Annual Groundwater Monitoring Report

Appalachian Power Company

John E. Amos Plant

Fly Ash Pond CCR Management Unit

Winfield, West Virginia

January 2021

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APPALACHIAN POWER
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I. Overview

This *Annual Groundwater Monitoring and Corrective Action Report* (Report) has been prepared to report the status of activities for the preceding year for an existing CCR unit at Appalachian Power Company's, a wholly-owned subsidiary of American Electric Power Company (AEP), John E. Amos Power Plant. The USEPA's CCR rules require that the initial Annual Groundwater Monitoring and Corrective Action Report for inactive surface impoundments be posted to the operating record no later than August 1, 2019 and then annually, thereafter. This Annual Groundwater Monitoring and Corrective Action Report covers all activities required by the CCR Rule for all of 2020.

In general, the following activities were completed:

- The Amos Fly Ash Pond (AMFAP) CCR unit began 2020 in detection monitoring and remained in detection monitoring throughout all of 2020.
- Groundwater data underwent various validation tests, including tests for completeness, valid values, transcription errors, and consistent units;
- Statistically significant increases (SSI's) were observed during the November 2019 detection monitoring event. The monitoring well locations and potential SSI parameters were re-sampled in February 2020 in accordance with the statistical analysis plan. Statistical analysis for this detection monitoring event was completed in April 2020. The re-sampling event confirmed SSI's for the following:
    - MW-5: Calcium and sulfate
    - MW-1804A: Chloride and sulfate

  An alternative source demonstration (ASD) for the above parameters was successfully completed in June 2020.
- SSI's were observed during the May 2020 detection monitoring event. The monitoring well locations and potential SSI parameters were re-sampled in July 2020 in accordance with the statistical analysis plan. Statistical analysis for this detection monitoring event was completed in July 2020. The following were concluded to be confirmed SSI's:
    - MW-5: Calcium and sulfate

  An ASD for the above parameters was successfully completed in November 2020.
- A detection monitoring sampling event occurred in November 2020. Potential SSI's have been observed at the following locations:
    - MW-5: Calcium and sulfate
    - MW-6: Fluoride
    - MW-7: Calcium and fluoride

- MW-8: Calcium, chloride, sulfate, and total dissolved solids
- MW-1804A: Chloride and sulfate

A re-sampling event occurred in January 2021 for the above mentioned parameters and well locations in accordance with the statistical analysis plan. Statistical analysis is ongoing. If any of the above potential SSI's are confirmed following statistical analysis, an ASD will be completed to determine if the CCR unit can remain in detection monitoring or if it must transition to assessment monitoring in accordance with the CCR rule.

The major components of this annual report, to the extent applicable at this time, are presented in sections that follow:

- A map, aerial photograph or a drawing showing the CCR management unit(s), all groundwater monitoring wells and monitoring well identification numbers.
- All of the monitoring data collected, including the rate and direction of groundwater flow, plus a summary showing the number of samples collected per monitoring well, the dates the samples were collected and whether the sample was collected as part of detection monitoring or assessment monitoring programs (**Appendix 1**).
- Results of the required statistical analysis of groundwater monitoring results (**Appendix 2**).
- Discussion of any alternative source demonstrations completed, if applicable (**Appendix 3**).
- A summary of any transition between monitoring programs or an alternate monitoring frequency, for example the date and circumstances for transitioning from detection monitoring to assessment monitoring, in addition to identifying the constituents detected at a statistically significant increase over background concentrations, if applicable (Appendix 4). This is not applicable to this report.
- Identification of any monitoring wells that were installed or decommissioned during the preceding year, along with a statement as to why that happened, if applicable (Appendix 5). This is not applicable to this report.
- Other information required to be included in the annual report such as an alternate monitoring frequency or assessment of corrective measures, if applicable.

In addition, this report summarizes key actions completed, and where applicable, describes any problems encountered and actions taken to resolve those problems. The report includes a projection of key activities for the upcoming year.

II. <u>Groundwater Monitoring Well Locations and Identification Numbers</u>

Figure 1 depicts the PE-certified groundwater monitoring network, the monitoring well locations and their corresponding identification numbers. The groundwater monitoring network has been determined to adequately monitor upgradient, downgradient, and background areas adjacent to the Fly Ash Pond, as detailed in the *Groundwater Monitoring System Design and Construction Certification* that was placed on the AEP CCR public internet site on May 1, 2019. The groundwater quality monitoring network includes the following:

- Five upgradient or sidegradient monitoring wells: MW-1807A, MW-1807B, MW-1808A, MW-1809A, and MW-1810A.
- Ten downgradient monitoring wells: MW-1, MW-2, MW-5, MW-6, MW-7, MW-8, MW-9, MW-1801A, MW-1804A, and MW-1806A.

MW-1807B is screened in the Clarksburg shale to provide background groundwater quality in a deeper secondary groundwater-bearing zone that is hydraulically connected to the uppermost aquifer. Since this monitoring well is not located within the uppermost aquifer but in a deeper groundwater bearing zone, it is shown only on the site figure and not included in the groundwater flow direction maps.

Legend
- Upgradient Sampling Location
- Downgradient Sampling Location
- Fly Ash Pond

Notes
- Monitoring well coordinates and site features provided by AEP.

1,000 500 0 1,000 Feet

Site Layout
Fly Ash Pond

AEP Amos Generating Plant
Winfield, West Virginia

Geosyntec consultants

Columbus, Ohio | 2019/07/30

Figure 1

P:\Projects\AEP\Groundwater Statistical Evaluation - CHA8423\Groundwater Mapping\GIS Files\MXD\Amos\2018\AEP-Amos_FAP_Site_Layout.mxd. ARevezzo. 7/30/2019. CHA8423.

III. Monitoring Wells Installed or Decommissioned

No monitoring wells were installed or decommissioned in 2020.

IV. Groundwater Quality Data and Static Water Elevation Data, With Flow Rate and Direction Calculations and Discussion

Appendix 1 contains Table 1 which displays the groundwater quality data collected since initiating CCR background sampling through results received in 2020. **Appendix 1** also contains Table 2 which displays the groundwater velocity and residence time determinations for each completed sampling event, to date. Static water elevation data from each monitoring event are used to develop potentiometric maps and determine the groundwater flow direction for each respective sampling event.

V. Groundwater Quality Data Statistical Analysis

Statistical analysis of the November 2019 detection monitoring samples was completed in April 2020. SSI's in the Appendix III parameters of calcium and sulfate at MW-5 and chloride and sulfate and MW-1804A were documented in the April 6, 2020 *Evaluation of Detection Monitoring Data at Amos Plant's Fly Ash Pond* memorandum (**Appendix 2**). A successful alternative source demonstration was completed for these confirmed SSI's. That demonstration is discussed in the next section of this report.

Statistical analysis of the May 2020 detection monitoring samples was completed in July 2020. SSI's in the Appendix III parameters of calcium and sulfate at MW-5 were documented in the July 29, 2020 *Evaluation of Detection Monitoring Data at Amos Plant's Fly Ash Pond* memorandum (**Appendix 2**). A successful alternative source demonstration was completed for these confirmed SSI's. That demonstration is discussed in the next section of this report.

The November 2020 detection monitoring samples received indicate potential SSI's listed below.

- MW-5: Calcium and sulfate
- MW-6: Fluoride
- MW-7: Calcium and fluoride
- MW-8: Calcium, chloride, sulfate, and total dissolved solids
- MW-1804A: Chloride and sulfate

The re-sampling event in accordance with the statistical analysis plan was conducted in early January 2021. Statistical analysis of this event will be completed in early 2021. If any SSI's are confirmed, an ASD will be attempted. If successful, the AMFAP will remain in detection monitoring. However, if unsuccessful, the AMFAP will transition into assessment monitoring.

VI. Alternative Source Demonstration

An alternative source demonstration (ASD) relative to the Appendix III SSI's confirmed for the November 2019 detection monitoring event was successfully completed in June 2020. The demonstration concluded that groundwater quality and the Appendix III indicator parameter SSI's identified in the statistical evaluation is attributable to an alternative source. The successful ASD is attached in **Appendix 3**.

An ASD relative to the Appendix III SSI's confirmed for the May 2020 detection monitoring event was successfully completed in November 2020. The demonstration concluded that groundwater quality and the Appendix III indicator parameters SSI's identified in the statistical evaluation is attributable to an alternative. The successful ASD is attached in **Appendix 3**.

VII. Discussion About Transition Between Monitoring Requirements or Alternate Monitoring Frequency

As of this annual groundwater report date there has been no transition between detection monitoring and assessment monitoring. Detection monitoring will continue throughout 2021 pending the results of the aforementioned statistical analysis regarding the November 2020 detection monitoring event. If the statistical analysis confirms any SSIs, an ASD will be performed if applicable. The sampling frequency of twice per year will be maintained for the Appendix III parameters upon a successful alternative source demonstration. If necessary, a transition to the assessment monitoring program will occur.

Regarding defining an alternate monitoring frequency, the groundwater velocity and monitoring well production is high enough at this facility that no modification of the twice-per-year detection monitoring effort is needed.

VIII. Other Information Required

All required information has been included in this annual groundwater monitoring report.

IX. Description of Any Problems Encountered in 2020 and Actions Taken

No significant problems were encountered. The low flow sampling effort went smoothly and the schedule was met to support the 2020 annual groundwater report preparation.

X. A Projection of Key Activities for 2021

Key activities for the upcoming year include:

- Complete the statistical evaluation of the November 2020 detection monitoring results and subsequent verification sampling, looking for any confirmed statistically significant increases.
- Perform an ASD, if necessary, for the November 2020 detection monitoring event if any SSI's are confirmed. If the ASD if necessary and is unsuccessful, the CCR unit will transition into assessment monitoring. If it is successful or no SSI's are confirmed, the CCR unit will continue detection monitoring on a semi-annual basis.
- Respond to any new data received in light of what the CCR rule requires.
- Preparation of the 2021 annual groundwater report.

APPENDIX 1

Tables follow, showing a summary of the number of samples collected per monitoring well and the groundwater monitoring data collected, the groundwater velocity, and the direction of groundwater flow. The dates that the samples were collected also is shown.

Table 1 - Groundwater Data Summary: MW-1
Amos - FAP
Appendix III Constituents

Collection Date	Monitoring Program	Boron	Calcium	Chloride	Fluoride	pH	Sulfate	Total Dissolved Solids
		mg/L	mg/L	mg/L	mg/L	SU	mg/L	mg/L
7/24/2018	Background	0.182	2.83	11.7	0.42	8.2	30.6	473
8/28/2018	Background	0.135	2.80	11.3	0.45	8.5	31.6	435
10/3/2018	Background	0.138	2.95	11.1	0.40	8.3	30.8	457
10/22/2018	Background	0.180	2.36	11.4	0.42	8.3	30.7	434
11/13/2018	Background	0.209	3.03	11.5	0.45	8.0	32.2	444
12/19/2018	Background	0.117	2.71	10.7	0.43	8.1	30.9	428
1/23/2019	Background	0.115	2.29	14.6	0.41	8.2	55.9	453
2/19/2019	Background	0.126	2.36	10.9	0.44	8.5	31.3	457
3/12/2019	Detection	0.110	2.60	11.0	0.43	8.2	31.6	458
11/8/2019	Detection	0.114	2.38	11.2	0.42	8.2	33.7	461
5/13/2020	Detection	0.122	2.74	11.2	0.42	8.2	33.6	457
11/2/2020	Detection	0.097	2.70	10.5	0.48	8.4	33.6	434

Notes:
mg/L: milligrams per liter
SU: standard unit
<: Non-detect value. Parameters which were not detected are shown as less than the method detection limit (MDL) followed by a 'U' flag.
J: Estimated value. Parameter was detected at concentration below the reporting limit
- -: Not analyzed

Table 1 - Groundwater Data Summary: MW-1
Amos - FAP
Appendix IV Constituents

Collection Date	Monitoring Program	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Combined Radium	Fluoride	Lead	Lithium	Mercury	Molybdenum	Selenium	Thallium
		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	pCi/L	mg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L
7/24/2018	Background	0.02 J	7.65	52.9	< 0.004 U	0.008 J	0.075	0.031	1.086	0.42	0.041	0.012	< 0.002 U	1.94	< 0.03 U	0.03 J
8/28/2018	Background	0.02 J	7.90	49.5	< 0.004 U	< 0.005 U	0.092	0.039	0.261	0.45	0.047	0.009	< 0.002 U	1.48	< 0.03 U	0.01 J
10/3/2018	Background	< 0.02 U	7.98	51.5	< 0.02 U	< 0.01 U	0.1 J	0.03 J	1.782	0.40	0.02 J	< 0.009 U	< 0.002 U	1 J	< 0.03 U	< 0.1 U
10/22/2018	Background	< 0.02 U	6.84	44.7	< 0.02 U	< 0.01 U	0.1 J	0.05 J	0.608	0.42	0.07 J	< 0.009 U	< 0.002 U	1 J	< 0.03 U	< 0.1 U
11/13/2018	Background	< 0.02 U	8.04	51.9	< 0.02 U	< 0.01 U	0.583	0.03 J	0.4563	0.45	0.06 J	< 0.009 U	< 0.002 U	1 J	< 0.03 U	< 0.1 U
12/19/2018	Background	0.03 J	7.65	48.6	< 0.02 U	< 0.01 U	0.08 J	0.03 J	0.3156	0.43	0.02 J	0.02 J	< 0.002 U	1 J	< 0.03 U	< 0.1 U
1/23/2019	Background	0.06 J	7.64	43.7	< 0.02 U	< 0.01 U	0.09 J	0.03 J	0.688	0.41	0.03 J	< 0.009 U	< 0.002 U	1 J	< 0.03 U	< 0.1 U
2/19/2019	Background	0.05 J	7.83	44.7	< 0.02 U	< 0.01 U	0.1 J	0.03 J	0.00538	0.44	0.111	0.01 J	< 0.002 U	1 J	0.05 J	< 0.1 U

Notes:
µg/L: micrograms per liter
mg/L: milligrams per liter
<: Non-detect value. Parameters which were not detected are shown as less than the method detection limit (MDL) followed by a 'U' flag.
J: Estimated value. Parameter was detected at concentration below the reporting limit
- -: Not analyzed
pCi/L: picocuries per liter

Table 1 - Groundwater Data Summary: MW-2
Amos - FAP
Appendix III Constituents

Collection Date	Monitoring Program	Boron	Calcium	Chloride	Fluoride	pH	Sulfate	Total Dissolved Solids
		mg/L	mg/L	mg/L	mg/L	SU	mg/L	mg/L
7/27/2018	Background	0.259	4.24	471	3.08	8.4	2.4	1,260
8/29/2018	Background	0.249	3.98	443	2.99	8.6	17.4	1,310
10/4/2018	Background	0.256	4.31	435	2.99	8.5	14.8	1,280
10/23/2018	Background	0.262	3.95	438	3.08	8.5	7.4	1,250
11/15/2018	Background	0.328	4.07	469	3.30	8.5	13.5	1,250
12/19/2018	Background	0.225	3.81	430	3.03	8.5	6.4	1,250
1/23/2019	Background	0.318	3.67	441	3.00	8.2	6.4	1,310
2/22/2019	Background	0.237	3.95	447	3.06	8.7	2.3	1,310
3/13/2019	Detection	0.230	3.98	441	3.02	8.7	1.8	1,300
11/12/2019	Detection	0.265	4.77	426	2.73	8.5	20.1	1,340
2/11/2020	Detection	--	4.31	--	--	8.3	--	--
5/12/2020	Detection	0.214	4.35	443	2.91	8.6	6 J	1,340
11/2/2020	Detection	0.194	4.13	435	3.24	8.6	6.6	1,310

Notes:
mg/L: milligrams per liter
SU: standard unit
<: Non-detect value. Parameters which were not detected are shown as less than the method detection limit (MDL) followed by a 'U' flag.
J: Estimated value. Parameter was detected at concentration below the reporting limit
- -: Not analyzed

Table 1 - Groundwater Data Summary: MW-2
Amos - FAP
Appendix IV Constituents

Collection Date	Monitoring Program	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Combined Radium	Fluoride	Lead	Lithium	Mercury	Molybdenum	Selenium	Thallium
		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	pCi/L	mg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L
7/27/2018	Background	0.06	1.68	202	0.008 J	0.02 J	0.312	0.102	1.354	3.08	0.406	0.019	< 0.002 U	27.2	0.04 J	0.02 J
8/29/2018	Background	0.02 J	1.62	178	< 0.004 U	< 0.005 U	0.129	0.034	1.7	2.99	0.033	0.023	< 0.002 U	34.5	< 0.03 U	0.02 J
10/4/2018	Background	< 0.02 U	1.76	192	< 0.02 U	< 0.01 U	0.2 J	0.05 J	1.288	2.99	0.1 J	< 0.009 U	< 0.002 U	30.8	< 0.03 U	< 0.1 U
10/23/2018	Background	< 0.02 U	1.24	181	< 0.02 U	< 0.01 U	0.2 J	0.055	0.594	3.08	0.214	0.03 J	< 0.002 U	26.1	< 0.03 U	< 0.1 U
11/15/2018	Background	< 0.02 U	1.66	185	< 0.02 U	< 0.01 U	0.2 J	0.04 J	0.953	3.30	0.110	0.02 J	< 0.002 U	29.2	< 0.03 U	< 0.1 U
12/19/2018	Background	0.03 J	1.33	182	< 0.02 U	0.03 J	0.967	0.04 J	1.058	3.03	0.290	0.02 J	< 0.002 U	25.5	< 0.03 U	< 0.1 U
1/23/2019	Background	< 0.02 U	1.55	178	< 0.02 U	< 0.01 U	0.382	0.050	0.725	3.00	0.166	0.01 J	< 0.002 U	29.2	0.04 J	< 0.1 U
2/22/2019	Background	< 0.1 U	1.35	169	< 0.1 U	< 0.05 U	< 0.2 U	< 0.1 U	0.2747	3.06	< 0.1 U	0.02 J	< 0.002 U	21.9	< 0.2 U	< 0.5 U

Notes:
µg/L: micrograms per liter
mg/L: milligrams per liter
<: Non-detect value. Parameters which were not detected are shown as less than the method detection limit (MDL) followed by a 'U' flag.
J: Estimated value. Parameter was detected at concentration below the reporting limit
- -: Not analyzed
pCi/L: picocuries per liter

Table 1 - Groundwater Data Summary: MW-5
Amos - FAP
Appendix III Constituents

Collection Date	Monitoring Program	Boron	Calcium	Chloride	Fluoride	pH	Sulfate	Total Dissolved Solids
		mg/L	mg/L	mg/L	mg/L	SU	mg/L	mg/L
7/24/2018	Background	0.252	6.75	793	3.32	8.1	0.2	1,890
8/29/2018	Background	0.240	6.71	780	3.33	8.2	0.2	1,880
10/3/2018	Background	0.276	7.03	776	3.33	8.1	0.1 J	1,860
10/24/2018	Background	0.249	7.09	811	3.44	8.1	< 0.06 U	1,840
11/13/2018	Background	0.264	6.79	832	3.63	8.0	0.1 J	1,880
12/19/2018	Background	0.221	6.48	783	3.43	7.9	< 0.06 U	1,890
1/23/2019	Background	0.323	5.98	782	3.36	8.1	< 0.06 U	1,910
2/19/2019	Background	0.239	6.79	793	3.38	8.2	< 0.06 U	1,920
3/13/2019	Detection	0.229	6.85	804	3.44	8.0	0.08 J	1,930
11/8/2019	Detection	0.182	21.0	663	3.04	8.0	32.0	1,840
2/11/2020	Detection	--	11.3	713	--	7.8	18.6	--
5/11/2020	Detection	0.211	9.85	746	2.97	7.9	11.0	1,820
7/7/2020	Detection	--	8.77	--	--	8.1	22.8	--
10/27/2020	Detection	0.207	9.50	729	3.24	8.2	25.1	1,770

Notes:
mg/L: milligrams per liter
SU: standard unit
<: Non-detect value. Parameters which were not detected are shown as less than the method detection limit (MDL) followed by a 'U' flag.
J: Estimated value. Parameter was detected at concentration below the reporting limit
- -: Not analyzed

Table 1 - Groundwater Data Summary: MW-5
Amos - FAP
Appendix IV Constituents

Collection Date	Monitoring Program	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Combined Radium	Fluoride	Lead	Lithium	Mercury	Molybdenum	Selenium	Thallium
		μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	pCi/L	mg/L	μg/L	mg/L	μg/L	μg/L	μg/L	μg/L
7/24/2018	Background	0.06	4.89	356	0.004 J	0.006 J	0.152	0.046	1.37	3.32	0.222	0.032	< 0.002 U	36.5	< 0.03 U	0.05 J
8/29/2018	Background	0.18	5.08	359	< 0.004 U	0.01 J	0.278	0.085	1.805	3.33	0.284	0.030	< 0.002 U	38.4	< 0.03 U	0.02 J
10/3/2018	Background	< 0.02 U	4.86	373	< 0.02 U	< 0.01 U	0.626	0.053	1.63	3.33	0.03 J	< 0.009 U	< 0.002 U	35.7	< 0.03 U	< 0.1 U
10/24/2018	Background	0.02 J	4.34	363	< 0.02 U	< 0.01 U	0.219	0.516	0.731	3.44	0.06 J	0.03 J	< 0.002 U	35.1	0.04 J	< 0.1 U
11/13/2018	Background	< 0.02 U	4.37	353	< 0.02 U	< 0.01 U	0.1 J	0.04 J	1.824	3.63	0.03 J	0.02 J	< 0.002 U	34.7	< 0.03 U	< 0.1 U
12/19/2018	Background	< 0.02 U	4.39	364	< 0.02 U	< 0.01 U	0.07 J	0.04 J	1.514	3.43	< 0.02 U	0.03 J	< 0.002 U	34.8	< 0.03 U	< 0.1 U
1/23/2019	Background	< 0.04 U	4.35	351	< 0.04 U	< 0.02 U	0.532	< 0.04 U	1.052	3.36	< 0.04 U	0.02 J	< 0.002 U	35.0	< 0.06 U	< 0.2 U
2/19/2019	Background	< 0.06 U	5.25	349	< 0.06 U	< 0.03 U	0.2 J	< 0.06 U	1.454	3.38	< 0.06 U	0.034	< 0.002 U	33.6	< 0.09 U	< 0.3 U

Notes:
μg/L: micrograms per liter
mg/L: milligrams per liter
<: Non-detect value. Parameters which were not detected are shown as less than the method detection limit (MDL) followed by a 'U' flag.
J: Estimated value. Parameter was detected at concentration below the reporting limit
- -: Not analyzed
pCi/L: picocuries per liter

Table 1 - Groundwater Data Summary: MW-6
Amos - FAP
Appendix III Constituents

Collection Date	Monitoring Program	Boron	Calcium	Chloride	Fluoride	pH	Sulfate	Total Dissolved Solids
		mg/L	mg/L	mg/L	mg/L	SU	mg/L	mg/L
7/24/2018	Background	0.120	61.0	19.3	0.22	6.9	44.4	392
8/28/2018	Background	0.096	59.7	19.4	0.24	6.9	44.6	398
10/3/2018	Background	0.125	60.7	18.9	0.21	6.8	43.4	402
10/24/2018	Background	0.1 J	61.5	18.4	0.23	6.9	42.0	400
11/13/2018	Background	0.111	64.9	19.8	0.24	6.7	44.6	390
12/19/2018	Background	0.07 J	55.8	17.7	0.23	6.7	41.7	376
1/23/2019	Background	0.08 J	54.1	17.8	0.22	6.6	41.3	411
2/19/2019	Background	0.09 J	55.8	17.3	0.24	7.0	40.4	406
3/12/2019	Detection	0.08 J	57.9	17.4	0.23	6.9	39.8	390
11/8/2019	Detection	0.079	56.6	17.2	0.24	6.9	41.7	368
5/11/2020	Detection	0.088	55.8	15.9	0.25	7.0	32.6	416
10/27/2020	Detection	0.089	53.4	16.5	0.28	7.1	38.6	384

Notes:
mg/L: milligrams per liter
SU: standard unit
<: Non-detect value. Parameters which were not detected are shown as less than the method detection limit (MDL) followed by a 'U' flag.
J: Estimated value. Parameter was detected at concentration below the reporting limit
- -: Not analyzed

Table 1 - Groundwater Data Summary: MW-6
Amos - FAP
Appendix IV Constituents

Collection Date	Monitoring Program	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Combined Radium	Fluoride	Lead	Lithium	Mercury	Molybdenum	Selenium	Thallium
		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	pCi/L	mg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L
7/24/2018	Background	0.01 J	1.81	536	0.009 J	0.01 J	0.094	0.242	2.73	0.22	0.02 J	0.012	< 0.002 U	0.58	< 0.03 U	0.03 J
8/28/2018	Background	0.02 J	1.82	527	0.008 J	0.02	0.663	0.323	2.439	0.24	0.167	0.009	< 0.002 U	0.60	< 0.03 U	0.02 J
10/3/2018	Background	< 0.02 U	1.91	523	< 0.02 U	0.01 J	0.09 J	0.260	4.59	0.21	< 0.02 U	< 0.009 U	< 0.002 U	0.5 J	< 0.03 U	< 0.1 U
10/24/2018	Background	< 0.02 U	1.72	494	0.03 J	< 0.01 U	0.07 J	0.258	2.202	0.23	0.03 J	0.01 J	< 0.002 U	0.6 J	< 0.03 U	< 0.1 U
11/13/2018	Background	< 0.02 U	2.12	524	< 0.02 U	< 0.01 U	0.08 J	0.233	2.325	0.24	0.03 J	< 0.009 U	< 0.002 U	0.7 J	< 0.03 U	< 0.1 U
12/19/2018	Background	< 0.02 U	1.88	510	< 0.02 U	0.01 J	0.06 J	0.234	2.53	0.23	0.02 J	0.01 J	< 0.002 U	0.7 J	< 0.03 U	< 0.1 U
1/23/2019	Background	0.04 J	1.89	486	< 0.02 U	< 0.01 U	0.04 J	0.220	1.82	0.22	< 0.02 U	< 0.009 U	< 0.002 U	0.6 J	< 0.03 U	< 0.1 U
2/19/2019	Background	< 0.02 U	1.53	482	< 0.02 U	< 0.01 U	0.277	0.219	2.136	0.24	< 0.02 U	0.02 J	< 0.002 U	0.6 J	0.04 J	< 0.1 U

Notes:
µg/L: micrograms per liter
mg/L: milligrams per liter
<: Non-detect value. Parameters which were not detected are shown as less than the method detection limit (MDL) followed by a 'U' flag.
J: Estimated value. Parameter was detected at concentration below the reporting limit
- -: Not analyzed
pCi/L: picocuries per liter

Table 1 - Groundwater Data Summary: MW-7
Amos - FAP
Appendix III Constituents

Collection Date	Monitoring Program	Boron	Calcium	Chloride	Fluoride	pH	Sulfate	Total Dissolved Solids
		mg/L	mg/L	mg/L	mg/L	SU	mg/L	mg/L
7/26/2018	Background	0.087	1.33	5.41	0.27	8.5	32.0	368
8/29/2018	Background	0.112	1.29	5.32	0.27	8.8	31.5	387
10/3/2018	Background	0.156	1.44	5.23	0.26	8.8	31.8	376
10/24/2018	Background	0.09 J	1.40	5.37	0.27	8.8	31.7	344
11/13/2018	Background	0.192	1.49	5.65	0.29	8.4	33.2	379
12/17/2018	Background	0.1 J	1.24	5.29	0.27	8.6	32.0	387
1/23/2019	Background	0.127	1.41	5.18	0.25	8.4	32.0	389
2/18/2019	Background	0.06 J	1.37	5.39	0.26	9.0	32.1	401
3/12/2019	Detection	0.06 J	1.47	5.49	0.27	8.9	32.5	385
11/11/2019	Detection	0.066	2.18	5.36	0.25	8.7	32.3	390
2/11/2020	Detection	--	1.39	--	--	8.5	--	--
5/11/2020	Detection	0.067	1.59	5.30	0.27	8.4	23.6	395
10/28/2020	Detection	0.065	1.81	5.34	0.31	8.9	31.2	387

Notes:
mg/L: milligrams per liter
SU: standard unit
<: Non-detect value. Parameters which were not detected are shown as less than the method detection limit (MDL) followed by a 'U' flag.
J: Estimated value. Parameter was detected at concentration below the reporting limit
- -: Not analyzed

Table 1 - Groundwater Data Summary: MW-7
Amos - FAP
Appendix IV Constituents

Collection Date	Monitoring Program	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Combined Radium	Fluoride	Lead	Lithium	Mercury	Molybdenum	Selenium	Thallium
		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	pCi/L	mg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L
7/26/2018	Background	0.04 J	5.31	34.0	< 0.004 U	0.01 J	0.082	0.038	1.958	0.27	0.211	0.009	< 0.002 U	1.12	< 0.03 U	0.01 J
8/29/2018	Background	0.05 J	5.51	32.3	< 0.004 U	0.01 J	0.190	0.023	0.745	0.27	0.121	0.010	< 0.002 U	1.06	< 0.03 U	0.02 J
10/3/2018	Background	0.07 J	5.65	33.9	< 0.02 U	< 0.01 U	0.07 J	< 0.02 U	2.391	0.26	0.111	< 0.009 U	< 0.002 U	1 J	0.03 J	< 0.1 U
10/24/2018	Background	0.18	5.13	37.0	< 0.02 U	0.02 J	0.296	0.134	0.1126	0.27	0.476	< 0.009 U	< 0.002 U	1 J	0.05 J	< 0.1 U
11/13/2018	Background	0.12	5.24	32.7	< 0.02 U	< 0.01 U	0.1 J	0.03 J	0.9538	0.29	0.146	< 0.009 U	< 0.002 U	1 J	< 0.03 U	< 0.1 U
12/17/2018	Background	0.06 J	5.21	33.5	< 0.02 U	< 0.01 U	0.1 J	< 0.02 U	1.236	0.27	0.1 J	< 0.009 U	< 0.002 U	1 J	0.04 J	< 0.1 U
1/23/2019	Background	0.44	5.86	36.8	< 0.02 U	0.02 J	0.221	0.068	0.558	0.25	0.420	< 0.009 U	< 0.002 U	1 J	0.05 J	< 0.1 U
2/18/2019	Background	0.27	5.33	34.3	0.03 J	0.02 J	0.1 J	0.057	0.543	0.26	0.230	0.01 J	< 0.002 U	1 J	< 0.03 U	< 0.1 U

Notes:
µg/L: micrograms per liter
mg/L: milligrams per liter
<: Non-detect value. Parameters which were not detected are shown as less than the method detection limit (MDL) followed by a 'U' flag.
J: Estimated value. Parameter was detected at concentration below the reporting limit
- -: Not analyzed
pCi/L: picocuries per liter

Table 1 - Groundwater Data Summary: MW-8
Amos - FAP
Appendix III Constituents

Collection Date	Monitoring Program	Boron	Calcium	Chloride	Fluoride	pH	Sulfate	Total Dissolved Solids
		mg/L	mg/L	mg/L	mg/L	SU	mg/L	mg/L
7/26/2018	Background	0.233	2.15	--	--	--	--	--
8/2/2018	Background	--	--	105	2.70	8.2	21.6	690
8/30/2018	Background	0.225	1.99	109	2.66	8.9	24.2	727
10/3/2018	Background	0.259	2.74	108	2.58	7.9	31.6	729
10/23/2018	Background	0.278	2.32	108	2.74	8.5	26.3	717
11/13/2018	Background	0.254	2.46	116	2.93	8.2	27.2	711
12/19/2018	Background	0.224	2.28	110	2.78	8.5	26.4	696
1/23/2019	Background	0.213	2.39	111	2.62	8.1	30.1	739
2/20/2019	Background	0.195	2.49	111	2.87	9.2	26.4	740
3/12/2019	Detection	0.192	2.32	110	2.87	8.5	27.4	716
11/8/2019	Detection	0.197	1.98	109	2.97	8.3	22.5	717
5/12/2020	Detection	0.191	1.83	108	2.73	7.3	19.9	720
10/26/2020	Detection	0.215	8.47	508	3.07	8.4	37.4	1,400

Notes:
mg/L: milligrams per liter
SU: standard unit
<: Non-detect value. Parameters which were not detected are shown as less than the method detection limit (MDL) followed by a 'U' flag.
J: Estimated value. Parameter was detected at concentration below the reporting limit
- -: Not analyzed

Table 1 - Groundwater Data Summary: MW-8
Amos - FAP
Appendix IV Constituents

Collection Date	Monitoring Program	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Combined Radium	Fluoride	Lead	Lithium	Mercury	Molybdenum	Selenium	Thallium
		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	pCi/L	mg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L
7/26/2018	Background	0.04 J	3.02	63.7	0.005 J	< 0.005 U	0.114	0.210	1.5625	--	0.237	0.013	< 0.002 U	11.7	0.05 J	0.02 J
8/2/2018	Background	--	--	--	--	--	--	--	--	2.70	--	--	--	--	--	--
8/30/2018	Background	0.85	5.71	58.2	0.049	0.05	1.89	1.69	0.655	2.66	2.78	0.012	0.004 J	20.6	0.2	0.076
10/3/2018	Background	0.20	5.18	86.2	< 0.02 U	0.02 J	0.2 J	0.270	3.981	2.58	0.427	< 0.009 U	< 0.002 U	8.76	0.08 J	< 0.1 U
10/23/2018	Background	0.15	4.26	70.9	< 0.02 U	< 0.01 U	0.229	0.284	0.294	2.74	0.491	0.02 J	< 0.002 U	10.2	0.08 J	< 0.1 U
11/13/2018	Background	0.14	3.49	71.5	< 0.02 U	< 0.01 U	0.2 J	0.253	0.691	2.93	0.352	< 0.009 U	< 0.002 U	7.64	0.08 J	< 0.1 U
12/19/2018	Background	0.26	2.91	73.3	< 0.02 U	< 0.01 U	0.264	0.231	0.956	2.78	0.357	0.02 J	< 0.002 U	6.93	0.1 J	< 0.1 U
1/23/2019	Background	0.27	3.49	76.8	< 0.02 U	< 0.01 U	0.463	0.513	0.3857	2.62	0.990	< 0.009 U	< 0.002 U	11.0	0.09 J	< 0.1 U
2/20/2019	Background	0.4 J	2.41	71.9	< 0.1 U	< 0.05 U	0.4 J	0.538	0.736	2.87	0.770	0.009 J	< 0.002 U	8 J	0.4 J	< 0.5 U

