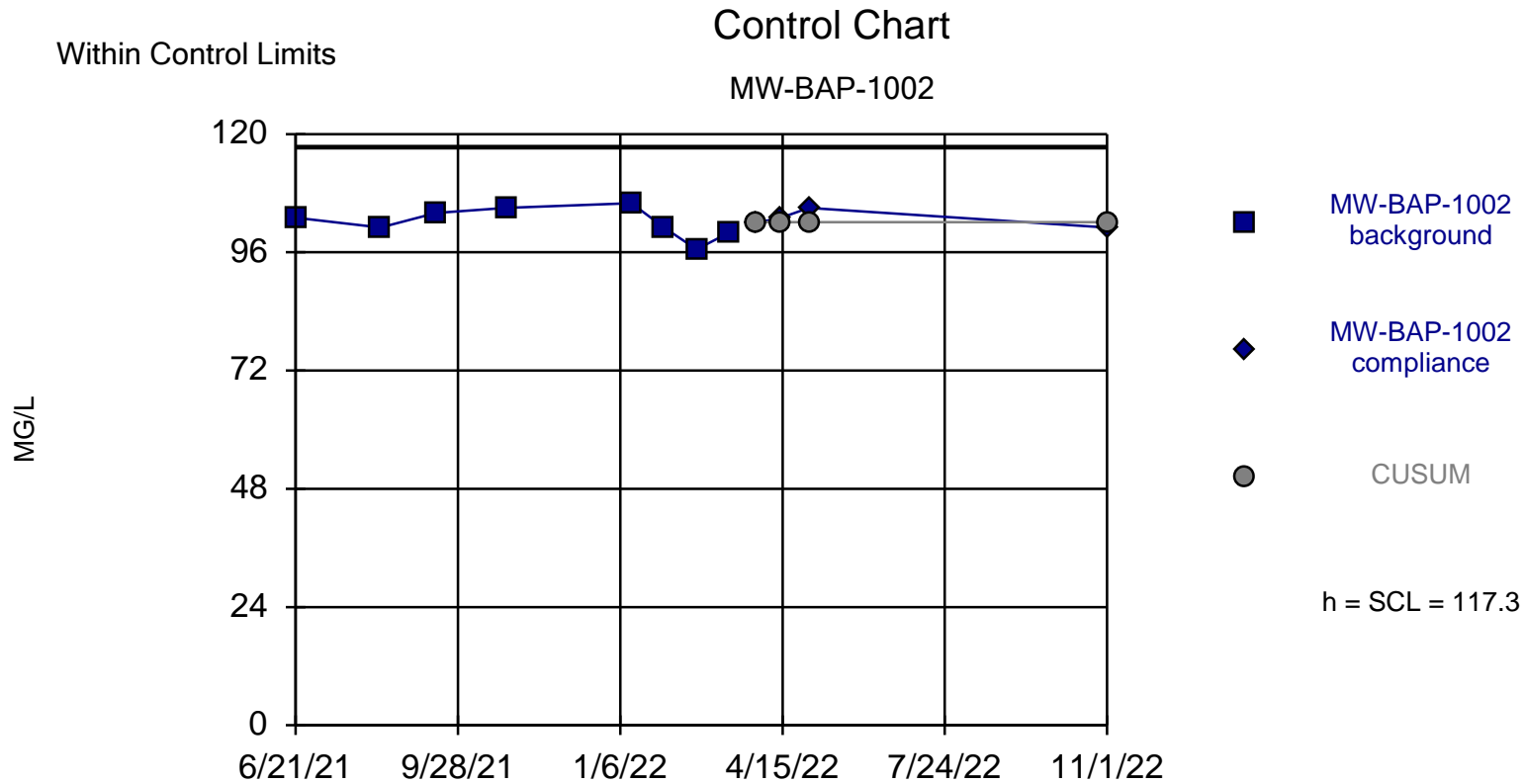
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 Cardinal Facility Client: Cox-Colvin Data: stats_data_rbap



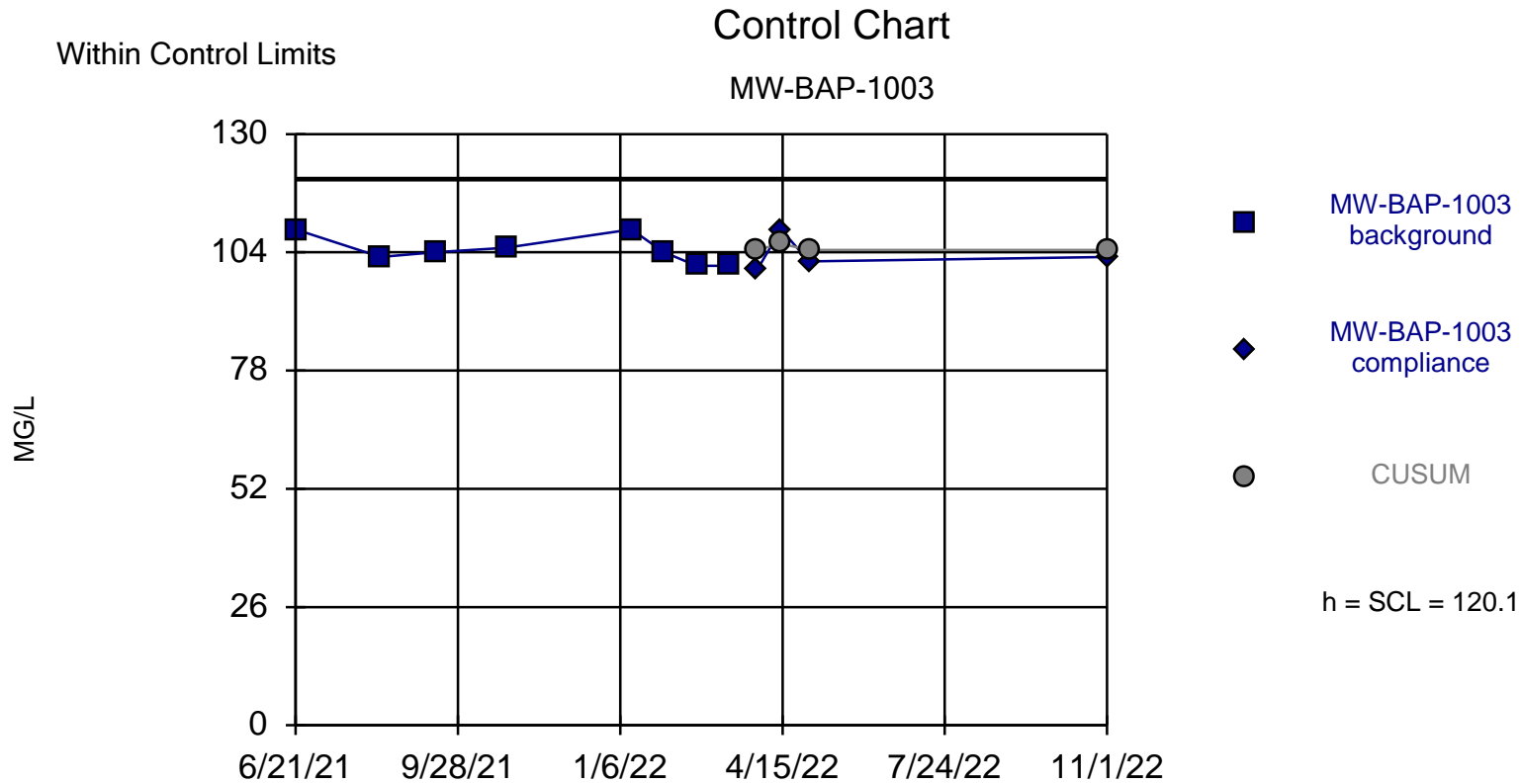
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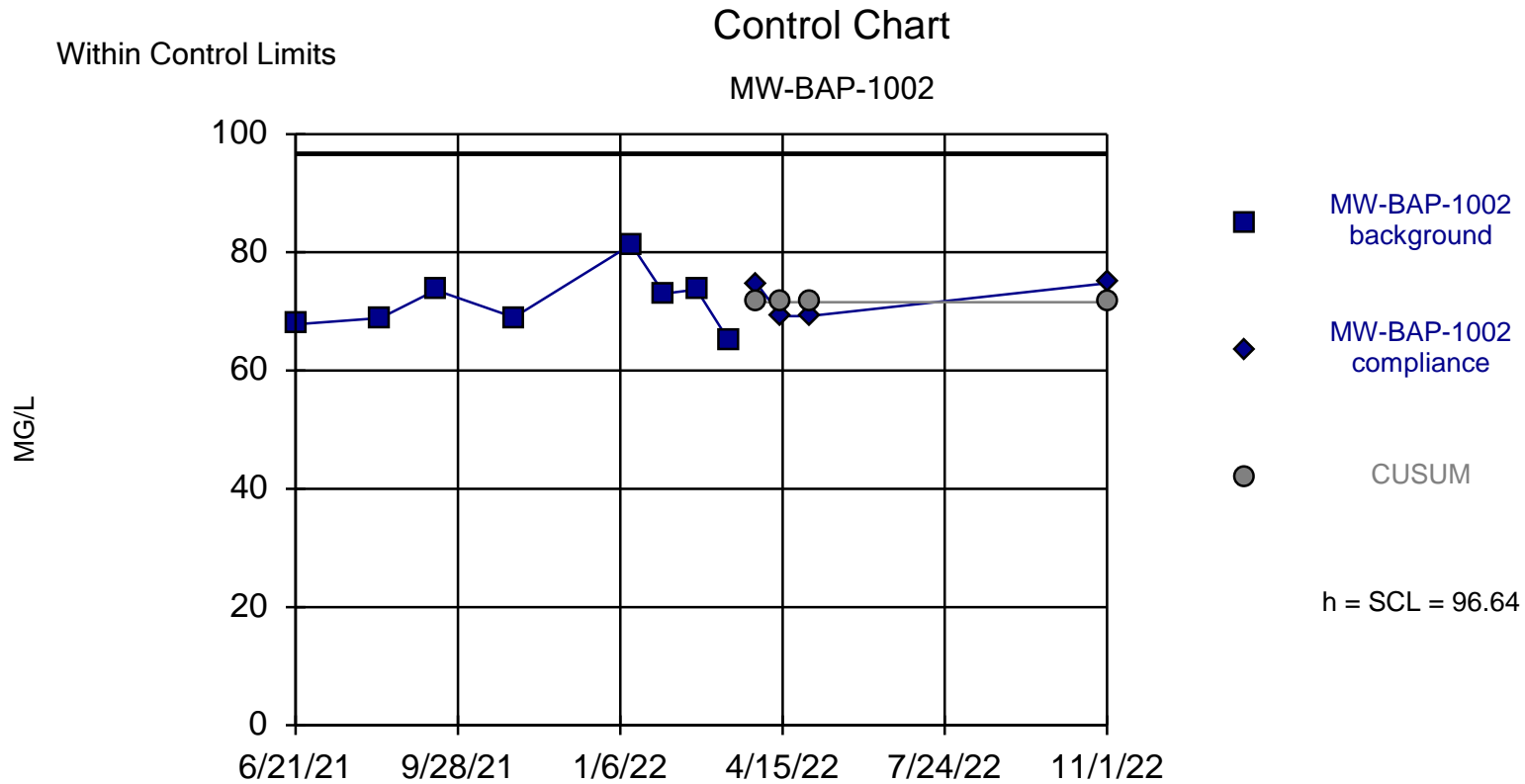
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 Cardinal Facility Client: Cox-Colvin Data: stats_data_rbp



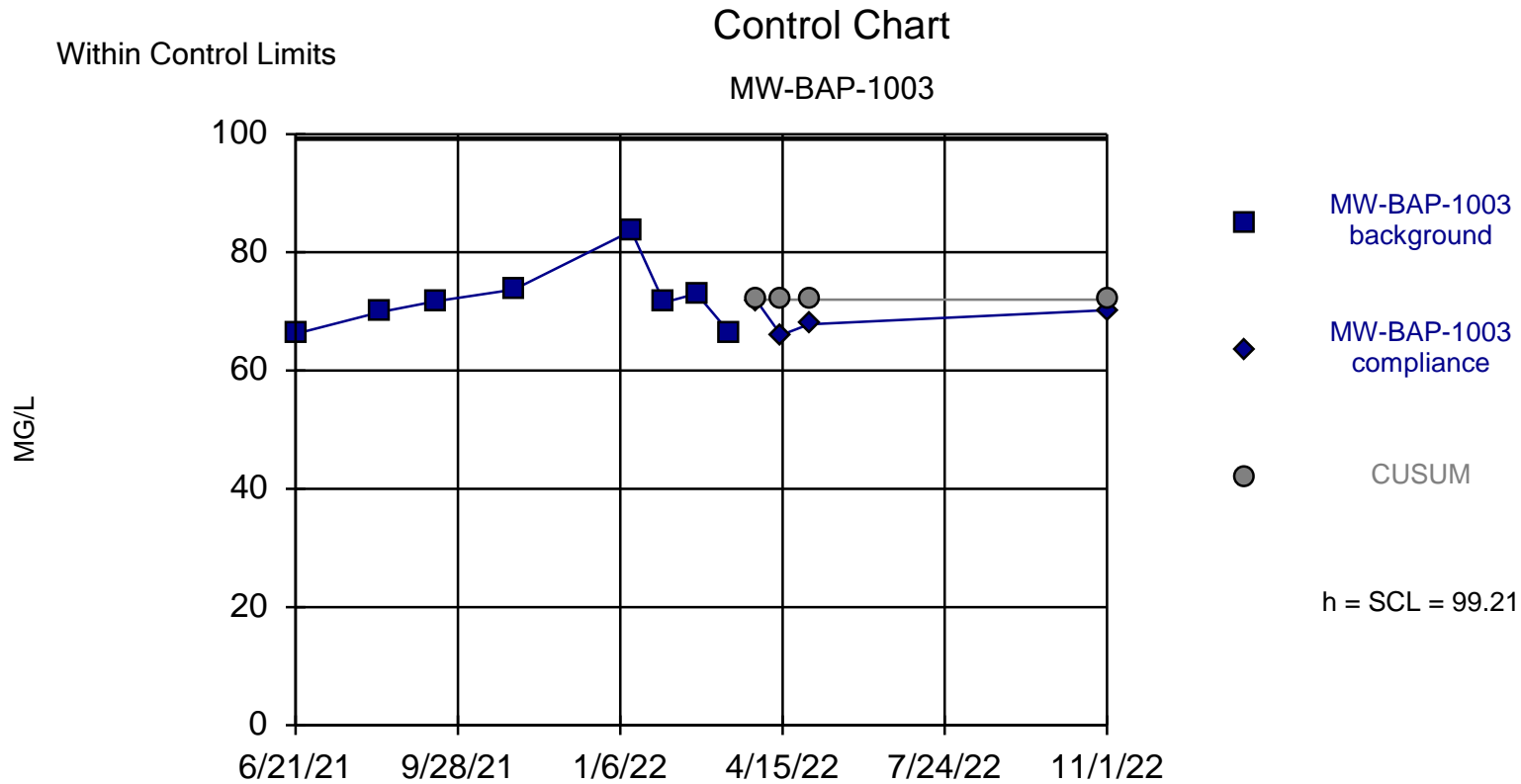
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Constituent: Calcium Analysis Run 04/14/2023 3:56 PM
 Cardinal Facility Client: Cox-Colvin Data: stats_data_rbp



Background Data Summary: Mean=71.54, Std. Dev.=5.021, n=8. Insufficient data to test for seasonality: data were not deseasonalized. Normality test: Shapiro Wilk @alpha = 0.05, calculated = 0.9248, critical = 0.818. Report alpha = 0.003882. Dates ending 03/14/2022 used for control stats. Standardized h=5, SCL=5.

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Cardinal Facility Client: Cox-Colvin Data: stats_data_rbp



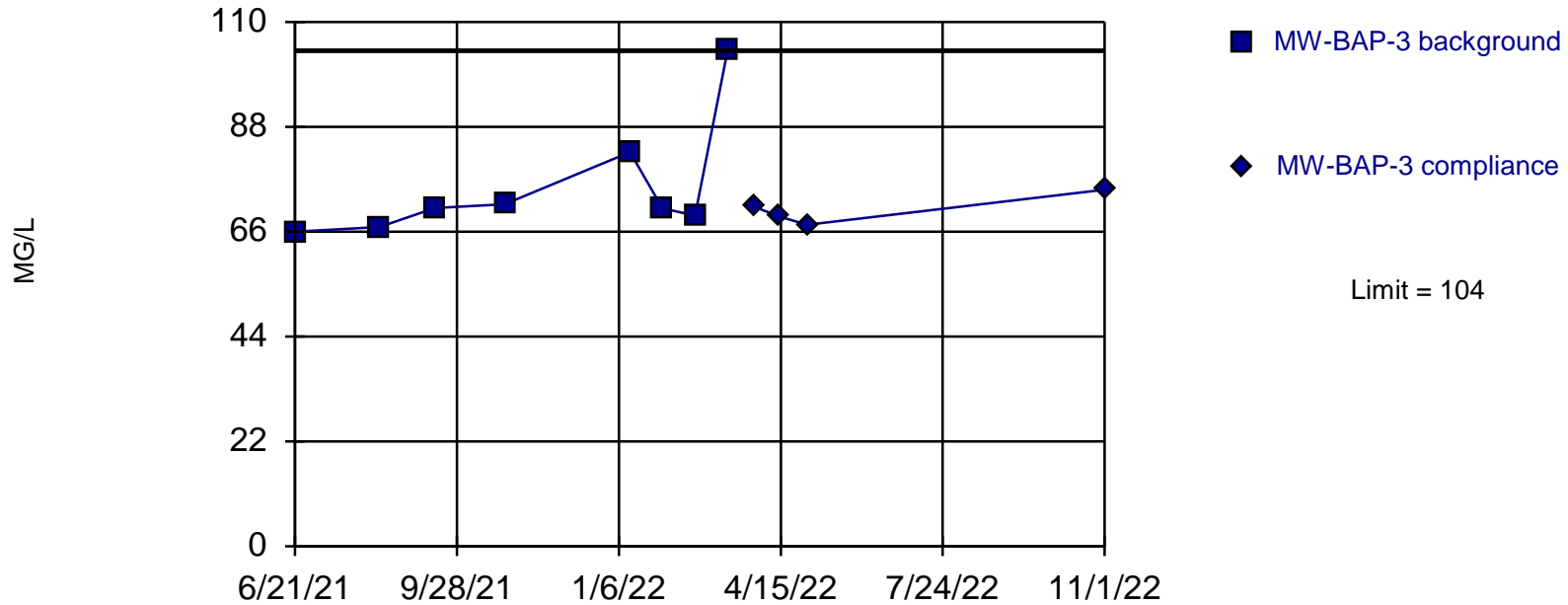
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Constituent: Chloride Analysis Run 04/14/2023 3:56 PM
 Cardinal Facility Client: Cox-Colvin Data: stats_data_rbap

Within Limit

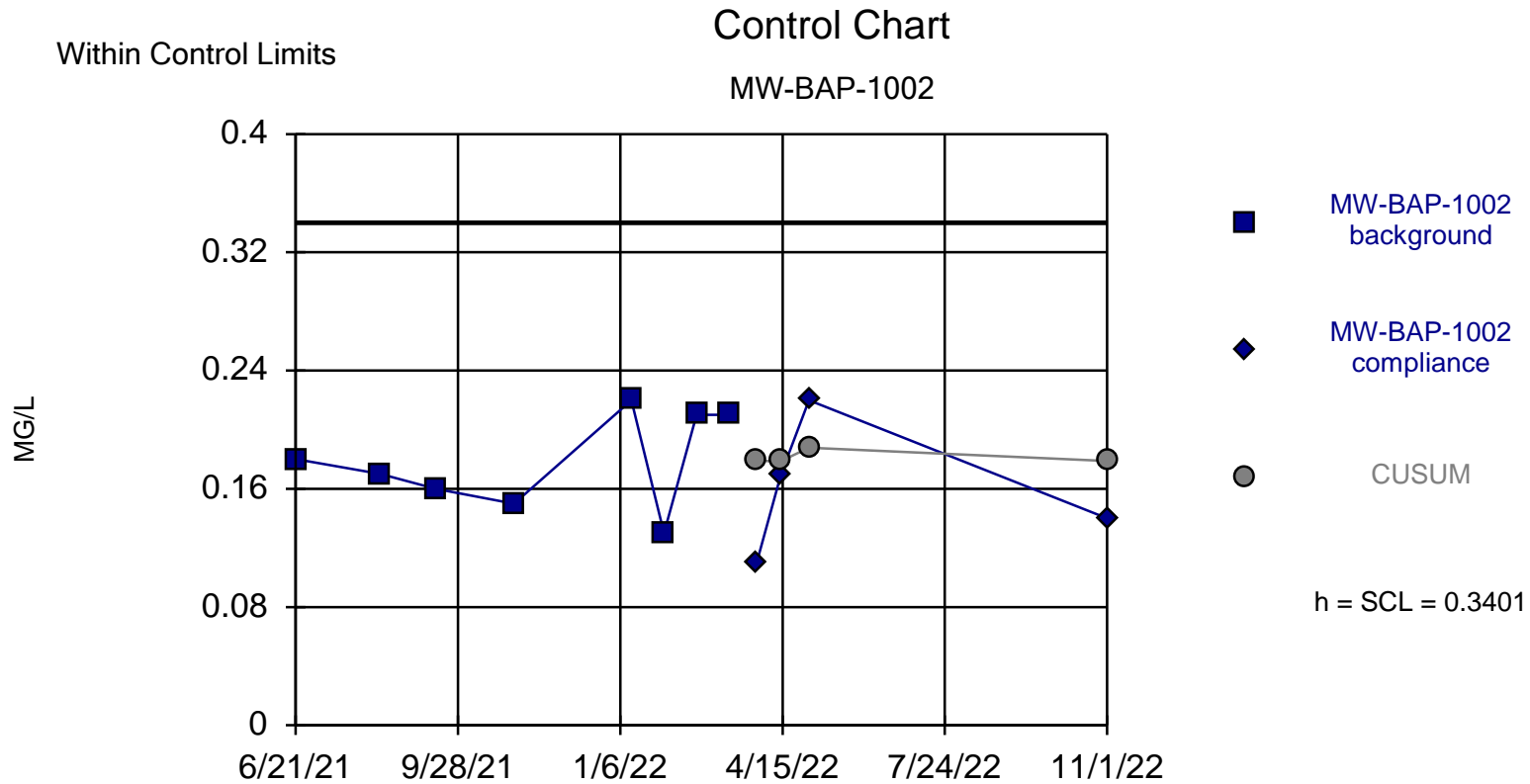
Prediction Limit

Intrawell Non-parametric



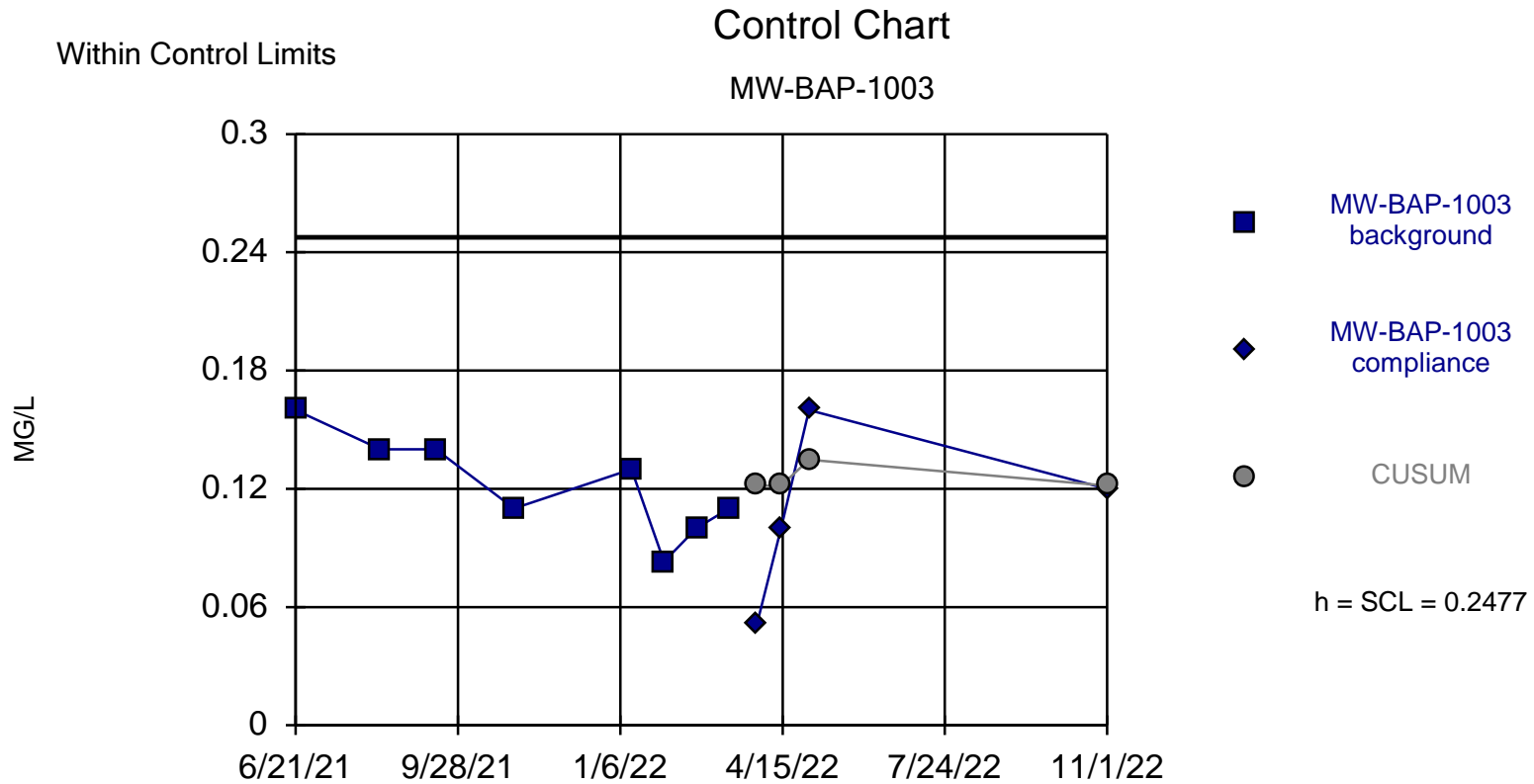
Non-parametric test used in lieu of control chart because the Shapiro Wilk normality test showed the data to be non-normal at the 0.05 alpha level. Limit is highest of 8 background values. Well-constituent pair annual alpha = 0.04242. Individual comparison alpha = 0.02144 (1 of 2). Most recent point compared to limit. Insufficient data to test for seasonality: data were not deseasonalized.

Constituent: Chloride Analysis Run 04/14/2023 3:56 PM
Cardinal Facility Client: Cox-Colvin Data: stats_data_rbp



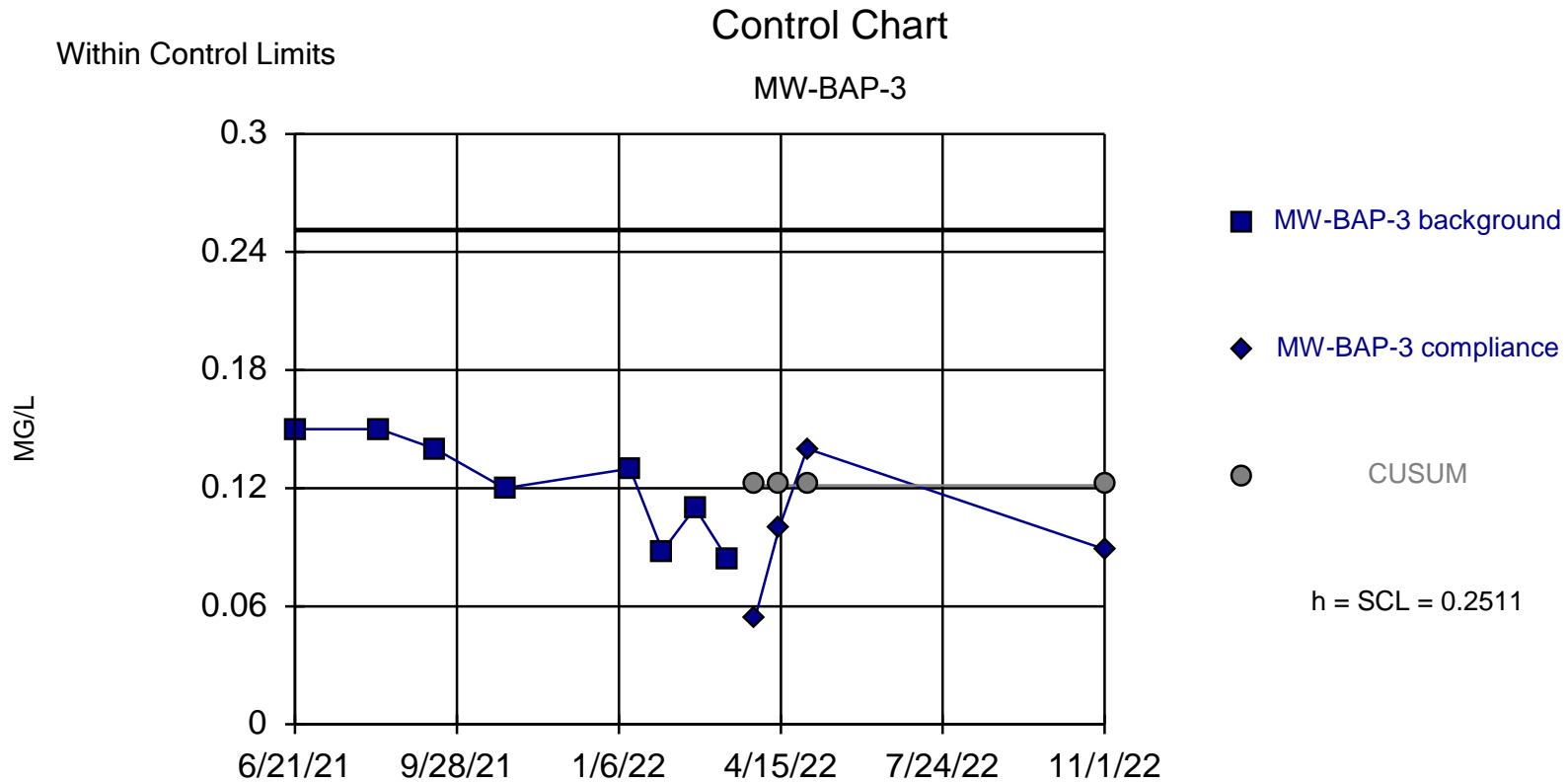
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Constituent: Fluoride Analysis Run 04/14/2023 3:56 PM
Cardinal Facility Client: Cox-Colvin Data: stats_data_rbp