Notes:
µg/L: micrograms per liter
mg/L: milligrams per liter
<: Non-detect value. Parameters which were not detected are shown as less than the method detection limit (MDL) followed by a 'U' flag.
J: Estimated value. Parameter was detected at concentration below the reporting limit
- -: Not analyzed
pCi/L: picocuries per liter

Table 1 - Groundwater Data Summary: MW-9
Amos - FAP
Appendix III Constituents

Collection Date	Monitoring Program	Boron	Calcium	Chloride	Fluoride	pH	Sulfate	Total Dissolved Solids
		mg/L	mg/L	mg/L	mg/L	SU	mg/L	mg/L
7/26/2018	Background	0.157	1.03	--	--	--	--	--
8/2/2018	Background	--	--	7.22	0.87	8.3	12.9	421
8/30/2018	Background	0.128	1.04	7.21	0.86	8.0	12.2	468
10/2/2018	Background	0.145	1.44	7.60	0.83	7.1	12.6	513
10/23/2018	Background	0.141	1.07	7.26	0.87	9.3	12.8	460
11/13/2018	Background	0.166	1.24	7.29	0.91	9.1	11.9	449
12/20/2018	Background	0.114	1.03	7.11	0.84	9.2	15.7	435
1/23/2019	Background	0.134	1.01	7.45	0.77	9.7	20.1	484
2/20/2019	Background	0.128	1.26	7.70	0.84	9.2	28.5	505
3/12/2019	Detection	0.122	1.18	7.50	0.91	9.0	24.0	463
11/8/2019	Detection	0.133	1.02	7.72	0.83	8.8	19.1	440
5/13/2020	Detection	0.122	0.959	7.27	0.82	9.0	12.0	459
10/29/2020	Detection	0.128	1.44	6.93	0.90	7.1	11.1	459

Notes:
mg/L: milligrams per liter
SU: standard unit
<: Non-detect value. Parameters which were not detected are shown as less than the method detection limit (MDL) followed by a 'U' flag.
J: Estimated value. Parameter was detected at concentration below the reporting limit
- -: Not analyzed

Table 1 - Groundwater Data Summary: MW-9
Amos - FAP
Appendix IV Constituents

Collection Date	Monitoring Program	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Combined Radium	Fluoride	Lead	Lithium	Mercury	Molybdenum	Selenium	Thallium
		μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	pCi/L	mg/L	μg/L	mg/L	μg/L	μg/L	μg/L	μg/L
7/26/2018	Background	0.21	5.23	46.8	0.004 J	0.01 J	0.218	1.00	0.912	--	1.12	0.010	< 0.002 U	7.31	0.06 J	0.060
8/2/2018	Background	--	--	--	--	--	--	--	--	0.87	--	--	--	--	--	--
8/30/2018	Background	0.91	5.87	46.8	0.02 J	0.35	1.17	2.15	1.162	0.86	5.23	0.010	0.012	6.28	0.2	0.209
10/2/2018	Background	0.59	7.04	66.0	0.192	0.07	4.52	3.70	0.543	0.83	8.66	0.009 J	0.016	6.07	0.9	0.4 J
10/23/2018	Background	1.28	4.58	45.4	0.08 J	0.02 J	1.90	1.39	0.658	0.87	2.68	0.01 J	0.008	5.93	0.4	0.3 J
11/13/2018	Background	0.35	5.83	51.1	0.115	0.02 J	2.54	1.92	0.635	0.91	3.44	< 0.009 U	0.004 J	6.06	0.6	0.2 J
12/20/2018	Background	0.33	4.47	35.8	< 0.02 U	0.10	0.725	0.393	0.847	0.84	1.03	< 0.009 U	0.010	6.51	0.4	0.1 J
1/23/2019	Background	1.08	5.84	44.6	0.09 J	0.03 J	2.46	1.43	1.464	0.77	2.45	< 0.009 U	0.009	6.49	0.5	0.2 J
2/20/2019	Background	0.4 J	5.45	41.5	< 0.1 U	< 0.05 U	0.7 J	0.349	0.2514	0.84	0.955	0.01 J	0.006	6 J	0.3 J	< 0.5 U

Notes:
μg/L: micrograms per liter
mg/L: milligrams per liter
<: Non-detect value. Parameters which were not detected are shown as less than the method detection limit (MDL) followed by a 'U' flag.
J: Estimated value. Parameter was detected at concentration below the reporting limit
- -: Not analyzed
pCi/L: picocuries per liter

Table 1 - Groundwater Data Summary: MW-1801A
Amos - FAP
Appendix III Constituents

Collection Date	Monitoring Program	Boron	Calcium	Chloride	Fluoride	pH	Sulfate	Total Dissolved Solids
		mg/L	mg/L	mg/L	mg/L	SU	mg/L	mg/L
7/24/2018	Background	0.274	62.5	9.64	0.1 J	7.6	49.4	372
8/29/2018	Background	0.288	64.0	10.8	0.11	7.4	54.8	420
10/2/2018	Background	0.137	61.0	7.48	0.1 J	7.4	46.7	356
10/24/2018	Background	0.105	63.1	8.14	0.1 J	7.5	41.8	357
11/14/2018	Background	0.236	65.4	9.86	0.1 J	7.3	49.3	386
12/19/2018	Background	0.289	62.8	9.08	0.12	7.3	45.5	361
1/24/2019	Background	0.168	53.4	9.18	0.14	6.3	46.3	365
2/20/2019	Background	0.09 J	53.3	8.96	0.13	8.0	40.0	343
3/12/2019	Detection	0.09 J	51.2	9.40	0.16	7.5	41.7	306
11/11/2019	Detection	0.229	61.6	9.76	0.12	7.4	45.3	385
5/13/2020	Detection	0.105	52.6	9.93	0.13	7.6	34.6	353
10/29/2020	Detection	0.216	61.6	9.06	0.11	--	40.5	367
11/4/2020	Detection	0.244	62.4	8.84	0.12	7.3	41.5	385

Notes:
mg/L: milligrams per liter
SU: standard unit
<: Non-detect value. Parameters which were not detected are shown as less than the method detection limit (MDL) followed by a 'U' flag.
J: Estimated value. Parameter was detected at concentration below the reporting limit
- -: Not analyzed

Table 1 - Groundwater Data Summary: MW-1801A
Amos - FAP
Appendix IV Constituents

Collection Date	Monitoring Program	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Combined Radium	Fluoride	Lead	Lithium	Mercury	Molybdenum	Selenium	Thallium
		μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	pCi/L	mg/L	μg/L	mg/L	μg/L	μg/L	μg/L	μg/L
7/24/2018	Background	0.13	0.36	54.4	< 0.004 U	0.01 J	0.113	0.194	0.602	0.1 J	0.042	0.009	< 0.002 U	4.97	0.09 J	0.04 J
8/29/2018	Background	0.05 J	0.57	56.5	< 0.004 U	< 0.005 U	0.143	0.260	1.222	0.11	0.024	0.007	< 0.002 U	3.07	0.05 J	0.04 J
10/2/2018	Background	0.14	0.82	47.1	< 0.02 U	< 0.01 U	0.09 J	0.422	0.254	0.1 J	0.04 J	0.02 J	< 0.002 U	4.79	0.1 J	< 0.1 U
10/24/2018	Background	0.06 J	0.72	51.3	< 0.02 U	< 0.01 U	0.08 J	0.380	0.654	0.1 J	0.02 J	0.009 J	< 0.002 U	2.08	0.2 J	< 0.1 U
11/14/2018	Background	0.08 J	1.01	51.3	< 0.02 U	0.03 J	0.08 J	0.414	0.6902	0.1 J	0.05 J	< 0.009 U	< 0.002 U	2.34	0.1 J	< 0.1 U
12/19/2018	Background	0.04 J	1.11	56.0	< 0.02 U	0.02 J	0.1 J	0.349	0.836	0.12	0.03 J	0.01 J	< 0.002 U	2.77	0.09 J	< 0.1 U
1/24/2019	Background	0.06 J	1.57	55.3	< 0.02 U	< 0.01 U	0.07 J	0.326	0.595	0.14	< 0.02 U	< 0.009 U	< 0.002 U	2.22	0.1 J	< 0.1 U
2/20/2019	Background	0.09 J	1.52	56.6	< 0.02 U	< 0.01 U	0.1 J	0.290	0.588	0.13	< 0.02 U	< 0.009 U	< 0.002 U	3.57	0.2 J	< 0.1 U

Notes:
μg/L: micrograms per liter
mg/L: milligrams per liter
<: Non-detect value. Parameters which were not detected are shown as less than the method detection limit (MDL) followed by a 'U' flag.
J: Estimated value. Parameter was detected at concentration below the reporting limit
- -: Not analyzed
pCi/L: picocuries per liter

Table 1 - Groundwater Data Summary: MW-1804A
Amos - FAP
Appendix III Constituents

Collection Date	Monitoring Program	Boron	Calcium	Chloride	Fluoride	pH	Sulfate	Total Dissolved Solids
		mg/L	mg/L	mg/L	mg/L	SU	mg/L	mg/L
7/27/2018	Background	0.672	28.1	--	--	--	--	--
8/1/2018	Background	--	--	3.87	0.70	7.4	35.2	423
8/28/2018	Background	0.779	15.9	5.27	0.84	8.3	44.7	452
10/2/2018	Background	0.629	38.8	3.63	0.61	7.9	35.7	458
10/23/2018	Background	0.675	12.9	4.79	0.78	7.6	36.9	452
11/13/2018	Background	0.846	8.90	5.32	0.91	7.8	46.0	498
12/19/2018	Background	0.772	10.1	4.51	0.78	7.9	40.1	433
1/24/2019	Background	0.673	12.1	3.14	0.71	7.4	32.3	414
2/21/2019	Background	0.611	7.43	3.29	0.89	8.0	33.8	461
3/12/2019	Detection	0.568	10.2	3.55	0.85	7.9	34.0	411
11/11/2019	Detection	0.730	6.77	11.2	0.64	8.0	85.4	582
2/12/2020	Detection	--	--	9.59	--	7.8	69.0	--
5/14/2020	Detection	0.739	4.51	6.20	0.85	8.1	51.4	484
11/3/2020	Detection	0.549	4.70	7.12	0.86	8.0	57.0	517

Notes:
mg/L: milligrams per liter
SU: standard unit
<: Non-detect value. Parameters which were not detected are shown as less than the method detection limit (MDL) followed by a 'U' flag.
J: Estimated value. Parameter was detected at concentration below the reporting limit
- -: Not analyzed

Table 1 - Groundwater Data Summary: MW-1804A
Amos - FAP
Appendix IV Constituents

Collection Date	Monitoring Program	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Combined Radium	Fluoride	Lead	Lithium	Mercury	Molybdenum	Selenium	Thallium
		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	pCi/L	mg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L
7/27/2018	Background	0.54	2.48	245	0.008 J	< 0.005 U	0.185	0.458	1.814	--	0.445	0.018	< 0.002 U	136	1.8	0.069
8/1/2018	Background	--	--	--	--	--	--	--	--	0.70	--	--	--	--	--	--
8/28/2018	Background	0.15	3.59	204	< 0.004 U	< 0.005 U	0.304	0.314	1.559	0.84	0.031	0.015	< 0.002 U	136	0.2	0.05 J
10/2/2018	Background	0.53	2.35	390	< 0.02 U	< 0.01 U	0.1 J	0.693	1.664	0.61	0.05 J	0.032	< 0.002 U	111	3.1	< 0.1 U
10/23/2018	Background	0.18	3.36	131	< 0.02 U	< 0.01 U	0.1 J	0.137	0.444	0.78	0.114	0.01 J	< 0.002 U	116	0.7	< 0.1 U
11/13/2018	Background	0.09 J	4.16	135	< 0.02 U	< 0.01 U	0.2 J	0.160	0.523	0.91	0.133	0.02 J	< 0.002 U	129	0.2	< 0.1 U
12/19/2018	Background	0.13	4.00	169	< 0.02 U	< 0.01 U	0.1 J	0.176	1.089	0.78	0.111	0.01 J	< 0.002 U	130	0.5	< 0.1 U
1/24/2019	Background	0.30	3.32	183	< 0.02 U	< 0.01 U	0.2 J	0.137	1.424	0.71	0.140	< 0.009 U	< 0.002 U	110	1.7	< 0.1 U
2/21/2019	Background	0.19	4.48	116	< 0.02 U	< 0.01 U	0.2 J	0.096	0.894	0.89	0.219	< 0.009 U	< 0.002 U	115	0.6	< 0.1 U

Notes:
µg/L: micrograms per liter
mg/L: milligrams per liter
<: Non-detect value. Parameters which were not detected are shown as less than the method detection limit (MDL) followed by a 'U' flag.
J: Estimated value. Parameter was detected at concentration below the reporting limit
- -: Not analyzed
pCi/L: picocuries per liter

Table 1 - Groundwater Data Summary: MW-1806A
Amos - FAP
Appendix III Constituents

Collection Date	Monitoring Program	Boron	Calcium	Chloride	Fluoride	pH	Sulfate	Total Dissolved Solids
		mg/L	mg/L	mg/L	mg/L	SU	mg/L	mg/L
7/27/2018	Background	0.164	12.9	--	--	--	--	--
8/1/2018	Background	--	--	17.7	0.56	7.6	48.4	426
8/29/2018	Background	0.162	12.0	16.2	0.55	8.0	45.6	445
10/2/2018	Background	0.150	5.81	7.21	0.80	8.5	36.2	435
10/23/2018	Background	0.158	7.43	8.62	0.77	8.4	40.8	423
11/13/2018	Background	0.213	7.51	8.15	0.85	8.1	40.1	442
12/19/2018	Background	0.162	5.14	5.29	0.85	8.5	30.9	409
1/24/2019	Background	0.168	12.2	11.7	0.59	8.1	48.1	445
2/18/2019	Background	0.133	5.67	6.24	0.81	8.6	33.0	460
3/12/2019	Detection	0.130	4.98	5.51	0.83	8.8	32.9	430
11/12/2019	Detection	0.156	13.5	11.1	0.48	7.9	42.8	423
5/15/2020	Detection	0.127	2.32	8.45	0.86	8.8	35.2	456
10/29/2020	Detection	0.153	7.38	10.2	0.85	8.7	49.7	480

Notes:
mg/L: milligrams per liter
SU: standard unit
<: Non-detect value. Parameters which were not detected are shown as less than the method detection limit (MDL) followed by a 'U' flag.
J: Estimated value. Parameter was detected at concentration below the reporting limit
- -: Not analyzed

Geosyntec Consultants, Inc.

Table 1 - Groundwater Data Summary: MW-1806A
Amos - FAP
Appendix IV Constituents

Collection Date	Monitoring Program	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Combined Radium	Fluoride	Lead	Lithium	Mercury	Molybdenum	Selenium	Thallium
		μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	pCi/L	mg/L	μg/L	mg/L	μg/L	μg/L	μg/L	μg/L
7/27/2018	Background	1.16	2.65	163	0.01 J	0.01 J	0.416	0.240	0.998	--	0.368	0.012	< 0.002 U	17.0	0.1	0.03 J
8/1/2018	Background	--	--	--	--	--	--	--	--	0.56	--	--	--	--	--	--
8/29/2018	Background	0.89	3.29	148	< 0.004 U	0.008 J	1.54	0.161	1.533	0.55	0.154	0.010	< 0.002 U	14.2	0.09 J	0.02 J
10/2/2018	Background	0.28	5.30	65.4	< 0.02 U	< 0.01 U	0.1 J	0.080	0.9	0.80	0.158	0.02 J	< 0.002 U	7.73	0.07 J	< 0.1 U
10/23/2018	Background	0.19	5.16	88.3	< 0.02 U	< 0.01 U	0.252	0.152	0.469	0.77	0.195	0.02 J	< 0.002 U	6.66	0.07 J	< 0.1 U
11/13/2018	Background	0.11	5.91	98.7	< 0.02 U	< 0.01 U	0.1 J	0.163	0.3442	0.85	0.137	< 0.009 U	< 0.002 U	7.44	0.05 J	< 0.1 U
12/19/2018	Background	0.17	5.65	65.6	< 0.02 U	< 0.01 U	0.1 J	0.071	0.8606	0.85	0.122	< 0.009 U	< 0.002 U	6.02	0.06 J	< 0.1 U
1/24/2019	Background	0.15	3.97	168	< 0.02 U	< 0.01 U	0.08 J	0.159	1.164	0.59	0.06 J	0.02 J	< 0.002 U	5.62	0.04 J	< 0.1 U
2/18/2019	Background	0.1 J	4.21	78.8	< 0.02 U	< 0.01 U	0.2 J	0.050	0.419	0.81	0.110	0.01 J	< 0.002 U	4.74	0.03 J	< 0.1 U

Notes:
μg/L: micrograms per liter
mg/L: milligrams per liter
<: Non-detect value. Parameters which were not detected are shown as less than the method detection limit (MDL) followed by a 'U' flag.
J: Estimated value. Parameter was detected at concentration below the reporting limit
- -: Not analyzed
pCi/L: picocuries per liter

Table 1 - Groundwater Data Summary: MW-1807A
Amos - FAP
Appendix III Constituents

Collection Date	Monitoring Program	Boron	Calcium	Chloride	Fluoride	pH	Sulfate	Total Dissolved Solids
		mg/L	mg/L	mg/L	mg/L	SU	mg/L	mg/L
7/26/2018	Background	0.170	146	9.57	0.21	7.5	334	929
8/28/2018	Background	0.137	136	11.8	0.21	6.9	356	953
10/4/2018	Background	0.129	166	12.5	0.16	6.7	367	985
10/24/2018	Background	0.199	144	10.3	0.20	6.9	308	838
11/14/2018	Background	0.175	155	10.5	0.21	6.8	326	904
12/20/2018	Background	0.208	151	9.68	0.19	7.2	315	931
1/25/2019	Background	0.183	156	11.3	0.15	8.2	361	876
2/21/2019	Background	0.08 J	150	12.0	0.14	7.2	396	1,050
3/14/2019	Detection	0.09 J	160	11.1	0.15	6.7	363	1,020
11/11/2019	Detection	0.074	173	11.9	0.13	6.9	392	1,070
5/12/2020	Detection	0.088	159	10.8	0.12	6.7	358	1,040
10/28/2020	Detection	0.069	170	12.4	0.13	7.0	392	1,020

Notes:
mg/L: milligrams per liter
SU: standard unit
<: Non-detect value. Parameters which were not detected are shown as less than the method detection limit (MDL) followed by a 'U' flag.
J: Estimated value. Parameter was detected at concentration below the reporting limit
- -: Not analyzed

Table 1 - Groundwater Data Summary: MW-1807A
Amos - FAP
Appendix IV Constituents

Collection Date	Monitoring Program	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Combined Radium	Fluoride	Lead	Lithium	Mercury	Molybdenum	Selenium	Thallium
		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	pCi/L	mg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L
7/26/2018	Background	0.13	0.99	32.6	0.006 J	0.02	0.098	0.629	1.366	0.21	0.046	0.020	< 0.002 U	1.65	0.3	0.03 J
8/28/2018	Background	0.87	1.13	32.6	0.005 J	0.06	0.253	0.565	1.507	0.21	0.300	0.018	0.002 J	9.07	0.6	0.054
10/4/2018	Background	0.14	1.10	30.1	< 0.02 U	0.05 J	0.205	0.918	1.127	0.16	0.142	< 0.009 U	< 0.002 U	11.1	0.2 J	< 0.1 U
10/24/2018	Background	0.18	0.84	27.8	< 0.02 U	0.03 J	0.2 J	0.579	0.38891	0.20	0.105	0.02 J	< 0.002 U	2 J	0.2 J	< 0.1 U
11/14/2018	Background	0.17	0.96	28.8	< 0.02 U	0.03 J	0.09 J	0.614	0.985	0.21	0.09 J	0.01 J	< 0.002 U	2 J	0.2	< 0.1 U
12/20/2018	Background	0.17	0.94	29.5	< 0.02 U	0.03 J	0.403	0.616	1.016	0.19	0.251	0.02 J	< 0.002 U	1 J	0.3	< 0.1 U
1/25/2019	Background	0.12	0.92	27.4	< 0.02 U	0.03 J	0.1 J	0.733	1.269	0.15	0.126	0.030	< 0.002 U	1 J	0.1 J	< 0.1 U
2/21/2019	Background	0.08 J	0.82	24.1	< 0.02 U	0.03 J	0.1 J	0.811	0.735	0.14	0.118	0.01 J	< 0.002 U	0.6 J	0.1 J	< 0.1 U

Notes:
µg/L: micrograms per liter
mg/L: milligrams per liter
<: Non-detect value. Parameters which were not detected are shown as less than the method detection limit (MDL) followed by a 'U' flag.
J: Estimated value. Parameter was detected at concentration below the reporting limit
- -: Not analyzed
pCi/L: picocuries per liter

Table 1 - Groundwater Data Summary: MW-1807B
Amos - FAP
Appendix III Constituents

Collection Date	Monitoring Program	Boron	Calcium	Chloride	Fluoride	pH	Sulfate	Total Dissolved Solids
		mg/L	mg/L	mg/L	mg/L	SU	mg/L	mg/L
7/26/2018	Background	0.195	8.76	8.46	0.75	8.3	218	732
8/28/2018	Background	0.178	8.39	10.8	1.13	8.1	219	706
10/5/2018	Background	0.201	9.21	9.94	1.01	7.9	219	752
10/24/2018	Background	0.176	8.92	7.93	0.81	8.3	220	735
11/14/2018	Background	0.211	8.87	8.52	0.91	7.7	230	732
12/20/2018	Background	0.164	11.6	9.88	1.16	8.2	230	738
1/25/2019	Background	0.277	9.33	7.68	0.79	6.9	227	742
2/21/2019	Background	0.168	11.0	9.53	1.06	8.4	238	791
3/14/2019	Detection	0.163	12.7	10.8	1.19	7.9	249	793
11/11/2019	Detection	0.189	12.7	13.3	1.40	8.0	247	807
5/13/2020	Detection	0.170	8.70	10.5	1.13	7.7	224	783
11/3/2020	Detection	0.079	168	10.9	0.18	6.7	343	1,020

Notes:
mg/L: milligrams per liter
SU: standard unit
<: Non-detect value. Parameters which were not detected are shown as less than the method detection limit (MDL) followed by a 'U' flag.
J: Estimated value. Parameter was detected at concentration below the reporting limit
- -: Not analyzed

Table 1 - Groundwater Data Summary: MW-1807B
Amos - FAP
Appendix IV Constituents

Collection Date	Monitoring Program	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Combined Radium	Fluoride	Lead	Lithium	Mercury	Molybdenum	Selenium	Thallium
		μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	pCi/L	mg/L	μg/L	mg/L	μg/L	μg/L	μg/L	μg/L
7/26/2018	Background	0.27	1.93	49.6	0.049	0.01 J	1.40	0.525	0.719	0.75	0.756	0.021	< 0.002 U	4.22	0.3	0.03 J
8/28/2018	Background	0.23	1.94	56.3	< 0.004 U	< 0.005 U	0.134	0.046	1.31	1.13	0.035	0.010	< 0.002 U	23.9	0.08 J	0.01 J
10/5/2018	Background	0.15	1.70	59.6	0.03 J	< 0.01 U	0.263	0.179	2.079	1.01	0.310	< 0.009 U	< 0.002 U	12.5	0.2 J	< 0.1 U
10/24/2018	Background	0.25	1.26	42.3	< 0.02 U	< 0.01 U	0.381	0.139	0.305	0.81	0.203	0.02 J	< 0.002 U	5.59	0.07 J	< 0.1 U
11/14/2018	Background	0.16	1.28	41.4	< 0.02 U	< 0.01 U	0.247	0.073	0.348	0.91	0.08 J	0.02 J	< 0.002 U	5.62	0.05 J	< 0.1 U
12/20/2018	Background	0.43	1.75	73.7	< 0.02 U	< 0.01 U	0.335	0.114	0.2672	1.16	0.145	0.02 J	< 0.002 U	13.5	0.1 J	< 0.1 U
1/25/2019	Background	0.09 J	1.23	43.0	< 0.02 U	< 0.01 U	0.08 J	0.05 J	1.003	0.79	0.04 J	0.02 J	< 0.002 U	4.21	0.06 J	< 0.1 U
2/21/2019	Background	0.35	1.48	66.9	< 0.02 U	< 0.01 U	0.1 J	0.051	0.291	1.06	0.04 J	< 0.009 U	< 0.002 U	9.27	0.08 J	< 0.1 U

Notes:
μg/L: micrograms per liter
mg/L: milligrams per liter
<: Non-detect value. Parameters which were not detected are shown as less than the method detection limit (MDL) followed by a 'U' flag.
J: Estimated value. Parameter was detected at concentration below the reporting limit
- -: Not analyzed
pCi/L: picocuries per liter

Table 1 - Groundwater Data Summary: MW-1808A
Amos - FAP
Appendix III Constituents

Collection Date	Monitoring Program	Boron	Calcium	Chloride	Fluoride	pH	Sulfate	Total Dissolved Solids
		mg/L	mg/L	mg/L	mg/L	SU	mg/L	mg/L
7/25/2018	Background	0.182	40.4	19.6	0.52	7.7	184	734
8/28/2018	Background	0.142	38.5	19.4	0.57	7.6	227	740
10/4/2018	Background	0.135	38.6	16.7	0.41	7.4	216	790
10/24/2018	Background	0.103	41.5	17.1	0.55	7.7	126	614
11/13/2018	Background	0.152	40.2	18.4	0.51	7.4	210	770
12/20/2018	Background	0.172	40.3	21.6	0.47	7.6	242	834
1/25/2019	Background	0.173	47.4	18.3	0.40	6.1	231	840
2/21/2019	Background	0.122	39.4	17.4	0.40	7.2	213	821
3/14/2019	Detection	0.112	62.9	20.9	0.33	7.7	290	912
11/11/2019	Detection	0.131	29.3	17.1	0.45	7.6	235	887
5/13/2020	Detection	0.124	69.6	23.3	0.29	7.0	321	1,010
11/3/2020	Detection	0.119	54.3	25.6	0.44	7.2	300	1,050

Notes:
mg/L: milligrams per liter
SU: standard unit
<: Non-detect value. Parameters which were not detected are shown as less than the method detection limit (MDL) followed by a 'U' flag.
J: Estimated value. Parameter was detected at concentration below the reporting limit
- -: Not analyzed

Table 1 - Groundwater Data Summary: MW-1808A
Amos - FAP
Appendix IV Constituents

Collection Date	Monitoring Program	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Combined Radium	Fluoride	Lead	Lithium	Mercury	Molybdenum	Selenium	Thallium
		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	pCi/L	mg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L
7/25/2018	Background	0.29	2.47	86.2	0.299	0.007 J	0.831	0.544	1.892	0.52	2.28	0.024	0.006	6.46	0.5	0.04 J
8/28/2018	Background	0.14	5.34	105	0.251	0.01 J	1.25	0.821	4.96	0.57	2.06	0.025	0.005 J	11.7	0.4	0.083
10/4/2018	Background	0.14	2.84	78.1	0.05 J	< 0.01 U	0.500	0.231	2.082	0.41	0.392	< 0.009 U	< 0.002 U	4.56	0.07 J	< 0.1 U
10/24/2018	Background	0.03 J	1.86	86.2	0.05 J	< 0.01 U	0.443	0.117	1.04	0.55	0.397	0.02 J	< 0.002 U	3.06	0.07 J	< 0.1 U
11/13/2018	Background	0.04 J	3.83	74.1	0.03 J	< 0.01 U	0.381	0.160	0.47	0.51	0.245	0.02 J	0.002 J	2.75	0.05 J	< 0.1 U
12/20/2018	Background	0.05 J	4.37	71.0	0.04 J	< 0.01 U	0.293	0.119	1.048	0.47	0.227	0.03 J	0.003 J	2 J	0.08 J	< 0.1 U
1/25/2019	Background	0.06 J	2.27	80.3	0.102	< 0.01 U	0.415	0.149	2.76	0.40	0.717	0.035	< 0.002 U	1 J	0.2 J	< 0.1 U
2/21/2019	Background	0.02 J	1.99	78.9	0.05 J	< 0.01 U	0.213	0.076	0.535	0.40	0.316	0.01 J	< 0.002 U	1 J	0.09 J	< 0.1 U

Notes:
µg/L: micrograms per liter
mg/L: milligrams per liter
<: Non-detect value. Parameters which were not detected are shown as less than the method detection limit (MDL) followed by a 'U' flag.
J: Estimated value. Parameter was detected at concentration below the reporting limit
- -: Not analyzed
pCi/L: picocuries per liter

Table 1 - Groundwater Data Summary: MW-1809
Amos - FAP
Appendix III Constituents

Collection Date	Monitoring Program	Boron	Calcium	Chloride	Fluoride	pH	Sulfate	Total Dissolved Solids
		mg/L	mg/L	mg/L	mg/L	SU	mg/L	mg/L
7/26/2018	Background	0.085	173	26.1	0.16	7.2	386	1,020
8/28/2018	Background	0.091	179	28.8	0.17	7.1	386	1,020
10/3/2018	Background	0.09 J	191	26.8	0.14	7.1	388	1,070
10/23/2018	Background	0.114	181	26.6	0.14	7.1	390	1,050
11/14/2018	Background	0.09 J	188	28.4	0.16	7.2	403	1,050
12/19/2018	Background	0.06 J	182	27.7	0.15	7.0	384	1,040
1/25/2019	Background	0.08 J	188	28.1	0.14	5.1	390	1,080
2/22/2019	Background	0.08 J	184	30.2	0.14	7.2	403	1,080
3/12/2019	Detection	0.05 J	189	31.0	0.14	7.2	396	1,090
11/8/2019	Detection	0.096	195	37.6	0.15	7.0	393	1,110
5/13/2020	Detection	0.081	179	34.9	0.11	7.3	400	1,100
11/5/2020	Detection	0.055	196	33.8	0.13	6.9	391	1,100

Notes:
mg/L: milligrams per liter
SU: standard unit
<: Non-detect value. Parameters which were not detected are shown as less than the method detection limit (MDL) followed by a 'U' flag.
J: Estimated value. Parameter was detected at concentration below the reporting limit
- -: Not analyzed

Table 1 - Groundwater Data Summary: MW-1809
Amos - FAP
Appendix IV Constituents

Collection Date	Monitoring Program	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Combined Radium	Fluoride	Lead	Lithium	Mercury	Molybdenum	Selenium	Thallium
		μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	pCi/L	mg/L	μg/L	mg/L	μg/L	μg/L	μg/L	μg/L
7/26/2018	Background	0.05	2.30	60.2	0.004 J	< 0.005 U	0.119	0.555	1.561	0.16	0.035	0.020	< 0.002 U	7.18	0.04 J	0.01 J
8/28/2018	Background	0.03 J	2.83	67.3	0.004 J	< 0.005 U	0.200	0.754	1.193	0.17	0.01 J	0.024	< 0.002 U	3.01	0.06 J	0.02 J
10/3/2018	Background	0.03 J	2.87	61.4	< 0.02 U	< 0.01 U	0.1 J	0.533	4.22	0.14	< 0.02 U	< 0.009 U	< 0.002 U	2.27	0.05 J	< 0.1 U
10/23/2018	Background	< 0.02 U	2.59	53.0	< 0.02 U	< 0.01 U	0.09 J	0.424	1.501	0.14	< 0.02 U	0.043	< 0.002 U	2 J	0.03 J	< 0.1 U
11/14/2018	Background	< 0.02 U	3.10	58.0	< 0.02 U	< 0.01 U	0.08 J	0.447	1.717	0.16	< 0.02 U	0.01 J	< 0.002 U	2 J	< 0.03 U	< 0.1 U
12/19/2018	Background	< 0.02 U	3.51	63.4	< 0.02 U	< 0.01 U	0.212	0.504	1.417	0.15	< 0.02 U	0.032	< 0.002 U	2.88	< 0.03 U	< 0.1 U
1/25/2019	Background	< 0.02 U	3.39	57.2	< 0.02 U	< 0.01 U	0.06 J	0.375	2.99	0.14	< 0.02 U	0.046	< 0.002 U	2 J	< 0.03 U	< 0.1 U
2/22/2019	Background	< 0.1 U	4.57	64.5	< 0.1 U	< 0.05 U	< 0.2 U	0.559	1.56	0.14	< 0.1 U	0.038	< 0.002 U	2 J	< 0.2 U	< 0.5 U

Notes:
μg/L: micrograms per liter
mg/L: milligrams per liter
<: Non-detect value. Parameters which were not detected are shown as less than the method detection limit (MDL) followed by a 'U' flag.
J: Estimated value. Parameter was detected at concentration below the reporting limit
- -: Not analyzed
pCi/L: picocuries per liter

Table 1 - Groundwater Data Summary: MW-1810
Amos - FAP
Appendix III Constituents

Collection Date	Monitoring Program	Boron	Calcium	Chloride	Fluoride	pH	Sulfate	Total Dissolved Solids
		mg/L	mg/L	mg/L	mg/L	SU	mg/L	mg/L
7/26/2018	Background	0.220	23.0	--	--	--	--	--
8/2/2018	Background	--	--	23.4	0.93	7.4	170	565
8/27/2018	Background	0.271	25.9	21.6	0.93	7.5	129	525
10/3/2018	Background	0.245	28.0	19.0	0.89	7.3	114	542
10/24/2018	Background	0.211	23.7	18.6	0.86	7.7	93.1	473
11/13/2018	Background	0.238	30.2	19.5	1.04	7.3	160	544
12/20/2018	Background	0.210	30.1	17.0	0.98	7.1	160	548
1/23/2019	Background	0.319	24.8	16.3	0.90	7.5	112	494
2/22/2019	Background	0.245	32.3	15.4	1.01	7.4	170	580
3/12/2019	Detection	0.228	30.5	15.4	1.00	7.3	153	548
11/8/2019	Detection	0.249	44.5	15.2	0.94	7.1	256	692
5/12/2020	Detection	0.226	67.5	17.2	0.78	7.4	379	993
11/3/2020	Detection	0.194	53.7	15.8	0.91	7.0	341	802

Notes:
mg/L: milligrams per liter
SU: standard unit
<: Non-detect value. Parameters which were not detected are shown as less than the method detection limit (MDL) followed by a 'U' flag.
J: Estimated value. Parameter was detected at concentration below the reporting limit
- -: Not analyzed

Table 1 - Groundwater Data Summary: MW-1810
Amos - FAP
Appendix IV Constituents

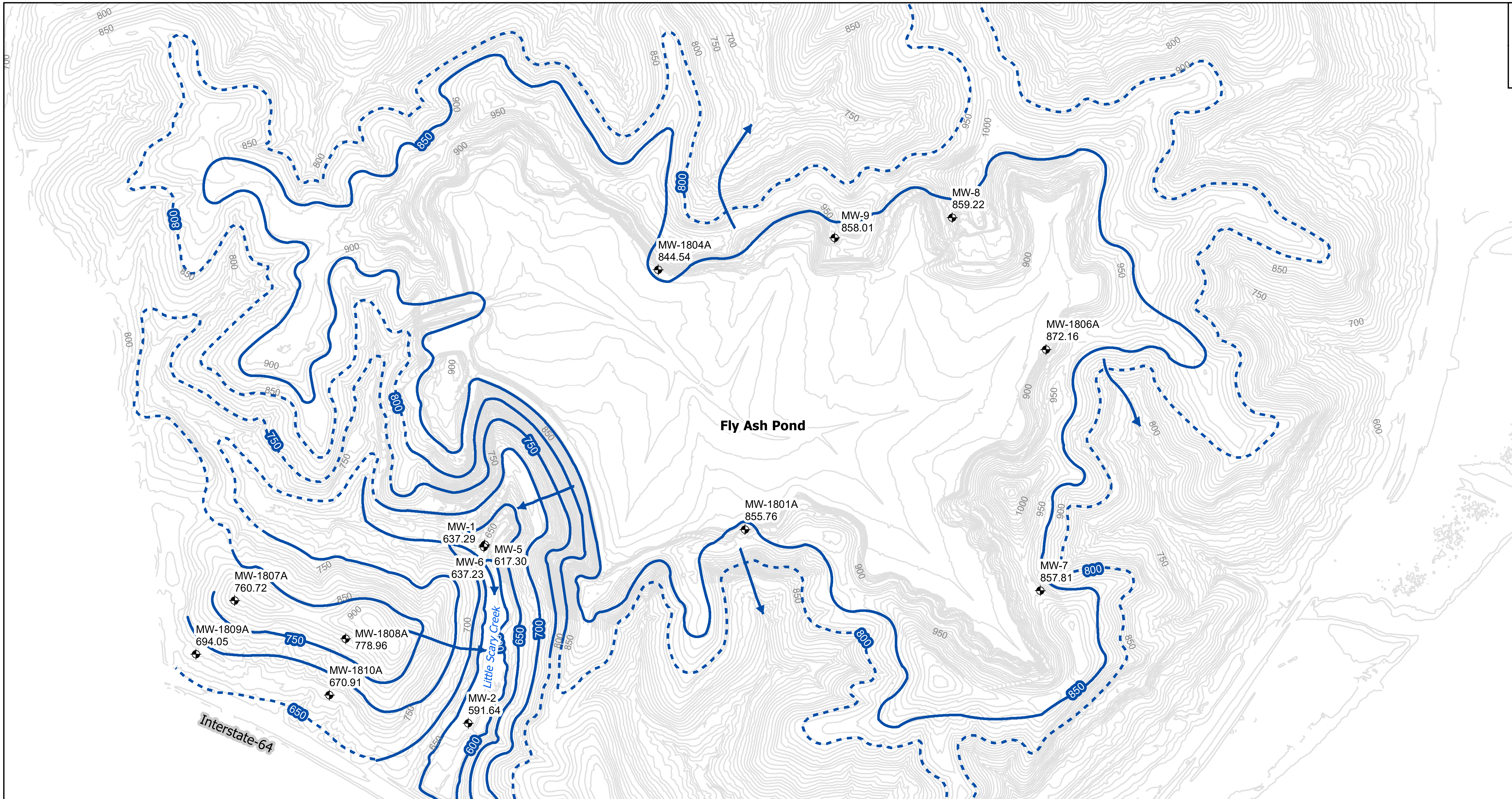
Collection Date	Monitoring Program	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Combined Radium	Fluoride	Lead	Lithium	Mercury	Molybdenum	Selenium	Thallium
		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	pCi/L	mg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L
7/26/2018	Background	0.13	0.88	124	0.009 J	< 0.005 U	0.442	0.150	0.382	--	0.149	0.018	< 0.002 U	9.26	0.06 J	0.051
8/2/2018	Background	--	--	--	--	--	--	--	--	0.93	--	--	--	--	--	--
8/27/2018	Background	0.10	0.51	83.4	< 0.004 U	< 0.005 U	0.229	0.048	0.842	0.93	0.057	0.015	< 0.002 U	8.52	0.04 J	0.02 J
10/3/2018	Background	0.11	0.49	83.0	< 0.02 U	< 0.01 U	0.2 J	0.03 J	1.218	0.89	0.09 J	< 0.009 U	< 0.002 U	7.06	0.05 J	< 0.1 U
10/24/2018	Background	0.07 J	0.54	88.5	< 0.02 U	< 0.01 U	0.1 J	0.02 J	0.992	0.86	0.03 J	0.02 J	< 0.002 U	6.28	0.04 J	< 0.1 U
11/13/2018	Background	0.09 J	0.40	83.5	< 0.02 U	< 0.01 U	0.1 J	0.02 J	0.24	1.04	0.04 J	< 0.009 U	< 0.002 U	6.03	0.03 J	< 0.1 U
12/20/2018	Background	0.08 J	0.43	87.9	< 0.02 U	< 0.01 U	0.1 J	0.03 J	0.5648	0.98	0.05 J	0.02 J	< 0.002 U	5.24	0.03 J	< 0.1 U
1/23/2019	Background	0.07 J	0.45	84.2	< 0.02 U	< 0.01 U	0.08 J	0.02 J	0.768	0.90	0.03 J	0.01 J	< 0.002 U	5.94	0.03 J	< 0.1 U
2/22/2019	Background	< 0.1 U	0.4 J	87.8	< 0.1 U	< 0.05 U	0.3 J	< 0.1 U	0.65	1.01	0.1 J	0.02 J	< 0.002 U	4 J	< 0.2 U	< 0.5 U

Notes:
µg/L: micrograms per liter
mg/L: milligrams per liter
<: Non-detect value. Parameters which were not detected are shown as less than the method detection limit (MDL) followed by a 'U' flag.
J: Estimated value. Parameter was detected at concentration below the reporting limit
- -: Not analyzed
pCi/L: picocuries per liter

Table 2: Residence Time Calculation Summary
Amos Fly Ash Pond

			2020-05		2020-10	
CCR Management Unit	Monitoring Well	Well Diameter (inches)	Groundwater Velocity (ft/year)	Groundwater Residence Time (days)	Groundwater Velocity (ft/year)	Groundwater Residence Time (days)
Fly Ash Pond	MW-1801A[1]	2.0	11.6	5.2	35.7	1.7
	MW-1804A[1]	2.0	14.5	4.2	26.8	2.3
	MW-1806A[1]	2.0	14.7	4.1	10.4	5.9
	MW-1807A[2]	2.0	11.9	5.1	6.9	8.9
	MW-1808A[2]	2.0	40.4	1.5	34.4	1.8
	MW-1809A[2]	2.0	9.9	6.1	14.1	4.3
	MW-1810A[2]	2.0	37.5	1.6	32.4	1.9
	MW-1 [1]	2.0	18.6	3.3	19.1	3.2
	MW-2 [1]	2.0	85.3	0.7	113.3	0.5
	MW-5 [1]	2.0	62.6	1.0	32.0	1.9
	MW-6 [1]	2.0	12.3	4.9	12.5	4.9
	MW-7 [1]	2.0	7.4	8.2	36.8	1.7
	MW-8 [1]	2.0	10.1	6.0	10.2	6.0
	MW-9 [1]	2.0	11.4	5.3	6.7	9.1

Notes:
[1] - Upgradient/Sidegradient Well
[2] - Downgradient Well



Legend

- Groundwater Monitoring Well
- Groundwater Flow Direction
- Groundwater Elevation Contour
- Groundwater Elevation Contour (Inferred)
- Fly Ash Pond

Notes

- Monitoring well coordinates and water level data (collected on May 7, 2020) provided by AEP.
- Potentiometric surface contour interval is 50 feet.
- Topography basemap from AEP Drawing No. 13-30705-0 (topographic contour interval: 10 feet).
- Site features based on information available in the Fly Ash Pond CCR Groundwater Monitoring Well Network Evaluation - Amos Plant report (Arcadis, 2019) provided by AEP.
- Groundwater elevation units are in feet above mean sea level.

700 350 0 700 Feet

Potentioetric Surface Map - Uppermost Aquifer
May 2020

AEP Amos Generating Plant - Fly Ash Pond
Winfield, West Virginia

Geosyntec consultants

Columbus, Ohio | 2020/09/10

Figure **2**

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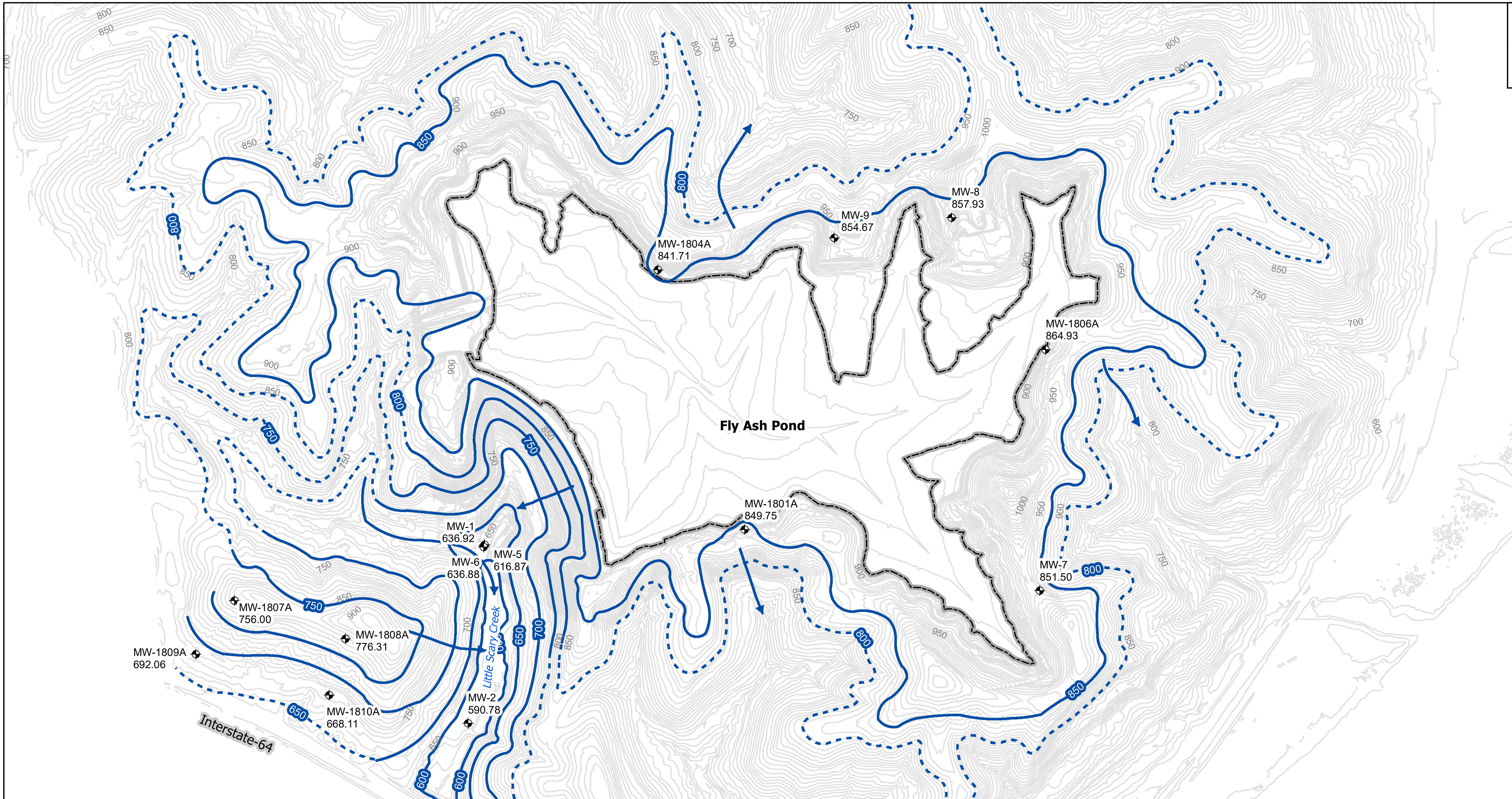

Legend

- Groundwater Monitoring Well
- Groundwater Flow Direction
- Groundwater Elevation Contour
- Groundwater Elevation Contour (Inferred)
- Fly Ash Pond

Notes

- Monitoring well coordinates and water level data (collected on October 26, 2020) provided by AEP.
- Potentiometric surface contour interval is 50 feet.
- Topography basemap from AEP Drawing No. 13-30705-0 (topographic contour interval: 10 feet).
- Site features based on information available in the Fly Ash Pond CCR Groundwater Monitoring Well Network Evaluation - Amos Plant report (Arcadis, 2019) provided by AEP.
- Groundwater elevation units are in feet above mean sea level.

700 350 0 700 Feet

Potentioetric Surface Map - Uppermost Aquifer
October 2020

AEP Amos Generating Plant - Fly Ash Pond
Winfield, West Virginia

Geosyntec consultants

Columbus, Ohio | 2021/01/28

Figure 3

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APPENDIX 2

The statistical analysis reports completed in 2020 follow.

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Memorandum

Date: April 6, 2020

To: David Miller (AEP)

Copies to: Ben Kepchar (AEP)

From: Allison Kreinberg (Geosyntec)

Subject: Evaluation of Detection Monitoring Data at Amos Plant's Fly Ash Pond (FAP)

In accordance with the United States Environmental Protection Agency's (USEPA's) regulations regarding the disposal of coal combustion residuals (CCR) in landfills and surface impoundments (40 CFR 257 Subpart D, "CCR rule"), the second semi-annual detection monitoring event of 2019 at the Fly Ash Pond (FAP), an existing CCR unit at the Amos Power Plant located in Winfield, West Virginia was completed on November 8-12, 2019. Based on the results, verification sampling was completed on February 11-12, 2020.

Eight background monitoring events were conducted at the Amos FAP prior to this detection monitoring event, and upper prediction limits (UPLs) were calculated for each Appendix III parameter to represent background values. Lower prediction limits (LPLs) were also calculated for pH. Details on the calculation of these background values are described in Geosyntec's *Statistical Analysis Summary* report, dated July 15, 2019 and revised on March 3, 2020.

To achieve an acceptably high statistical power while maintaining a site-wide false-positive rate (SWFPR) of 10% per year or less, prediction limits were calculated based on a one-of-two retesting procedure. With this procedure, a statistically significant increase (SSI) is concluded only if both samples in a series of two exceed the UPL (or are below the LPL for pH). In practice, if the initial result did not exceed the UPL, a second sample was not collected or analyzed.

Detection monitoring results and the relevant background values are compared in Table 1 and noted exceedances are described in the list below.

- Calcium concentrations exceeded the intrawell UPL of 7.79 mg/L in both the initial (21.0 mg/L) and second (11.3 mg/L) samples collected at MW-5. Therefore, an SSI over background is concluded for calcium at MW-5.

- Chloride concentrations exceeded the intrawell UPL of 6.93 mg/L in both the initial (11.2 mg/L) and second (9.59 mg/L) samples collected at MW-1804A. Therefore, an SSI over background is concluded for chloride at MW-1804A.

- Sulfate concentrations exceeded the intrawell UPL of 0.200 mg/L in both the initial (32.0 mg/L) and second (18.6 mg/L) samples collected at MW-5. Sulfate concentrations also exceeded the intrawell UPL of 53.9 mg/L in both the initial (85.4 mg/L) and second (69.0 mg/L) samples collected at MW-1804A. Therefore, SSIs over background are concluded for sulfate at MW-5 and MW-1804A.

In response to the exceedances noted above, the Amos FAP CCR unit will either transition to assessment monitoring or an alternative source demonstration (ASD) for calcium, chloride, and sulfate will be conducted in accordance with 40 CFR 257.94(e)(2). If the ASD is successful, the Amos FAP will remain in detection monitoring.

The statistical analysis was conducted within 90 days of completion of sampling and analysis in accordance with 40 CFR 257.93(h)(2). A certification of these statistics by a qualified professional engineer is provided in Attachment A.

Table 1: Detection Monitoring Data Evaluation
Amos Plant - Fly Ash Pond

Parameter	Unit	Description	MW-1	MW-2		MW-5		MW-6	MW-7		MW-8	MW-9	MW-1801A	MW-1804A		MW-1806A
			11/8/2019	11/12/2019	2/11/2020	11/8/2019	2/11/2020	11/8/2019	11/11/2019	2/11/2020	11/8/2019	11/8/2019	11/11/2019	11/11/2019	2/12/2020	11/12/2019
Boron	mg/L	Intrawell Background Value (UPL)	0.261	0.382		0.355		0.159	0.248		0.320	0.192	0.459	0.965		0.235
		Detection Monitoring Result	0.114	0.265	-	0.182	-	0.0790	0.0660	-	0.197	0.133	0.229	0.730	-	0.156
Calcium	mg/L	Intrawell Background Value (UPL)	3.58	4.66		7.79		70.6	1.63		3.06	1.63	75.4	51.2		18.8
		Detection Monitoring Result	2.38	**4.77**	4.31	**21.0**	**11.3**	56.6	**2.18**	1.39	1.98	1.02	61.6	6.77	-	13.5
Chloride	mg/L	Intrawell Background Value (UPL)	14.6	495		853		21.4	5.80		120	8.00	12.4	6.93		24.6
		Detection Monitoring Result	11.2	426	-	663	713	17.2	5.36	-	109	7.72	9.76	**11.2**	**9.59**	11.1
Fluoride	mg/L	Intrawell Background Value (UPL)	0.485	3.39		3.72		0.264	0.304		3.11	0.976	0.162	1.10		1.14
		Detection Monitoring Result	0.420	2.73	-	3.04	-	0.240	0.250	-	2.97	0.830	0.120	0.640	-	0.480
pH	SU	Intrawell Background Value (UPL)	8.8	8.9		8.4		7.3	9.3		9.8	11.4	8.8	8.8		9.3
		Intrawell Background Value (LPL)	7.7	8.0		7.8		6.3	8.0		7.0	6.1	5.9	6.8		7.2
		Detection Monitoring Result	8.2	8.5	-	8.0	-	6.9	8.7	-	8.3	8.8	7.4	8.0	-	7.9
Sulfate	mg/L	Intrawell Background Value (UPL)	55.9	26.7		0.200		48.0	33.6		36.5	36.2	61.2	53.9		61.4
		Detection Monitoring Result	33.7	20.1	-	**32.0**	**18.6**	41.7	32.3	-	22.5	19.1	45.3	**85.4**	**69.0**	42.8
Total Dissolved Solids	mg/L	Intrawell Background Value (UPL)	536	1410		1980		424	458		798	640	518	599		485
		Detection Monitoring Result	461	1340	-	1840	-	368	390	-	717	440	385	582	-	423

Notes:
UPL: Upper prediction limit
LPL: Lower prediction limit
Bold values exceed the background value.
Background values are shaded gray.
-: Not analyzed

ATTACHMENT A

Certification by Qualified Professional Engineer

CERTIFICATION BY QUALIFIED PROFESSIONAL ENGINEER

I certify that the selected statistical method, described above and in the July 15, 2019 *Statistical Analysis Summary* report (revised March 3, 2020), is appropriate for evaluating the groundwater monitoring data for the Amos FAP CCR management area and that the requirements of 40 CFR 257.93(f) have been met.

DAVID ANTHONY MILLER

Printed Name of Licensed Professional Engineer

David Anthony Miller

Signature

22663	WEST VIRGINIA	04.06.2020
License Number	Licensing State	Date

Geosyntec consultants

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Memorandum

Date: July 29, 2020

To: David Miller (AEP)

Copies to: Ben Kepchar (AEP)

From: Allison Kreinberg (Geosyntec)

Subject: Evaluation of Detection Monitoring Data at Amos Plant's Fly Ash Pond (FAP)

In accordance with the United States Environmental Protection Agency's (USEPA's) regulations regarding the disposal of coal combustion residuals (CCR) in landfills and surface impoundments (40 CFR 257 Subpart D, "CCR rule"), the first semi-annual detection monitoring event of 2020 at the Fly Ash Pond (FAP), an existing CCR unit at the Amos Power Plant located in Winfield, West Virginia, was completed on May 11-15, 2020. Based on the results, verification sampling was completed on July 7, 2020.

Eight background monitoring events were conducted at the Amos FAP prior to this detection monitoring event, and upper prediction limits (UPLs) were calculated for each Appendix III parameter to represent background values. Lower prediction limits (LPLs) were also calculated for pH. Details on the calculation of these background values are described in Geosyntec's *Statistical Analysis Summary* report, dated July 15, 2019 and revised on March 3, 2020.

To achieve an acceptably high statistical power while maintaining a site-wide false-positive rate (SWFPR) of 10% per year or less, prediction limits were calculated based on a one-of-two retesting procedure. With this procedure, a statistically significant increase (SSI) is concluded only if both samples in a series of two exceed the UPL (or are below the LPL for pH). In practice, if the initial result did not exceed the UPL, a second sample was not collected or analyzed.

Detection monitoring results and the relevant background values are compared in Table 1 and noted exceedances are described in the list below.

- Calcium concentrations exceeded the intrawell UPL of 7.79 mg/L in both the initial (9.85 mg/L) and second (8.77 mg/L) samples collected at MW-5. Therefore, an SSI over background is concluded for calcium at MW-5.

- Sulfate concentrations exceeded the intrawell UPL of 0.20 mg/L in both the initial (11.0 mg/L) and second (22.8 mg/L) samples collected at MW-5. Therefore, an SSI over background is concluded for sulfate at MW-5.

In response to the exceedances noted above, the Amos FAP CCR unit will either transition to assessment monitoring or an alternative source demonstration (ASD) for calcium and sulfate will be conducted in accordance with 40 CFR 257.94(e)(2). If the ASD is successful, the Amos FAP will remain in detection monitoring.

The statistical analysis was conducted within 90 days of completion of sampling and analysis in accordance with 40 CFR 257.93(h)(2). A certification of these statistics by a qualified professional engineer is provided in Attachment A.

Table 1: Detection Monitoring Data Evalation
Amos Plant - Fly Ash Pond

Parameter	Unit	Description	MW-1	MW-2	MW-5		MW-6	MW-7	MW-8	MW-9	MW-1801A	MW-1804A	MW-1806A
			5/13/2020	5/12/2020	5/11/2020	7/7/2020	5/11/2020	5/11/2020	5/12/2020	5/13/2020	5/13/2020	5/14/2020	5/15/2020
Boron	mg/L	Intrawell Background Value (UPL)	0.261	0.382	0.355		0.159	0.248	0.32	0.192	0.459	0.965	0.235
		Detection Monitoring Result	0.122	0.214	0.211	--	0.088	0.067	0.191	0.122	0.086	0.739	0.127
Calcium	mg/L	Intrawell Background Value (UPL)	3.58	4.66	7.79		70.6	1.63	3.06	1.63	75.4	51.2	18.8
		Detection Monitoring Result	2.74	4.35	**9.85**	**8.77**	55.8	1.59	1.89	0.959	52.8	4.51	2.32
Chloride	mg/L	Intrawell Background Value (UPL)	14.6	495	853		21.4	5.80	120	8.00	12.4	6.93	24.6
		Detection Monitoring Result	11.2	443	746	--	15.9	5.30	109	7.27	10.3	6.20	8.45
Fluoride	mg/L	Intrawell Background Value (UPL)	0.485	3.39	3.72		0.264	0.304	3.11	0.976	0.162	1.1	1.14
		Detection Monitoring Result	0.42	2.91	2.97	--	0.25	0.27	2.74	0.82	0.15	0.85	0.86
pH	SU	Intrawell Background Value (UPL)	8.8	9.0	8.4		7.3	9.3	9.8	11.4	8.8	8.8	9.3
		Intrawell Background Value (LPL)	7.7	8.0	7.8		6.3	8.0	7.0	6.1	5.9	6.8	7.2
		Detection Monitoring Result	8.2	8.6	7.9	--	7.0	8.4	7.3	9.0	7.6	8.1	8.8
Total Dissolved Solids	mg/L	Intrawell Background Value (UPL)	536	1410	1980		424	458	798	640	518	599	485
		Detection Monitoring Result	457	1340	1820	--	416	395	715	459	365	484	456
Sulfate	mg/L	Intrawell Background Value (UPL)	55.9	26.7	0.20		48	33.6	36.5	36.2	61.2	53.9	61.4
		Detection Monitoring Result	33.6	6.0	**11.0**	**22.8**	32.6	23.6	20.1	12.0	34.4	51.4	35.2

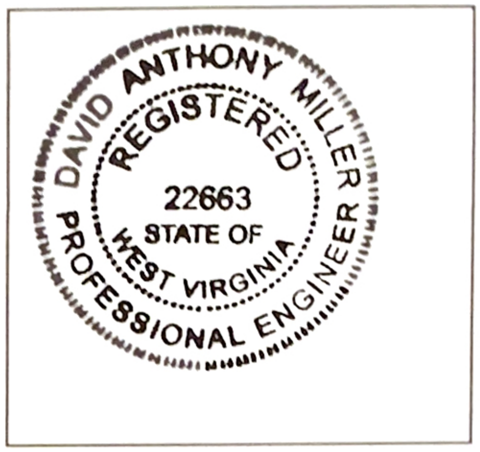
Notes:
UPL: Upper prediction limit
LPL: Lower prediction limit
Bold values exceed the background value.
Background values are shaded gray.

ATTACHMENT A

Certification by a Qualified Professional Engineer

CERTIFICATION BY QUALIFIED PROFESSIONAL ENGINEER

I certify that the selected statistical method, described above and in the July 15, 2019 *Statistical Analysis Summary* report (revised March 3, 2020), is appropriate for evaluating the groundwater monitoring data for the Amos FAP CCR management area and that the requirements of 40 CFR 257.93(f) have been met.



DAVID ANTHONY MILLER

Printed Name of Licensed Professional Engineer

David Anthony Miller

Signature

22663

License Number

WEST VIRGINIA

Licensing State

08.03.2020

Date

APPENDIX 3

The alternative source demonstrations completed in 2020 follow.

Addendum Report to Alternative Source Demonstration Report for Calcium and Sulfate

John E. Amos Plant Fly Ash Pond
Winfield, West Virginia

Prepared for:

American Electric Power

Prepared by:

EHS Support LLC and EnviroProbe Integrated Solutions, Inc.

November 2020

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Acronyms

amsl	above mean sea level
ASD	alternative source demonstration
bgs	below ground surface
Ca	calcium
CCR	Coal Combustion Residual
CFR	Code of Federal Regulations
EPRI	Electric Power Research Institute
ft	feet
JAFAP	John E. Amos Plant Fly Ash Pond
Mg	manganese
mg/L	milligrams per liter
MSL	mean sea level
NaCl	sodium chloride
$Na\text{-}HC0_3$	sodium bicarbonate
SRF	stress relief fracturing
SSI	statistically significant increases
TDS	total dissolved solids
USEPA	United States Environmental Protection Agency

Certification by Qualified Professional Engineer

I certify that the alternative source demonstration (ASD) conducted and presented within this addendum report is appropriate for evaluating the groundwater monitoring data for the John E. Amos Plant Fly Ash Pond Coal Combustion Residual (CCR) management area associated with the John E. Amos Plant Power Plant located in Winfield. West Virginia. This ASD meets the requirements of the United States Environmental Protection Agency CCR Rule defined at 40 Code of Federal Regulations 257.94(e)(2).

Roderic E. Moore
Printed Name of Licensed Professional Engineer

Signature

RODERIC E. MOORE
REGISTERED
16390
STATE OF
WEST VIRGINIA
PROFESSIONAL ENGINEER

16390	West Virginia	November 2, 2020
License Number	Licensing State	Date

1 Introduction

EHS Support LLC ("EHS Support") was retained by Appalachian Power Company, doing business as American Electric Power ("AEP") to conduct a second alternative source demonstration (ASD) investigation for coal combustion residual (CCR) constituents at the John E. Amos Plant Fly Ash Pond (JAFAP) located in Putnam County, Winfield, West Virginia (**Appendix A**). An initial ASD investigation was completed on 2019 detection monitoring data and reported in *Alternative Source Demonstration Report for Calcium, Chloride, and Sulfate John E. Amos Plant Fly Ash Pond, Winfield, West Virginia* dated June 2020 (EHS Support, 2020). This ASD investigation has been prepared as an addendum to the initial investigation.

EHS Support has teamed with EnviroProbe Integrated Solutions, Inc. of Nitro, West Virginia to complete this ASD investigation addendum per the requirements of the United States Environmental Protection Agency (USEPA) CCR Rule (40 Code of Federal Regulations [CFR] 257.94).

1.1 Objectives

The objective for this ASD investigation addendum is to assess groundwater monitoring data collected in compliance with the CCR Rule as allowed under paragraph 40 CFR 257.94(e)(2) of the CCR Rule. This part of the rule allows AEP to determine whether the source(s) for statistically significant increases (SSIs) reported from groundwater monitoring are associated with the CCR unit, or if the SSIs resulted from an error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality. The focus of this JAFAP ASD investigation addendum is specifically on calcium and sulfate, the constituents which demonstrated SSIs at monitoring well MW-5 during the May 2020 detection monitoring event and subsequent July 2020 confirmation sampling event.

1.2 Lines of Evidence

This ASD investigation addendum for the JAFAP has been conducted to evaluate potential alternate sources or reasons for the SSIs of calcium and sulfate in MW-5. A potential alternate source is evident, when based on the following lines of evidence:

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

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

- 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.
- Constituent 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 sulfate is a primary indicator for coal ash leachate (Electric Power Research Institute [EPRI], 2012) it has been evaluated in this ASD investigation addendum. Calcium is one other potential indicator that was evaluated in this ASD investigation addendum. Calcium is considered to only have a potential direct association with fly ash leachate and has abundant natural sources in the Site vicinity, specifically significant thicknesses of various limestone formations (EPRI 2017).

2 Project Background

Details about the site location and history, geology, groundwater geochemistry, and monitoring well network details are provided in the *Alternative Source Demonstration Report for Calcium, Chloride, and Sulfate John E. Amos Plant Fly Ash Pond, Winfield, West Virginia* dated June 2020 (EHS Support, 2020). Pertinent details to this ASD investigation addendum are summarized as follows.

Appalachian Plateau groundwater geochemistry, including the JAFAP site area in West Virginia, is established through several regional studies (Piper, 1933, Trap and Horn, 1997; Warner et al., 2012; Siegel et al., 2015). Groundwater recharge generally occurs on hill tops and circulates along hill slopes to shallow depths in Appalachian Plateau sedimentary bedrock aquifers. Saline (connate) water is frequently encountered beneath a thin (a few feet [ft]) transitional mixing zone with the overlying "fresh" (low total dissolved solids [TDS]) water (Trap and Horn, 1997; Siegel et al., 2015). The chemistry of groundwater in recharge areas on hilltops is characterized by low TDS calcium bicarbonate ($Ca-HCO_3$-type) water, that evolves to low TDS sodium bicarbonate ($Na-HCO_3$-type) groundwater as groundwater percolates down slopes owing to calcium (Ca) and manganese (Mg) ion exchange with sodium (Na) in Na-bearing clay minerals. Saline sodium chloride (NaCl-type) high TDS waters are naturally occurring connate brines that are found in "restricted flow zones" where recharge waters do not flush the host lithology (Siegel et al., 2015). The NaCl-type water is further characterized by low to non-detectable sulfate, due to reducing conditions that promote sulfide as the predominant sulfur species. The compositional evolution of these water types is shown on a Piper plot in **Figure 2-1** taken from Siegel et al., (2015)**.**

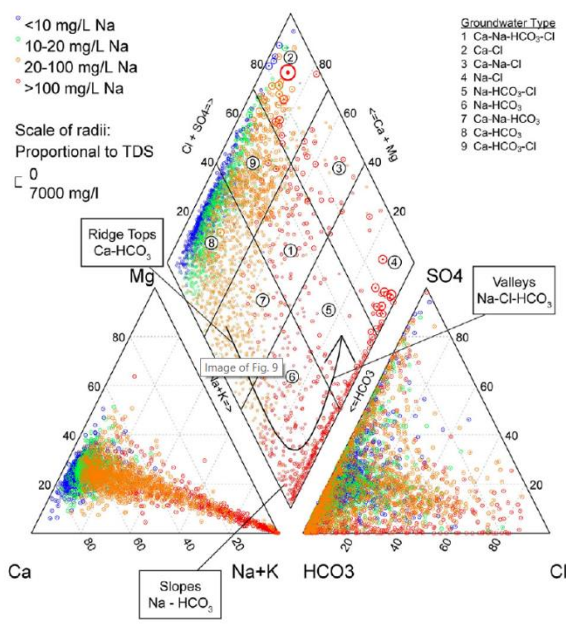


Figure 2-1 Generalized Groundwater Major Ion Chemistry within the Appalachian Plateau

(Siegel et al., 2015).

Regionally throughout the Appalachian Plateau, NaCl-type water is typically encountered at low elevations in valley centers at approximately 100 ft beneath the level of the nearest major stream (Trap and Horn, 1997; Warner et al., 2012; Siegel et al., 2015). In West Virginia, NaCl-type groundwater is frequently encountered at even shallower depths beneath streams in valley bottoms owing to the overall lower topographic elevation and associated lower potential groundwater head available to depress underlying saline water (Siegel et al., 2015).

An additional control on regional groundwater chemistry is the occurrence of natural coal intervals and laminations within bedrock formations. Where coal occurs, oxygenated groundwater leads to oxidation of sulfide minerals (principally the iron sulfide pyrite) in the coal, which leads to elevated concentrations of iron and sulfate in groundwater (Siegel et al., 2015).

2.1 Groundwater Monitoring Network

Four of the monitoring wells (MW-1807A, MW-1808A, MW-1809A, and MW-1810A) are installed upgradient of the JAFAP to support background monitoring. Ten monitoring wells (MW-1, MW-2, MW-5, MW-6, MW-1801A, MW-1804A, MW-1806A, MW-7, MW-8, and MW-9) are located downgradient of the JAFAP and used for compliance monitoring.

The details of each groundwater monitoring location used for water quality sampling are summarized in Error! Reference source not found. and the location of the monitoring wells within the uppermost aquifer is shown on Figure 3 (Arcadis 2019) in **Appendix A**.