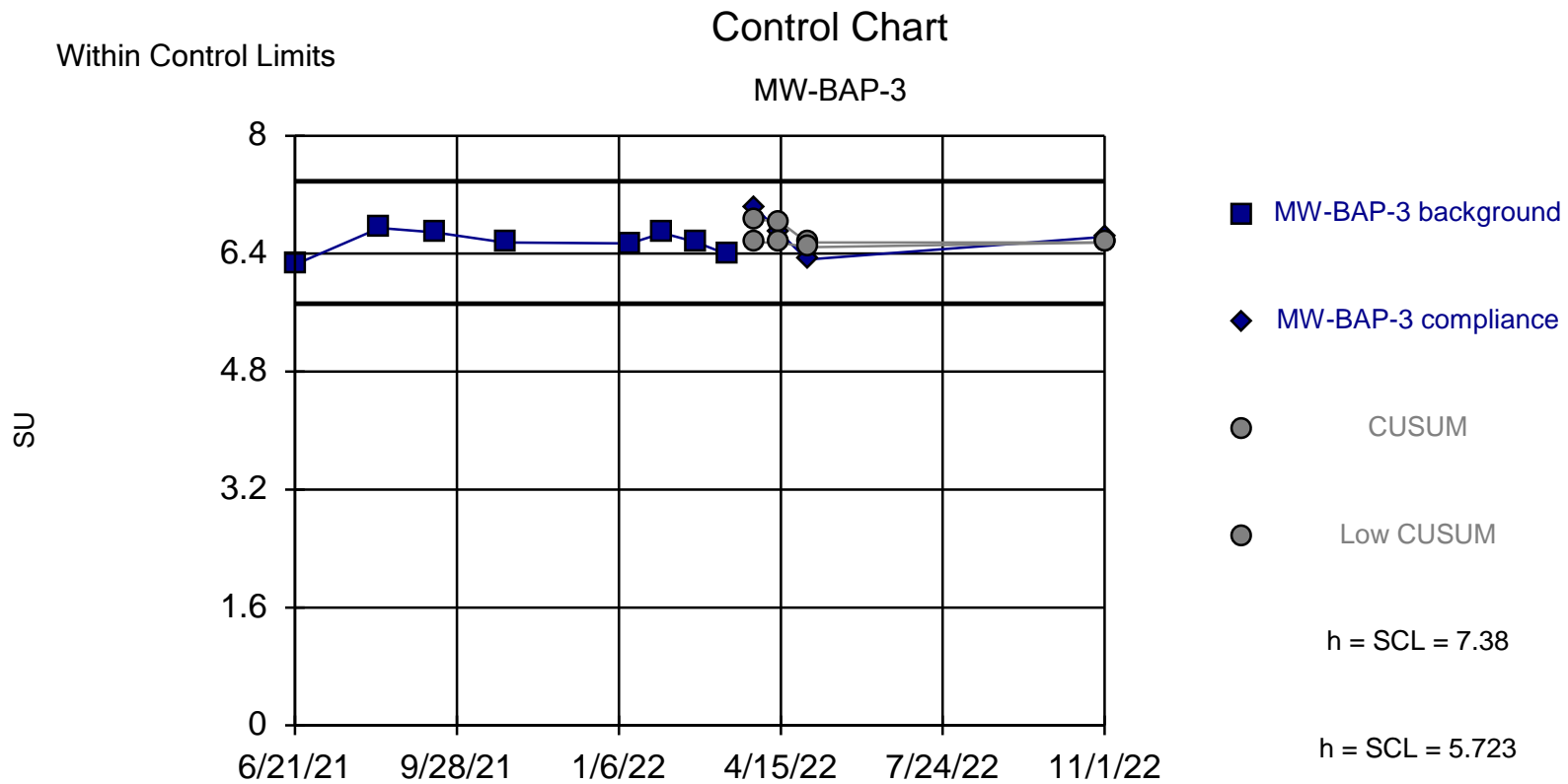
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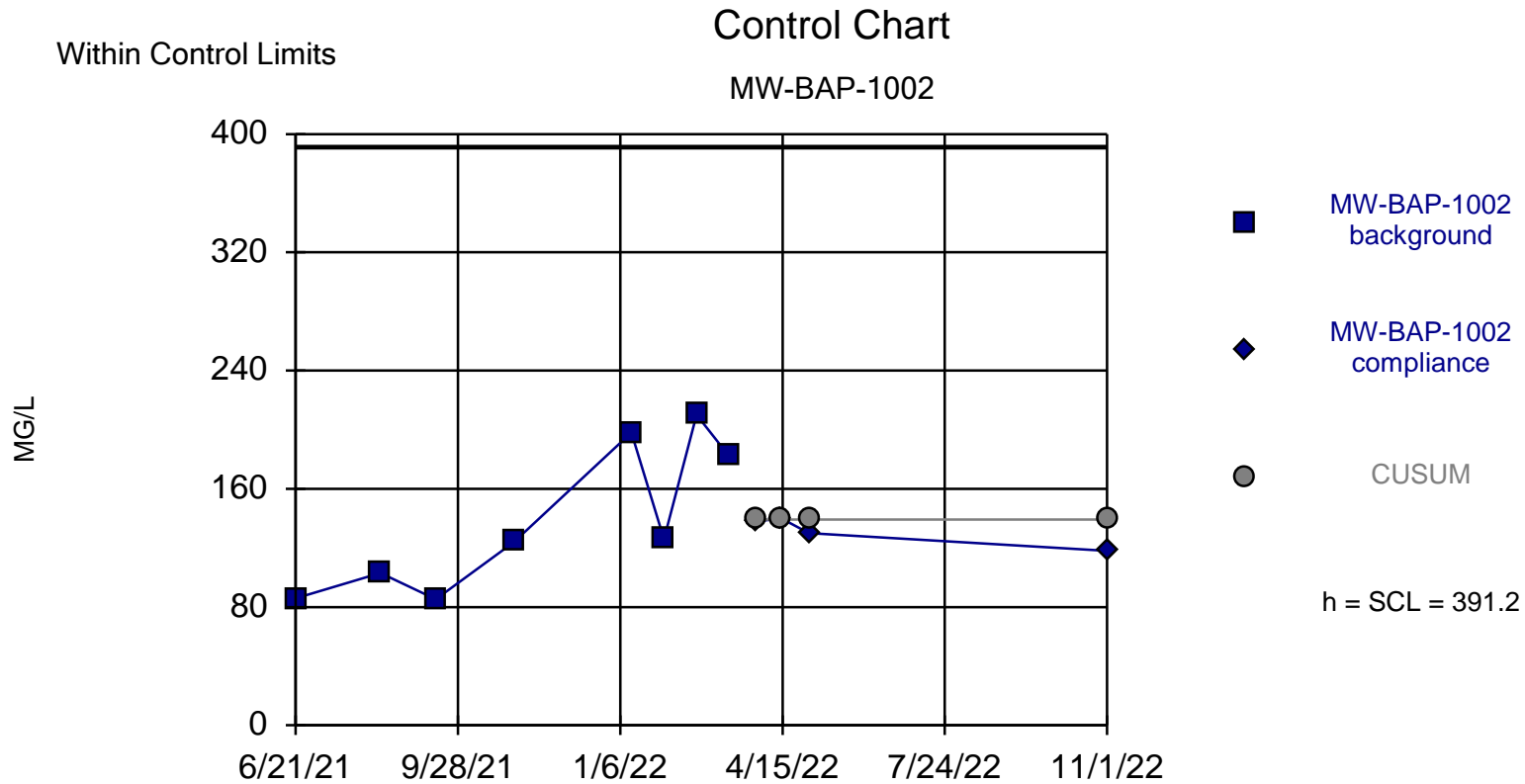
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Cardinal Facility Client: Cox-Colvin Data: stats_data_rbp



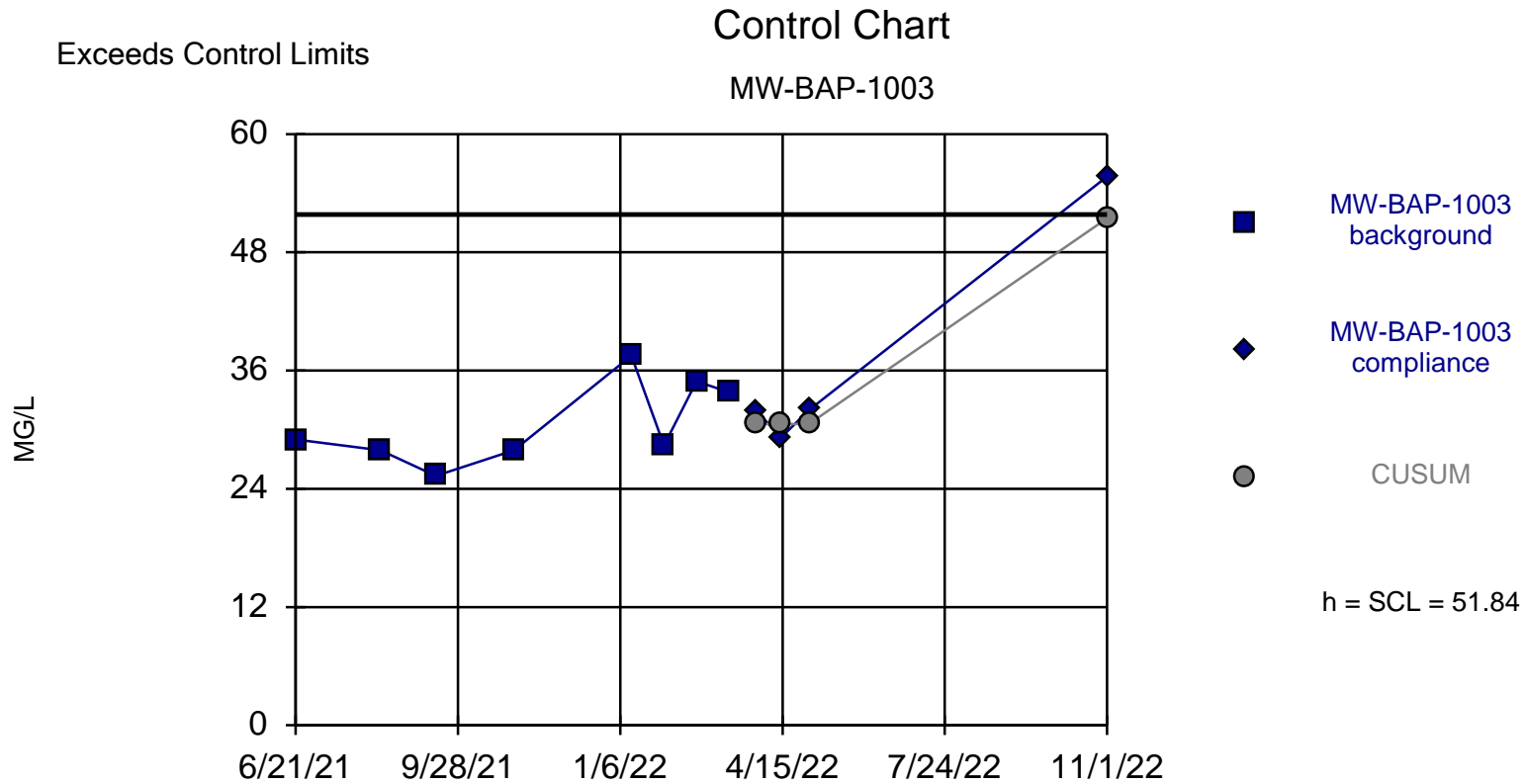
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Constituent: pH Analysis Run 04/14/2023 3:56 PM
 Cardinal Facility Client: Cox-Colvin Data: stats_data_rbp



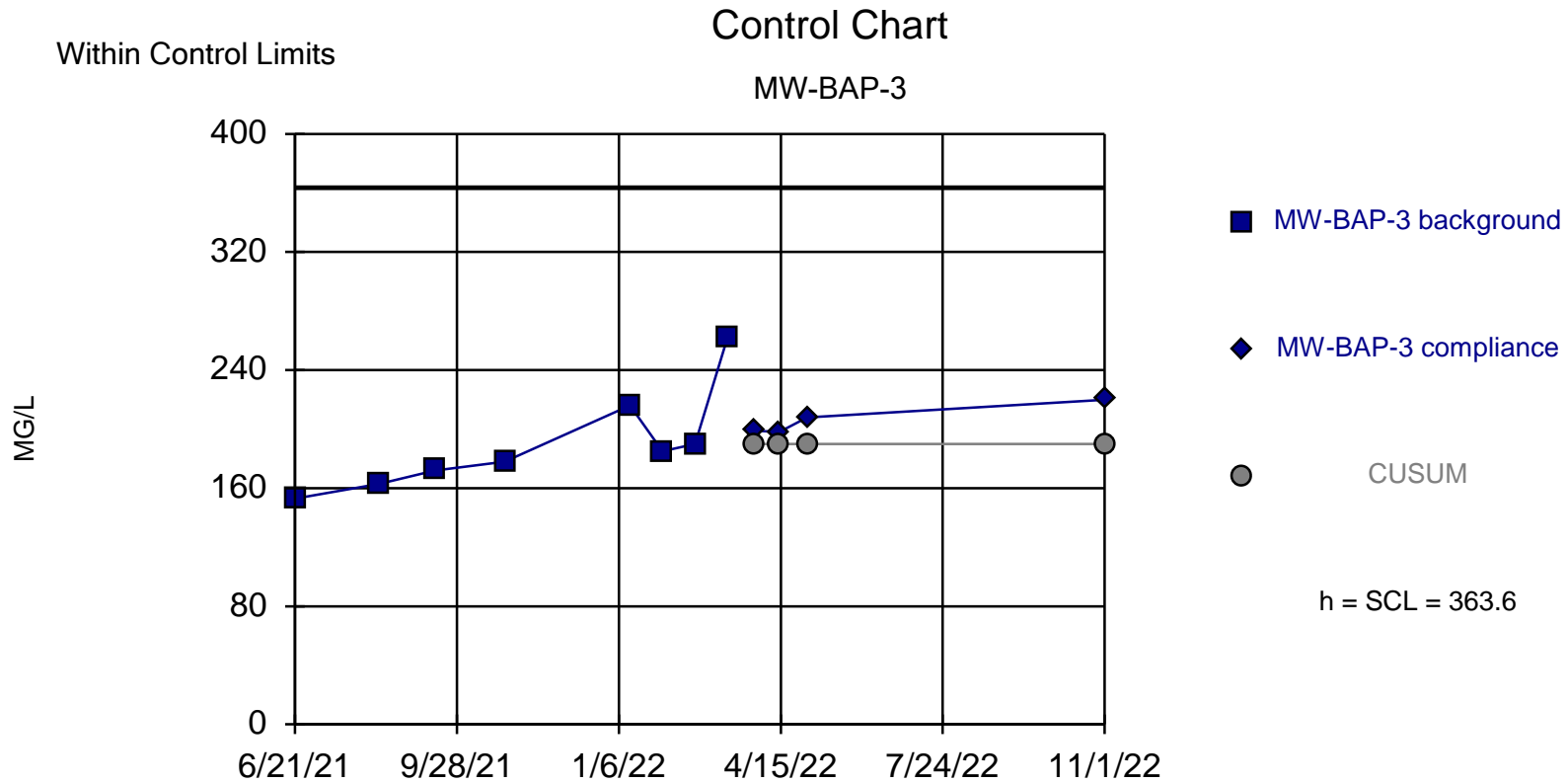
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Constituent: Sulfate Analysis Run 04/14/2023 3:56 PM
Cardinal Facility Client: Cox-Colvin Data: stats_data_rbap



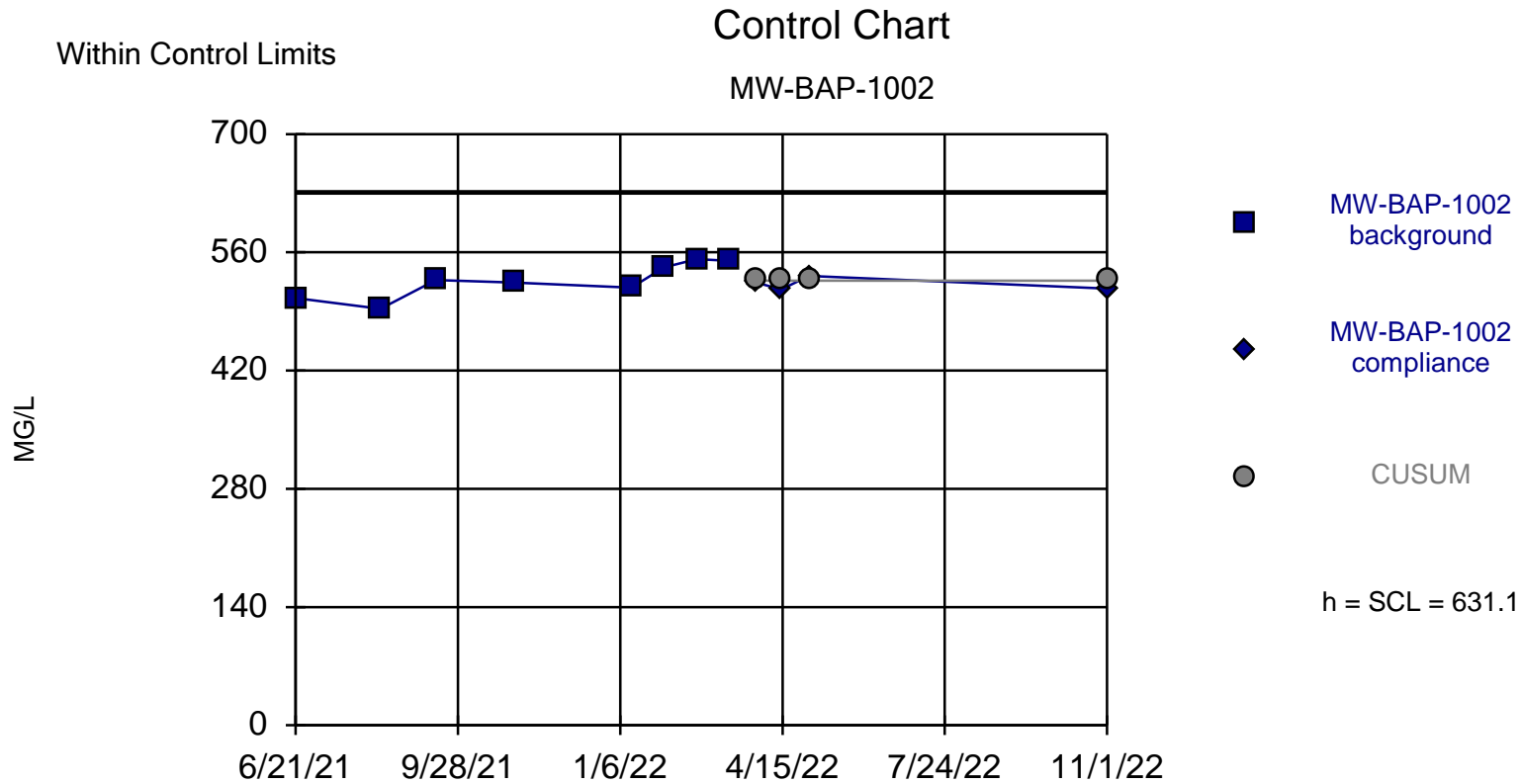
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Constituent: Sulfate Analysis Run 04/14/2023 3:56 PM
 Cardinal Facility Client: Cox-Colvin Data: stats_data_rbp



Background Data Summary: Mean=189.9, Std. Dev.=34.75, n=8. Insufficient data to test for seasonality: data were not deseasonalized. Normality test: Shapiro Wilk @alpha = 0.05, calculated = 0.8806, critical = 0.818. Report alpha = 0.003882. Dates ending 03/14/2022 used for control stats. Standardized h=5, SCL=5.