2.2 ASD Investigation Monitoring Well - MW-5

MW-5 was the only monitoring well with constituents that showed SSIs (calcium and sulfate) in May 2020 groundwater monitoring data. These SSIs were confirmed in a verification sampling event in July 2020. The details of this monitoring well are provided in the following sections to support the ASD investigation addendum.

MW-5 is installed near the base of the incised valley of Little Scary Creek where the ground surface (648.03 ft above mean sea level [amsl]) and piezometric surface are within the Morgantown Sandstone and stratigraphically lower than the base of the JAFAP. In deepening stratigraphic succession, the 114.8-foot boring intercepted approximately 23 ft of predominantly clay unconsolidated deposits, 11 ft of Morgantown Sandstone, 69.5 ft of variably weathered Birmingham Shale (shale and clay shale), 7 ft of sandstone (Interpreted as Grafton Sandstone) before terminating within approximately 4 ft of shale (See cross section A-A' [Arcadis 2019] in **Appendix B** and MW-5 boring log in **Appendix C**). The MW-5 sand pack and screen extends over the Grafton Sandstone and includes several ft of the over- and under-lying shale. The following lines of evidence indicate that groundwater in MW-5 includes a component of deep brine:

- MW-5 is located at the base of the Little Scary Creek stream valley and is screened at a lower elevation (546.43 to 537.03 ft amsl) than all other site wells.
- MW-5 screen is set at 101.6 to 111.0 ft below ground surface (bgs), which is approximately 100 ft lower in elevation than the adjacent Little Scary Creek bed, corresponding to the depth beneath Appalachian Plateau streams where NaCl-type connate water is typically encountered in the Appalachian Plateau.
- The screen for MW-5 is vertically lower and laterally distal to the base of the JAFAP. According to the stress relief fracturing (SRF) model, groundwater from the JAFAP would migrate through

coal-bearing strata (specifically the Elk Lick Coal within Birmingham Shale) prior to entering the screened interval for MW-5 with concomitant geochemical effects on groundwater composition. We do not see the expected effects on groundwater composition, indicating JAFAP water has not reached MW-5.

- TDS values for MW-5 historically exceed values in the JAFAP by nearly an order of magnitude (AEP, 2020). Additionally, sulfate is historically near or below the laboratory reporting limit in MW-5. The geochemistry of MW-5 historically corresponds with the composition of Appalachian Plateau NaCl-type connate water.
- The NaCl-type groundwater in MW-5 is distinct from the Na-HCO_3-type water typically encountered in site wells screened in the SRF at higher elevations and located on the hilltops surrounding the site, and is distinct from porewater in the JAFAP (**Section 4**). The exception is MW-2, the only site well that is also at the base of Little Scary Creek alluvial valley and is screened at a similar elevation (549.10 to 540.20) to MW-5.
- During packer testing, MW-5 did not accept flow with up to 100 pounds per square inch pressure (Arcadis, 2019), indicating the presence of low permeability units typical of those that are not regularly flushed with groundwater and that may host NaCl connate waters.
- Wells co-located with MW-5, MW-6 (screen = 619.00 to 614.00 ft amsl) and MW-1 (screen = 606.47 to 597.57 ft amsl), are screened at higher elevations and exhibit lower TDS and a $NaHCO_3$-type water, which is expected with the fresher shallower groundwater being present in these shallower wells versus the deeper connate (brine) groundwater.

2.3 JAFAP Porewater Piezometer

AEP installed a multi-level port piezometer (STN-12-4) within the JAFAP to evaluate fly ash porewater. This multi-port piezometer has seven screened intervals, as detailed in the boring log (Stantec, 2012) provided in **Appendix C**.

Fly ash porewater was sampled during five events: September 28, 2017, December 11, 2017, November 16, 2018, March 12, 2019, November 11, 2019, and May 11 through May 14, 2020. Water quality results for CCR constituents in the fly ash, with the geometric mean of each constituent over the seven interval ports, are presented in Error! Reference source not found.. These data will be used in this ASD investigation to represent the JAFAP porewater when comparing to CCR constituent concentrations in the monitoring well network.

2.4 Groundwater Monitoring

AEP has conducted groundwater monitoring of the uppermost aquifer to meet the requirements of the CCR Rules. These monitoring activities 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, 2019)
- Completion of validation tests for groundwater data, including tests for completeness, valid values, transcription errors, and consistent units
- Establishment of background values for each Appendix III and Appendix IV constituent (eight sampling events conducted over a seven-month period between July 25, 2018 and February 18, 2019) (AEP, 2020)

- Evaluation of the groundwater data using a statistical process in accordance with 40 CFR 257.93, which was prepared and certified in April 2019 in AEP's *Statistical Analysis Plan* (Geosyntec, 2019), and most recently posted to AEP's CCR website in May 2019. The statistical process was guided by USEPA's *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance* ("Unified Guidance", USEPA, 2009).
- Completion of the initial detection monitoring sampling event (March 2019), which resulted in no SSIs of Appendix III parameters.
- Completion of a second detection monitoring event (November 2019), which resulted in potential SSIs for Appendix III parameters in MW-2 (calcium), MW-5 (calcium and sulfate), MW-7 (calcium), and MW-1804A (chloride and sulfate).
- Completion of confirmation sampling (February 2020) for constituents identified as potentially exhibiting SSIs per AEP's *Statistical Methods Selection Certification* (AEP, 2019), which confirmed SSI's for Appendix III parameters at MW-5 (calcium and sulfate) and MW-1804A (chloride and sulfate).
- An ASD investigation (between April and June 2020) for the JAFAP was conducted to evaluate potential alternate sources or reasons for the SSIs of calcium and sulfate in MW-5 and chloride and sulfate in MW-1804A (EHS Support, 2020).
- Completion of a third detection monitoring event (May 2020), which resulted in potential SSIs for Appendix III parameters in MW-5 (calcium and sulfate).
- Completion of confirmation sampling (February 2020) for constituents identified as potentially exhibiting SSIs per AEP's *Statistical Methods Selection Certification* (AEP, 2019), which confirmed SSI's for Appendix III parameters at MW-5 (calcium and sulfate).

A table summarizing monitoring data for key wells analyzed during this ASD investigation addendum, including the background sampling events through the May 2020 monitoring event, and the July 2020 verification sampling event is included in Error! Reference source not found..

3 Alternative Source Demonstration Assessment

As identified in **Section 1.1**, SSIs in the concentration of calcium and sulfate in MW-5 have been reported for the May 2020 detection monitoring event.

Per the CCR Rule at 40 CFR 257.94(e)(2), "The owner or operator may demonstrate that a source other than the CCR unit caused the SSI over background levels for a constituent or that the SSI 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 an SSI over background levels to include obtaining a certification from a qualified professional engineer verifying the accuracy of the information in the report."

EPRI (2017) guidelines for developing an ASD indicates potential causes that support the ASD may include, but are not limited to:

1. sampling causes (ASD Type I),
2. laboratory causes (ASD Type II),
3. statistical evaluation causes (ASD Type III),
4. natural variation causes (ASD Type IV), and/or
5. alternative sources (natural) (ASD Type V).

This ASD investigation addendum for the JAFAP is focused on assessing whether Type I, Type III and/or Type IV causes identified in the initial ASD investigation (EHS Support, 2020) could be the reason for SSIs for calcium and sulfate in MW-5 in the May 2020 detection monitoring event**.**

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:

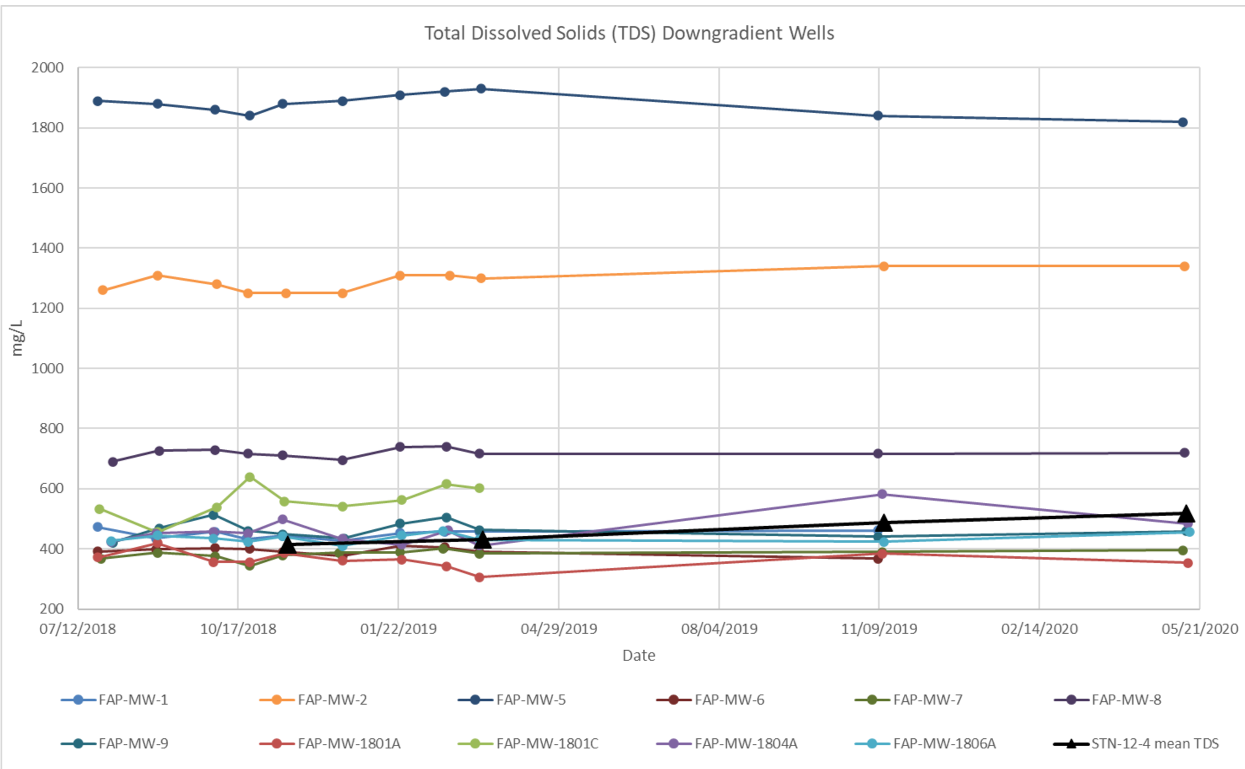
- Tier I: Trend Analysis and Statistics (**Section 3.1** and **Section 3.2**)
- Tier II: Advanced Geochemical Evaluation Methods (**Section 3.1**, **Section 3.3** and **3.4**)
- Tier III: Isotopic Analyses (not conducted as part of this ASD)

These assessments are presented in the following sections. Additionally, an analysis of potential variation due to sampling techniques (ASD Type I) is included in **Section 3.5** and statistical evaluations (ASD Type III) is included in **Section 3.6**.

3.1 Groundwater Data Analysis

3.1.1 Site Groundwater Sources

Total dissolved solids measurements provide a robust means to distinguish groundwater with a connate brine and/or low TDS precipitation source. Consistent with a brine origin, historical TDS data for MW-2, MW-5 and MW-8 are notably elevated (almost by an order of magnitude in MW-5) compared with other site wells that produce sodium/calcium bicarbonate-type waters (**Figure 3-1**). TDS in the majority of site wells is below about 600 to 650 milligrams per Liter (mg/L), in comparison to a range of 174 to 840 mg/L (geometric mean 474 mg/L) for JAFAP porewater measured in all seven ports of STN-12-4 between September 2017 and May 2020. Clearly, the TDS data (coupled with historical boron, fluoride, and chloride systematics for these wells) rule out JAFAP porewater as the origin of the high TDS measurements in MW-2, MW-5 and MW-8. Whereas a connate brine component is expected to be the source of high TDS concentrations for MW-2 and MW-5 based on the location of the wells at the base of the Little Scary Creek valley and deep (>100 ft bgs) well screen/sand pack depths (**Section 2.3**), MW-8 is situated on a ridge with a sand pack/screen interval over a higher elevation (sand pack from 797 to 821.21 ft amsl in MW-8 compared to 534.20 to 560.50 and 535.93 and 557.03 ft amsl in MW-2 and MW-5, respectively; Error! Reference source not found.). As discussed by Siegel et al., (2015), connate brine is periodically encountered along ridgelines in formations with low throughput of groundwater in the Appalachian Plateau of West Virginia, thus, MW-8 conceivably also contains a brine component that is responsible for the elevated TDS in this well.



Note: MW-1801C has not been sampled since March 2019

Figure 3-1 Total Dissolved Solids in Downgradient Monitoring Wells

3.1.2 MW-5 Evaluation

A temporal plot for the primary indicator sulfate reported in groundwater monitoring well MW-5 is presented in **Figure 3-2**, and a temporal plot for the elevated ASD constituent calcium is presented in **Figure 3-3**. Data for the geometrical mean of JAFAP porewater (Error! Reference source not found.) is provided for comparison.

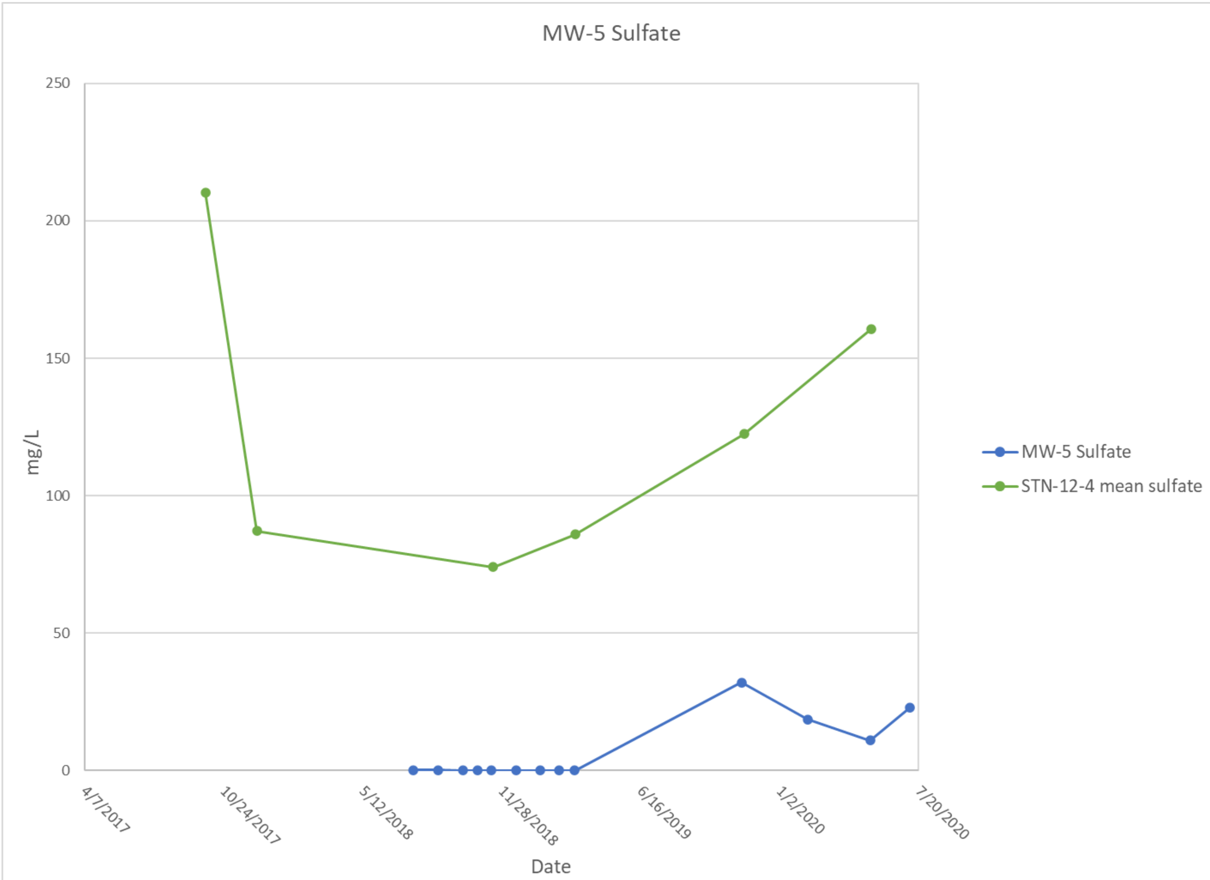


Figure 3-2 MW-5 Sulfate Concentrations

Sulfate concentrations in MW-5 have remained relatively constant up until the last two groundwater monitoring events in November 2019 and May 2020 (geometric mean = 0.1 mg SO4/L). Sulfate concentrations measured in November 2019 and May 2020 were approximately two orders of magnitude higher (32 mg/L and 11 mg/L, respectively) than those reported historically. Comparing the concentrations in MW-5 groundwater to the JAFAP, sulfate concentrations in groundwater are 100 times lower than the concentrations reported in the JAFAP porewater. Sulfate is typically absent or at low concentrations in Appalachian Plateau connate brines due to overall reducing conditions that favor sulfide (Siegel et al., 2015). In contrast, sulfate is present at higher concentrations in oxygenated groundwater sourced from more recent precipitation, particularly following interaction with pyrite, which is documented in the Birmingham Shale and Grafton Sandstone rock matrix in the logs for MW-1802C, MW-1803C, MW-1805C; rock units that are within and directly overlying the sand pack interval for MW-5.

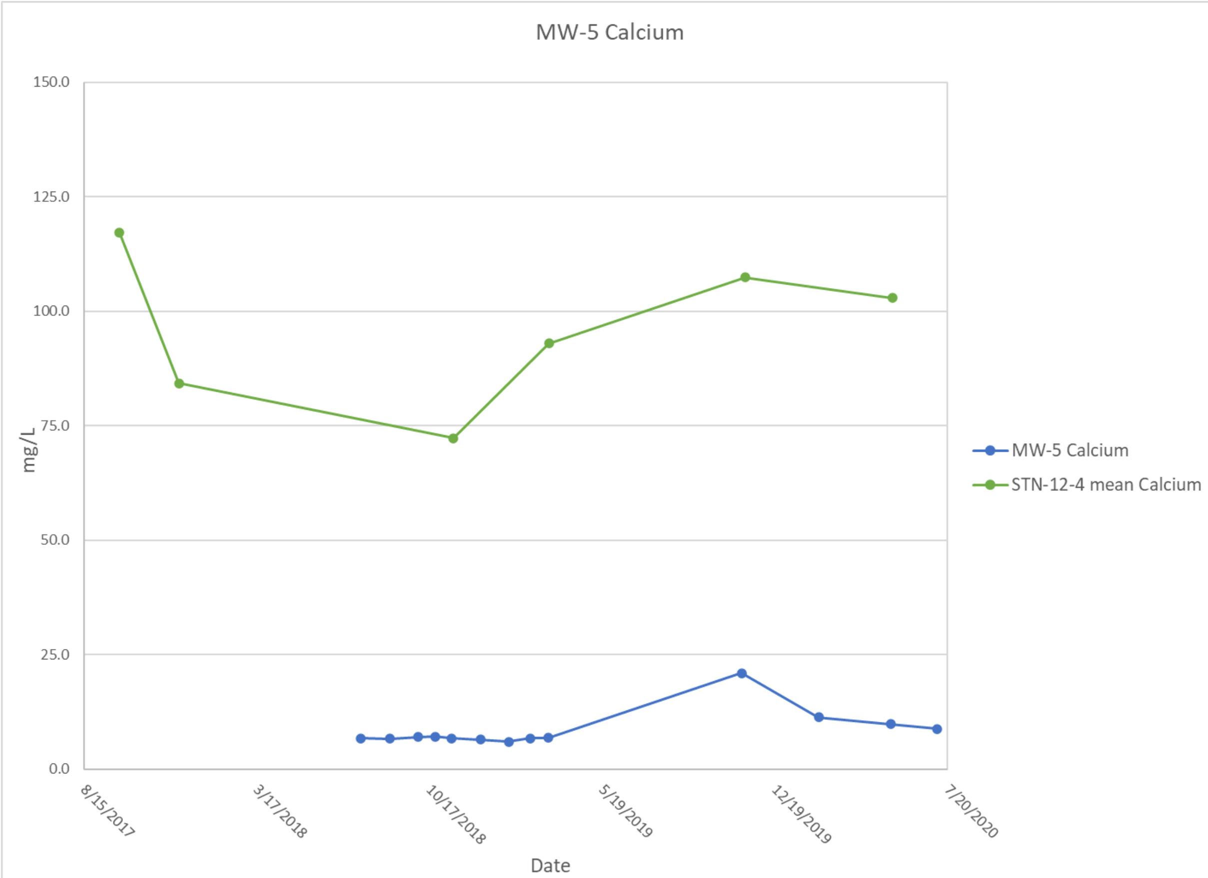


Figure 3-3 MW-5 Calcium Concentrations

Calcium concentrations in MW-5 have remained relatively constant up until the November 2019 groundwater monitoring event (geometric mean = 6.7 mg/L). In November 2019 and May 2020, the calcium concentration of groundwater sampled from MW-5 was 21 mg/L and 9.85 mg/L, respectively. The range of calcium concentrations in MW-5 in November 2019 and May 2020 were approximately 10 times lower than the concentrations reported in the JAFAP porewater (**Figure 3-3**). The relative sodium: calcium concentration ratios reported from groundwater at MW-5 in November 2019 and May 2020 was lower than all previous sampling events (**Table 3-1**). The relative changes in calcium and sodium suggests mixing between different groundwater types with distinct aqueous sodium:calcium ratios set through ion exchange reactions with distinctive rock types or secondary minerals within formations.

Table 3-1 MW-5 Relative Sodium and Calcium Concentrations

Date	Sodium (mg/L)	Calcium (mg/L)	Sodium/Calcium Ratio
7/24/2018	777	6.75	115
8/29/2018	714	6.71	106
10/3/2018	742	7.03	106
10/24/2018	735	7.09	104
11/13/2018	586	6.79	86
12/19/2018	595	6.48	92
1/23/2019	599	5.98	100

Date	Sodium (mg/L)	Calcium (mg/L)	Sodium/Calcium Ratio
2/19/2019	687	6.79	101
3/13/2019	660	6.85	96
11/8/2019	**571**	**21**	**27**
5/11/2020	**694**	**9.85**	**70**

The increase in dissolved calcium and sulfate may be attributed to a change in the proportion of mixing between sodium chloride and calcium/sodium bicarbonate water types; with the November 2019 result reflecting a higher proportion of more Ca- and SO4-rich, low TDS sodium bicarbonate water type. Groundwater in the vicinity of MW-5 is identified as a sodium chloride water type (further discussed in **Section 3.1.1**) and the elevation of the screened section of MW-5 is very close to the expected mixing interface between sodium bicarbonate and sodium chloride (connate brine) water types, as discussed in **Section 2.3**. External influences such as pumping rates or intense and extended rainfall events can perturb the transition between the connate aquifer and the overlying sodium bicarbonate aquifer.

Boron, another primary indicator, has historically fluctuated in MW-5 between 0.22 to 0.32 mg/L, whereas the November 2019 concentration was notably lower at 0.18 mg/L (**Figure 3-4**). Boron is typically elevated in groundwater that has contacted aquifer rock for extended periods of time or that has experienced elevated temperatures; therefore, elevated boron in connate brine is expected. The observation of decreased boron during the November 2019 sampling event supports dilution by a younger sodium bicarbonate water type in MW-5.

Figure 3-4 MW-5 Boron Concentrations

Temporal plots for potential indicators bromide, fluoride, molybdenum, potassium, and sodium reported in groundwater monitoring well MW-5 are provided in **Figure 3-5**, **Figure 3-6**, **Figure 3-7**, **Figure**

3-8 and **Figure 3-9**, respectively, with geometrical mean data for the JAFAP porewater presented for comparison. Molybdenum and potassium are present in groundwater at concentrations below the concentrations within the JAFAP for MW-5. For MW-5, bromide, fluoride and sodium concentrations in groundwater are elevated in comparison to the JAFAP.

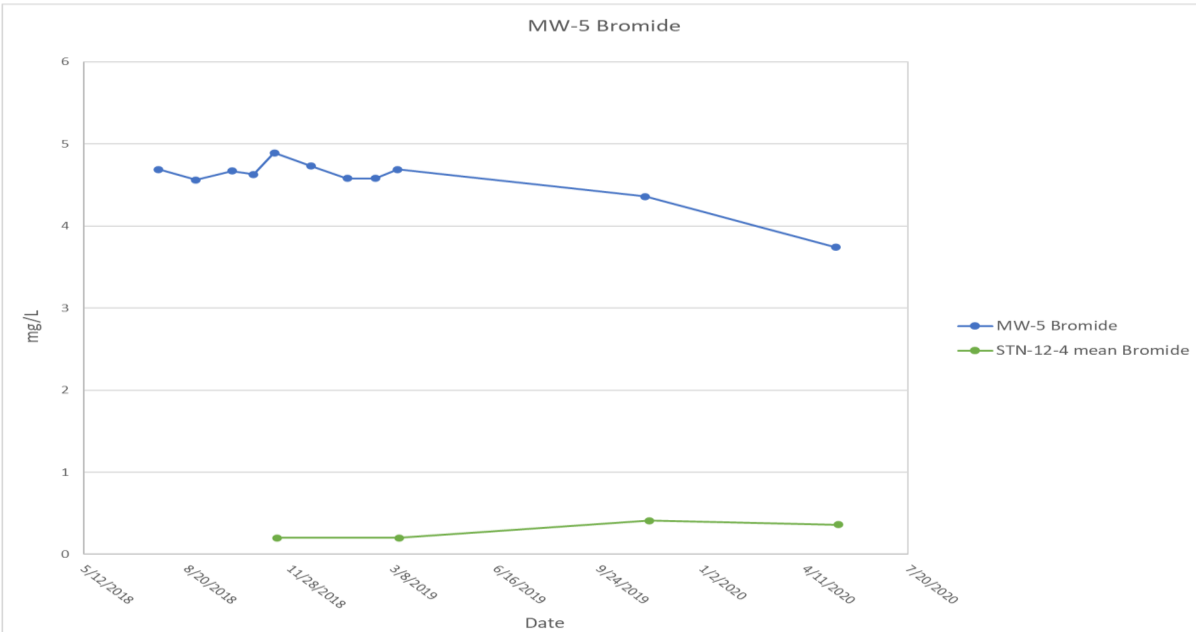


Figure 3-5 MW-5 Bromide Concentrations

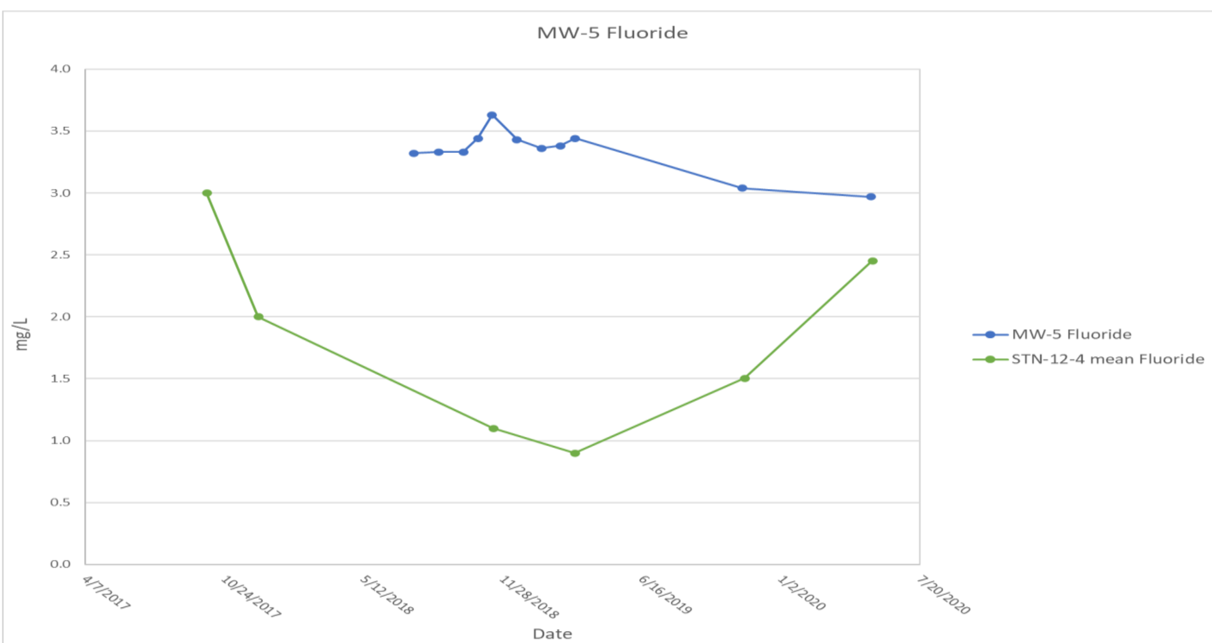


Figure 3-6 MW-5 Fluoride Concentrations

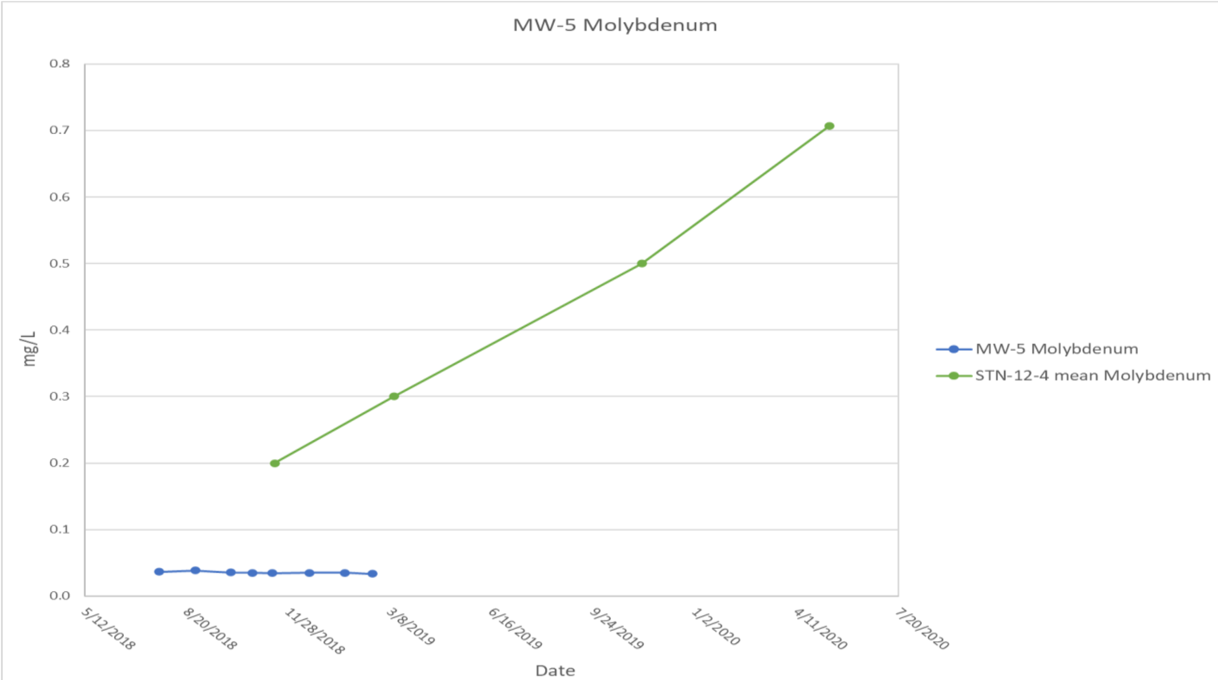


Figure 3-7 MW-5 Molybdenum Concentrations

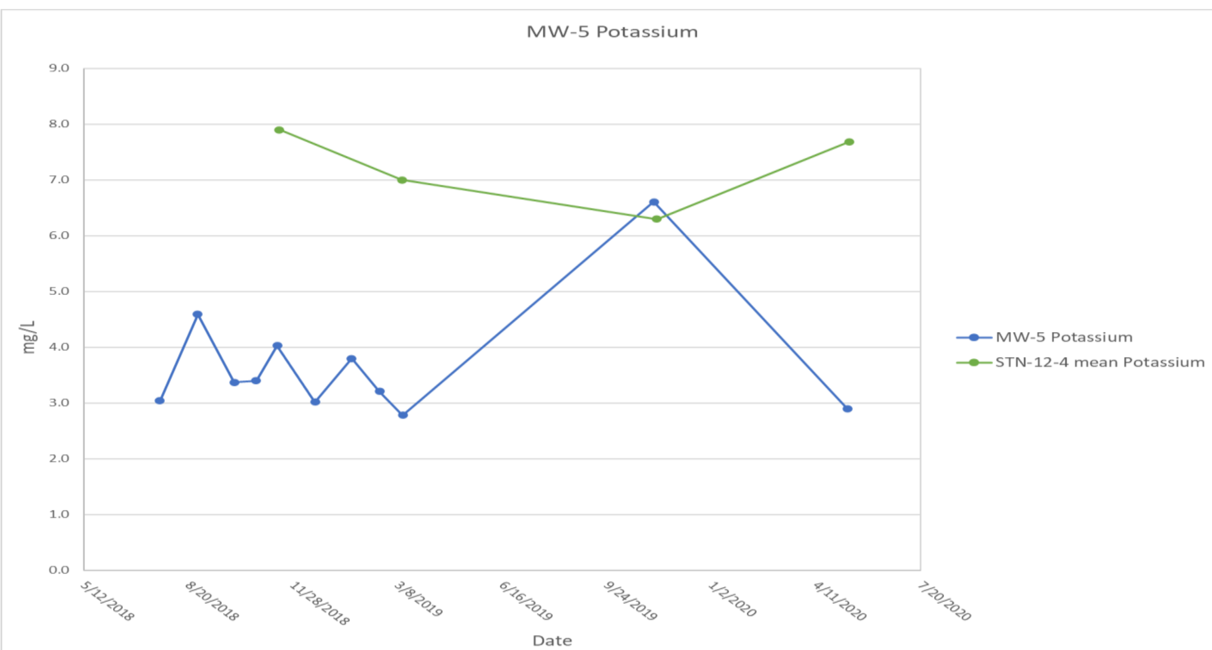


Figure 3-8 MW-5 Potassium Concentrations

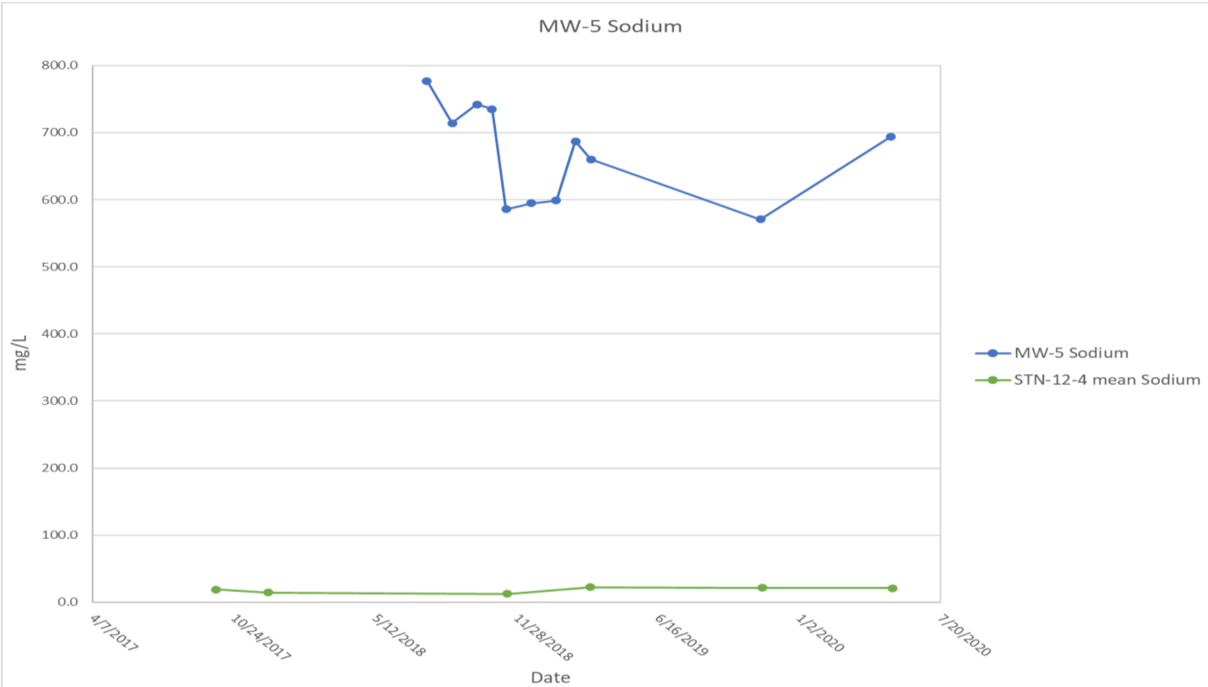


Figure 3-9 MW-5 Sodium Concentrations

3.2 Statistical Evaluation

Mann Kendall analysis was used to compare the temporal variation in MW-5 sulfate and calcium. Results for these analytes were investigated by reviewing the entire 2018 through 2020 dataset (including confirmation sampling event data) and the dataset omitting the November 2019 and May 2020 groundwater monitoring and confirmation sampling results (**Table 3-2**). Non-detect values for sulfate in MW-5 were evaluated by using half the reported detection limit.