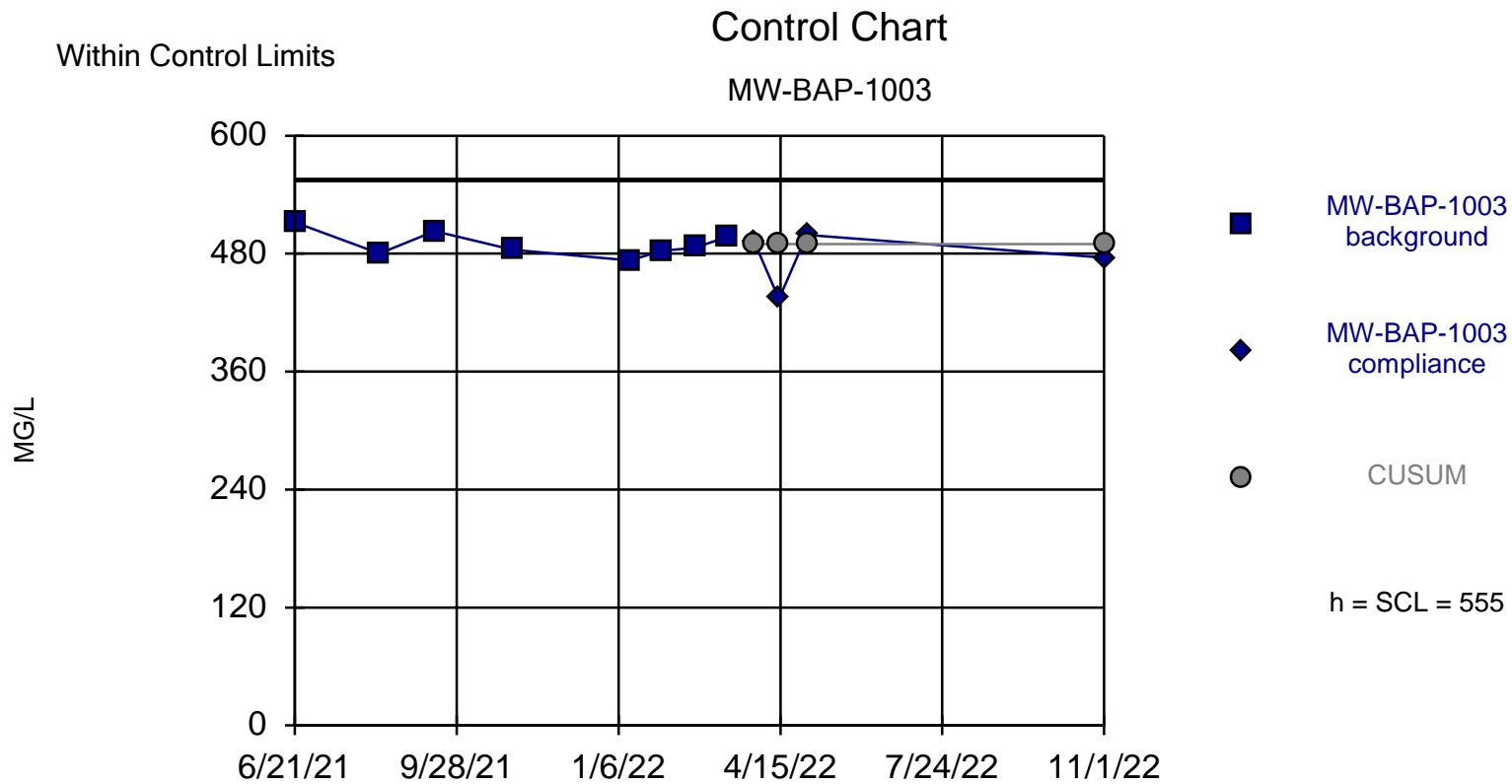
Constituent: Sulfate Analysis Run 04/14/2023 3:56 PM
Cardinal Facility Client: Cox-Colvin Data: stats_data_rbp



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Constituent: Total Dissolved Solids Analysis Run 04/14/2023 3:56 PM

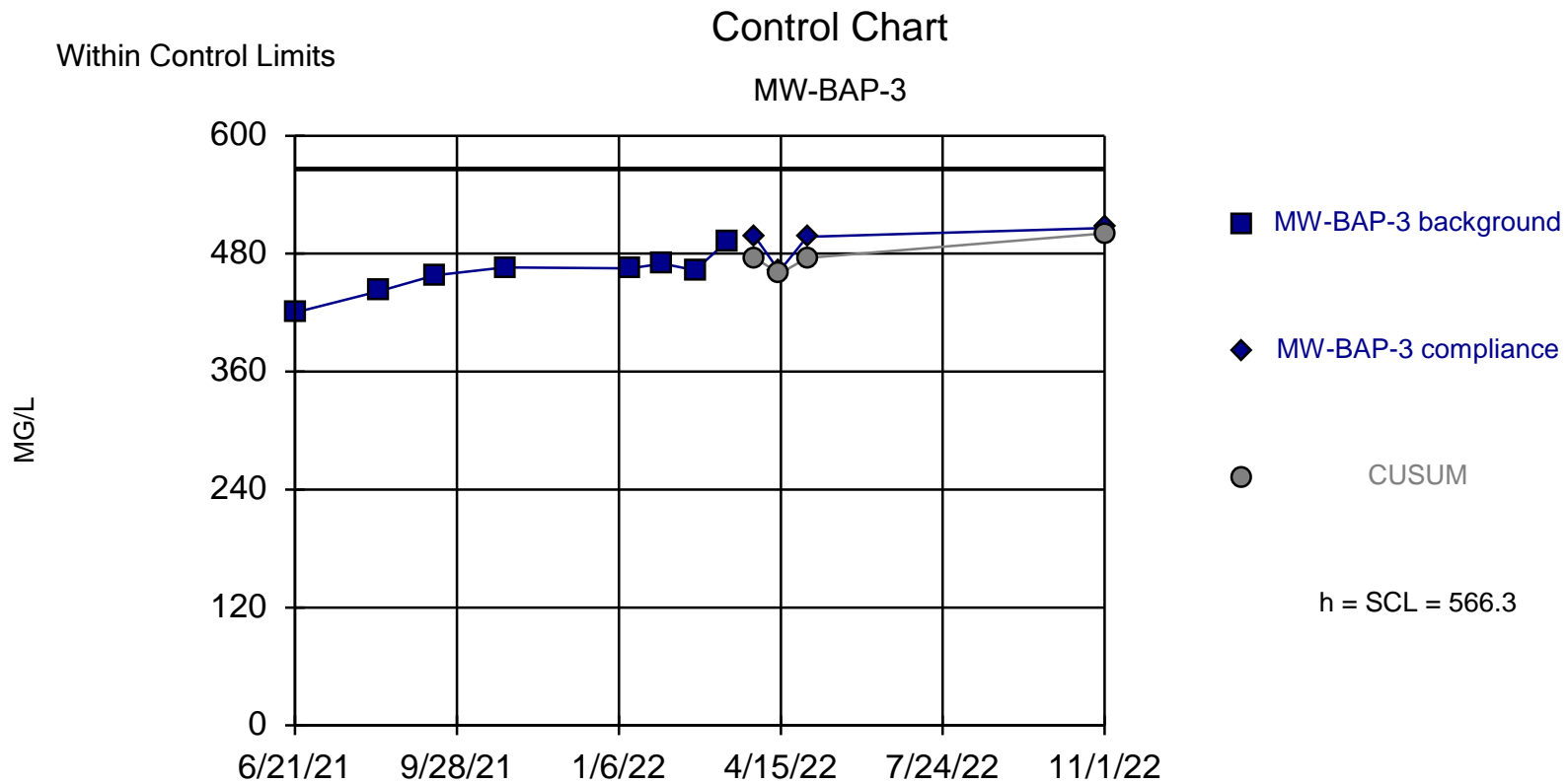
Cardinal Facility Client: Cox-Colvin Data: stats_data_rbp



Background Data Summary: Mean=489.8, Std. Dev.=13.05, n=8. Insufficient data to test for seasonality: data were not deseasonalized. Normality test: Shapiro Wilk @alpha = 0.05, calculated = 0.9381, critical = 0.818. Report alpha = 0.003882. Dates ending 03/14/2022 used for control stats. Standardized h=5, SCL=5.

Constituent: Total Dissolved Solids Analysis Run 04/14/2023 3:56 PM

Cardinal Facility Client: Cox-Colvin Data: stats_data_rbp



Background Data Summary: Mean=459.6, Std. Dev.=21.33, n=8. Insufficient data to test for seasonality: data were not deseasonalized. Normality test: Shapiro Wilk @alpha = 0.05, calculated = 0.9339, critical = 0.818. Report alpha = 0.003882. Dates ending 03/14/2022 used for control stats. Standardized h=5, SCL=5.

Constituent: Total Dissolved Solids Analysis Run 04/14/2023 3:56 PM

Cardinal Facility Client: Cox-Colvin Data: stats_data_rbp

Appendix B

Alternative Source Demonstration (ASD) for the
Retrofit Bottom Ash Pond (RBAP) – October 2023

**Alternative Source Demonstration (ASD) for the
Retrofit Bottom Ash Pond (RBAP)
Federal CCR Rule
Cardinal Operating Company – Cardinal Power Plant
306 County Road 7E
Brilliant, Ohio**

October 24, 2023

Submitted to:

Cardinal Operating Company
306 County Road 7E
Brilliant, Ohio 43913

Submitted by:

Cox-Colvin & Associates, Inc.
7750 Corporate Blvd.
Plain City, Ohio 43064
(614) 526-2040



**Alternative Source Demonstration (ASD) for the
Retrofit Bottom Ash Pond (RBAP)
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Cardinal Operating Company – Cardinal Power Plant
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Brilliant, Ohio**

October 24, 2023

Submitted to:

Cardinal Operating Company
306 County Road 7E
Brilliant, Ohio 43913

Submitted by:



Nate Wanner, CPG
Senior Scientist



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Figure

1	Regional Mining Activity
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Appendix

A	Control Charts
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1.0 Introduction

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 was conducted in April 2023 at the Retrofit BAP (RBAP), a CCR unit at the Cardinal Power Plant located in Brilliant, Ohio. As the RBAP CCR unit was only recently created, to replace the former Bottom Ash Pond (BAP) Complex, the April 2023 groundwater sampling event is the second monitoring event to be conducted following the initial determination of background concentrations.

Statistical analyses were performed following semi-annual groundwater sampling to evaluate whether the concentrations of any constituent represent a statistically significant increase (SSI) – i.e., exceeding recently established background upper prediction limits (UPLs) defined in accordance with §257.93(f)(3) of the CCR Rule. The analyses were conducted in accordance with the Statistical Analysis Plan (StAP) (Geosyntec 2020). SSIs above background levels were identified.

The purpose of this technical memorandum is to document the completion of an alternative source demonstration (ASD) in accordance with §257.94(e)(2) of the CCR Rule. This ASD demonstrates that sources other than the RBAP are responsible for the SSIs. These sources include, but may not be limited to, the former BAP Complex and acidic drainage from former coal mines. Because the SSIs are attributable to sources other than the RBAP, it will remain in detection monitoring and not enter assessment monitoring.

1.1 Statistically Significant Increases (SSIs)

SSIs above background levels were identified for the constituents and well pairings below. These SSIs were identified on September 27, 2023 (Cox-Colvin 2023).

- Boron: MW-BAP-3, MW-BAP-1002, MW-BAP-1003
- Calcium: MW-BAP-1002, MW-BAP-1003
- Chloride: MW-BAP-3, MW-BAP-1002, MW-BAP-1003
- Sulfate: MW-BAP-3, MW-BAP-1002
- Total Dissolved Solids (TDS): MW-BAP-3, MW-BAP-1001, MW-BAP-1003

1.2 CCR Rule Requirements

CCR Rule §257.94(e)(2) states that:

The owner or operator may demonstrate that a source other than the CCR unit caused the statistically significant increase over background levels for a constituent or that the statistically significant increase resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality. The owner or operator must complete the written demonstration within 90 days of detecting a statistically significant increase over background levels to include obtaining a certification from a qualified professional engineer or approval from the Participating State Director or approval from EPA where EPA is the permitting authority verifying the accuracy of the information in the report. If a successful demonstration is completed within the 90-day period, the owner or operator of the CCR unit may continue with a detection monitoring program under this section. If a successful demonstration is not completed within the 90-day period, the owner or operator of the CCR unit must initiate an assessment monitoring program as required under § 257.95. The owner or operator must also include the demonstration in the annual groundwater monitoring and corrective action report required by § 257.90(e), in addition to the certification by a qualified professional engineer or approval from the Participating State Director or approval from EPA where EPA is the permitting authority.

1.3 RBAP Construction and Operational History

The Bottom Ash Complex at the Cardinal Power Plant consists of a South Pond and a North Pond, located at the southern end of the plant and directly west of the Ohio River. The Cardinal Operating Company elected to retrofit the former BAP complex by segregating it into two separate ponds designed to manage CCR wastes and Low Volume Waste, respectively. The South Pond ceased receiving waste streams and initiated retrofit in August 2021 by excavating the deposited ash and relining with a CCR compliant liner (Buckeye Power, Inc. 2021).

On March 7, 2022, the Cardinal Operating Company completed the retrofit activities for the South Pond of the Bottom Ash Complex (Sargent & Lundy 2022). The retrofit activities were completed in accordance with the written retrofit plan (Sargent & Lundy 2020) and the requirements of 40 CFR 257.102(k). Upon completion of the retrofit, the South Pond's name was changed from the former Recirculation Pond to the Retrofit Bottom Ash Pond.

The adjacent North Pond ceased receiving waste streams and initiated retrofit in accordance with the North Pond Closure Plan on March 24, 2023, and work is still ongoing.

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Figure

- 1 Regional Mining Activity

Appendix

- A Control Charts

1.0 Introduction

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- Calcium: MW-BAP-1002, MW-BAP-1003
- Chloride: MW-BAP-3, MW-BAP-1002, MW-BAP-1003
- Sulfate: MW-BAP-3, MW-BAP-1002
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The adjacent North Pond ceased receiving waste streams and initiated retrofit in accordance with the North Pond Closure Plan on March 24, 2023, and work is still ongoing.

2.0 Background Determinations

Background concentrations were initially established in October 2022 using background data collected from June 2021 to May 2022 at MW-BAP-1001. Interwell UPLs were calculated for Appendix III constituents based upon a one-of-two sampling plan with seven constituents analyzed twice per year at three downgradient (compliance) wells. Additionally, a lower prediction limit (LPL) was calculated for pH (Cox-Colvin 2022).

While the established prediction limits accurately represent *background* conditions at background monitoring well MW-BAP-1001, they are not representative of *baseline* conditions (conditions when RBAP began operation) at compliance monitoring wells MW-BAP-3, MW-BAP-1002, and MW-BAP-1003. This is a result of natural variation in groundwater quality and the presence of sources other than the RBAP CCR Unit, as discussed below.

The disparity between background and baseline conditions was recognized prior to statistical evaluation of the April 2023 sampling event data, but CCR Rules do not provide for consideration of baseline conditions during background determination. Baseline conditions are instead considered in this ASD.

2.1 Natural Variation in Groundwater Quality

CCR Rule §257.91(a)(1) requires that a groundwater monitoring system “accurately represent the quality of background groundwater that has not been affected by leakage from a CCR unit.” It is preferred to use data from background monitoring wells placed immediately upgradient of the CCR unit and in geologic materials identical to those at downgradient compliance wells. However, site conditions and operational history limit the ability to do so at the RBAP.

The uppermost aquifer at the RBAP consists of unconsolidated materials overlying a sandstone bedrock. The sandstone bedrock was encountered at 51 feet below ground surface (bgs) at MW-BAP-1001 on the west side of the RBAP. This bedrock surface slopes downward towards the Ohio River to the east and is estimated to be at least 30 feet deeper on the east side of the RBAP than it is at MW-BAP-1001.

MW-BAP-1001 is screened primarily in alluvial lean clay, silty sand, and silty sand clay overlying the sandstone bedrock. Some organic matter was also present. In contrast, MW-BAP-3, MW-BAP-1002, and MW-BAP-1003 are fully screened in glacial outwash and alluvial deposits consisting of sand and gravel materials. The difference in grain sizes and organic content are likely to result in different natural groundwater chemistry (e.g., spatial variation).

Sand and gravel materials that are more consistent with the downgradient wells are likely to be encountered at locations east of MW-BAP-1001. However, MW-BAP-1001 is already at the western bank of the RBAP, and a background well farther to the east would not be fully upgradient of the RBAP. Such well placement would also require the RBAP liner to be punctured.

CCR Rule §257.91(a)(1) allows that “a determination of background quality may include sampling of wells that are not hydraulically upgradient of the CCR management area where [...] sampling at other wells will provide an indication of background groundwater quality that is as representative or more representative than that provided by the upgradient wells.”

Based off neighboring monitor wells and borings, sand and gravel materials similar to those encountered at RBAP compliance wells are expected to be present north of the RBAP. Hydrogeology and measured flow direction in the area indicate the area would not be affected by the RBAP. However, the materials lie beneath the North Pond that was historically part of the former BAP Complex that processed CCR prior to the retrofit. SSIs of CCR Appendix III constituents were previously identified for the former BAP Complex, which entered into assessment monitoring in August 2018.

Placement of background monitoring wells immediately to the north of the RBAP is not possible because CCR Rule §257.91(a)(1) requires that background groundwater not be “affected by leakage from a CCR unit.” The CCR Rule does not provide consideration as to whether the currently monitored CCR unit (e.g., RBAP), or a separate CCR unit (e.g., former BAP Complex), affected groundwater. As a result, upgradient locations adjacent to the RBAP where geologic materials are likely similar to those at RBAP compliance wells cannot be used to determine background concentrations.

The groundwater quality at background well MW-BAP-1001 is expected to have natural variations relative to groundwater quality at compliance wells. However, it is at present the best location to establish background quality in accordance with the CCR Rule due to the unique layout of the RBAP relative to underlying geology and historical operations in the area.

2.2 Statistical Evaluations

When significant spatial variation is present between monitoring wells, EPA statistical guidance states that it is preferable to use intrawell statistical tests that compare historical and recent data at a single well, as opposed to interwell statistical tests that compare concentrations between wells (EPA 2009, Section 6.3.2). However, CCR Rule §257.93(d) requires that background groundwater quality be established “in a hydraulically upgradient or background well(s)”. Because of this requirement, use of intrawell statistical tests is not used to identify SSIs above background concentrations during RBAP detection monitoring. Instead, detection monitoring data is compared to interwell UPLs in compliance with the StAP and CCR Rule §257.93(f)(3).

3.0 Other Potential Sources

As discussed in Section 1.3, the RBAP is constructed atop the southern portion of the former BAP Complex. In accordance with §257.95 of the CCR Rules, assessment monitoring at the former BAP Complex was initiated in August 2018 after an SSI over groundwater background levels was first detected (nearly five years prior to RBAP operation). Although SSIs above background were identified for the former BAP Complex, no statistically significant levels (SSLs) above groundwater protection standards (GWPSs) have been identified for the former BAP Complex. As such, no corrective actions are necessary.

SSIs above background levels were identified at the former BAP Complex groundwater monitoring network for boron, chloride, fluoride, and pH during the most recent evaluation. While SSIs were not identified for sulfate and TDS in the most recent evaluation of the former BAP Complex, they were identified in previous evaluations. Although an SSI was not identified for calcium in the former BAP Complex monitoring, the calcium UPL for the former BAP Complex monitoring program is higher (233 mg/L) than it is for the RBAP monitoring program (90 mg/L). This is because the background concentrations are based upon different background wells (the former BAP Complex covers a larger area) and natural variations exist in groundwater quality (Section 2.1).

On March 24, 2023, the North Pond ceased receiving waste streams and closure was initiated. As specified in §257.102(c) of the CCR Rules, closure activities at the former BAP Complex will be complete when all CCR has been removed and groundwater monitoring concentrations do not exceed GWPS. Groundwater impacts related to the former BAP Complex will remain, although there is no reason to expect groundwater concentrations to increase above GWPS following removal of all CCR material. With time, groundwater concentrations are expected to attenuate to background levels.

Additionally, many constituents of concern in CCR monitoring are also associated with acid mine drainage (AMD) related to coal mining. The area surrounding the facility has been extensively mined historically (Figure 1). This historical coal mining was performed at elevations higher than the RBAP, and AMD is expected to affect groundwater quality in shallow aquifers throughout the region.

4.0 Source Evaluation

As detailed in previous sections, groundwater monitoring of the RBAP is complicated by the following:

1. Unconsolidated materials at the background monitoring well (silts, clays, and silty sand) differ from sand/gravel materials at the compliance wells and are, therefore, likely to have differing natural chemistry.
2. Immediately adjacent locations to the north of the RBAP are expected to have similar sand/gravel materials as those found at compliance wells; however, these locations are impacted from another CCR unit and are not presently suitable as background well locations.
3. The RBAP is located in an area formerly occupied by the southern portion of the former BAP Complex. CCR monitoring detected SSIs above background concentrations at the former BAP Complex prior to construction and operation of the RBAP.
4. The northern portion of the former BAP Complex, adjacent to the RBAP, ceased receiving CCR in March 2023 (after a November 2022 sampling event during which SSIs were initially observed at the RBAP). Furthermore, closure activities in the northern portion of the former BAP Complex are still underway and not all CCR materials have been removed. These operations and materials, that are separate from the RBAP, could affect groundwater quality.
5. During detection monitoring, the CCR Rule requires evaluation of SSIs above background levels, as opposed to baseline conditions at the time a CCR unit began operating.

Although there is no provision in the CCR Rule to establish background concentrations based on baseline conditions, §257.94(e)(2) allows that “the owner or operator may demonstrate that a source other than the CCR unit caused the statistically significant increase over background levels for a constituent or that the statistically significant increase resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality.”

No errors in sampling, analysis, or statistical evaluation have been identified. However, the former BAP Complex is known to have resulted in SSIs in groundwater beneath the present-day RBAP, even before the RBAP went into operation.

Because groundwater impact is present from sources other than the RBAP, and the newly constructed RBAP has a CCR-compliant liner, it is highly unlikely that SSIs are a result of releases from the RBAP. However, it is prudent to confirm that no release from the RBAP contributed to SSIs. Such a demonstration is best performed using intrawell statistical

tests to compare groundwater conditions at each compliance well prior to RBAP operation to groundwater conditions during RBAP operation, as described below.

4.1 Statistical Methodology

CCR Rule §257.93(f)(4) allows the use of control charts as a valid statistical method to evaluate groundwater monitoring data. EPA's "Unified Guidance" introduces control charts as follows (EPA 2009, Section 20.1):

As a well-established statistical methodology, there are many kinds of control charts. Historically, control charts have been put to great use in quality engineering and manufacturing, but have more recently been adapted for use in groundwater monitoring. The specific control chart recommended in the Unified Guidance is known as a combined Shewhart-CUSUM control chart (Lucas, 1982). It is a 'combined' chart because it simultaneously utilizes two separate control chart evaluation procedures. The Shewhart portion is almost identical to a prediction limit in that compliance measurements are individually compared against a background limit. The cumulative sum [CUSUM] portion sequentially analyzes each new measurement with prior compliance data. Both portions are used to assess the similarity of compliance data to background in detection monitoring.

The Shewhart-CUSUM control chart works as follows. Appropriate background data are first collected from the specific compliance well for intrawell comparisons or from separate background wells for interwell tests. The baseline parameters for the chart, estimates of the mean and standard deviation, are obtained from these background data. These baseline measurements characterize the expected background concentrations at compliance wells.

As future compliance observations are collected, the baseline parameters are used to standardize the newly gathered data. After these measurements are standardized and plotted, a control chart is declared out-of-control if future concentrations exceed the baseline control limit. This is indicated on the control chart when either the Shewhart or CUSUM plot traces begins to exceed a control limit. The limit is based on the rationale that if the well remains uncontaminated as it was during the baseline period, new standardized observations should not deviate substantially from the baseline mean. If a release occurs, the standardized values will deviate significantly from baseline and tend to exceed the control limit. The historical baseline parameters then no longer accurately represent current well concentration levels.

Shewhart-CUSUM control charts are an effective way to evaluate not only whether current groundwater quality differs from pre-RBAP groundwater quality, but also whether there are "drifts" in concentrations over time. If the RBAP is contributing to SSIs, then

concentrations following its implementation are expected to be higher than those prior its implementation, and to also increase over time. Conversely, removal of all CCR material associated with the former BAP Complex is expected to result in decreasing concentrations of CCR constituents over time (although other factors may be involved).

4.2 Statistical Evaluation

Sanitas™ statistical software was used to prepare control charts for well/constituent pairs exhibiting an SSI above background, as listed in Section 1.1.

The baseline data set for this evaluation consists of data from eight sampling events performed from June 2021 until implementation of the RBAP on March 7, 2022. The post-construction “compliance” data set consists of compliance well data from five sampling events performed from March 31, 2022, to April 2023. This baseline data set differs from the background data set comprised of data from MW-BAP-1001.

Results of the evaluation can be found in Appendix A. No SSIs above baseline conditions were identified.

5.0 Conclusion

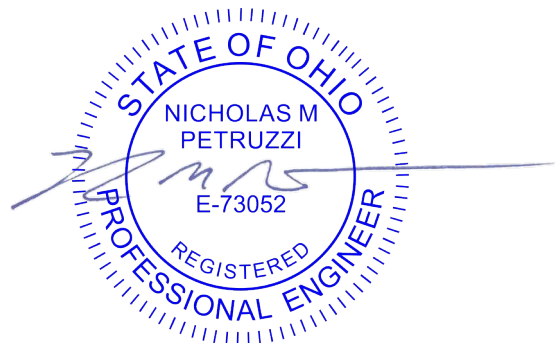
SSIs above background conditions have been detected at the RBAP. However, these SSIs are due to conditions that existed prior to implementation of the RBAP and, therefore, unrelated to RBAP operations.

Statistical evaluations of CCR constituents against baseline, as opposed to background, concentrations do not reveal evidence of a release from the RBAP.

6.0 Professional Engineer Certification

The undersigned Professional Engineer registered in the State of Ohio is familiar with the requirements of 40 CFR part 257, subpart D and has visited and examined the facility. The undersigned Registered Engineer attests that, to the best of his knowledge, the RBAP ASD has been prepared in accordance with good engineering practice, including the requirements of §257.94(e)(2).

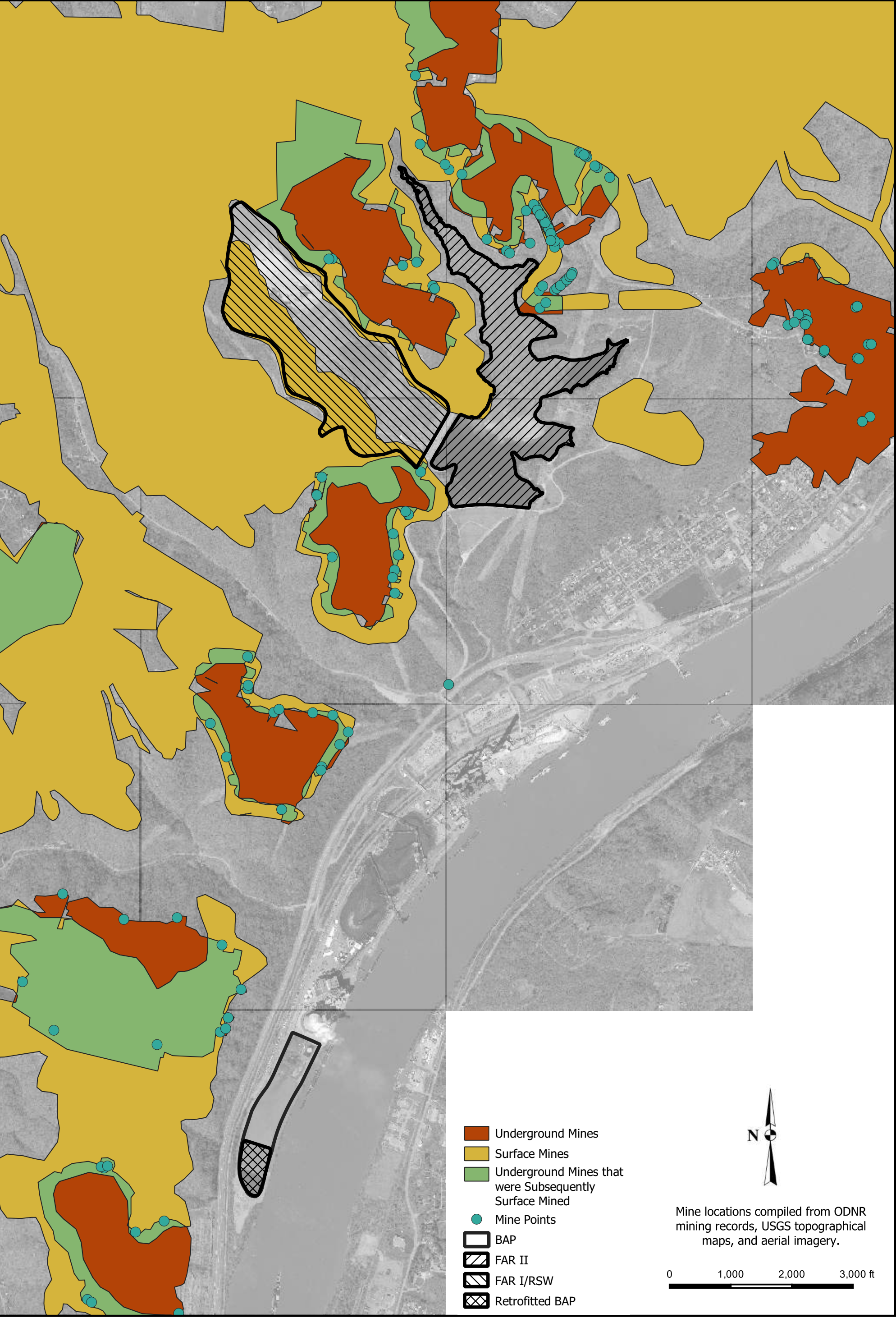
Nick M. Petruzzi, PE, CPG
Supervising Engineer
Registration No. E-73052 (Ohio)
T&M Associates



7.0 References

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https://pvt.buckeyepower.com/private/ccr/2022/BAP/Retrofit%20Completion_S.Pond.pdf.