Table 3-2 Mann Kendall Statistics

Monitoring Well ID	Type	Trend 2018 - 2020	Trend (excluding Nov 2019 and May 2020)
MW-5	Sulfate	No trend	Decreasing
MW-5	Calcium	Increasing	Stable

For the entire dataset, sulfate had no trend and calcium had an increasing trend. With the November 2019 and May 2020 results omitted, sulfate had a decreasing trend and calcium concentrations were stable. Based on the trend analysis, the set of results that triggered the SSI evaluation do not appear to be contributing towards any statistically significant temporal change in sulfate concentrations, the primary coal ash leachate indicator. Whereas the overall dataset indicates a statistically significant temporal increase in calcium concentrations, this result is attributed to the outcome of mixing between two distinct water types that was triggered by a change in sample practices as described in **Section 3.4**. Additionally, calcium is a secondary indicator that may be attributed to dissolution of the abundant limestone (calcium carbonate) formations and hydrogeochemical maturity of a likely groundwater mixing endmember in the broader Appalachian area.

3.3 Ion Ratios and Conservative Ion Binary Plots

3.3.1 Ion Ratios

EPRI (2012) recommends the use of ion ratios to identify source waters, or to determine that an additional source water is being added along a flow path. The premise is that the concentration of two constituents in groundwater is maintained unless mixing with a water source that has different ion concentration ratios occurs. Care must be taken to select unreactive constituents (conservative ions) to support this analysis. Conservative ions are generally not volatile, largely do not participate in ion exchange or redox reactions, generally form minerals with high solubilities, and are not typically leached from or incorporated into reactive minerals along groundwater paths in appreciable concentrations. These characteristics result in preservation of conservative ion ratios through binary mixing, dilution, and evaporation processes. Sulfate should be assessed with caution using the conservative ion ratio approach, since sulfate is typically a conservative ion in oxygenated waters, however, oxidation of sulfide or reduction of sulfate on mixing between anoxic and oxygenated waters can shift the sulfate concentration substantially from an expected binary mixing result.

Ion ratios for key constituents in groundwater and JAFAP porewater samples from the May 2020 sampling round are provided in Error! Reference source not found.. Notably, the SO_4/Cl and F/Cl ratios for most groundwater samples are indistinguishable from JAFAP porewater; therefore, these SO_4/Cl and F/Cl ratios are not useful for distinguishing JAFAP porewater influence for the majority of locations in the monitoring network. The exception is for wells MW-5, MW-2 and MW-8, which have distinct SO_4/Cl and F/Cl ratios that likely reflect a connate brine component. In contrast, Ca/Cl and B/Cl ion ratios are distinct for most groundwater and JAFAP porewater samples and provide useful indicators of mixing relationships between different water types. To better assess mixing relationships based on ion ratios, ion ratio plots were developed following the method and rationale described below.

Ion ratio plots were developed from historical and current data for MW-5 (**Figure 3-10**). These plots illustrate SSI benchmark exceedances in November 2019 and May 2020 in the context of historical and current JAFAP porewater samples. Ion ratio plots for MW-5 show that the water in both historical and the November 2019/May 2020 samples show a distinct ion composition compared to shallower co-located wells (MW-1 and MW-6) and JAFAP porewater. This result supports an Appalachian Plateau connate brine origin. Indeed, the composition of MW-5 groundwater on these plots is sufficiently unique that no clear mixing relationship between the November 2019 sampling result and other water sources is clear based on ion ratios. For this reason, absolute conservative ion concentrations (not ratios) are used to better assess mixing between MW-5 and alternative sources, as discussed below (**Section 3.3.2**).

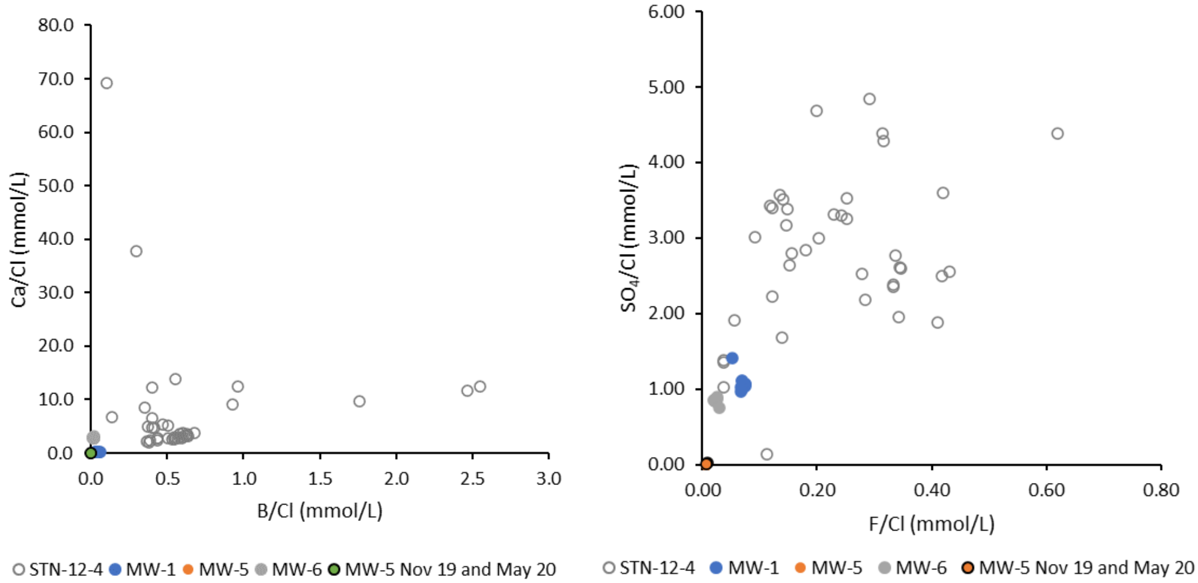


Figure 3-10 Ion Ratio Plots of Historical and Current Data from MW-5, MW-1, MW-6, and STN-12-4 JAFAP Porewater

Note: the MW-5 data from November 2019 and May 2020 plot in the same location as historical MW-5 data.

3.3.2 Conservative Ion binary plots

Binary plots of the molar concentrations of conservative ions in waters that have undergone binary mixing or dilution trace a straight line between the mixing endmembers, and the intermediate (resulting) water falls on the mixing line. Molal concentrations are preferred in this type of diagram as mineral precipitation effects are more readily apparent. Dissolved elements broadly considered as conservative for this purpose include the halides (e.g. chloride and fluoride) and boron.

Binary conservative ion plots (B-Cl, F-Cl, and B-F) were constructed for MW-5 (**Figure 3-11**). Data for each well from nine sampling events between July 2018 and March 2019 were compared to the data points showing SSI exceedances from November 2019. Data for JAFAP porewater from the seven ports in multilevel well STN-12-4 from September 2017 through November 2019, representing JAFAP porewater, were included on the charts as a possible mixing endmember. For MW-5, co-located and shallower wells MW-1 and MW-6 were included as possible mixing endmembers.

For well MW-5, the November 2019 and May 2020 samples fall on a mixing line between historical MW-5 waters and $NaHCO_3$-type waters in the shallower co-located wells MW-1 and MW-6 for all conservative ion plots, and does not indicate mixing with JAFAP porewater (**Figure 3-11**). This relationship indicates that mixing between Appalachian Plateau NaCl-type connate water and overlying more dilute $NaHCO_3$-type water best explains the May 2020 sampling result and mixing with JAFAP porewater is not supported.

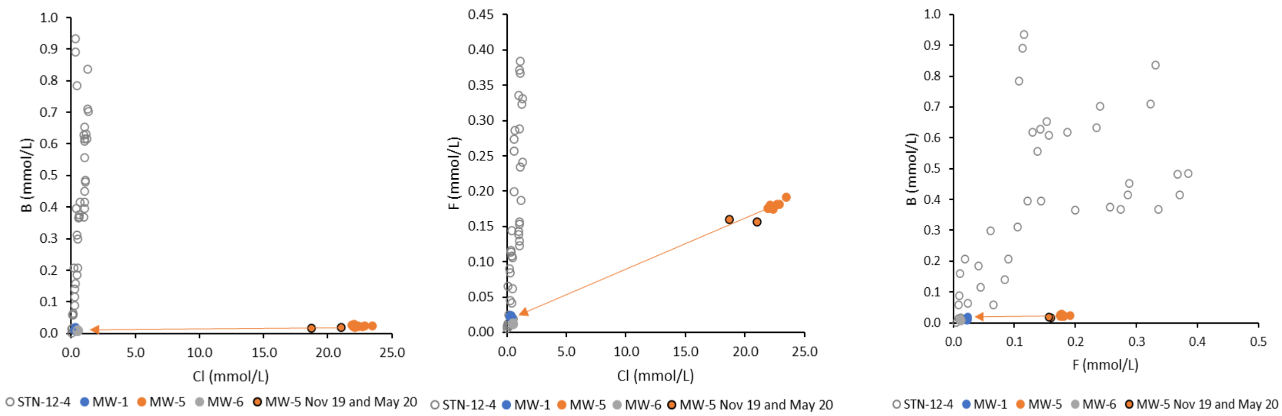


Figure 3-11 Conservative Ion Binary Plots for MW-5

3.4 Tier II Evaluation - Geochemical Evaluation

A simple analysis of primary and potential indicator constituents (as performed in **Section 3.1**) may not provide the lines of evidence required for a robust ASD investigation. It is recognized that naturally occurring indicator constituents and upgradient sources may have an additional influence on groundwater quality. Spatially across a site, groundwater quality may be observed to change due to chemical interactions with the aquifer matrix. EPRI (2012) recommends more sophisticated methods that can be used for multiple parameters over multiple locations.

Piper plots are used to classify groundwater types based on the major ion ratios of calcium, magnesium, sodium (and potassium), alkalinity, chloride, and sulfate. They can be used to visually illustrate ion exchange and mixing between different water chemistries.

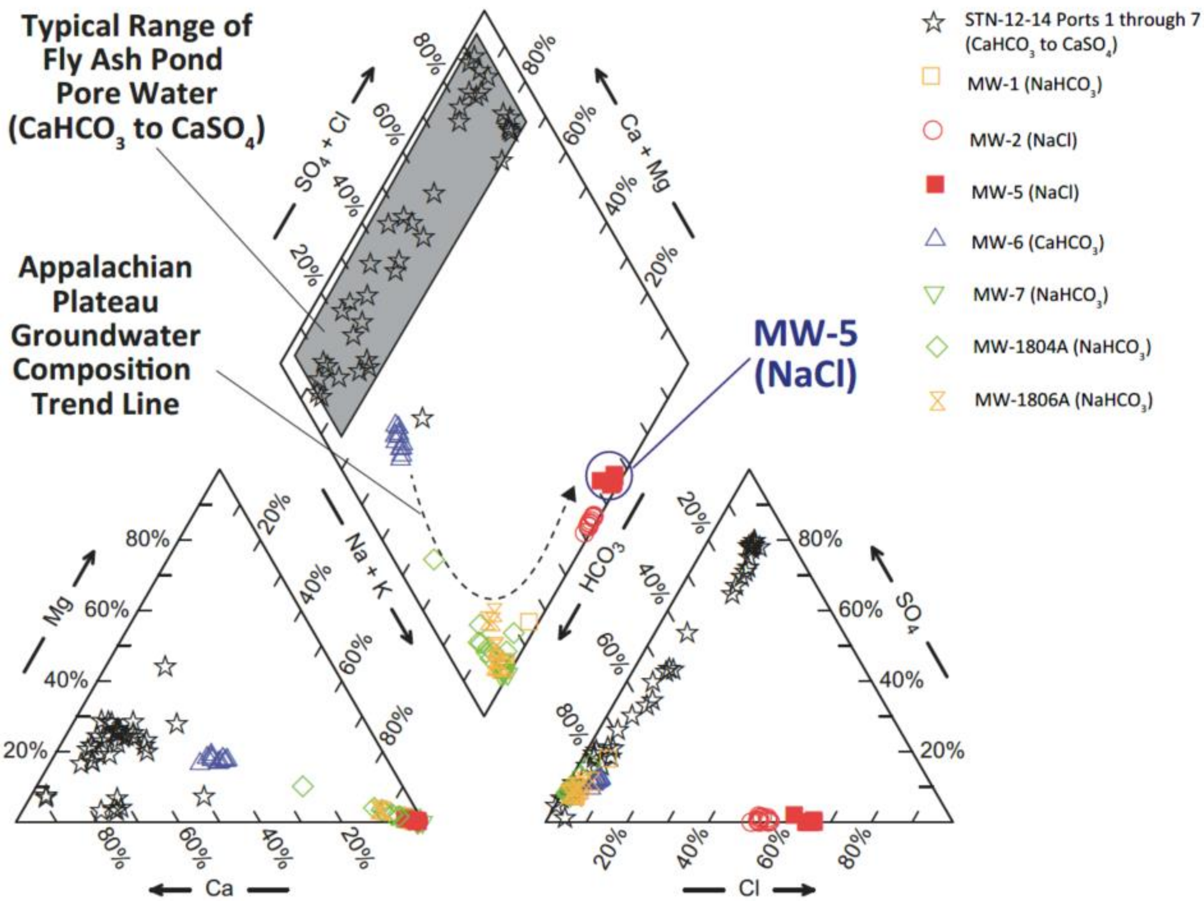


Figure 3-12 JAFAP and Groundwater Piper Plot (water types)

Not all site monitoring wells are shown.

Ash porewater and groundwater are represented by different water types. In **Figure 3-12** above, the water types related to the JAFAP porewater are dominated by calcium, bicarbonate, and sulfate.

The groundwater composition of MW-5 is largely distinct from other JAFAP wells (except MW-2) and is a sodium chloride water type. Groundwater samples collected in the vicinity of MW-5 between July 2018 and May 2020 consistently report a sodium chloride water type. This water type is typically indicative of connate brines that are relict within the aquifer. This groundwater type is also consistent with the construction of well MW-5, which monitors a deeper section of the bedrock aquifer than other site wells (except MW-2) where a connate brine is expected to be encountered, as discussed in **Section 2.3**.

In summary, based on the geochemical evaluation there is insufficient evidence to support the presence of CCR constituents, as derived from the JAFAP, in groundwater sampled in the vicinity of MW-5. The Piper plot does not support mixing between groundwater and JAFAP water at any of the groundwater monitoring locations reviewed. The JAFAP water type is calcium bicarbonate (shallow porewater) and calcium sulfate (deeper porewater). Only four other groundwater locations report these two water types – MW-1801A and MW-6 (calcium bicarbonate); and MW-1807A and MW1809A (calcium sulfate).

Bicarbonate concentrations are generally more elevated in groundwater in comparison to JAFAP porewater. Sulfate concentrations are mostly higher within groundwater compared to JAFAP, except for MW-6. Additionally, bromide, fluoride and sodium are all present at higher concentrations in MW-5 groundwater compared to the JAFAP water. These concentration imbalances indicate an alternate source of these constituents. Based on this evidence, it is considered that porewater from JAFAP is unlikely to be influencing the surrounding groundwater chemistry in MW-5 where the November 2019 and May 2020 SSIs were identified. Any compositional similarity between JAFAP pore water and the monitoring locations mentioned reflects the local groundwater origin for JAFAP pore water.

3.5 ASD Type I – Natural Variation due to Sampling Causes

EPRI (2012) describes sampling anomalies as a defensible cause for an SSI. Review of field documents indicates a notable change in the sampling technique at MW-5 during the November 2019 and May 2020 sampling compared to the eight background monitoring events, in that the maximum purge rate was between one half and one quarter the rate used historically (**Figure 3-13**). Additionally, the total volume purged during the November 2019 and May 2020 sampling and verification events at MW-5 was lower than all previous instances (**Figure 3-13**).

Sampling events used to establish benchmark values for evaluating SSIs were formulated through statistical analysis of the historical samples that were collected at higher purge rates and purge volumes. In the case of MW-5, the excess pumping in the associated low-yield formation during SSI benchmark calibration sampling is expected to result in incursion of reducing, low sulfate, high TDS NaCl-type connate water into the well screen. Subsequent sampling at a lower purge rate and purge volume on November 2019 is expected to have minimized connate water incursion into the well and facilitated sampling of low TDS and sulfate bearing water with elevated Ca from above the connate water mixing interface.

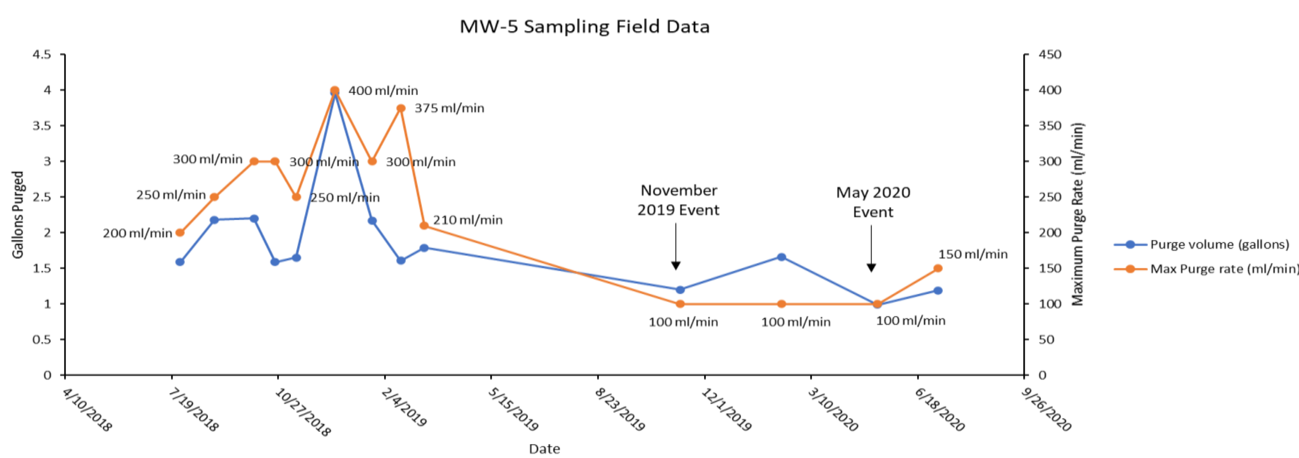


Figure 3-13 Historical Well Purge Rates and Volume Purged for MW-5

3.6 ASD Type III – Statistical Evaluation Causes

Samples to establish SSI benchmarks were obtained over a seven month period between July 25, 2018 to February 18, 2019. For this reason, benchmark statistical calulations are qualified with "Insufficient data to test for seasonality: data were not deseasonalized" (AEP, 2020). Additionally, annual variations owing to high rainfall years (**Section 3.6**) are not accounted for, as detection monitoring began immediately following the establishment of SSI benchmarks. Therefore, periodic SSI exceedences related to seasonal and/or annual weather variations should be expected until a broader dataset is available that incorporates seasonal and annual weather patterns.

3.7 ASD Type IV – Natural Variation

Historical groundwater geochemistry data for MW-5 show that it is screened close to a mixing zone between low TDS and comparatively young recharge water and high TDS and comparatively ancient connate brine. Regionally, the mixing interface between these two disparate water types is known to be only a few ft thick. The two water types constitute two natural groundwater sources with distinct groundwater geochemistry that may periodically contribute water to the saturated zone within the MW-5 screen/sand pack zone. Given that SSI benchmarks were established over approximately a seven-month period, seasonality and longer timescale natural variations in the location of the mixing interface are unlikely captured in the benchmark dataset.

4 Summary and Conclusions

Table 4-1 (Table 6-1 in EPRI, 2017) highlights the potential causes of SSIs at MW-5 during the November 2019 and May 2020 detection monitoring events that have been identified during this ASD investigation.

Table 4-1 Summary of Potential Causes Identified by ASD Investigation

Table 6-1
Potential Causes for an SSI/SSL

Sampling Causes (ASD Type I)	Laboratory Causes (ASD Type II)	Statistical Evaluation Causes (ASD Type III)	Natural Variation (ASD Type IV)	Alternative Sources (ASD Type V - Natural and Anthropogenic)
• Sample mislabeling • Contamination • Change in technique • Excessive suspended solids or turbidity • Other sampling anomalies	• Analytical method • Calibration • Analytical technique • Contamination • Interference • Recording • Dilution errors • Digestion methods	• Lack of statistical independence • Outliers • Trends • Non-detect Processing • False positives • New background data	• Geology • Precipitation • Seasonality • Water level • Changes in pH and/or ORP • Biological activity • Time of travel	• See Appendix A, Tables A-3 and A-4

Using the EPRI (2017) guidance for completing an ASD, the conclusions that are based on the lines of evidence presented and discussed within **Sections 3** indicate that groundwater in the vicinity of the JAFAP is not being influenced by CCR constituents from the JAFAP. Concentrations of the constituents calcium and sulfate in MW-5 that led to SSIs in November 2019 and May 2020 are primarily caused by a change in the sampling procedure (ASD Type I – Sampling Causes), which led to a difference in where sampled water originated in the formation, as detailed in **Table 4-2.** Additionally, ASD Type III – Statistical Evaluation Causes, ASD Type IV Natural Variation Causes, and Type V – Alternatives Source Causes at MW-5 were identified, as discussed below.

Table 4-2 Evidence of ASD for SSIs at the John Amos Fly Ash Pond

MW-5 Evidence
MW-5: Calcium SSI
1. High purge rates and purge volumes during background sampling resulted in intrusion of sodium chloride water, setting an unrealistically low calcium SSI value for future comparison. 2. Mixing of shallower calcium-rich groundwater occurred during the November 2019 sampling event due to a substantially lower purge rate and volume, which led to the SSI as evidenced by: a. Calcium was 5.7 times lower in MW-5 than calcium in the shallower, co-located well MW-6. b. Shallow groundwater mixing is supported by Ca/Cl and B/Cl ratios in MW-5 similar to shallow groundwater and notably different than JAFAP porewater. c. Shallow groundwater mixing with brine is supported by conservative element (B, Cl, F) concentrations.
MW-5: Sulfate SSI
1. High purge rates and purge volumes during background sampling resulted in intrusion of sodium chloride water, with essentially no sulfate, setting an unrealistically low SSI value for future comparison (sulfate SSI benchmark is over 100 times lower than typical groundwater sulfate concentrations due to incursion of reducing, sulfide-bearing and sulfate-free brine) 2. Mixing of shallower sulfate-rich groundwater occurred during the November 2019 and May 2020 sampling events due to substantially lower purge rates and volumes, as evidenced by: a. Sulfate in MW-5 was lower than in co-located and shallower wells MW-1 and MW-6. b. SO_4/Cl ratios were substantially lower than JAFAP porewater and closer to those in shallow groundwater wells. c. Piper plot relationships that show MW-5 is compositionally distinct from JAFAP porewater

An ASD Type III – Statistical evaluation cause could also be the reason for SSIs in the November 2019 and May 2020 detection monitoring events. SSI benchmarks were established over approximately a seven-month period preceding three quarters of detection monitoring. The November 2019 and May 2020 events were the second and third of three monitoring events following establishment of SSI benchmark values. The eight-month background period does not fully capture seasonal and annual weather variations, and future reevaluation of benchmarks may be required to ensure a background data set which accurately reflects the natural variation in groundwater chemistry across the hydrogeologic units surrounding the JAFAP.

ASD Type V – Alternative sources (Natural) is also a potential contributing factor to explain MW-5 groundwater composition, in addition to ASD Type I – Sampling Causes and ASD Type III – Statistical Evaluation Causes. Historical groundwater geochemistry data for MW-5 show that it is screened close to a mixing zone between low TDS and comparatively young recharge water and high TDS and comparatively ancient connate brine. Regionally, the mixing interface between these two disparate water types is known to be only a few ft thick. The two water types constitute two natural groundwater sources with distinct groundwater geochemistry that may periodically contribute water to the saturated zone within the MW-5 screen/sand pack zone.

5 References

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Tables

Table 1
Screened Interval of Monitoring Wells
Fly Ash Pond Alternative Source Demonstration Investigation
AEP, John E. Amos Plant, Winfield, WV
November 2019

Well/ Boring	Hydraulic Location	Hydrolitho-stratigraphic Unit	Surface Elevation (ft amsl)	Screened Interval (ft amsl)	Sand Pack Interval (ft amsl)	Geologic Formation
MW-1807A	Upgradient/ Background	SRF	861.99	766.99 – 746.99	745.99 – 769.99	Unnamed clay shale/ Lower Connellsville SS
MW-1808A	Upgradient/ Background	SRF	857.55	733.73 – 748.35	746.55 – 776.55	Unnamed clay shale/ Lower Connellsville SS
MW-1809A	Upgradient/ Background	SRF	738.09	666.09 – 681.09	664.09 – 683.69	Clarksburg Shale
MW-1810A	Upgradient/ Background	SRF	735.26	655.26 – 675.26	653.26 – 681.26	Clarksburg Shale
MW-1	Downgradient	SRF	647.57	587.57 – 606.47	569.47 – 609.57	Birmingham Shale
MW-2	Downgradient	SRF	645.20	540.20 – 549.10	534.20 – 560.50	Birmingham Shale
MW-5	Downgradient	SRF	648.03	537.03 – 546.43	535.93 – 557.03	Birmingham Shale /Grafton SS
MW-6	Downgradient	SRF	647.50	614.00 – 619.00	613.30 – 620.30	Morgantown SS/ Birmingham Shale
MW-7	Downgradient	U/SRF	953.00	823.00 – 843.00	820.50 – 845.00	Conemaugh Shale/ Upper Connellsville SS
MW-8	Downgradient	U/SRF	963.01	800.01 – 819.01	797.01 – 821.21	Conemaugh Shale/ Upper Connellsville SS
MW-9	Downgradient	U/SRF	944.66	805.56 – 824.56	804.56 – 824.56	Conemaugh Shale/ Upper Connellsville SS
MW-1801A	Downgradient	U/SRF	901.12	826.12 – 846.12	824.12 – 849.12	Conemaugh Shale/ Upper Connellsville SS
MW-1804A	Downgradient	U/SRF	858.53	811.03 – 831.03	809.53 – 838.63	Conemaugh Shale/ Upper Connellsville SS/ Unnamed clay shale
MW-1806A	Downgradient	U/SRF	889.63	809.23 – 829.23	808.63 – 832.63	Conemaugh Shale/ Upper Connellsville SS/ Unnamed clay shale

--- = Boring advanced below the coal interval
~ = Approximate
ft = feet
amsl = above mean sea level
U=Upper Connellsville Sandstone
SRF=Stress Relief Fracture System
SS=Sandstone

EHS Support

Table 2
Multi-Port Piezometer STN-12-4 Water Quality Data
Fly Ash Pond Alternative Source Demonstration Investigation
AEP, John E. Amos Plant, Winfield, WV
May 2020

Multi-Port Interval	Sampling Date	Major Ions					Minor Ions						TDS	pH
		Bicarbonate (Alkalinity as CaCO3) mg/L	Calcium mg/L	Chloride mg/L	Magnesium mg/L	Sulfate mg/L	Boron mg/L	Bromide mg/L	Fluoride mg/L	Molybdenum mg/L	Potassium mg/L	Sodium mg/L	mg/L	s.u.
1	9/29/2017	630	182	13	41.7	151	10.1	--	2.2	--	--	75.6	810	--
2	9/28/2017	181	84.9	15.8	23.1	129	2	--	0.78	--	--	10.2	394	--
3	9/28/2017	108	69.2	16.3	11.9	146	3.36	--	2	--	--	16.1	344	--
4	9/28/2017	187	103	24.3	25.3	164	4.48	--	5.43	--	--	23.5	458	--
5	9/28/2017	62	122	39.5	22.9	280	5.23	--	7.3	--	--	15.7	582	--
6	9/28/2017	44	134	35.9	3.59	341	6.79	--	2.71	--	--	38.5	612	--
7	9/28/2017	51	168	46.4	29.3	409	9.05	--	6.28	--	--	19.9	740	--
GeoMean	September 2017	118.1	117.1	24.5	18.3	210.3	5.2	--	3.0	--	--	23.1	539.2	--
1	12/12/2017	597	170	12.8	22.6	152	9.63	--	2.16	--	--	20.1	816	--
2	12/12/2017	122	30.7	3.98	19.9	1.4	0.169	--	0.24	--	--	12.6	174	--
3	12/12/2017	102	34.5	6.18	3.06	28.1	0.698	--	0.46	--	--	33.7	224	--
4	12/11/2017	185	91.9	22.5	25.1	156	3.98	--	5.2	--	--	16.2	446	--
5	12/11/2017	67.1	105	38.1	38.5	268	4.5	--	7.05	--	--	66.6	550	--
6	12/11/2017	50.6	122	36.3	6.36	351	6.02	--	2.62	--	--	6.01	608	--
7	12/11/2017	49.6	143	45.6	6.81	435	7.67	--	6.14	--	--	7.42	774	--
GeoMean	December 2017	112.7	84.3	17.2	12.8	87.1	2.7	--	2.0	--	--	17.0	448.9	--
1	11/15/2018	360	58.5	3.74	15.3	44.4	0.634	0.1	1.24	0.0375	8.76	13.6	406	7.57
2	11/14/2018	289	67.9	1.59	17.4	20.2	0.145	0.1	0.17	0.0158	7.36	10.5	320	7.32
3	11/15/2018	181	50	0.64	12.6	8.4	<0.02	0.1	0.1	0.00892	7.6	7.78	217	7.47
4	11/15/2018	229	63.6	10.6	15.1	62.8	1.52	0.2	1.61	0.231	8.26	12.1	330	4.48
5	11/15/2018	80.4	86	35.8	17.9	229	3.98	0.508	6.38	1.62	6.34	10.6	440	7.65
6	11/15/2018	38.7	82.7	36.8	4.82	342	4.27	0.5	2.32	2.52	10.8	22.2	840	8.92
7	11/16/2018	55.8	115	40.8	19.3	332	6.83	0.502	4.45	3.17	7.83	16.1	600	8.01
GeoMean	November 2018	133.3	72.3	8.0	13.6	74.1	1.6	0.2	1.1	0.2	8.0	12.6	413.4	7.2
1	3/12/2019	392	107	7.59	26.8	74.1	2.23	0.1	1.71	0.0924	8.47	39.9	508	7.76
2	3/13/2019	281	73	5.24	19.1	27.1	0.643	<0.1	0.16	0.101	5.43	13	314	7.28
5	3/14/2019	213	75.3	10.3	19	78.2	1.25	<0.1	0.86	0.45	4.67	13.6	346	7.26
6	3/15/2019	47.4	127	37.6	3.98	346	6.67	0.548	2.46	2.5	11.2	37.8	628	9.52
GeoMean	March 2019	182.6	93.0	11.1	14.0	85.9	1.9	0.2	0.9	0.3	7.0	22.7	431.5	7.9
1	11/11/2019	627	173	15.8	36.8	141	8.47	0.311	2.05	0.146	10.4	70.8	816	7.55
2	11/11/2019	314	86.5	8.95	19.5	24.7	0.955	0.224	0.18	0.0714	6.14	12	361	7.25
3	11/11/2019	211	64.6	11.2	13.8	41.8	1.72	0.263	0.22	0.114	4.9	13.4	285	7.46
4	11/11/2019	201	83.4	20.6	20.5	109	3.95	0.423	3.79	0.551	6.01	20.4	391	7.68
5	11/11/2019	75.7	114	36.6	21.6	250	4.88	0.634	5.47	1.69	3.86	12.3	512	7.82
6	11/12/2019	47.7	132	36.8	3.7	337	7.05	0.584	2.91	2.68	10	42	632	9.26
7	11/12/2019	62	136	43.3	19.5	310	6.67	0.657	3.54	2.81	5.58	18.7	625	7.64
GeoMean	November 2019	151.9	107.4	21.2	16.4	122.5	3.9	0.4	1.5	0.5	6.3	21.7	488.5	7.8
1	5/11/2020	568	155	15.1	38.7	113	4.28	0.2	2.73	0.186	11.4	61.4	758	7.82
2	5/11/2020	281	101	18.4	27.6	67.6	2.23	0.297	0.36	0.202	6.89	11.9	457	7.24
3	5/13/2020	120	56.8	17.8	14.3	107	3.24	0.294	1.17	0.315	7.83	14.6	336	7.4
4	5/13/2020	192	75.9	22.2	23.2	113	4.06	0.336	4.88	0.543	6.22	18.8	368	7.67
5	5/13/2020	555	104	39	22.7	252	5.2	0.534	6.97	1.67	5.14	11	555	7.76
6	5/14/2020	46.1	123	38	4.32	327	6.58	0.455	2.98	2.49	11.9	40	624	9.34
7	5/14/2020	40.6	142	47.1	20.5	363	7.6	0.546	4.57	3.3	6.76	19.3	676	7.69
GeoMean	May 2020	168.3	103.0	25.8	18.4	160.7	4.4	0.4	2.5	0.7	7.7	20.8	518.2	7.8