Figure



Appendix A

Control Charts

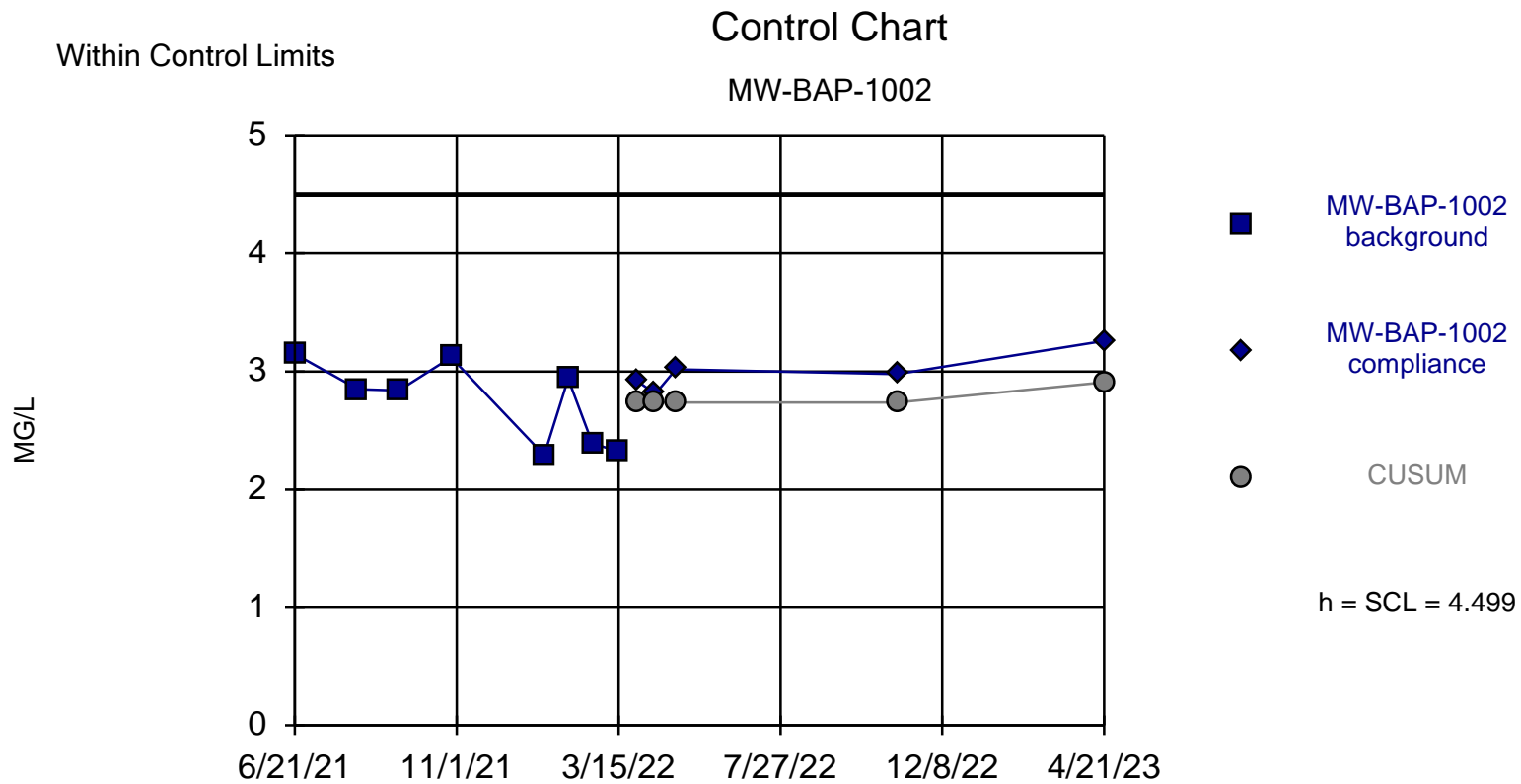
Shewhart-Cusum Control Chart / Rank Sum

Cardinal Facility

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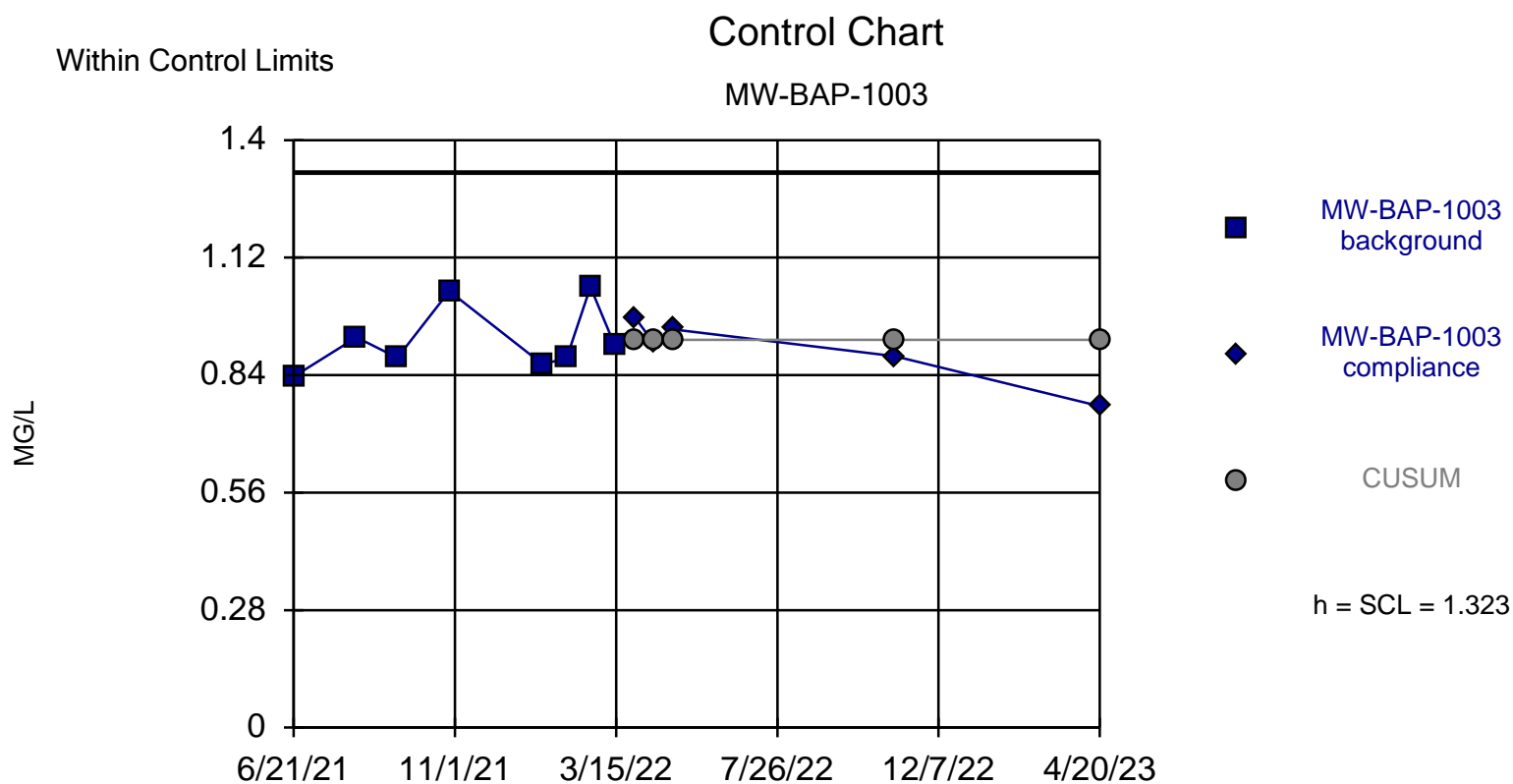
<u>Constituent</u>	<u>Well</u>	<u>Sig.</u>	<u>N</u>	<u>%NDs</u>	<u>Transform</u>	<u>Method</u>
Boron (MG/L)	MW-BAP-1002	No	8	0	No	Param Intra
Boron (MG/L)	MW-BAP-1003	No	8	0	No	Param Intra
Boron (MG/L)	MW-BAP-3	No	8	0	No	Param Intra
Calcium (MG/L)	MW-BAP-1002	No	8	0	No	Param Intra
Calcium (MG/L)	MW-BAP-1003	No	8	0	No	Param Intra
Chloride (MG/L)	MW-BAP-1002	No	8	0	No	Param Intra
Chloride (MG/L)	MW-BAP-1003	No	8	0	No	Param Intra
Chloride (MG/L)	MW-BAP-3	No	8	0	No	NP Intra PL (normality)
Sulfate (MG/L)	MW-BAP-1002	No	8	0	No	Param Intra
Sulfate (MG/L)	MW-BAP-3	No	8	0	No	Param Intra
Total Dissolved Solids (MG/L)	MW-BAP-10...	No	8	0	No	Param Intra
Total Dissolved Solids (MG/L)	MW-BAP-1003	No	8	0	No	Param Intra
Total Dissolved Solids (MG/L)	MW-BAP-3	No	8	0	No	Param Intra



Background Data Summary: Mean=2.739, Std. Dev.=0.3521, n=8. Insufficient data to test for seasonality: data were not deseasonalized. Normality test: Shapiro Wilk @alpha = 0.05, calculated = 0.866, critical = 0.818. Report alpha = 0.004942. Dates ending 03/14/2022 used for control stats. Standardized h=5, SCL=5.

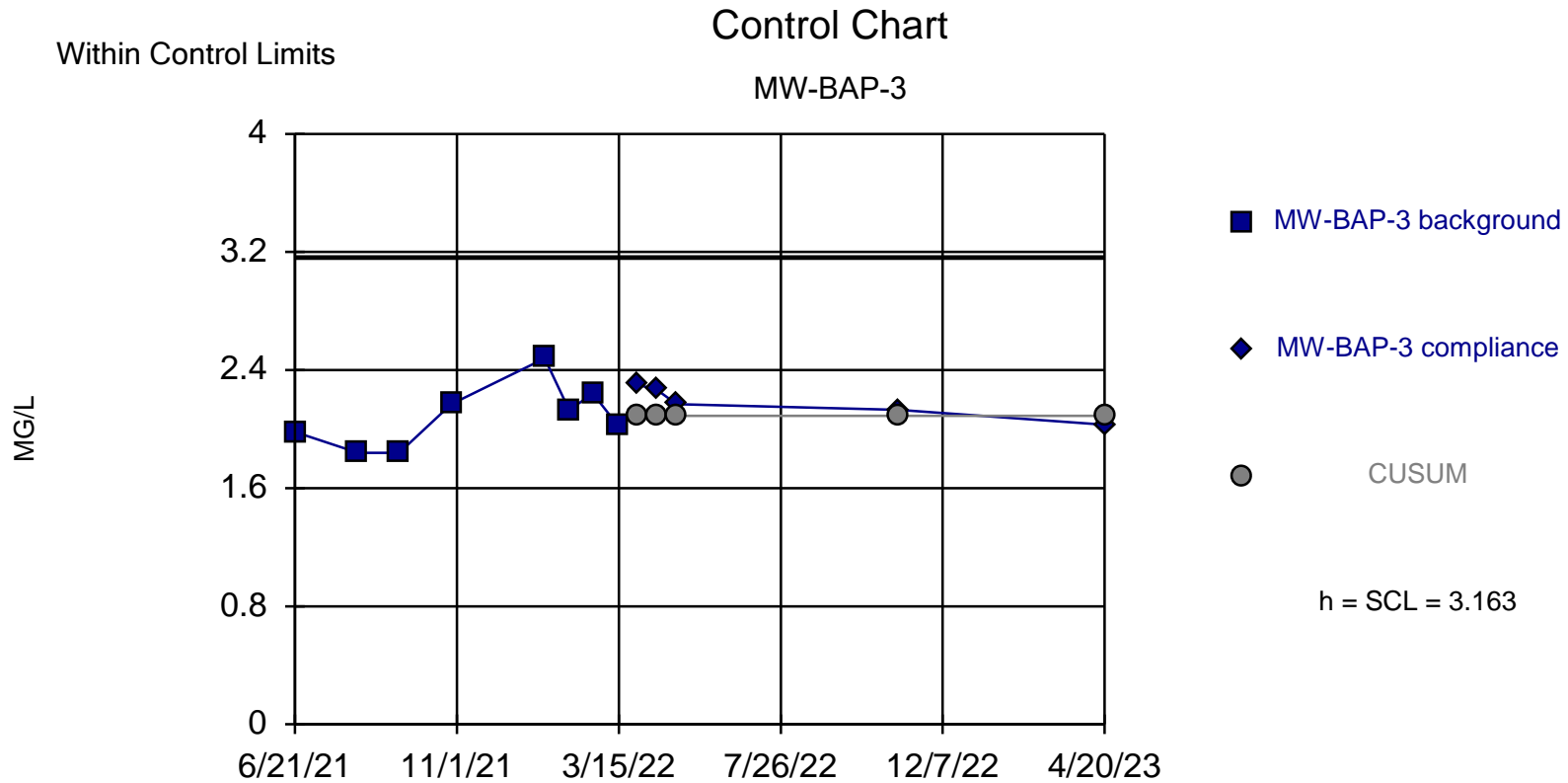
Constituent: Boron Analysis Run 09/29/2023 1:21 PM

Cardinal Facility Data: stats_data_rbap_20230726



Background Data Summary: Mean=0.9243, Std. Dev.=0.07967, n=8. Insufficient data to test for seasonality: data were not deseasonalized. Normality test: Shapiro Wilk @alpha = 0.05, calculated = 0.8555, critical = 0.818. Report alpha = 0.004942. Dates ending 03/14/2022 used for control stats. Standardized h=5, SCL=5.

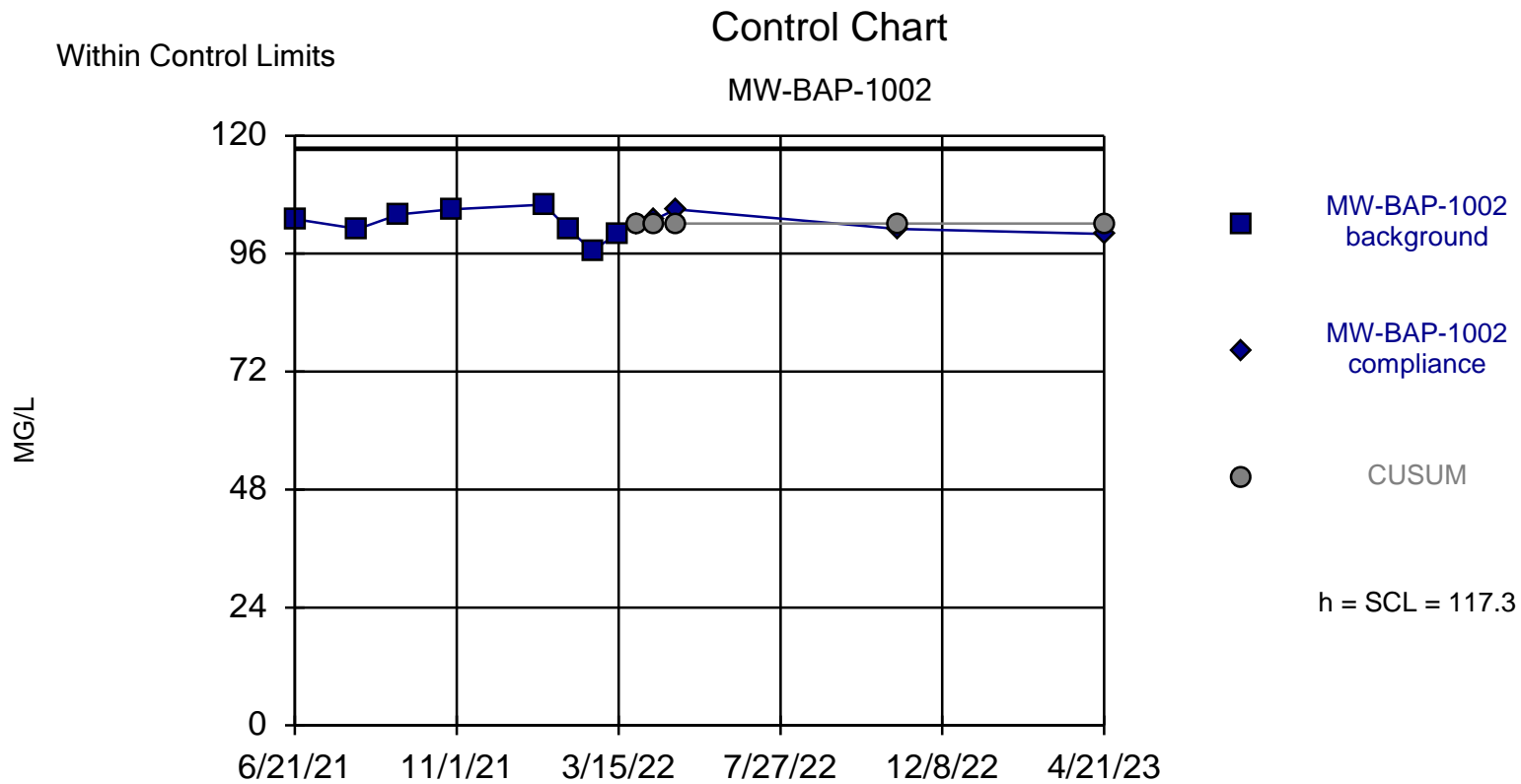
Constituent: Boron Analysis Run 09/29/2023 1:21 PM
Cardinal Facility Data: stats_data_rbp_20230726



Background Data Summary: Mean=2.089, Std. Dev.=0.2149, n=8. Insufficient data to test for seasonality: data were not deseasonalized. Normality test: Shapiro Wilk @alpha = 0.05, calculated = 0.9446, critical = 0.818. Report alpha = 0.004942. Dates ending 03/14/2022 used for control stats. Standardized h=5, SCL=5.

Constituent: Boron Analysis Run 09/29/2023 1:21 PM

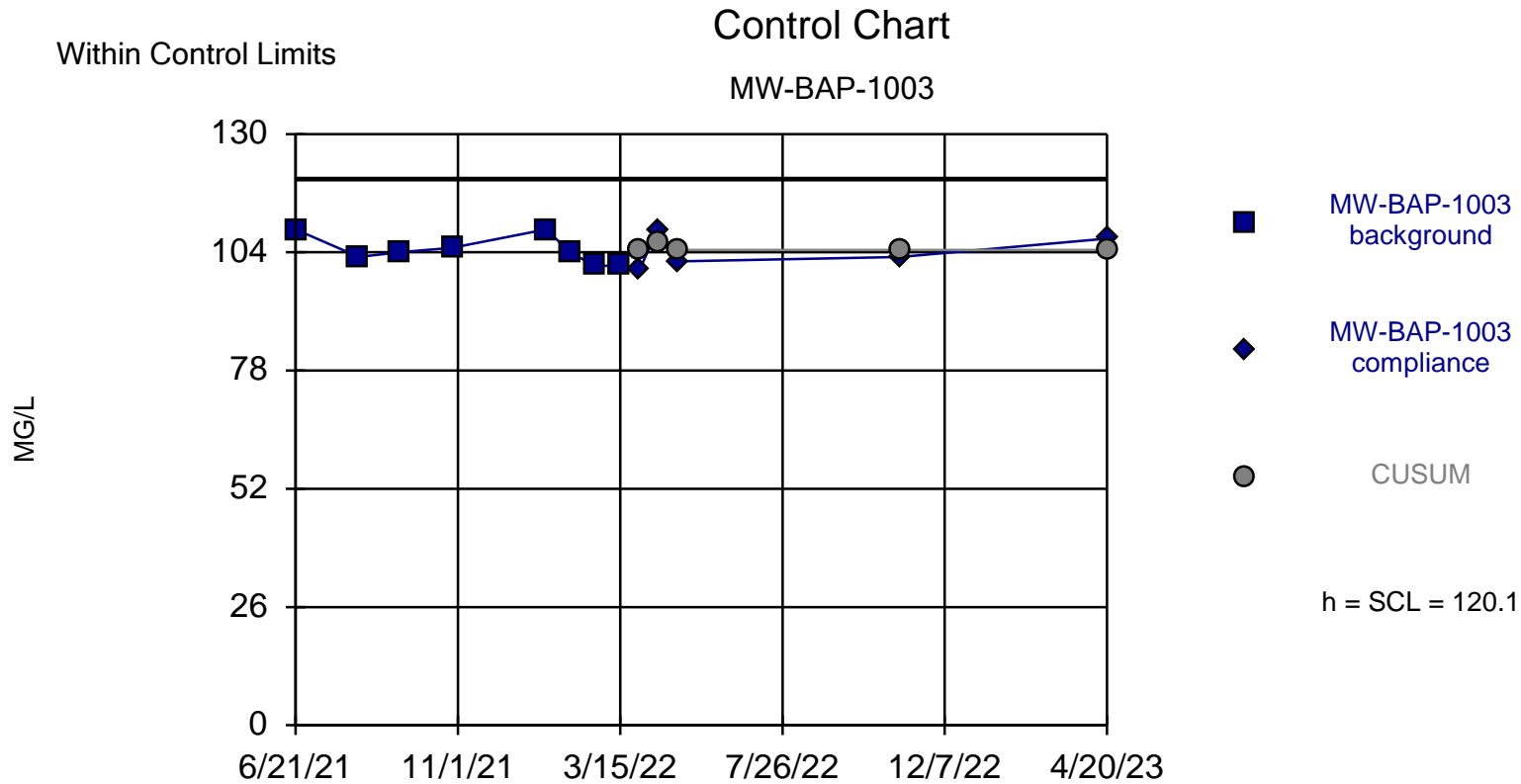
Cardinal Facility Data: stats_data_rbap_20230726



Background Data Summary: Mean=102.1, Std. Dev.=3.05, n=8. Insufficient data to test for seasonality: data were not deseasonalized. Normality test: Shapiro Wilk @alpha = 0.05, calculated = 0.9599, critical = 0.818. Report alpha = 0.004942. Dates ending 03/14/2022 used for control stats. Standardized h=5, SCL=5.

Constituent: Calcium Analysis Run 09/29/2023 1:21 PM

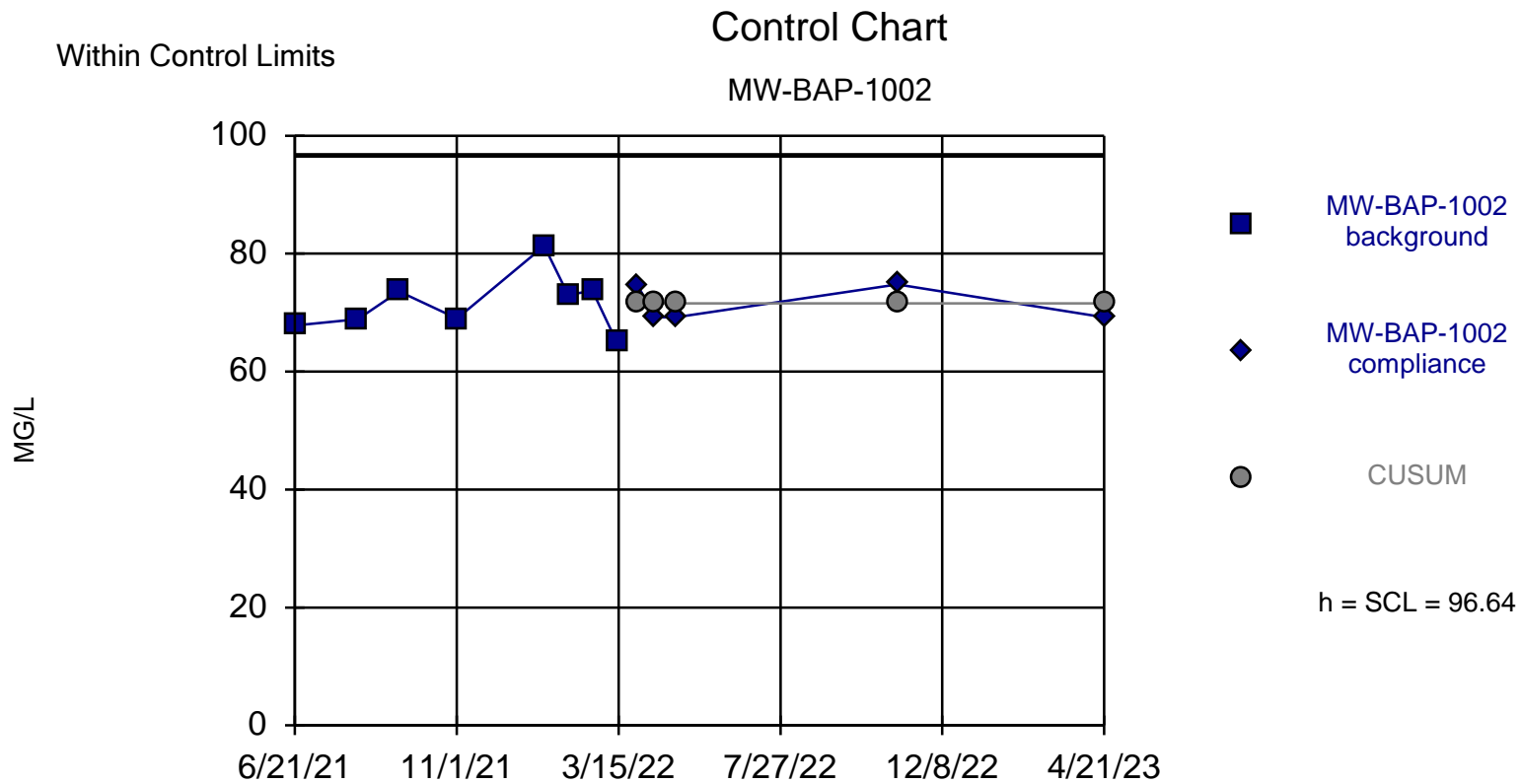
Cardinal Facility Data: stats_data_rbap_20230726



Background Data Summary: Mean=104.5, Std. Dev.=3.117, n=8. Insufficient data to test for seasonality: data were not deseasonalized. Normality test: Shapiro Wilk @alpha = 0.05, calculated = 0.8768, critical = 0.818. Report alpha = 0.004942. Dates ending 03/14/2022 used for control stats. Standardized h=5, SCL=5.

Constituent: Calcium Analysis Run 09/29/2023 1:21 PM

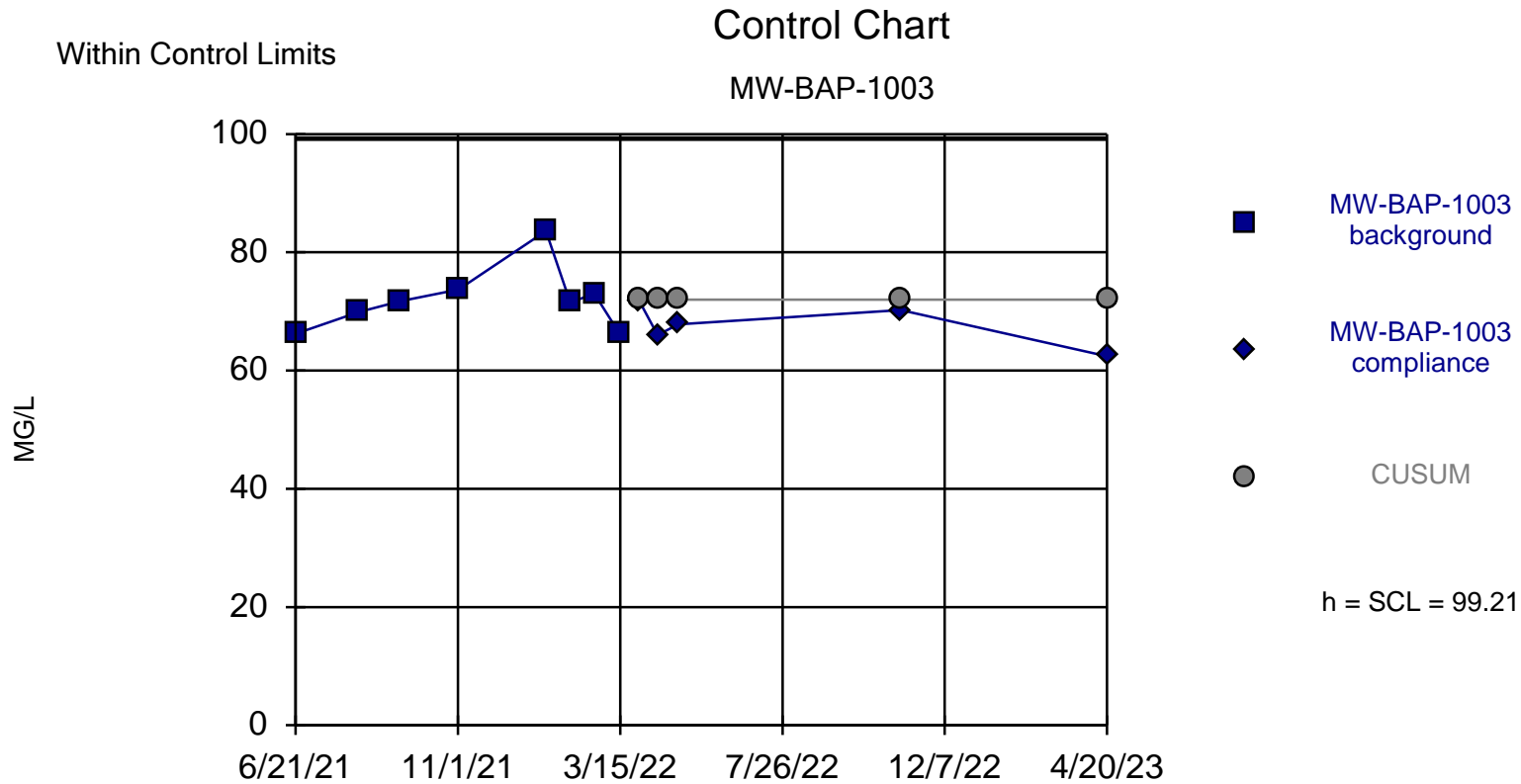
Cardinal Facility Data: stats_data_rbap_20230726



Background Data Summary: Mean=71.54, Std. Dev.=5.021, n=8. Insufficient data to test for seasonality: data were not deseasonalized. Normality test: Shapiro Wilk @alpha = 0.05, calculated = 0.9248, critical = 0.818. Report alpha = 0.004942. Dates ending 03/14/2022 used for control stats. Standardized h=5, SCL=5.

Constituent: Chloride Analysis Run 09/29/2023 1:21 PM

Cardinal Facility Data: stats_data_rbap_20230726



Background Data Summary: Mean=72.01, Std. Dev.=5.439, n=8. Insufficient data to test for seasonality: data were not deseasonalized. Normality test: Shapiro Wilk @alpha = 0.05, calculated = 0.8619, critical = 0.818. Report alpha = 0.004942. Dates ending 03/14/2022 used for control stats. Standardized h=5, SCL=5.

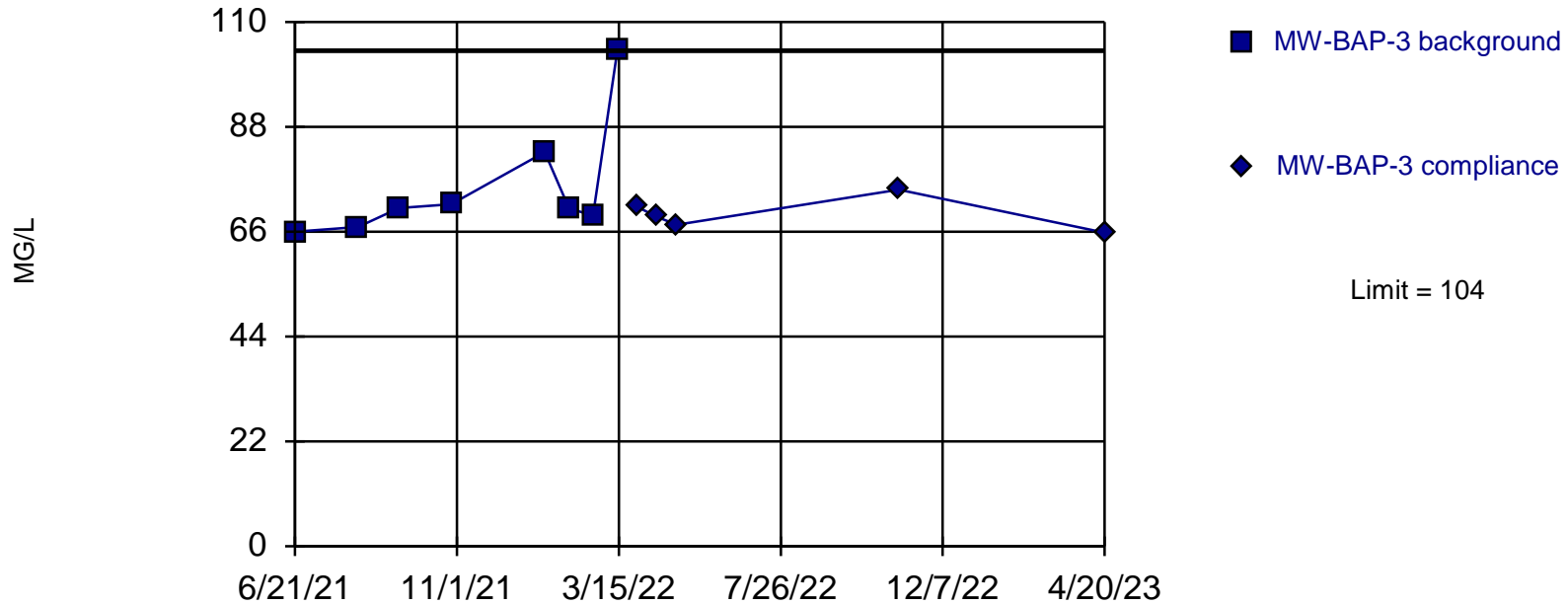
Constituent: Chloride Analysis Run 09/29/2023 1:21 PM

Cardinal Facility Data: stats_data_rbap_20230726

Within Limit

Prediction Limit

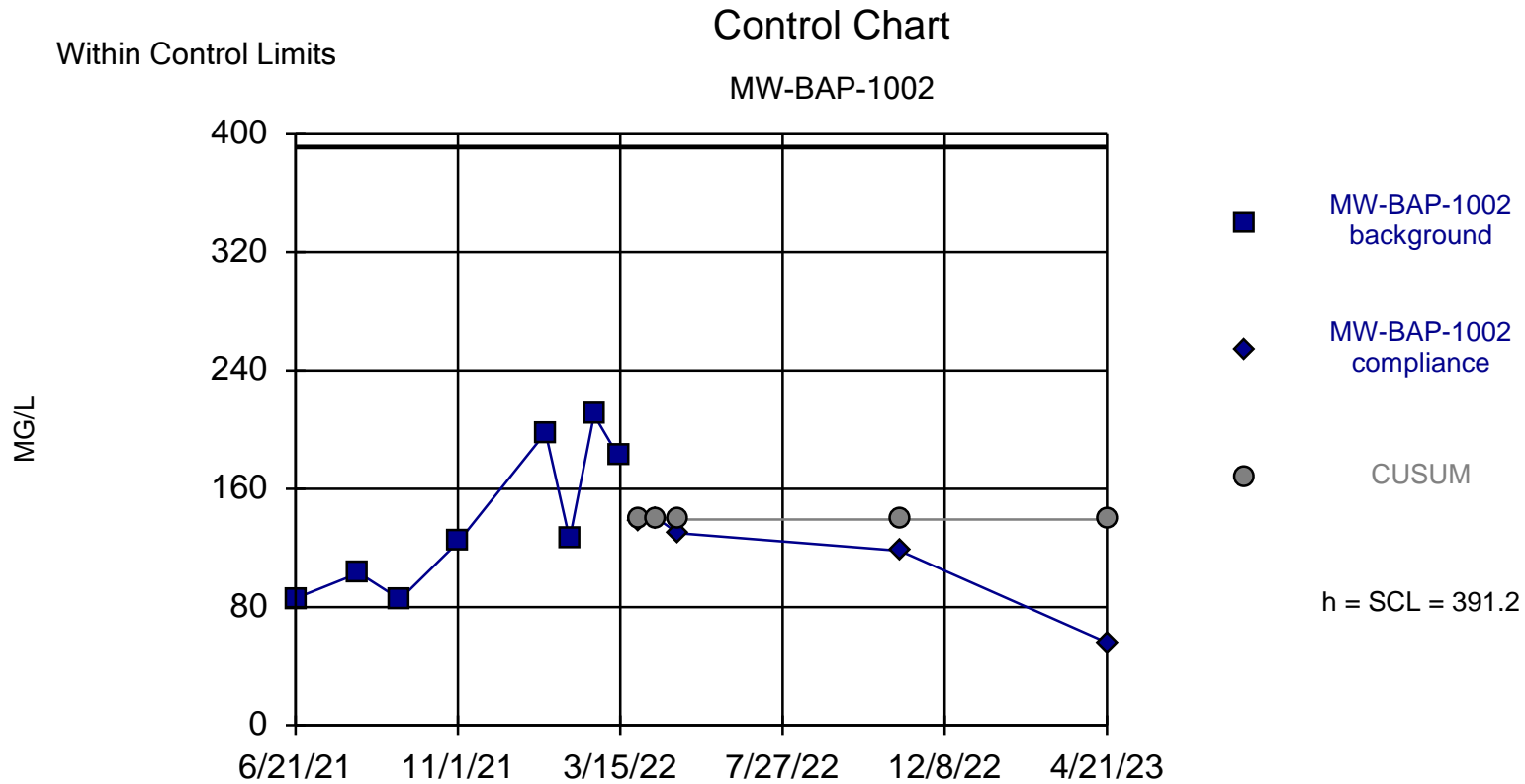
Intrawell Non-parametric



Non-parametric test used in lieu of control chart because the Shapiro Wilk normality test showed the data to be non-normal at the 0.05 alpha level. Limit is highest of 8 background values. Well-constituent pair annual alpha = 0.04242. Individual comparison alpha = 0.02144 (1 of 2). Most recent point compared to limit. Insufficient data to test for seasonality: data were not deseasonalized.