Notes:
mg/L : milligrams per Liter
TDS : total dissolved solids
s.u. : standard units
- - : not analyzed
< : value less than reporting limit

Table 3
Monitoring Well Water Quality Data
Fly Ash Pond Alternative Source Demonstration Investigation
AEP, John E. Amos, Winfield, WV
May 2020

			Major Ions					Minor Ions							
Monitoring Well	**Collection Date**	**Monitoring Program**	**Bicarbonate (Alkalinity as CaCO3)**	**Calcium**	**Chloride**	**Magnesium**	**Sulfate**	**Boron**	**Bromide**	**Fluoride**	**Molybdenum**	**Potassium**	**Sodium**	**TDS**	**pH**
			mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**s.u.**
MW-1	7/24/2018	Background	382	2.83	11.7	0.466	30.6	0.182	0.106	0.42	1.94	1.75	159	473	8.2
	8/28/2018	Background	371	2.80	11.3	0.502	31.6	0.135	0.121	0.45	1.48	1.63	168	435	8.5
	10/3/2018	Background	385	2.95	11.1	0.456	30.8	0.138	0.100	0.40	1.00	1.40	172	457	8.3
	10/22/2018	Background	380	2.36	11.4	0.396	30.7	0.180	0.100	0.42	1.00	1.49	170	434	8.3
	11/13/2018	Background	388	3.03	11.5	0.424	32.2	0.209	0.100	0.45	1.00	2.27	159	444	8.0
	12/19/2018	Background	372	2.71	10.7	0.441	30.9	0.117	0.0900	0.43	1.00	1.31	162	428	8.1
	1/23/2019	Background	242	2.29	14.6	0.404	55.9	0.115	0.0400	0.41	1.00	1.41	148	453	8.2
	2/19/2019	Background	367	2.36	10.9	0.371	31.3	0.126	0.0900	0.44	1.00	1.22	175	457	8.5
	MW-1 Intrawell Prediction Limit		- -	**3.58**	**14.6**	- -	**55.9**	**0.261**	- -	**4.85**	- -	- -	- -	**536**	**8.8**
	3/12/2019	Detection	390	2.60	11.0	0.383	31.6	0.110	0.080	0.43	- -	1.14	170.0	458	8.2
	11/8/2019	Detection	353	2.38	11.2	0.413	33.7	0.114	0.100	0.42	- -	1.42	165.0	461	8.2
	5/13/2020	Detection	335	2.74	11.2	0.410	33.6	0.122	0.070	0.42	- -	1.38	163.0	457	8.2
MW-2	07/27/2018	Background	545	4.24	471	0.924	2.40	0.259	2.60	3.08	27.2	1.97	427	1260	8.4
	08/29/2018	Background	547	3.98	443	0.891	17.4	0.249	2.49	2.99	34.5	3.05	426	1310	8.6
	10/04/2018	Background	550	4.31	435	0.870	14.8	0.256	2.55	2.99	30.8	2.33	532	1280	8.5
	10/23/2018	Background	561	3.95	438	0.866	7.40	0.262	2.41	3.08	26.1	2.47	516	1250	8.5
	11/15/2018	Background	546	4.07	469	0.861	13.5	0.328	2.67	3.30	29.2	2.69	482	1250	8.5
	12/19/2018	Background	551	3.81	430	0.822	6.40	0.225	2.34	3.03	25.5	2.03	443	1250	8.5
	01/23/2019	Background	513	3.67	441	0.903	6.40	0.318	2.22	3.00	29.2	2.40	447	1310	8.2
	02/22/2019	Background	568	3.95	447	0.855	2.30	0.237	2.26	3.06	21.9	2.02	461	1310	8.7
	MW-2 Intrawell Prediction Limit		- -	**4.66**	**495**	- -	**26.7**	**0.382**	- -	**3.39**	- -	- -	- -	**1410**	**8.9**
	3/13/2019	Detection	605	3.98	441	0.826	1.8	2.300	2.38	3.02	26.2	1.86	470	1300	8.7
	11/8/2019	Detection	543	4.77	426	1.08	20.1	0.265	2.39	2.73	- -	2.91	481	1340	8.5
	2/11/2020	Verification	- -	4.31	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	5/12/2020	Detection	505	4.35	443	1.05	6.0	0.214	2.1	2.91	- -	2.06	471	1340	8.6
MW-5	7/24/2018	Background	599	6.75	793	1.60	0.2	0.252	4.69	3.32	36.5	3.04	777	1890	8.1
	8/29/2018	Background	601	6.71	780	1.63	0.2	0.240	4.56	3.33	38.4	4.59	714	1880	8.2
	10/3/2018	Background	581	7.03	776	1.56	0.1	0.276	4.67	3.33	35.7	3.37	742	1860	8.1
	10/24/2018	Background	623	7.09	811	1.61	<0.06	0.249	4.63	3.44	35.1	3.40	735	1840	8.1
	11/13/2018	Background	600	6.79	832	1.38	0.1	0.264	4.89	3.63	34.7	4.03	586	1880	8.0
	12/19/2018	Background	609	6.48	783	1.53	<0.06	0.221	4.73	3.43	34.8	3.02	595	1890	7.9
	1/23/2019	Background	619	5.98	782	1.60	<0.06	0.323	4.58	3.36	35.0	3.80	599	1910	8.1
	2/19/2019	Background	599	6.79	793	1.69	<0.06	0.239	4.58	3.38	33.6	3.21	687	1920	8.2
	MW-5 Intrawell Prediction Limit		- -	**7.79**	**853**	- -	**0.2**	**0.355**	- -	**3.72**	- -	- -	- -	**1980**	**7.8**
	3/13/2019	Detection	609	6.85	804	1.60	0.08	0.229	4.69	3.44	- -	2.78	660	1930	8.0
	11/8/2019	Detection	588	21.00	663	2.61	32	0.182	4.36	3.04	- -	6.61	571	1840	8.0
	2/11/2020	Verification	- -	11.30	713	- -	18.6	- -	- -	- -	- -	- -	- -	- -	7.8
	5/11/2020	Detection	540	9.85	746	2.32	11	0.211	3.74	2.97	- -	2.9	694	1820	7.9
	7/7/2020	Verification	- -	8.77	- -	- -	22.8	- -	- -	- -	- -	- -	- -	- -	8.1

Table 3
Monitoring Well Water Quality Data
Fly Ash Pond Alternative Source Demonstration Investigation
AEP, John E. Amos, Winfield, WV
May 2020

			Major Ions					Minor Ions							
Monitoring Well	**Collection Date**	**Monitoring Program**	**Bicarbonate (Alkalinity as CaCO3)**	**Calcium**	**Chloride**	**Magnesium**	**Sulfate**	**Boron**	**Bromide**	**Fluoride**	**Molybdenum**	**Potassium**	**Sodium**	**TDS**	**pH**
			mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**s.u.**
MW-6	7/24/2018	Background	294	61.0	19.3	15.5	44.4	0.120	0.168	0.22	0.580	2.73	59.0	392	6.9
	8/28/2018	Background	310	59.7	19.4	15.6	44.6	0.096	0.203	0.24	0.600	2.87	60.8	398	6.9
	10/3/2018	Background	309	60.7	18.9	15.3	43.4	0.125	0.200	0.21	0.500	2.72	62.5	402	6.8
	10/24/2018	Background	302	61.5	18.4	15.0	42.0	0.1	0.200	0.23	0.600	2.76	68.3	400	6.9
	11/13/2018	Background	304	64.9	19.8	14.0	44.6	0.111	0.200	0.24	0.700	3.24	57.4	390	6.7
	12/19/2018	Background	324	55.8	17.7	14.1	41.7	0.07	0.100	0.23	0.700	2.80	57.4	376	6.7
	1/23/2019	Background	309	54.1	17.8	15.0	41.3	0.08	0.100	0.22	0.600	2.77	54.8	411	6.6
	2/19/2019	Background	325	55.8	17.3	15.1	40.4	0.09	0.100	0.24	0.600	2.92	67.4	406	7.0
	MW-6 Intrawell Prediction Limit		- -	**70.6**	**21.4**	- -	**48.0**	**0.159**	- -	**0.26**	- -	- -	- -	**424**	**6.3**
	3/12/2019	Detection	314	57.9	17.4	14.7	39.8	0.08	0.1	0.23	- -	2.69	65.5	390	6.9
	11/8/2019	Detection	308	56.6	17.2	15.3	41.7	0.079	0.201	0.24	- -	2.84	66.1	368	6.9
	5/11/2020	Detection	295	55.8	15.9	15.3	32.6	0.088	0.1	0.25	- -	2.65	69.0	416	7.0
MW-7	07/26/2018	Background	314	1.33	5.41	0.175	32.0	0.0870	0.0960	0.270	1.12	0.590	138	368	8.53
	08/29/2018	Background	306	1.29	5.32	0.159	31.5	0.112	0.0900	0.270	1.06	1.15	133	387	8.75
	10/03/2018	Background	312	1.44	5.23	0.162	31.8	0.156	0.100	0.260	<1.00	0.910	147	376	8.75
	10/24/2018	Background	309	1.40	5.37	0.203	31.7	0.0900	0.100	0.270	<1.00	0.940	154	344	8.82
	11/13/2018	Background	318	1.49	5.65	0.169	33.2	0.192	0.100	0.290	<1.00	1.45	135	379	8.36
	12/17/2018	Background	323	1.24	5.29	0.173	32.0	0.100	0.0900	0.270	<1.00	0.730	155	387	8.62
	01/23/2019	Background	330	1.41	5.18	0.191	32.0	0.127	0.0800	0.250	<1.00	1.04	128	389	8.44
	02/18/2019	Background	325	1.37	5.39	0.181	32.1	0.0600	0.0900	0.260	<1.00	0.780	154	401	8.96
	MW-7 Intrawell Prediction Limit		- -	**1.63**	**5.80**	- -	**33.6**	**0.248**	- -	**0.34**	- -	- -	- -	**458**	**9.3**
	3/13/2019	Detection	308	1,47	5.5	0.185	32.5	0.060	0.090	0.270	- -	0.650	162	385	
	11/8/2019	Detection	295	2.18	5.4	1.54	32.3	0.066	0.100	0.250	- -	1.760	139	390	8.7
	2/11/2020	Verification	- -	1.39	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
	5/11/2020	Detection	284	1.59	5.3	0.286	23.6	0.067	0.08	0.27	- -	0.7	143	395	8.4
MW-1804A	7/27/2018	Background	< 1	28.1	- -	7.61	- -	0.672	0.5	- -	136	2.45	113	- -	- -
	8/1/2018	Background	367	- -	3.87	- -	35.2	- -	0.0400	0.70	- -	- -	- -	423	7.4
	8/28/2018	Background	395	15.9	5.27	4.03	44.7	0.779	0.0800	0.84	136	2.82	157	452	8.3
	10/2/2018	Background	377	38.8	3.63	10.00	35.7	0.629	0.0400	0.61	111	3.18	118	458	7.9
	10/23/2018	Background	423	12.9	4.79	3.22	36.9	0.675	0.0500	0.78	116	1.90	167	452	7.6
	11/13/2018	Background	425	8.90	5.32	1.72	46	0.846	0.0600	0.91	129	1.58	187	498	7.8
	12/19/2018	Background	446	10.1	4.51	2.14	40.1	0.772	0.0400	0.78	130	1.91	170	433	7.9
	1/24/2019	Background	367	12.1	3.14	3.09	32.3	0.673	0.04	0.71	110	1.86	146	414	7.4
	2/21/2019	Background	362	7.43	3.29	1.74	33.8	0.611	0.04	0.89	115	1.29	164	461	8.0
	MW-1804A Intrawell Prediction Limit		- -	**51.20**	**6.93**	- -	**53.9**	**0.965**	- -	**1.10**	- -	- -	- -	**599**	**6.8**
	3/12/2019	Detection	329	10.2	3.55	2.27	34.0	0.568	<0.04	0.85	- -	1.37	165.0	411	7.9
	11/11/2019	Detection	438	6.8	11.20	1.16	85.4	0.730	0.203	0.64	- -	0.80	211.0	582	8.0
	2/12/2020	Verification	- -	- -	9.59	- -	69	- -	- -	- -	- -	- -	- -	- -	7.8
	5/14/2020	Detection	357	4.51	6.2	0.767	51.4	0.739	0.04	0.85	- -	1.13	180	484	8.1

Table 3
Monitoring Well Water Quality Data
Fly Ash Pond Alternative Source Demonstration Investigation
AEP, John E. Amos, Winfield, WV
May 2020

Monitoring Well	Collection Date	Monitoring Program	Major Ions					Minor Ions							TDS	pH
			Bicarbonate (Alkalinity as CaCO3)	Calcium	Chloride	Magnesium	Sulfate	Boron	Bromide	Fluoride	Molybdenum	Potassium	Sodium			
			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	s.u.
MW-1806A	7/27/2018	Background	328	12.9	- -	3.19	- -	0.164	0.0700	- -	17	1.63	129	- -	- -
	8/1/2018	Background	331	- -	17.7	- -	48.4	- -	0.0600	0.56	- -	- -	- -	426	7.6
	8/29/2018	Background	333	12.0	16.2	2.9	45.6	0.162	0.0630	0.55	14.2	2.01	139	445	8.0
	10/2/2018	Background	380	5.81	7.21	1.3	36.2	0.15	0.04	0.80	7.73	1.31	160	435	8.5
	10/23/2018	Background	363	7.43	8.62	1.72	40.8	0.158	0.04	0.77	6.66	1.30	158	423	8.4
	11/13/2018	Background	371	7.51	8.15	1.67	40.1	0.213	0.04	0.85	7.44	1.32	159	442	8.1
	12/19/2018	Background	369	5.14	5.29	1.12	30.9	0.162	0.04	0.85	6.02	1.20	161	409	8.5
	1/24/2019	Background	360	12.2	11.7	2.89	48.1	0.168	0.0500	0.59	5.62	2.17	153	445	8.1
	2/18/2019	Background	351	5.67	6.24	1.3	33.0	0.133	0.04	0.81	4.74	1.14	159	460	8.6
	MW-1806A Intrawell Prediction Limit		- -	**18.80**	**24.60**	- -	**61.4**	**0.235**	- -	**1.14**	- -	- -	- -	**485**	**7.2**
	3/12/2019	Detection	375	4.98	5.51	1.10	32.9	0.130	0.040	0.83	- -	0.98	180.0	430	8.8
	11/12/2019	Detection	351	13.50	11.10	3.26	42.8	0.156	0.100	0.48	- -	1.78	149.0	423	7.9
	5/15/2020	Detection	363	2.32	8.45	0.451	35.2	0.127	<0.04	0.86	- -	0.90	175.0	456	8.8

Notes:

Intrawell Prediction Limits are "Lower" for pH and "Upper" for all other consitutents (AEP, 2020)

- - : not analyzed

TDS : total disolved solids

mg/L : milligrams per Liter

s.u. : standard units

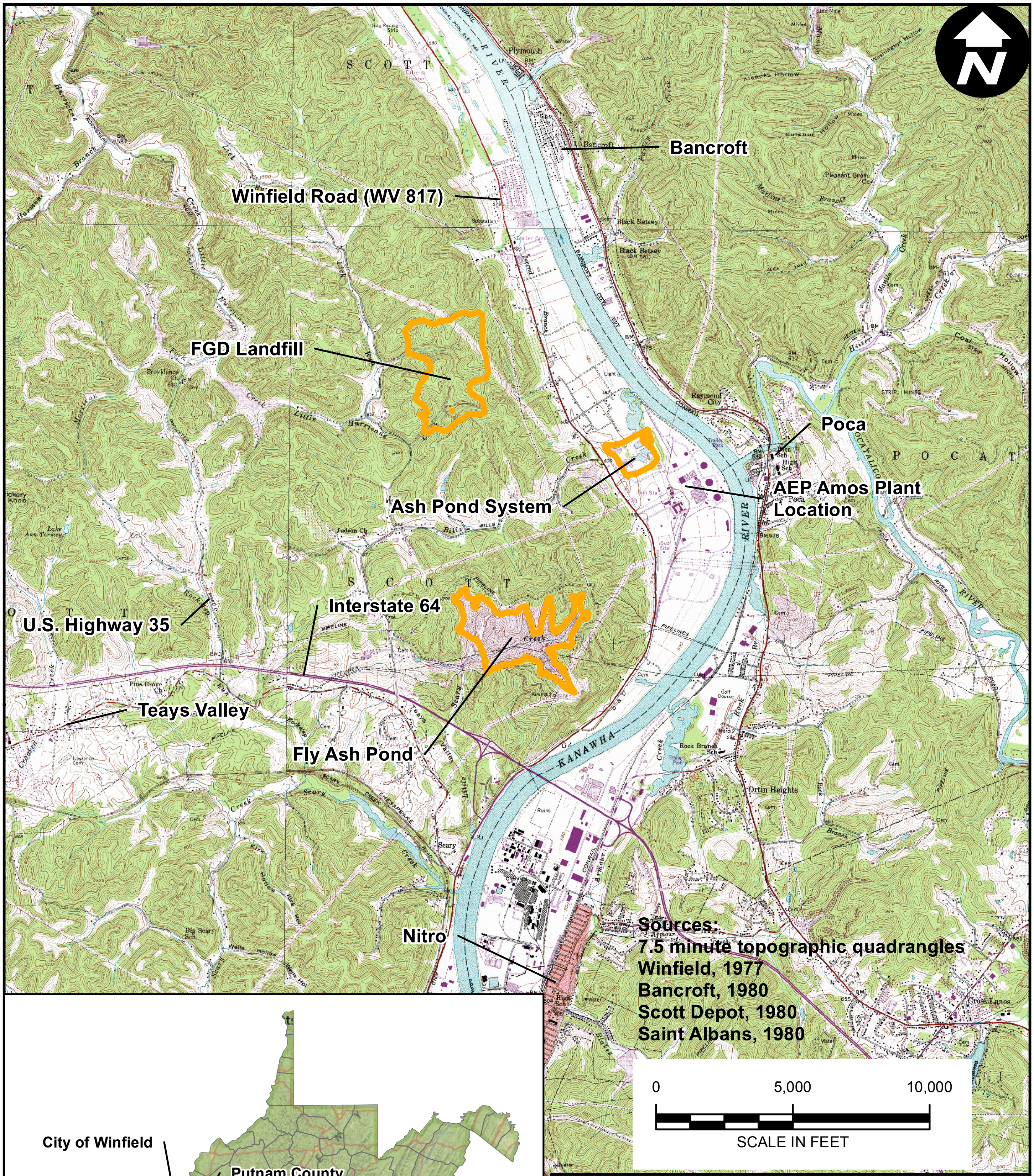
< - Non-detect value, less than the Method Detection Limit

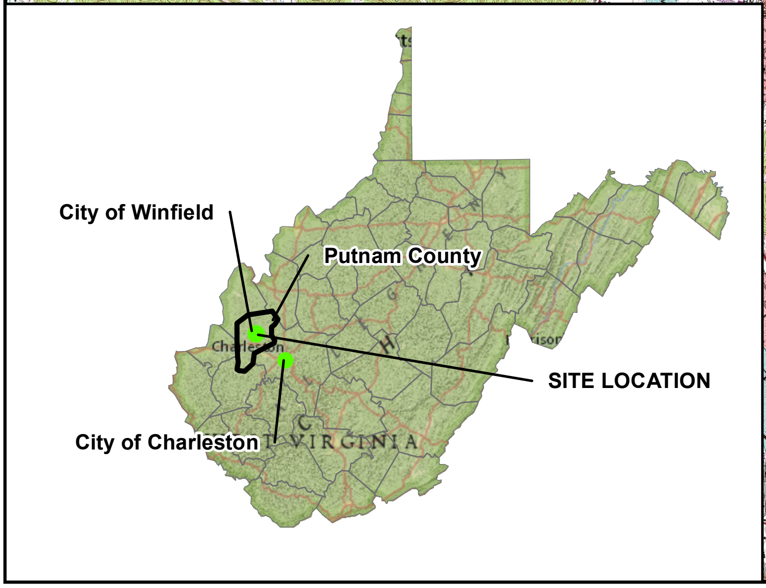
Table 4
Ion Ratios for Key Constituents in Groundwater
Fly Ash Pond Alternative Source Demonstration Investigation
AEP, John E. Amos Plant, Winfield, WV
May 2020

	Collection Date	Monitoring Program	Boron mg/L	Calcium mg/L	Chloride mg/L	Fluoride mg/L	Sulfate mg/L	B/Cl *100	Ca/Cl	F/Cl *1000	SO_4/Cl *1000
JAFAP Pore Water											
STN-12-4 Port 1	5/11/2020	Fly Ash	4.28	155	15.1	2.73	113	283	10.3	0.18	7,483
STN-12-4 Port 2	5/11/2020	Fly Ash	2.23	101	18.4	0.36	67.6	121	5.5	0.02	3,674
STN-12-4 Port 3	5/13/2020	Fly Ash	3.24	56.8	17.8	1.17	107	182	3.2	0.07	6,011
STN-12-4 Port 4	5/13/2020	Fly Ash	4.06	75.9	22.2	4.88	113	183	3.4	0.22	5,090
STN-12-4 Port 5	5/13/2020	Fly Ash	5.20	104	39	6.97	252	133	2.7	0.18	6,462
STN-12-4 Port 6	5/14/2020	Fly Ash	6.58	123	38	2.98	327	173	3.2	0.08	8,605
STN-12-4 Port 7	5/14/2020	Fly Ash	7.60	142	47.1	4.57	363	161	3.0	0.10	7,707
Benchmark SSI Exceedences											
MW-5	5/11/2020	Detection	0.211	**9.85**	746	2.97	**11**	0.3	0.01	0.004	15
Downgradient Wells											
MW-1	5/13/2020	Detection	0.122	2.74	11.2	0.42	33.6	11	0.2	0.04	3,000
MW-2	5/12/2020	Detection	0.214	4.35	443	2.91	6.0	0	0.01	0.01	14
MW-6	5/11/2020	Detection	0.088	55.8	15.9	0.25	32.6	6	3.5	0.02	2,050
MW-7	5/11/2020	Detection	0.067	1.59	5.3	0.27	23.6	13	0.3	0.05	4,453
MW-8	5/12/2020	Detection	0.191	1.83	108	2.73	19.9	2	0.02	0.03	184
MW-9	5/13/2020	Detection	0.122	0.959	7.27	0.82	12.0	17	0.1	0.11	1,651
MW-1801A	5/13/2020	Detection	0.105	52.6	9.93	0.13	34.6	11	5.3	0.01	3,484
MW-1804A	5/14/2020	Detection	0.739	4.51	6.20	0.85	51.4	119	0.7	0.14	8,290
MW-1806A	5/15/2020	Detection	0.127	2.32	8.45	0.86	35.2	15	0.3	0.10	4,166

Notes:
mg/L : milligrams per Liter
B/Cl : Boron/Chloride
Ca/Cl : Calcium/Chloride
F/Cl : Fluoride/Chloride
SO_4/Cl : Sulfate/Chloride

Appendix A Site Maps





AEP AMOS GENERATING PLANT - FLY ASH POND
WINFIELD ROAD
WINFIELD, WEST VIRGINIA

SITE LOCATION MAP

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FIGURE
1

Document Path: Z:\GISProjects_ENV\AEP\Amos\mxd\Impoundment\Report\F1_ site map.mxd

LEGEND:

Coal Combustion Residual (CCR) Unit

Rivers and Streams

Streamflow Direction

NOTES:
1. 2016 AERIAL IMAGERY OBTAINED FROM ESRI IMAGE SERVICE.
2. 2018 SITE SPECIFIC AERIAL IMAGERY OBTAINED FROM AEP.
3. WEST VIRGINIA 1983 STATE PLANAR COORDINATES

0 3,000 6,000 Feet

GRAPHIC SCALE

AEP AMOS GENERATING PLANT - FLY ASH POND
WINFIELD ROAD
WINFIELD, WEST VIRGINIA

PLANT AND CCR UNIT LOCATION MAP

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FIGURE
2

City: CITRIX Div/Group: IM/DV Created By: K.Ives Last Saved By: webb
OH015976.0009.00001 (Mountaineer Ash Pond)
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Well Identifiers
A – uppermost aquifer (Upper Connellsville sandstone/stress relief fracture system)
B – intermediate secondary groundwater-bearing zone (Clarksburg disconformity and fissile shale)
C – deep secondary groundwater-bearing zone (Morgantown sandstone – upper and basal disconformity contacts)

LEGEND:

- CCR Unit Boundary
- 2014 Soil and Rock Boring Location
- Oil & Gas Well
- 2008 Soil Boring and/or Rock Core
- Dewatering Well Converted to Piezometer
- Dewatering Well - Abandoned
- Downgradient Monitoring Well
- Upgradient or Background Monitoring Well
- 2012 Direct Push Boring with Cone Penetration Test (SCPTU)
- 2012 Direct Push Boring
- Piezometer
- 2012 Direct Push Soil Boring with Undisturbed (Shelby) Tube Samples and/or Standard Penetration Tests
- 2012 Direct Push Soil Boring with Undisturbed (Shelby) Tube Samples and/or Standard Penetration Tests and Piezometer
- 2012 Soil Boring with Standard Penetration Tests and Rock Core
- Rivers and Streams
- Stream Flow Direction
- Access Road

NOTES:
1. 2018 aerial imagery obtained from AEP.
2. FAP monitor well, STN boring, B-1401, and B-1402 coordinate source: AEP Drawing No. 13-30702-1
3. FAP piezometer and 2008 soil boring coordinate source: AEP-provided boring logs
4. Oil and gas well coordinate source: WVDEP Oil and Gas Well Database
5. West Virginia 1983 State Planar Coordinates

0 600 1,200 Feet

GRAPHIC SCALE

AEP AMOS GENERATING PLANT - FLY ASH POND
WINFIELD ROAD
WINFIELD, WEST VIRGINIA

FLY ASH POND LAYOUT AND WELL LOCATIONS MAP

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FIGURE 3

City: Div/Group: Created By: Last Saved By: acarlone
Project (Project #)
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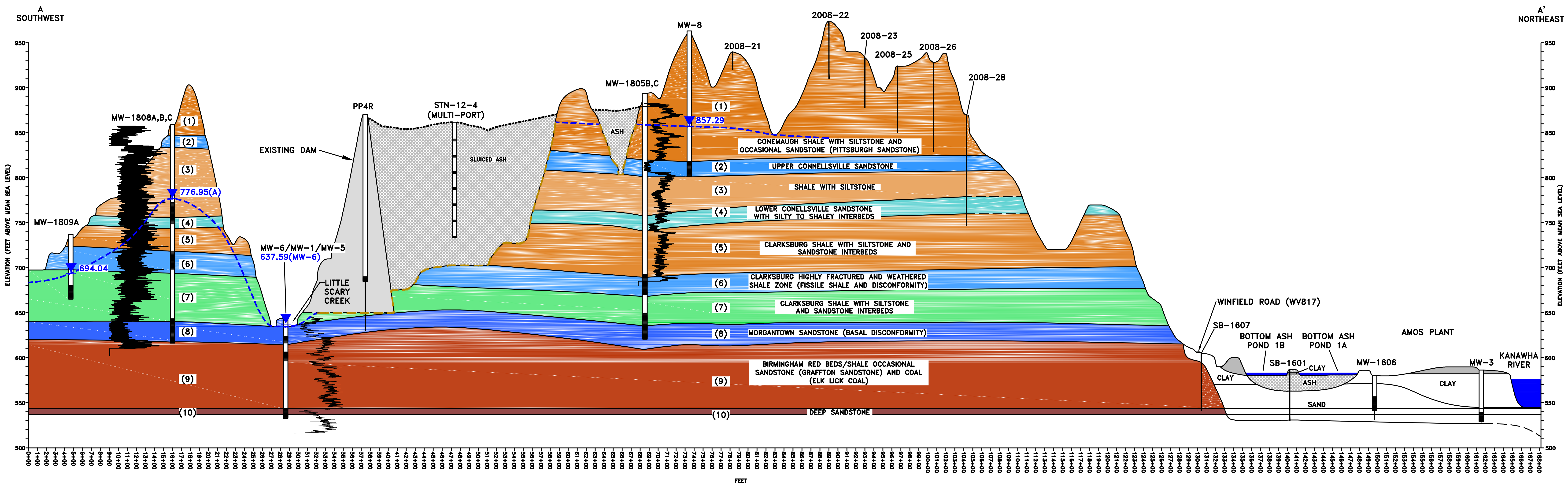
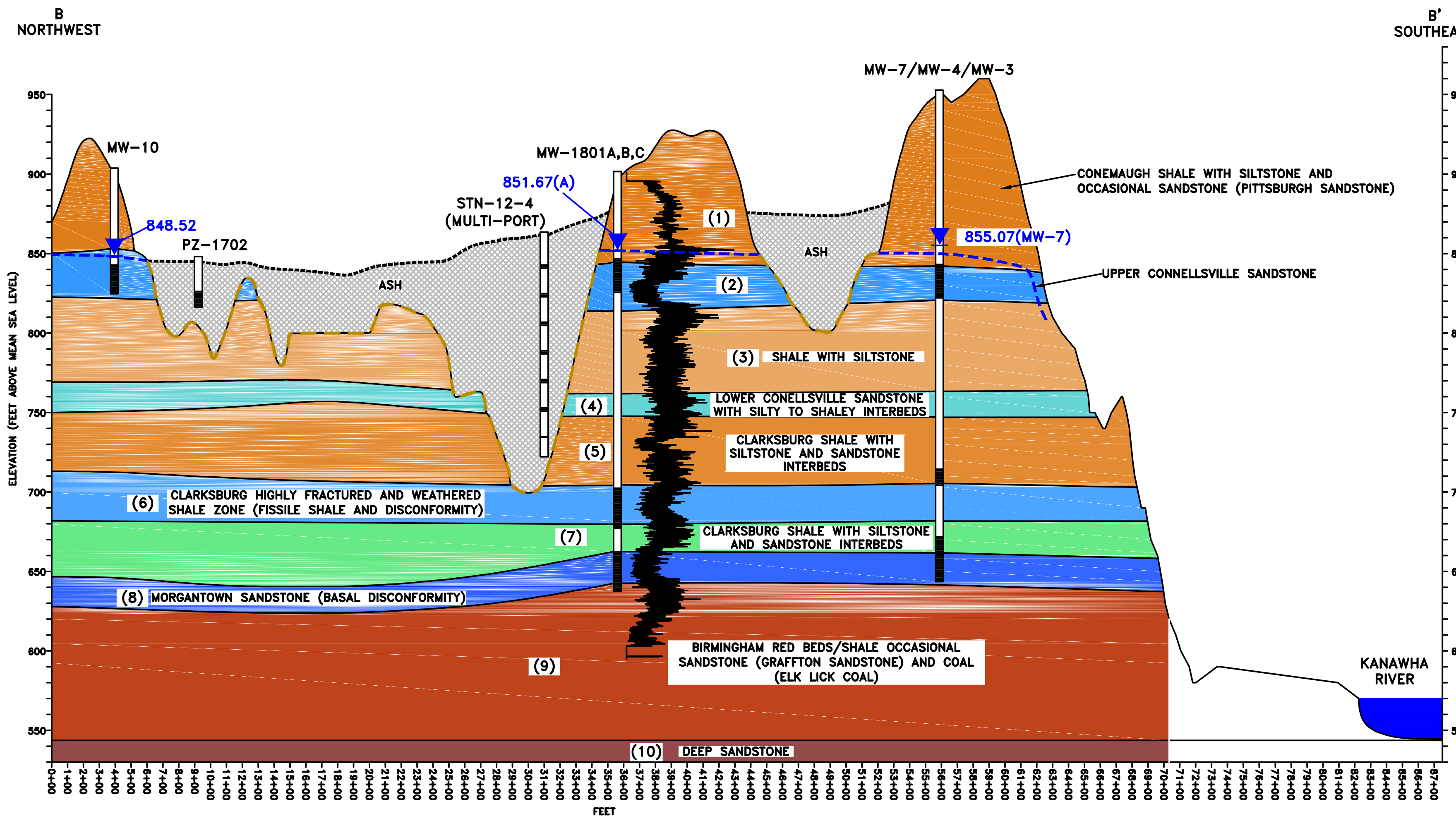
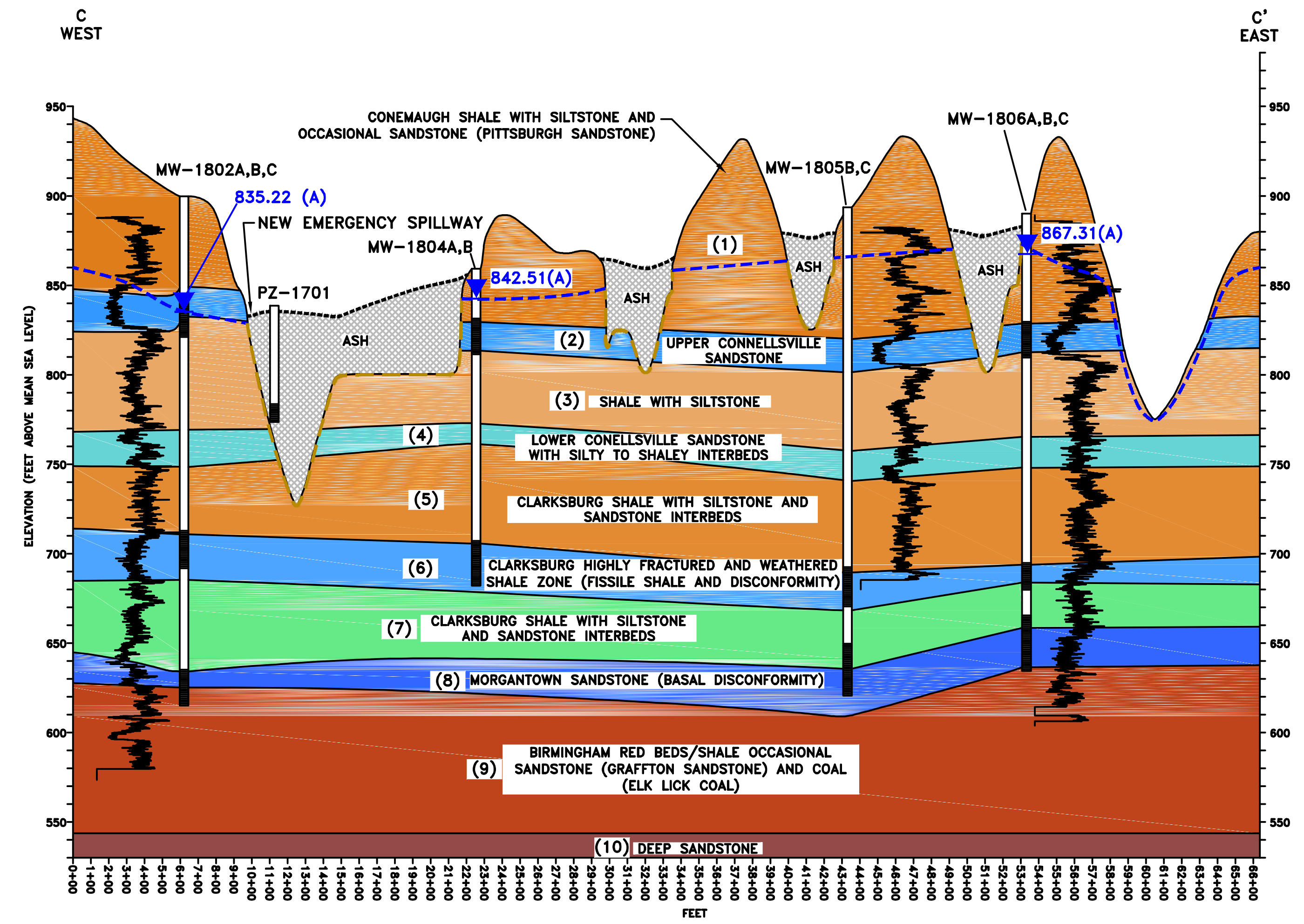
Appendix B Geologic Cross-Sections







LEGEND

MW-9 — WELL OR BORING IDENTIFICATION

- WELL
- WELL SCREEN
- BORING

CAP CONSTRUCTION (BOTTOM TO TOP):

- SUBGRADE PREPARATION (IN-PLACE FLY ASH AND ONSITE BORROW MATERIAL DEWATERING, EXCAVATING, GRADING)
- 40-MIL LINEAR LOW-DENSITY POLYETHYLENE (LLDPE) FLEXIBLE MEMBRANE LINER
- 8oz. GEOTEXTILE CUSHION LAYER
- 18 INCHES OF PROTECTIVE SOIL COVER LAYER
- 6 INCHES OF VEGETATIVE COVER LAYER
- DRAINAGE STRUCTURES
- SEEDING AND MULCHING

UPPERMOST AQUIFER (UPPER CONNELLSVILLE SANDSTONE AND SRF) MONITORING WELL WATER LEVEL OCTOBER 22, 2018

UPPERMOST AQUIFER (UPPER CONNELLSVILLE SANDSTONE AND SRF) POTENTIOMETRIC SURFACE

UPPERMOST AQUIFER (UPPER CONNELLSVILLE SANDSTONE AND SRF) TOP BELOW SATURATED ASH

NATURAL GAMMA LOG

0 100 200 300 COUNTS PER SECOND

(1) CONEMAUGH SHALE WITH SILTSTONE AND OCCASIONAL SANDSTONE (PITTSBURGH SANDSTONE)
(2) UPPER CONNELLSVILLE SANDSTONE
(3) SHALE WITH SILTSTONE
(4) LOWER CONELLSVILLE SANDSTONE WITH SILTY TO SHALEY INTERBEDS
(5) CLARKSBURG SHALE WITH SILTSTONE AND SANDSTONE INTERBEDS
(6) CLARKSBURG HIGHLY FRACTURED AND WEATHERED SHALE ZONE (FISSILE SHALE AND DISCONFORMITY)
(7) CLARKSBURG SHALE WITH SILTSTONE AND SANDSTONE INTERBEDS
(8) MORGANTOWN SANDSTONE (BASAL DISCONFORMITY)
(9) BIRMINGHAM RED BEDS/SHALE OCCASIONAL SANDSTONE (GRAFFTON SANDSTONE) AND COAL (ELK LICK COAL)
(10) DEEP SANDSTONE

VERTICAL SCALE: 1" = 100'
HORIZONTAL SCALE: 1" = 1000'

AEP AMOS GENERATING PLANT - FLY ASH POND
WINFIELD ROAD
WINFIELD, WEST VIRGINIA

CROSS SECTIONS A-A', B-B' AND C-C'

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FIGURE
6

CITY:(COLUMBUS, OHIO) DIV/GROUP:(ENV) DB:(R. SMITH) LD:(Opt) PIC:(Opt) PM:(T. FORTNER) TM:(Opt) LYR:(Opt)ON=*;OFF=*REF* LAYOUT: CS ALL SAVED: 2/1/2019 8:34 AM ACADVER: 21.0S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: ACAD.CTB
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City: Div/Group: Created By: Last Saved By: akens
Project (Project #)
Z:\GISProjects_ENV\AEP\Amos\mxd\ImpoundmentReport\F5_Layout_CrossSectionLocationRevJan2019.mxd 3/29/2019 7:44:22 AM

LEGEND:

- CCR Unit Boundary
- Stormwater Pond
- 2014 Soil and Rock Boring Location
- Oil & Gas Well
- 2008 Soil Boring and/or Rock Core
- Dewatering Well Converted to Piezometer
- Dewatering Well - Abandoned
- Downgradient Monitoring Well
- Upgradient or Background Monitoring Well
- Monitoring wells for the Ash Pond CCR Unit
- 2012 Direct Push Boring with Cone Penetration Test (SCPTU)
- 2012 Direct Push Boring
- Piezometer
- 2012 Direct Push Soil Boring with Undisturbed (Shelby) Tube Samples and/or Standard Penetration Tests
- 2012 Direct Push Soil Boring with Undisturbed (Shelby) Tube Samples and/or Standard Penetration Tests and Piezometer
- 2012 Soil Boring with Standard Penetration Tests and Rock Core
- Rivers and Streams
- Stream Flow Direction
- Access Road
- Cross Section Location

NOTES:

1. Topography from AEP dwg no. 13-30705-0 and 3dAMtopo_FAP11_aerial05.dgn. Contour Interval: 10 feet (2 feet within CCR unit boundary)
2. FAP monitor well, STN boring, B-1401, and B-1402 coordinate source: AEP Drawing No. 13-30702-1
3. FAP piezometer and 2008 soil boring coordinate source: AEP-provided boring logs
4. Oil and gas well coordinate source: WVDEP Oil and Gas Well Database
5. Amos Generating Plant monitor well, piezometer, and soil boring coordinate source: June 2016 AEP survey and EPRI, April 1999, Groundwater Quality at the John E. Amos Power Plant, Putnam County, West Virginia
6. West Virginia 1983 State Planar Coordinates
7. CSM = Conceptual Site Model

AEP AMOS GENERATING PLANT - FLY ASH POND
WINFIELD ROAD
WINFIELD, WEST VIRGINIA

CROSS SECTION LOCATION MAP

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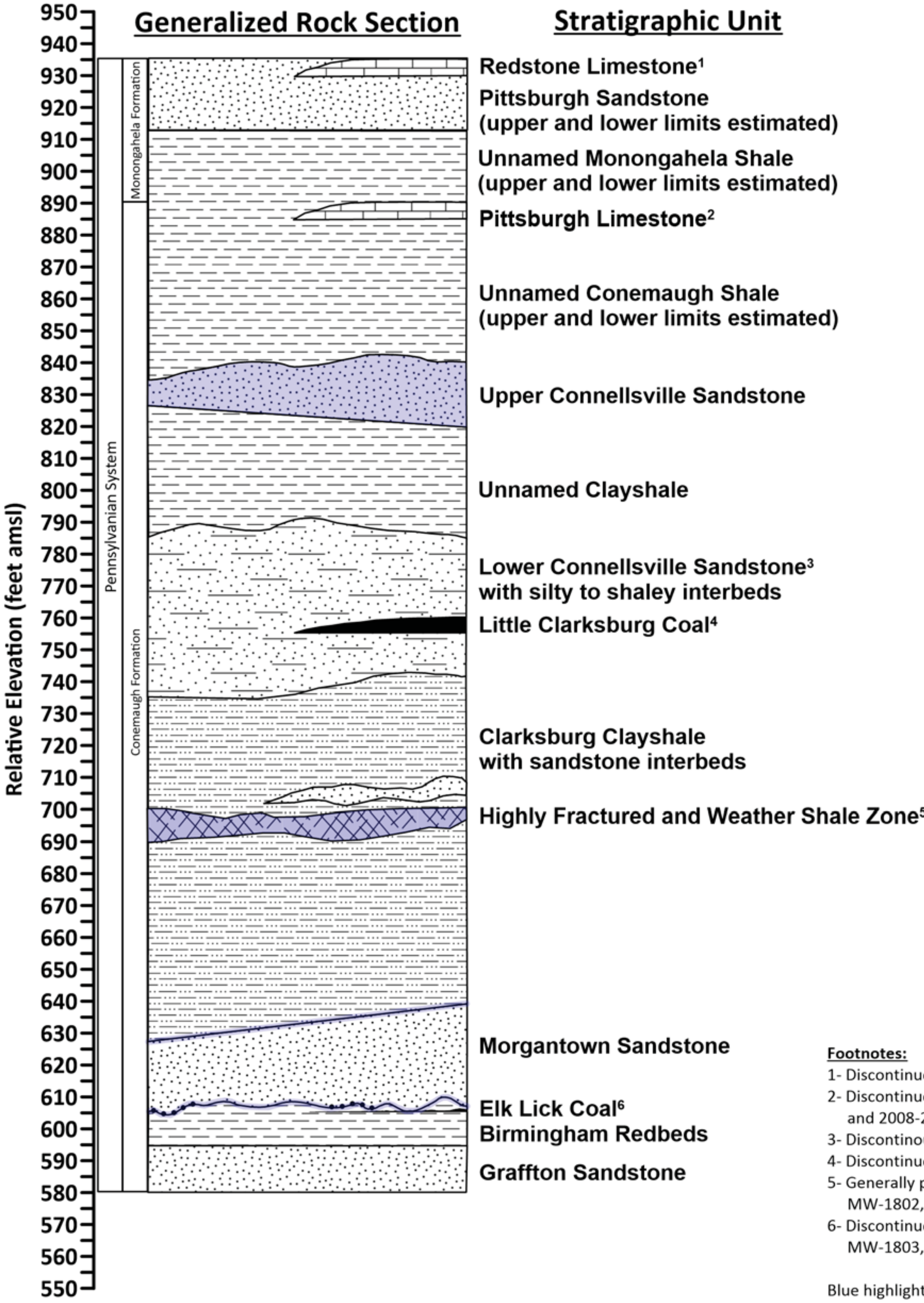
FIGURE
5



Footnotes:

1- Discontinuous - only present at boring MW-3

2- Discontinuous - only present at borings MW-3 and 2008-26

3- Discontinous - interbeds of sandstone

4- Discontinuous - only present at boring B-0608

5- Generally present at borings MW-1801, MW-1802, MW-1803, and MW-1805

6- Discontinuous and thin - present at MW-1802, MW-1803, MW-1805

Blue highlighted areas designate groundwater-bearing fracture zones

References:

- Site stratigraphic and geophysics from current data collection and historical reports.
- Cross, A.T and M.P. Shemel. 1956. *Geology and Economic Resources of the Ohio River Valley in West Virginia, Part I Geology.* West Virginia Geological Survey Volume XXII.
- Latimer, W.J., et al. 1911. *Jackson, Mason and Putnam Counties, Volume 1, County Reports and Maps*. Wheeling News Litho. Company.
- Orsborn, N.P. 2008. *Deposition and Structural Features of the Basal Morgantown Sandstone of the Casselman Formation (Pennsylvanian) of the Greater Pittsburgh Region.* MS Thesis.
- Reger, D.B., et al. 1918. *Barbour and Upshur Counties and Western Portion of Randolph, Volume 1, County Reports and Maps.* Wheeling News Litho. Company.

AEP AMOS GENERATING PLANT - FLY ASH POND
WINFIELD ROAD
WINFIELD, WEST VIRGINIA

GENERALIZED STRATIGRAPHIC COLUMN

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FIGURE 4

Appendix C Boring Logs

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

AEP

JOB NUMBER			
COMPANY		BORING NO.	D=MW-05 DATE 8/27/07 SHEET 1 OF 5
PROJECT	EPRI GROUND WATER STUDY - AMOS	BORING START 7/11/95	BORING FINISH 7/26/95
COORDINATES	N 531,282.0 E 1,724,360.0	PIEZOMETER TYPE	WELL TYPE OW
GROUND ELEVATION	648.0 SYSTEM STATE PLANE	HGT. RISER ABOVE GROUND 1.9	DIA 2.0
		DEPTH TO TOP OF WELL SCREEN 101.6	BOTTOM 111.0
		WELL DEVELOPMENT YES	BACKFILL QUICK GROUT
		FIELD PARTY MCR-RLY=TJH-REB	RIG BK-81 CME-75

Water Level, ft	▽	▼	▼
TIME			
DATE			

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										AUGERED TO 2'		
1	SS	2.0	3.5	??-28-19	15"				GM	**GRAY ROCK FRAGMENTS, GRAVEL, SILT,** DRY, (FILL).		
									ML	**CLAYEY SILT AND GRAVEL**, MODERATE BROWN (5YR 3\4), Moist.		
										AUGERED TO 7.0'		
							5					
2	SS	7.0	22.0	10-9-9	7.5"				ML	**CLAYEY SILT AND GRAVEL**, MODERATE BROWN (5YR 4\8) LIGHT BROWN (5YR 5\6 AND MODERATE BROWN (5YR 3\4), TRACE FELDSPAR, MOIST.		
										AUGERED TO 12.0'		
							10					
3	SS	12.0	13.5	13-8-5	17"				ML	**SAME AS ABOVE**		
									CL	**SILTY CLAY**, PALE YELLOWISH BROWN (12YR 6\2) AND LIGHT OLIVE GRAY (5YR 5\2), LOW TO MEDIUM PLASTICITY, MOIST.		
										AUGERED TO 17.0'		
							15					
4	SS	17.0	18.5	3-3-3	18"				SC	**CLAYEY-SILTY FINE SAND**, DUSKY YELLOWISH BROWN (10 YR 2\2),MOIST TO WET.		
										AUGERED TO 22.0'		

TYPE OF CASING USED

X	NQ-2 ROCK CORE	
X	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
	NW CASING	3"
	SW CASING	6"
	AIR HAMMER	8"

Continued Next Page

PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER D.BENNETT

AMERICAN ELECTRIC POWER SERVICE CORPORATION
AEP CIVIL ENGINEERING LABORATORY
LOG OF BORING

JOB NUMBER ____________

COMPANY ____________

PROJECT **EPRI GROUND WATER STUDY - AMOS**

BORING NO. **D=MW-05** DATE **8/27/07** SHEET **2** OF **5**

BORING START **7/11/95** BORING FINISH **7/26/95**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	USCS	SOIL / ROCK IDENTIFICATION	DRILLER'S NOTES
5	SS	22.0	23.2	7-7-50/3"	13"			SC	**SAME AS SAMPLE No. 4**	
								SW	**MEDIUM TO COARSE SAND**, LIGHT BLUISH GRAY (5B 7\1), MOIST.	
1	NQ	24.0	29.8		5.0	60			AUGERED TO 23.9' - AUGERED THROUGH OBSTRUCTION (ROCK?)	
							25		**MORGANTOWN SANDSTONE?**, GRAY. 24.0 - 25.0' Solid, light gray, (N-7) 25.0 - 26.0' Fractured, brown clay lined fractures, light gray (N-7). 26.0 - 27.0' Minimal fractures 27.0 - 27.7' Fractured, weathered, very fine dark gray (N-3) bedding. 27.7 - 29.8' Light gray (N-7) sandstone	25.0 Fracture = 8 26.0 Fracture = 3 26.5 Lost water 27.0 Fracture = 5
2	NQ	29.8	39.8		10.0	93	30		29.8 - 33.8' Light gray (N-7) sandstone	
									CLAY SHALE, MEDIUM GRAY (N4) MOIST, VERY SOFT.	
							35			
									CLAY SHALE, GRAYISH BROWN (5YR 3\2), MOIST, VERY SOFT.	35.2 Fracture = 3
									CLAY SHALE, LIGHT OLIVE GRAY (5Y 5\2) MEDIUM LIGHT GRAY (N6), SOFT, MODERATE WEATHERING.	36.3 Fracture = 3
									SHALE, MEDIUM BLUISH GRAY (5B 5\1), TRACE IRREGULAR BEDDING PLANES, SOFT.	37.3 Fracture = 2
3	NQ	39.8	49.8		9.8	67	40		**SAME AS ABOVE**	39.8 Fracture = 6
									SAME, WITH MODERATE BROWN (5YR 3\4) BEDDING PLANES, MEDIUM TO HIGHLY FRACTURED, MODERATE WEATHERING.	42.5 Fracture = 8
									SHALE, MEDIUM BLUISH GRAY 5Y 5\2), SLIGHT TO MODERATE WEATHERED	
							45		**CLAY SHALE**, PALE BROWN (5YR 5/2), TO DARK YELLOWISH BROWN (10YR 4/2) AND	44.6 numerous fractures.

Continued Next Page

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER ______

COMPANY ______

PROJECT **EPRI GROUND WATER STUDY - AMOS**

BORING NO. **D=MW-05** DATE **8/27/07** SHEET **3** OF **5**

BORING START **7/11/95** BORING FINISH **7/26/95**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										LIGHT OLIVE GRAY (5YR 4/2), SOFT, SOME IRREGULAR BEDDING PLANES		
4	NQ	49.8	56.5		4.7	54	50					
												51.0 Regained drill water
							55					
5	NQ	56.5	59.8		2.55	50				**SAME EXCEPT VERY SOFT**		56.5 Fracture = 7
6	NQ	59.8	67.3		7.5	96	60			**CLAYEY SILT**, DARK YELLOWISH BROWN (10yr 4\2), MOIST - WET		
										SAME, VERY WEATHERED, SOFT		
										CLAY SHALE, PALE BROWN (5YR 5\2), SLIGHTLY WEATHERED		
							65					
										SAME, SOME MODERATELY WEATHERED, SOFT		
7	NQ	67.3	69.8		2.5	40				**SAME**, VERY WEATHERED, VERY SOFT		
										SAME, MODERATELY WEATHERED, SOFT		68.0 Fracture = 5
										SHALE, MEDIUM GRAY (N5), SOFT.		
8	NQ	69.8	78.8		6.8	64	70			**SAME**		
										CLAY SHALE, PALE BROWN (YR 5\2) AND		71.6 Fracture = 12

Continued Next Page

JOB NUMBER ______

COMPANY ______ BORING NO. **D=MW-05** DATE **8/27/07** SHEET **4** OF **5**

PROJECT **EPRI GROUND WATER STUDY - AMOS** BORING START **7/11/95** BORING FINISH **7/26/95**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										MEDIUM GRAY (N5), MODERATELY WEATHERED, SOFT.		
							75					
9	NQ	78.8	79.8		1.0	40				**SHALE**, PALE BROWN (5YR 5\2) AND LIGHT OLIVE GRAY (5Y 5\2), IRREGULAR BEDDING, WEATHERED, SOFT.		78.8 numerous fracture.
10	NQ	79.8	87.8		6.3	48	80			**SAME**, SOME SEDIMENT FILLED FRACTURES		
							85					
												86.0 Top of seal.
										SHALE, GRAYISH OLIVE (10 YR 4\2) AND MODERATE BROWN (5YR 3\4), INTERBEDDED LAYERS, SOFT, SLIGHTLY WEATHERED.		
11	NQ	87.8	89.8		2.0	75						
12	NQ	89.8	90.8		.75	0	90			**SAME**, EXCEPT WEATHERED		
13	NQ	90.8	99.8		9.0	100				**SHALE**, MEDIUM BLUISH GRAY (5B 5\1), WITH SOME INTERBEDDED BROWNISH GRAY (5YR 4\1) COLOR, SLIGHTLY WEATHERED, SOFT		91.0 Top sand.
							95					

Continued Next Page

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

COMPANY

PROJECT **EPRI GROUND WATER STUDY - AMOS**

BORING NO. **D=MW-05** DATE **8/27/07** SHEET **5** OF **5**

BORING START **7/11/95** BORING FINISH **7/26/95**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
14	NQ	99.8	100.3		.25	0	100			**SAME**, EXCEPT WEATHERED		Lost water return on run #14.
15	NQ	100.3	109.8		9.5	95				**SHALE**, MEDIUM BLUISH GRAY 5B 5\1), SLIGHTLY WEATHERED, SOFT		101.6 Top of screen.
										SANDSTONE, MEDIUM BLUISH GRAY (5B 5\1), SLIGHTLY WEATHERED AT 104', SOFT.		
							105					
16	NQ	109.8	114.8		4.4	40	110			**SAME**, SOFT		
										SHALE, MEDIUM BLUISH GRAY (5B 5\1), SOFT.		111.0 Bottom of screen.
										SHALE, MEDIUM DARK GRAY, SOFT, WEATHERED, VERY FRACTURED.		112.0 Fracture = 7 112.1 Bottom of sand.
										CLAY SHALE, GRAYISH BROWN (5YB 3\2), WEATHERED, SOFT TO VERY SOFT, FRACTURED.		
										114.8 BOTTOM OF HOLE		114.7 Bottom of seal.

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

MONITORING WELL CONSTRUCTION

JOB NUMBER ____________

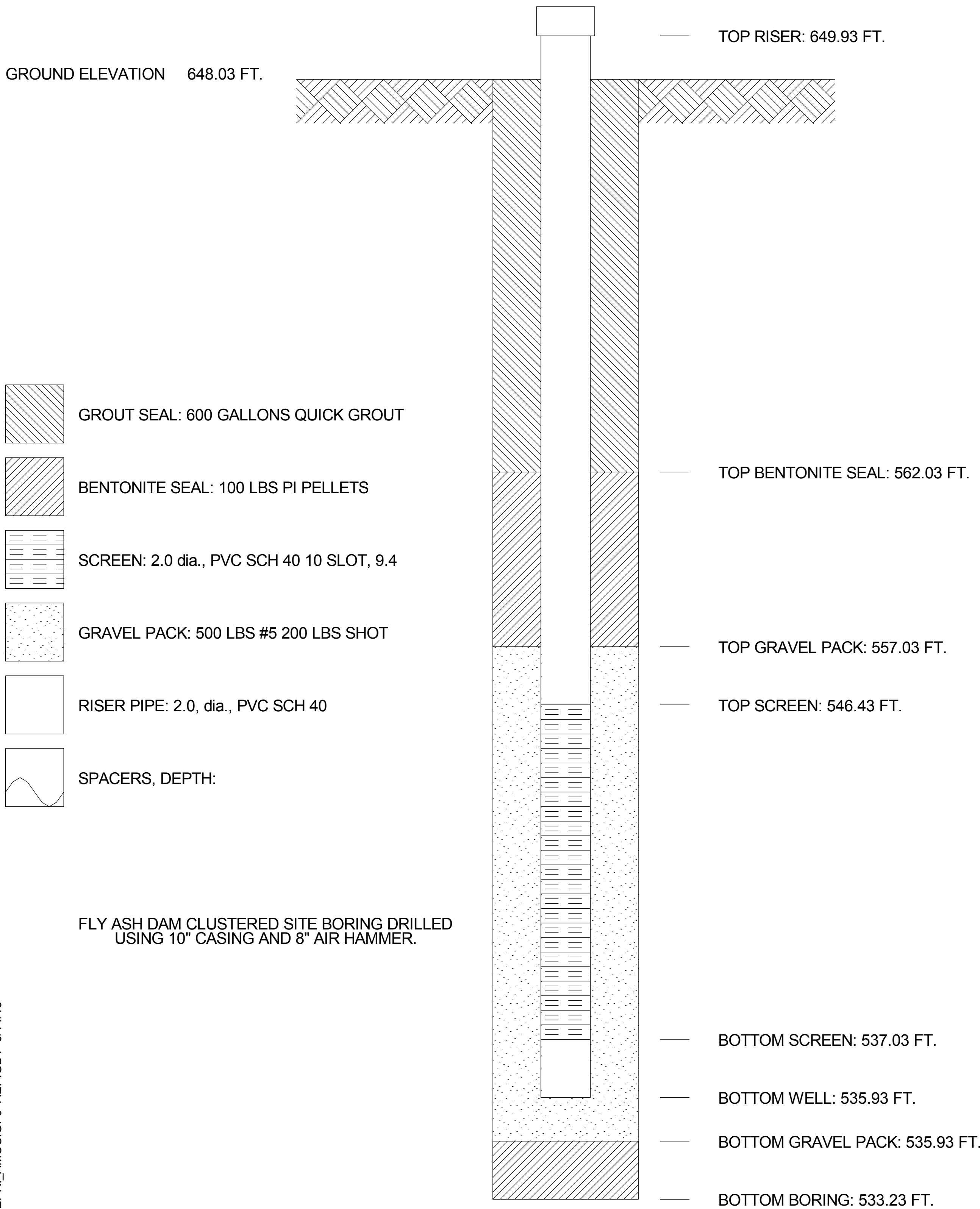
COMPANY ____________

WELL No. **MW-5** BORING No. **D=MW-05** INSTALLED **7/26/95**

PROJECT **EPRI GROUND WATER STUDY - AMOS**

COORDINATES **N 531,282.0 E 1,724,360.0**

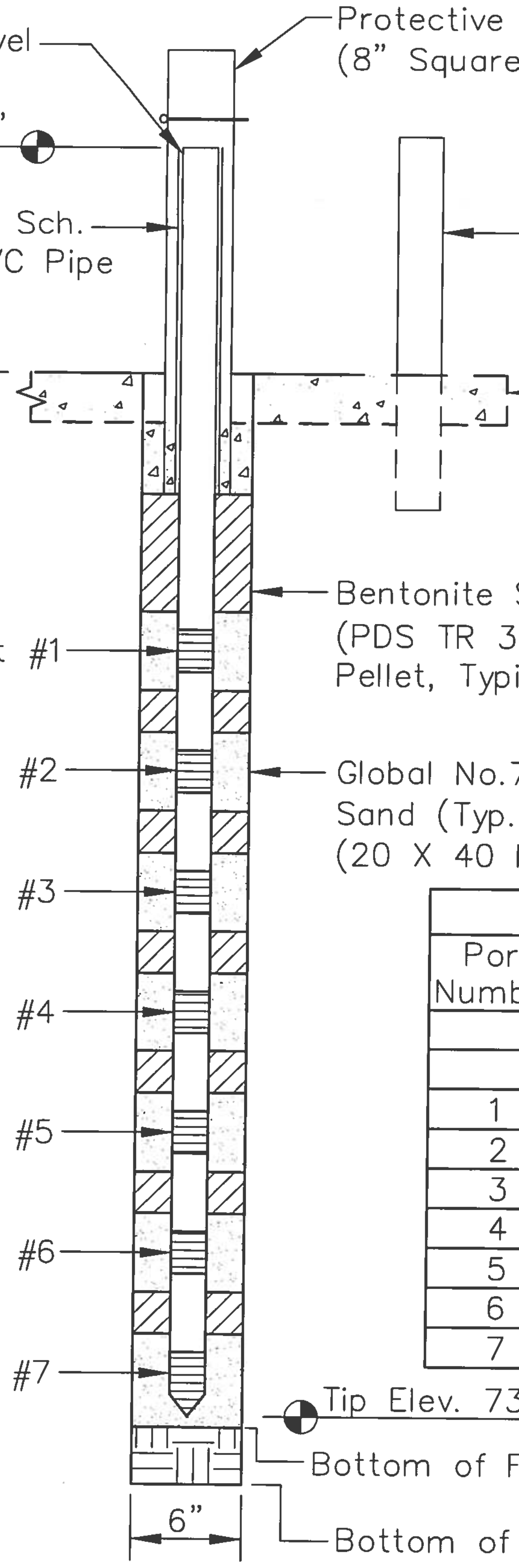
SYSTEM **STATE PLANE**



GEOMCNST EPRI_AMOS.GPJ AEP.GDT 6/14/13

NOTES:

1. All Units Are in Feet Unless Noted Otherwise.
2. Typical Port Length is 2 ft. Unless Noted Otherwise.
3. 4.4" Dia. Centralizers Placed at 10ft. Spacing Along Well Tubing (Not Shown).



Port Number	Elevation (ft.) Screened Interval		Filter Pack Interval		Bentonite Seal Interval	
	From	To	From	To	From	To
					861.5	845.1
1	843.0	841.0	845.1	839.1	839.1	827.0
2	825.0	823.0	827.0	821.0	821.0	809.1
3	807.0	805.0	809.1	803.0	803.0	791.2
4	789.0	787.0	791.2	785.0	785.0	773.2
5	771.0	769.0	773.2	767.2	767.2	756.5
6	753.0	751.0	756.5	749.0	749.4	737.5
7	735.0	734.5	737.5	734.0		

PLOT DATE: 04/27/2012 USER: JENNINGS, MATTHEW
U:\1756\175661014\ENVIRONMENTAL\DRAWING\SHEET_FILES\MONITORING WELLS\STN-12-4-WELL-LOG.DWG

LOCATION:

Northing: 531,882.29
Easting: 1,726,127.18
Ground Elevation: 861.83'
Installation Date: 3/8/12
Horizontal Datum: NAD 83 WV. South
Vertical Datum: NAVD 88

PIEZOMETER DETAIL
AEP AMOS POWER PLANT, FLY ASH DAM COMPLEX
STN-12-4, WEST VIRGINIA WELL ID WV00054-0003-12

Stantec

Stantec Consulting Services Inc.
11687 Lebanon Rd.
Cincinnati, Ohio
45241-2012
513-842-8200
www.stantec.com

DRAWN BY	MSJ	DATE	4/25/12	REVISED		SHEET
CHECKED BY	JMM	PROJ. NO.	175661014	1.	3.	1 OF 1
CHECKED BY	JSD	SCALE	NTS	2.	4.	

Alternative Source Demonstration Report for Calcium, Chloride and Sulfate

John E. Amos Plant Fly Ash Pond
Winfield, West Virginia

Prepared for:

American Electric Power

Prepared by:

EHS Support LLC and EnviroProbe Integrated Solutions, Inc.

June 2020

Table of Contents

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Acronyms

amsl	above mean sea level
ASD	alternative source demonstration
bgs	below ground surface
Ca	calcium
$CaCO_3$	alkalinity
$Ca\text{-}HC0_3$	calcium bicarbonate
$CaS0_4$	gypsum
CCR	Coal Combustion Residual
CFR	Code of Federal Regulations
EPRI	Electric Power Research Institute
ft	feet
JAFAP	John E. Amos Plant Fly Ash Pond
Mg	manganese
mg/L	milligrams per liter
MSL	mean sea level
NaCl	sodium chloride
$Na\text{-}HC0_3$	sodium bicarbonate
SRF	stress relief fracturing
SSI	statistically significant increases
TDS	total dissolved solids
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 appropriate for evaluating the groundwater monitoring data for the John E. Amos Plant Fly Ash Pond Coal Combustion Residual (CCR) management area associated with the John E. Amos Plant Power Plant located in Winfield. West Virginia. This ASD meets the requirements of the United States Environmental Protection Agency CCR Rule defined at 40 Code of Federal Regulations 257.94(e)(2).

Roderic E. Moore, P.E.

Printed Name of Licensed Professional Engineer

Signature

16390	West Virginia	June 25, 2020
License Number	Licensing State	Date

1 Introduction

EHS Support LLC ("EHS Support") was retained by Appalachian Power Company, doing business as American Electric Power (AEP) to conduct an alternative source demonstration (ASD) investigation for coal combustion residual (CCR) constituents at the John E. Amos Plant Fly Ash Pond (JAFAP) located in Putnam County, Winfield, West Virginia (**Appendix A**). EHS Support has teamed with EnviroProbe Integrated Solutions, Inc. of Nitro, West Virginia to complete this ASD investigation per the requirements of the United States Environmental Protection Agency (USEPA) CCR Rule (40 Code of Federal Regulations [CFR] 257.94).

1.1 Objectives

The objective for this ASD investigation is to assess groundwater monitoring data collected in compliance with the CCR Rule as allowed under paragraph 40 CFR 257.94(e)(2) of the CCR Rule. This part of the rule allows AEP to determine whether the source(s) for statistically significant increases (SSIs) reported from groundwater monitoring are associated with the CCR unit, or if the SSIs resulted from an error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality. The focus of this JAFAP ASD investigation is specifically on the constituents which demonstrated SSIs at the following two monitoring wells during the November 2019 detection monitoring event (and subsequent February 2020 confirmation sampling event):

- MW-5: Calcium and Sulfate
- MW-1804A: Chloride and Sulfate

1.2 Lines of Evidence

This ASD investigation for the JAFAP has been conducted to evaluate potential alternate sources or reasons for the SSIs of calcium and sulfate in MW-5 and chloride and sulfate in MW-1804A. A potential alternate source is evident, when based on the following lines of evidence:

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

- 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.
- Constituent 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 sulfate is a primary indicator for coal ash leachate (Electric Power Research Institute [EPRI], 2012) it has been evaluated in this ASD investigation. Other potential indicators that were evaluated in this ASD investigation include calcium and chloride. Calcium is considered to only have a potential direct association with fly ash leachate and chloride a negligible direct association (EPRI 2017).

2 Project Background

2.1 Site Location and History

The JAFAP is located in Putnam County approximately 1.5 miles southwest of the power plant and approximately 0.5 miles west of Winfield Road (WV 817) (**Appendix A**). The site occupies approximately 170 total acres (Terracon, 2017a).

The JAFAP is in a valley at the headwaters of Little Scary Creek and is surrounded by ridges on most sides (Stantec, 2012). The southwestern corner of the JAFAP consists of an earthen dam that is approximately 220 feet (ft) tall with a crest elevation of 875 ft above mean sea level (amsl). The dam is approximately 30 ft wide and 2,000 ft long.