Constituent: Chloride Analysis Run 09/29/2023 1:22 PM

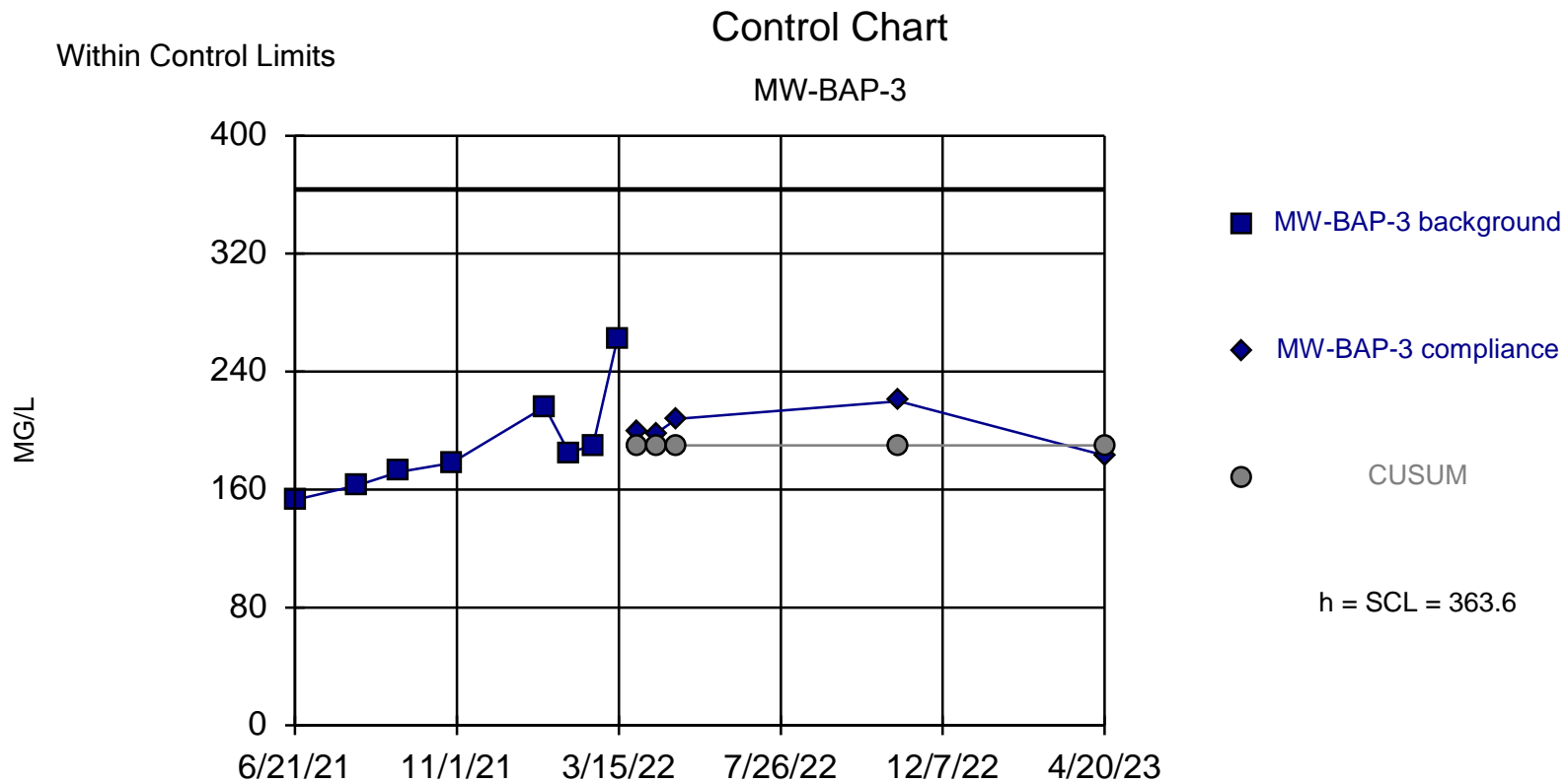
Cardinal Facility Data: stats_data_rbap_20230726



Background Data Summary: Mean=139.3, Std. Dev.=50.39, n=8. Insufficient data to test for seasonality: data were not deseasonalized. Normality test: Shapiro Wilk @alpha = 0.05, calculated = 0.877, critical = 0.818. Report alpha = 0.004942. Dates ending 03/14/2022 used for control stats. Standardized h=5, SCL=5.

Constituent: Sulfate Analysis Run 09/29/2023 1:22 PM

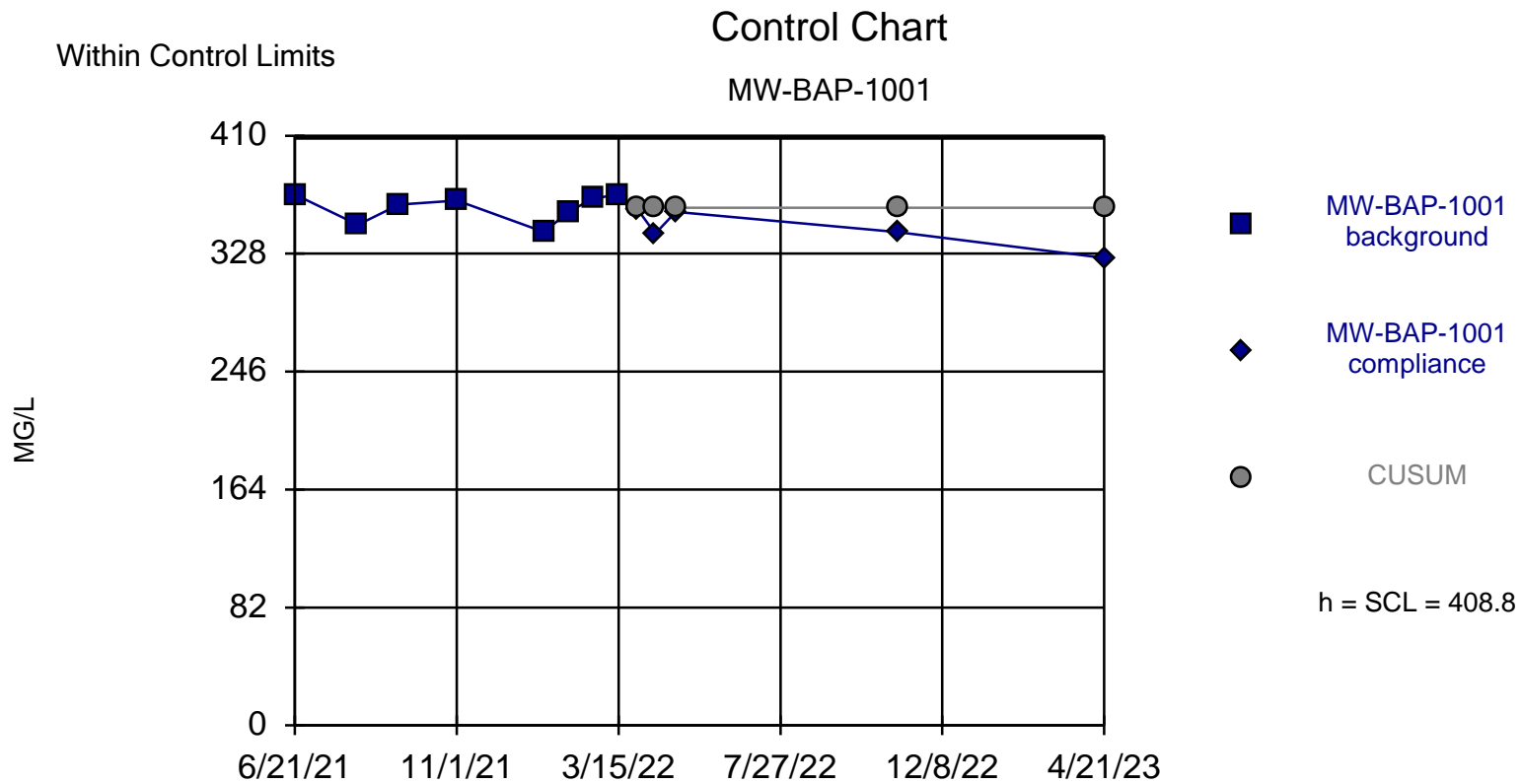
Cardinal Facility Data: stats_data_rbap_20230726



Background Data Summary: Mean=189.9, Std. Dev.=34.75, n=8. Insufficient data to test for seasonality: data were not deseasonalized. Normality test: Shapiro Wilk @alpha = 0.05, calculated = 0.8806, critical = 0.818. Report alpha = 0.004942. Dates ending 03/14/2022 used for control stats. Standardized h=5, SCL=5.

Constituent: Sulfate Analysis Run 09/29/2023 1:22 PM

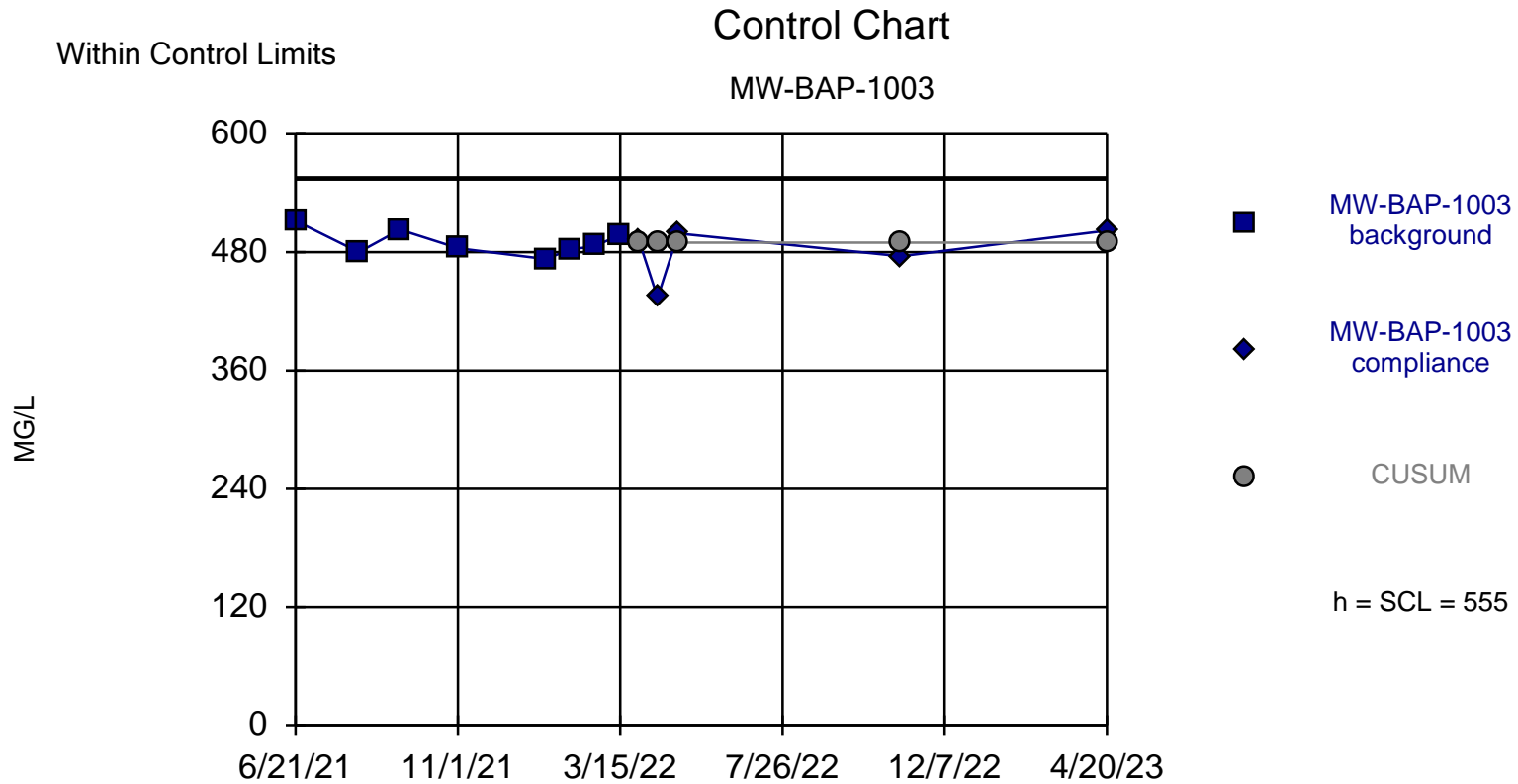
Cardinal Facility Data: stats_data_rbap_20230726



Background Data Summary: Mean=359.9, Std. Dev.=9.775, n=8. Insufficient data to test for seasonality: data were not deseasonalized. Normality test: Shapiro Wilk @alpha = 0.05, calculated = 0.8695, critical = 0.818. Report alpha = 0.004942. Dates ending 03/14/2022 used for control stats. Standardized h=5, SCL=5.

Constituent: Total Dissolved Solids Analysis Run 09/29/2023 1:22 PM

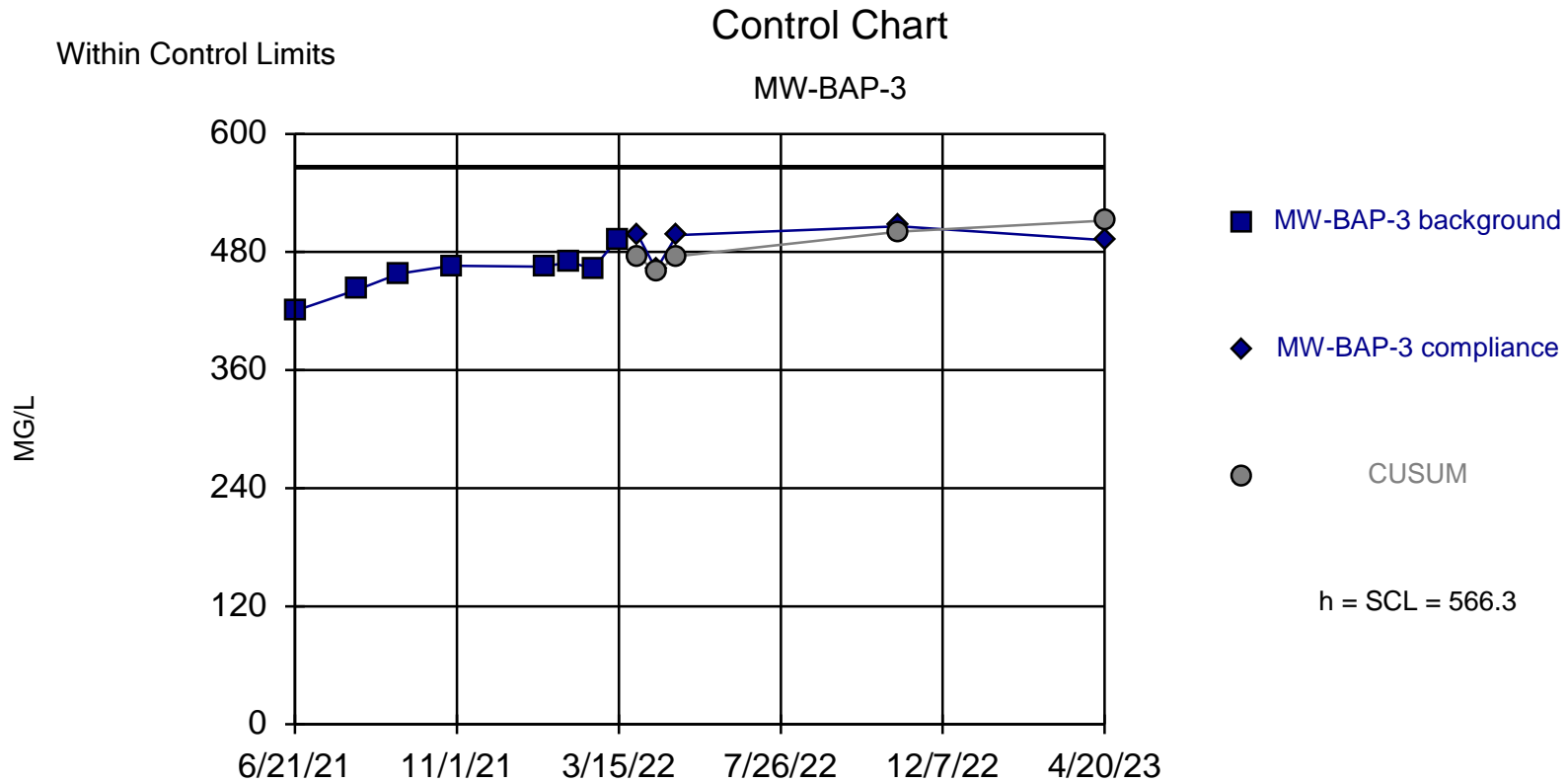
Cardinal Facility Data: stats_data_rbap_20230726



Background Data Summary: Mean=489.8, Std. Dev.=13.05, n=8. Insufficient data to test for seasonality: data were not deseasonalized. Normality test: Shapiro Wilk @alpha = 0.05, calculated = 0.9381, critical = 0.818. Report alpha = 0.004942. Dates ending 03/14/2022 used for control stats. Standardized h=5, SCL=5.

Constituent: Total Dissolved Solids Analysis Run 09/29/2023 1:22 PM

Cardinal Facility Data: stats_data_rbap_20230726



Background Data Summary: Mean=459.6, Std. Dev.=21.33, n=8. Insufficient data to test for seasonality: data were not deseasonalized. Normality test: Shapiro Wilk @alpha = 0.05, calculated = 0.9339, critical = 0.818. Report alpha = 0.004942. Dates ending 03/14/2022 used for control stats. Standardized h=5, SCL=5.

Constituent: Total Dissolved Solids Analysis Run 09/29/2023 1:22 PM

Cardinal Facility Data: stats_data_rbap_20230726