The JAFAP began receiving fly ash in October 1971. The final of three construction stages for the unlined impoundment was completed in 1978 (EPRI, 1999), and operations continued until 2010. In 2010, the JAFAP reached its maximum capacity, Unit 3 at the power plant had been converted to a dry system, and fly ash was being disposed at the Amos FGD Landfill. As a result, operation of the JAFAP for placement of CCR waste ceased in 2010.

The surface of the JAFAP impoundment is covered with an engineered cover consisting of subgrade fill (fly ash and onsite borrow material), flexible membrane and geotextile layers, and soil/vegetative layers. General construction of the landfill and landfill closure is further detailed in the Phase I, Phase II, and Phase III *Construction Certification Reports* (Terracon, 2016; 2017a; 2017b) and the *Design Basis Report* for the site (Stantec, 2012).

2.2 Site Geology

The site is located in the Appalachian Plateau physiographic province, which is composed of Paleozoic sedimentary sandstones, conglomerates, and shales with locally significant coal beds (Fenneman and Johnson, 1946). To support a review of the site geology as it relates to this ASD investigation, cross sections from the Arcadis U.S., Inc. ("Arcadis") 2019 Fly Ash Pond CCR Groundwater Monitoring Well Network Evaluation report are provided in **Appendix B**.

The sedimentary rocks in the Appalachian Plateau are largely present as horizontal beds that have been incised by streams to form mountainous terrain. Unconsolidated deposits are virtually absent on ridges surrounding the JAFAP except for a veneer of colluvium (Arcadis, 2019). Unconsolidated deposits are not considered a water-bearing unit on the ridges as groundwater is typically encountered within bedrock (Arcadis, 2019). Arcadis (2019) found that the soil-rock interface on the ridges is abrupt with little to no occurrence of weathered bedrock. Unconsolidated alluvium deposits occur southwest of the JAFAP and dam in the Little Scary Creek where they are 8.5 ft-thick at boring 2008-1 and 43 ft-thick at MW-6. The unconsolidated deposits consist of four zones of alluvium that include an upper surficial gravel zone, a clay zone with discontinuous sand lenses, a sand zone with interbedded clay, and a basal gravel (EPRI, 1999).

Pennsylvanian-age bedrock of the Monongahela Group and Conemaugh Group form the ridges surrounding and the basement directly beneath the site. Whereas both the Monongahela Group and Conemaugh Group are present regionally in West Virginia, Maryland, Pennsylvania, and Ohio, there are local variations in the presence of geologic formations and members of the groups (Trap and Horn, 1997; Sweezy, 2002). Members of the Monongahela Group and Conemaugh Group that are present at the site are described by EPRI (1999) and included on the generalized cross sections presented in **Appendix B** (Arcadis, 2019).

The Monongahela Group consists of cyclic sequences of non-marine sandstone, siltstone, limestone, and coal (Krebs, 1911; Cardwell et al., 1968). The base of the Pittsburgh Coal (i.e. No. 8 Coal) is typically used to mark the transition from the Monongahela to the underlying Conemaugh Group (Cardwell et al., 1968; EPRI, 1999). Consistent with regional studies of northern West Virginia (Krebs and Teets, 1914), the Pittsburgh Coal is not identified in site borings. However, the Pittsburgh Limestone, (the uppermost member of the Casselman Group of the Conemaugh Formation) has been identified in two borings at the JAFAP, MW-3 and 2008-26, and is used to mark the Monongahela-Conemaugh transition at the site. The Monongahela-Conemaugh transition is identified at elevations above about 880 ft amsl, therefore, Monongahela Group rocks are present only at the highest elevations on ridges surrounding the JAFAP.

The Conemaugh Group forms the majority of basement rocks beneath the site. The Conemaugh Group consists of cyclic sequences of marine and non-marine shale, siltstone, sandstone, red beds, impure limestone, and thin non-persistent coal beds. The Conemaugh Group is divided into the Casselman Formation that is separated from the underlying Glenshaw Formation by the top of the Ames Limestone (Cardwell et al., 1968). The Ames Limestone has not been identified in site borings or wells, therefore only the Casselman Formation of the Conemaugh Group is identified at the JAFAP (EPRI, 1999). Several coal horizons present in the region serve as marker beds for unit identification (Fonner et al., 1981). The Little Clarksburg Coal has been identified at JAFAP boring B-0608 to the northeast of the JAFAP and is used to mark the base of the Lower Connellsville Sandstone member of the Conemaugh Group. The Elk Lick Coal has been identified at JAFAP borings MW-1802, MW-1803, and MW-1805 and is used to mark the base of the Morgantown Sandstone and top of the Birmingham Red Shale members of the Conemaugh Group.

Studies of bedrock geologic structure by Arcadis (2019), suggest that bedrock in the vicinity of the site strikes primarily north-northeast and dips to the west-northwest. Fractures or joints within the sandstone are near vertical and strike east-northeast. The formation of subvertical fractures in Appalachian Plateau Valleys are attributed to reduced lithostatic stress following erosion and valley formation (Wyrick and Borchers, 1981; Sheets and Kozar, 2000). The stress relief fracturing (SRF) process provides secondary porosity that controls groundwater flow in shallow bedrock in the Appalachian Plateau (Wyrick and Borchers, 1981; Sheets and Kozar, 2000). SRF is more pronounced in resistant lithologic units (e.g. sandstone and limestone) than shale units. As a result, groundwater flow in shallow bedrock is largely controlled by fracture interconnectivity and to a lesser extent by lithologic variations. A conceptual model of shallow groundwater flow in Appalachian Plateau bedrock aquifers by Sheets and Kozar (2000) is provided as **Figure 2-1**.

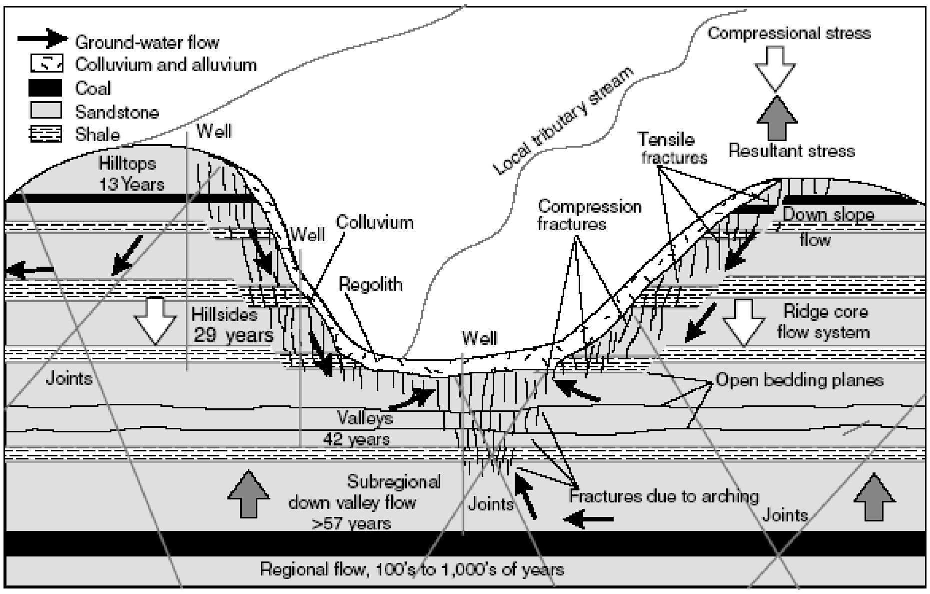

Figure 2-1 Conceptual model of groundwater flow in Appalachian Plateau fractured bedrock aquifers (Sheets and Kozar, 2000). The stress relief fracture (SRF) system is termed "tensile fractures".

2.3 Regional Groundwater Geochemistry

Appalachian Plateau groundwater geochemistry, including the JAFAP site area in West Virginia, is established through several regional studies (Piper, 1933, Trap and Horn, 1997; Warner et al., 2012; Siegel et al., 2015). A generalized model of the regional groundwater geochemistry is summarized in **Figure 2-2** (Siegel et al., 2015).

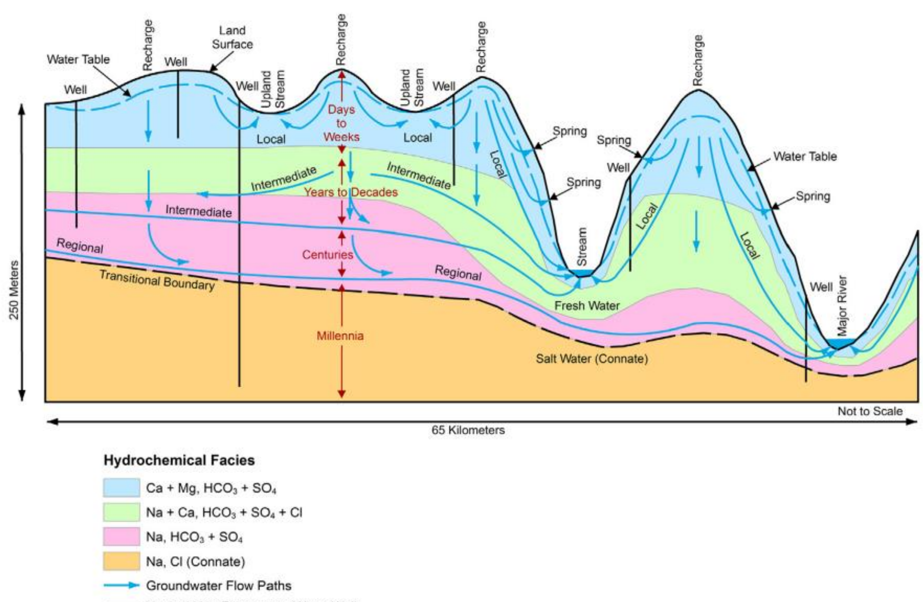

Figure 2-2 Generalized Model of the Regional Groundwater Geochemistry (Siegel et al., 2015)

Groundwater recharge generally occurs on hill tops and circulates along hill slopes to shallow depths in Appalachian Plateau sedimentary bedrock aquifers. Saline (connate) water is frequently encountered beneath a thin (a few ft) transitional mixing zone with the overlying "fresh" (low total dissolved solids [TDS]) water (Trap and Horn, 1997; Siegel et al., 2015). The chemistry of groundwater in recharge areas on hilltops is characterized by low TDS calcium bicarbonate (Ca-HCO_3-type) water, that evolves to low TDS sodium bicarbonate (Na-HCO_3-type) groundwater as groundwater percolates down slopes owing to calcium (Ca) and manganese (Mg) ion exchange with sodium (Na) in Na-bearing clay minerals. Saline sodium chloride (NaCl-type) high TDS waters are naturally occurring connate brines that are found in "restricted flow zones" where recharge waters do not flush the host lithology (Siegel et al., 2015). The NaCl-type water is further characterized by low to non-detectable sulfate, due to reducing conditions that promote sulfide as the predominant sulfur species. Differences in the major ion chemistry of Appalachian Plateau waters are illustrated on the Piper diagram in **Figure 2-3**.

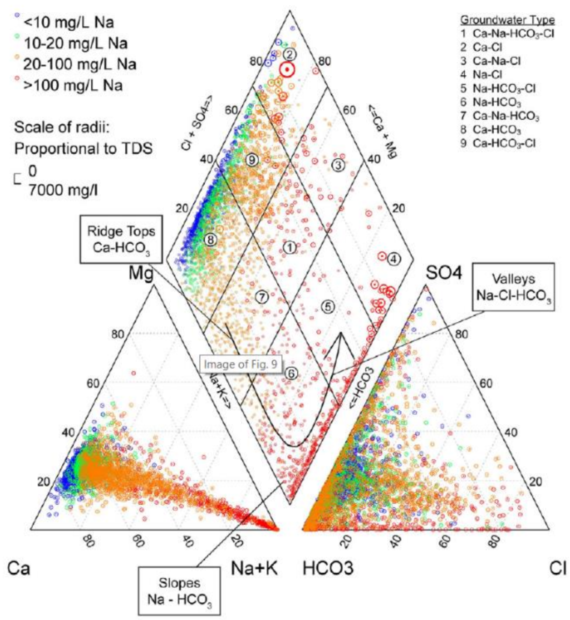

Figure 2-3 Generalized Groundwater Major Ion Chemistry within the Appalachian Plateau (Siegel et al., 2015).

Regionally in the Appalachian Plateau, NaCl-type water is typically encountered at low elevations in valley centers at approximately 100 ft beneath the level of the nearest major stream (Trap and Horn, 1997; Warner et al., 2012; Siegel et al., 2015). In West Virginia, NaCl-type groundwater is frequently encountered at even shallower depths beneath streams in valley bottoms owing to the overall lower topographic elevation and associated lower potential groundwater head available to depress underlying saline water (Siegel et al., 2015).

An additional control on regional groundwater chemistry is the occurrence of natural coal intervals and laminations within bedrock formations. Where coal occurs, oxygenated groundwater leads to oxidation of sulfide minerals (principally the iron sulfide pyrite) in the coal, which leads to elevated concentrations of iron and sulfate in groundwater (Siegel et al., 2015).

2.4 Groundwater Monitoring Network Evaluation

2.4.1 Monitoring Network Details

The groundwater monitoring network in the uppermost aquifer associated with the JAFAP was assessed on behalf of AEP by Arcadis (2019). Arcadis determined that an interconnected water-bearing system (the uppermost shallow aquifer) composed of Pennsylvanian-aged Upper Connellsville Sandstone bedrock combined with the saturated portion of the SRF system laterally surrounds the JAFAP. The SRF system is independent of lithology and is suggested to provide a hydraulic connection between bedrock on the ridge and in the valley.

The uppermost water-bearing aquifer was evaluated in accordance with 40 CFR 257.91, which resulted in additional well installations and redevelopment of existing wells (Arcadis, 2019). The existing groundwater monitoring network consists of 14 groundwater monitoring wells used for water quality sampling to provide detection monitoring in the uppermost shallow aquifer (Upper Connellsville and SRF):

- Six monitoring wells screened in Upper Connellsville Sandstone/SRF (MW-1801A, MW-1804A, MW-1806A, MW-7, MW-8, and MW-9)
- Eight monitoring wells screened in the SRF only (MW-1, MW-2, MW-5, MW-6, MW-1807A, MW-1808A, MW-1809A and MW-1810A)

Four of the network monitoring wells (MW-1807A, MW-1808A, MW-1809A, and MW-1810A) are installed upgradient of the JAFAP to support background monitoring. The remaining ten monitoring wells (MW-1, MW-2, MW-5, MW-6, MW-1801A, MW-1804A, MW-1806A, MW-7, MW-8, and MW-9) are located downgradient of the JAFAP and used for compliance monitoring.

The details of each groundwater monitoring location used for water quality sampling are summarized in **Table 1** and the location of the monitoring wells within the uppermost aquifer is shown on Figure 3 (Arcadis 2019) in **Appendix A**.

Arcadis (2019) 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 shallow aquifer that accurately represent the quality of background groundwater and groundwater passing the waste boundary of the JAFAP.

2.4.2 ASD Investigation Monitoring Wells

MW-5 and MW-1804A were the two monitoring wells with constituents that showed a SSI in November 2019 groundwater monitoring data which was then confirmed in a verification sampling event in February 2020. The details of these specific monitoring wells are provided in the following sections to support the ASD investigation.

2.4.2.1 MW-5

MW-5 is installed near the base of the incised valley of Little Scary Creek where the ground surface (648.03 ft amsl) and piezometric surface are within the Morgantown Sandstone and stratigraphically lower than the base of the JAFAP. In deepening stratigraphic succession, the 114.8-foot boring intercepted approximately 23 ft of predominantly clay unconsolidated deposits, 11 ft of Morgantown Sandstone, 69.5 ft of variably weathered Birmingham Shale (shale and clay shale), 7 ft of sandstone (Interpreted as Grafton Sandstone) before terminating within approximately 4 ft of shale (See MW-5 boring log in **Appendix C** and cross section A-A' [Arcadis 2019] in **Appendix B**). The MW-5 sand pack and screen extends over the Grafton Sandstone and includes several ft of the over- and under-lying shale. The following lines of evidence indicate that groundwater in MW-5 includes a component of deep brine:

- MW-5 is located at the base of the Little Scary Creek stream valley and is screened at a lower elevation (546.43 to 537.03 ft amsl) than all other site wells.
- MW-5 screen is set at 101.6 to 111.0 ft below ground surface (bgs), which is approximately 100 ft lower in elevation than the adjacent Little Scary Creek bed, corresponding to the depth beneath Appalachian Plateau streams where NaCl-type connate water is typically encountered in the Appalachian Plateau.
- The screen for MW-5 is vertically lower and laterally distal to the base of the JAFAP. According to the SRF model, groundwater from the JAFAP would migrate through coal-bearing strata (specifically the Elk Lick Coal within Birmingham Shale) prior to entering the screened interval for MW-5 with concomitant geochemical effects on groundwater composition. We do not see the expected effects on groundwater composition, indicating JAFAP water has not reached MW-5.
- TDS values for MW-5 historically exceed values in the JAFAP by nearly an order of magnitude (AEP, 2020). Additionally, sulfate is historically near or below the laboratory reporting limit in MW-5. The geochemistry of MW-5 historically corresponds with the composition of Appalachian Plateau NaCl-type connate water.
- The NaCl-type groundwater in MW-5 is distinct from the Na-HCO_3-type water typically encountered in site wells screened in the SRF at higher elevations and located on the hilltops surrounding the site, and is distinct from porewater in the JAFAP (**Section 4**). The exception is MW-2, the only site well that is also at the base of Little Scary Creek alluvial valley and is screened at a similar elevation (549.10 to 540.20).
- During packer testing, MW-5 did not accept flow with up to 100 pounds per square inch pressure (Arcadis, 2019), indicating the presence of low permeability units typical of those that are not regularly flushed with groundwater and that may host NaCl connate waters.
- Wells co-located with MW-5, MW-6 (screen = 619.00 to 614.00 ft amsl) and MW-1 (screen = 606.47 to 597.57 ft amsl), are screened at higher elevations and exhibit lower TDS and a $NaHCO_3$-type water, which is expected with the fresher shallower groundwater versus the deeper connate (brine) groundwater.

2.4.2.2 MW-1804A

MW-1804A is installed on the inside edge of the northern JAFAP berm where the ground surface (858.53 ft amsl) and piezometric surface are stratigraphically within the Pittsburgh Sandstone/Conemaugh Shale members of the upper interval of the Conemaugh Formation. In deepening stratigraphic succession, the boring for MW-1804A intercepted approximately 14 ft of overburden, 16 ft of interbedded sandstone and shale (Pittsburgh Sandstone/Conemaugh Shale), approximately 15 ft of upper Connellsville Sandstone, before terminating within approximately 4 ft of shale. The MW-1804A sand pack and screen extends across the Conemaugh Shale, Upper Connellsville Sandstone, and an unnamed shale/siltstone unit (See boring log in **Appendix C** and cross section B-B' [Arcadis 2019] in **Appendix B**). The following places MW-1804A in the context of the groundwater monitoring network:

- MW-1804A is primarily screened over the Upper Connellsville Sandstone, similar to wells MW-7, MW-8, MW-9, MW-1801A, and MW-1806A (as presented in **Table 1**).
- MW-1806A provides a convenient comparison for potential groundwater compositional variations in MW-1804A, as it is the only other site well with a sand pack that extends across the same combination of units (substantial interval of the Conemaugh Shale and the Upper Connellsville Sandstone and an unnamed shale/siltstone unit).

2.5 JAFAP Porewater Piezometer

AEP installed a multi-level port piezometer (STN-12-4) within the JAFAP to evaluate fly ash porewater. This multi-port piezometer has seven screened intervals, as detailed in the boring log (Stantec, 2012) provided in **Appendix C**.

Fly ash porewater was sampled during five events: September 28, 2017, December 11, 2017, November 16, 2018, March 12, 2019, and November 11, 2019. Water quality results for CCR constituents in the fly ash, with the geometric mean of each constituent over the seven interval ports, are presented in **Table 2**. These data will be used in this ASD investigation to represent the JAFAP porewater when comparing to CCR constituent concentrations in the monitoring well network. It should be noted that based on the multi-port screen elevations, multi-port intervals 1 and 2, with a filter pack elevation range from 845.1 amsl to 821 amsl are the only intervals at higher elevations than the well screen and sand pack for MW-1804A.

2.6 Groundwater Monitoring

AEP has conducted groundwater monitoring of the uppermost aquifer to meet the requirements of the CCR Rules. These monitoring activities 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, 2019)
- Completion of validation tests for groundwater data, including tests for completeness, valid values, transcription errors, and consistent units
- Establishment of background values for each Appendix III and Appendix IV constituent (eight sampling events conducted over a seven-month period between July 25, 2018 and February 18, 2019) (AEP, 2020)
- Evaluation of the groundwater data using a statistical process in accordance with 40 CFR 257.93, which was prepared and certified in April 2019 in AEP's *Statistical Analysis Plan* (Geosyntec, 2019), and most recently posted to AEP's CCR website in May 2019. The statistical process was guided by USEPA's *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance* ("Unified Guidance", USEPA, 2009).
- Completion of the initial detection monitoring sampling event (March 2019), which resulted in no SSIs of Appendix III parameters

- Completion of a second detection monitoring event (November 2019), which resulted in potential SSIs for Appendix III parameters in MW-2 (calcium), MW-5 (calcium and sulfate), MW-7 (calcium), and MW-1804A (chloride and sulfate)
- Completion of confirmation sampling (February 2020) for constituents identified as potentially exhibiting SSIs per AEP's *Statistical Methods Selection Certification* (AEP, 2019), which confirmed SSI's for Appendix III parameters at MW-5 (calcium and sulfate) and MW-1804A (chloride and sulfate)

A table summarizing monitoring data for key wells analyzed during this ASD investigation, including the background sampling events through the November 2019 monitoring event, and the February 2020 verification sampling event is included in **Table 3**.

3 Alternative Source Demonstration Assessment

As identified in **Section 1.1**, SSIs in the concentration of calcium and sulfate in MW-5 and chloride and sulfate in MW-1804A have been reported for the November 2019 detection monitoring event.

Per the CCR Rule at 40 CFR 257.94(e)(2), "The owner or operator may demonstrate that a source other than the CCR unit caused the SSI over background levels for a constituent or that the SSI 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 SSI over background levels to include obtaining a certification from a qualified professional engineer verifying the accuracy of the information in the report."

EPRI (2017) guidelines for developing an ASD indicates potential causes that support the ASD may include, but are not limited to:

1. sampling causes (ASD Type I),
2. laboratory causes (ASD Type II),
3. statistical evaluation causes (Type III) and/or
4. natural variation causes (Type IV).

This ASD investigation for the JAFAP will be focused on assessing whether Type I, Type III and/or Type IV causes could be the reason for SSIs for calcium and sulfate in MW-5 and chloride and sulfate in MW-1804A**.**

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 (**Section 3.1** and **Section 3.2**)
- Tier II: Advanced Geochemical Evaluation Methods (**Section 3.1**, **Section 3.3** and **3.4**)
- Tier III: Isotopic Analyses (not conducted as part of this ASD)

These assessments are presented in the following sections. Additionally, an analysis of potential variation due to sampling techniques (ASD Type I) is included in **Section 3.5** and statistical evaluations (ASD Type III) is included in **Section 3.6**.

3.1 Groundwater Data Analysis

3.1.1 Site Groundwater Sources

Total dissolved solids measurements provide a robust means to distinguish groundwater with a connate brine and/or low TDS precipitation source. Consistent with a brine origin, historical TDS data for MW-2, MW-5 and MW-8 are notably elevated (almost by an order of magnitude in MW-5) compared with other site wells that produce sodium/calcium bicarbonate-type waters (**Figure 3-1**). TDS in the majority of Site wells is below about 600 to 650 milligrams per Liter (mg/L), in comparison to a range of 174 to 840 mg/L (geometric mean 465 mg/L) for JAFAP porewater measured in all seven ports of STN-12-4 between

September 2017 and November 2019. Clearly, the TDS data (coupled with historical boron, fluoride, and chloride systematics for these wells) rule out JAFAP porewater as the origin of the high TDS measurements in MW-2, MW-5 and MW8. Whereas a connate brine component is expected for MW-2 and MW-5 based on the location of the wells at the base of the Little Scary Creek valley and deep (>100 feet bgs) well screen/sand pack depths (**Section 2.3**), MW-8 is situated on a ridge with a sand pack/screen interval over a higher elevation (sand pack from 797 to 821.21 ft amsl in MW-8 compared to 534.20 to 560.50 and 535.93 and 557.03 ft amsl in MW-2 and MW-5, respectively; **Table 1**). As discussed by Siegel et al., (2015), connate brine is periodically encountered along ridgelines in formations with low throughput of groundwater in the Appalachian Plateau of West Virginia, thus, MW-8 conceivably also contains a brine component.

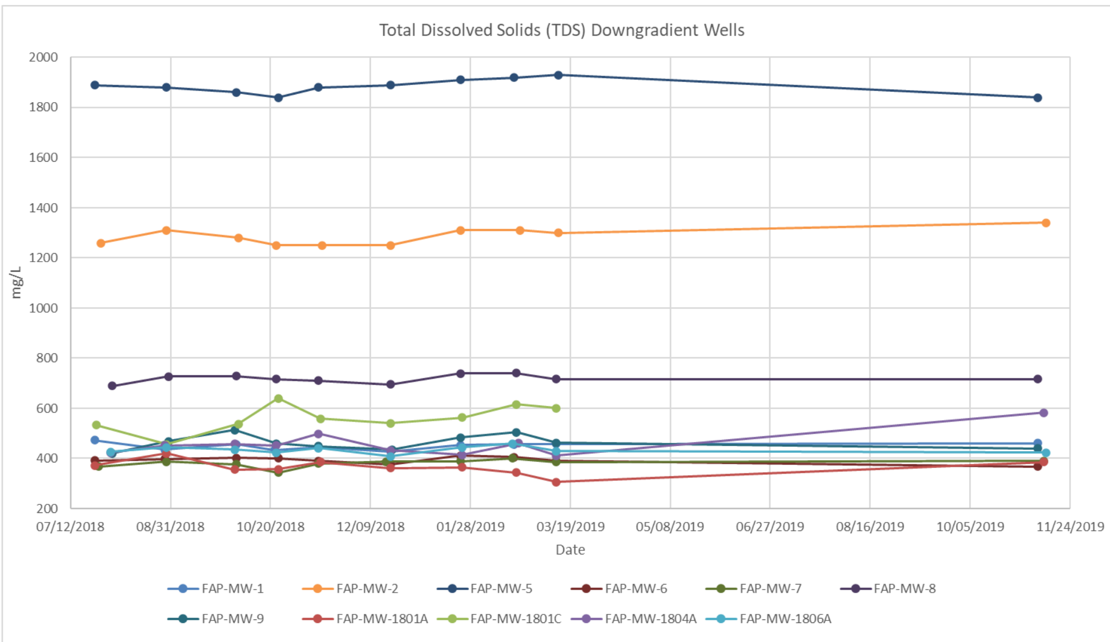

Figure 3-1 Total Dissolved Solids in Downgradient Monitoring Wells

The comparison of pH between groundwater in MW-5, MW-1804A and JAFAP porewater is provided in **Figure 3-2**. This shows that the pH increases as water moves from the porewater into the shallow water represented by MW-1804A and increases even further in MW-5 groundwater. This increasing pH trend outside of the JAFAP, demonstrates the influence of the various hydrogeologic formations represented by MW-1804A and MW-5, as well as potential mixing of groundwater across these formations during sampling events where the pH lines for these monitoring wells cross.

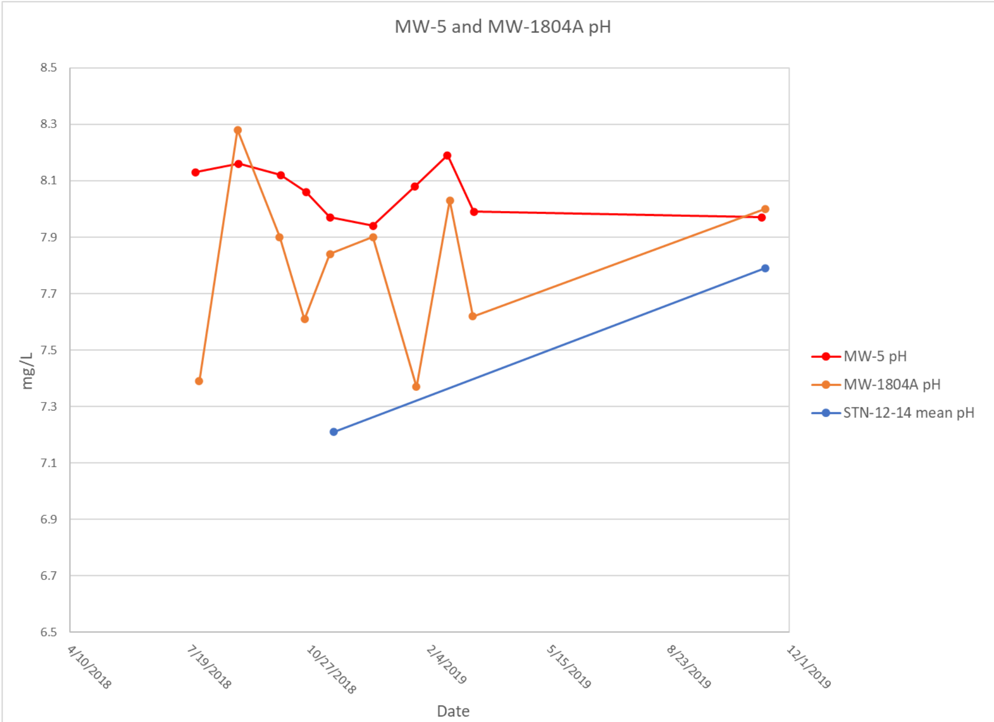

Figure 3-2 MW-5 and MW-1804A pH values

3.1.2 MW-5 Evaluation

A temporal plot for the primary indicator sulfate reported in groundwater monitoring well MW-5 is presented in **Figure 3-3**, and a temporal plot for the elevated ASD constituent calcium is presented in **Figure 3-4**. Data for the geometrical mean of JAFAP porewater (**Table 2**) is provided for comparison.

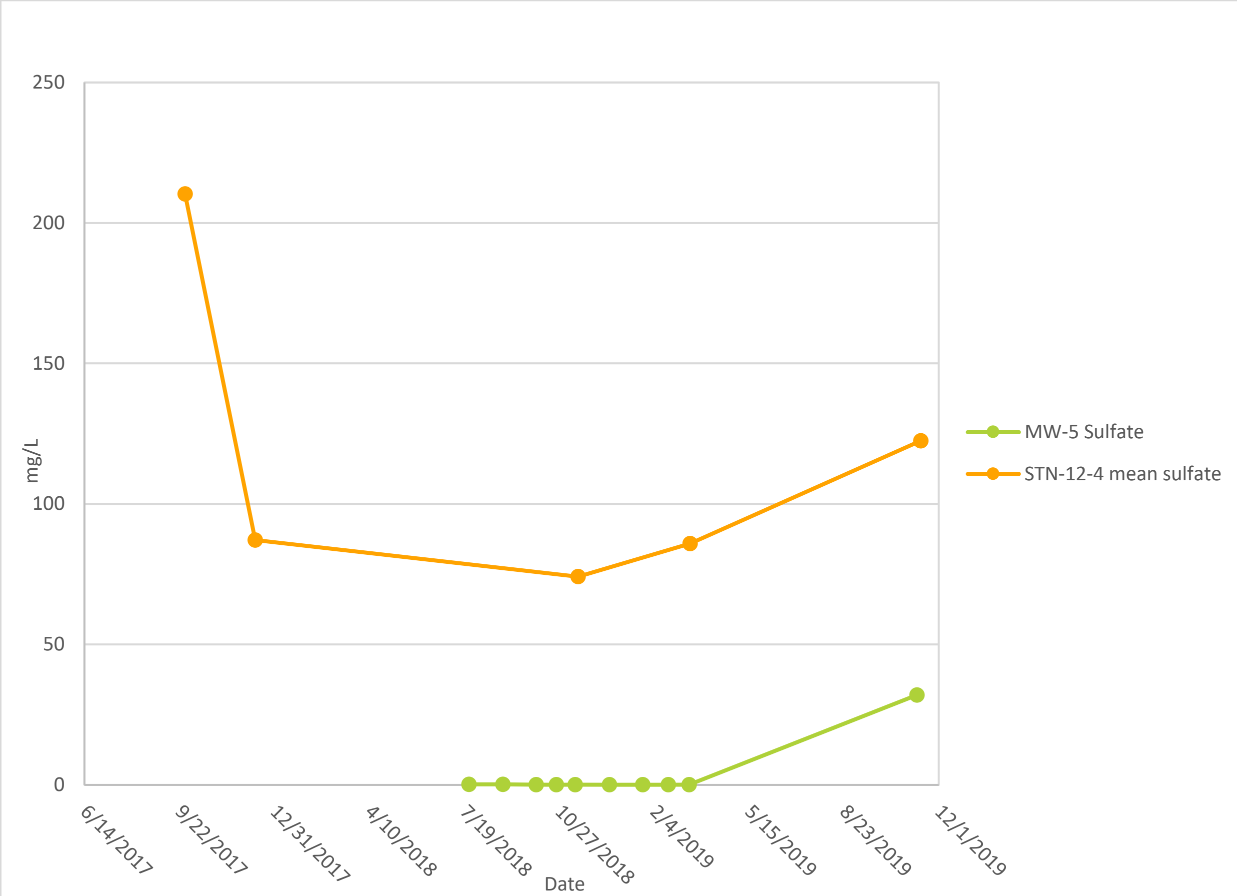

Figure 3-3 MW-5 Sulfate Concentrations

Sulfate concentrations in MW-5 have remained relatively constant up until the last groundwater monitoring event in November 2019 (geometric mean = 0.1 mg SO_4/L). Sulfate concentrations measured in November 2019 were approximately two orders of magnitude higher (32 mg/L) than those reported historically. Comparing the concentrations in MW-5 groundwater to the JAFAP, sulfate concentrations in groundwater are 100 times lower than the concentrations reported in the JAFAP porewater. Sulfate is typically absent or at low concentrations in Appalachian Plateau connate brines due to overall reducing conditions that favor sulfide (Siegel et al., 2015). In contrast, sulfate is present at higher concentrations in oxygenated groundwater sourced from more recent precipitation, particularly following interaction with pyrite, which is documented in the Birmingham Shale and Grafton Sandstone rock matrix in the logs for MW-1802C, MW-1803C, MW-1805C that are within and directly overlying the sand pack interval for MW-5.

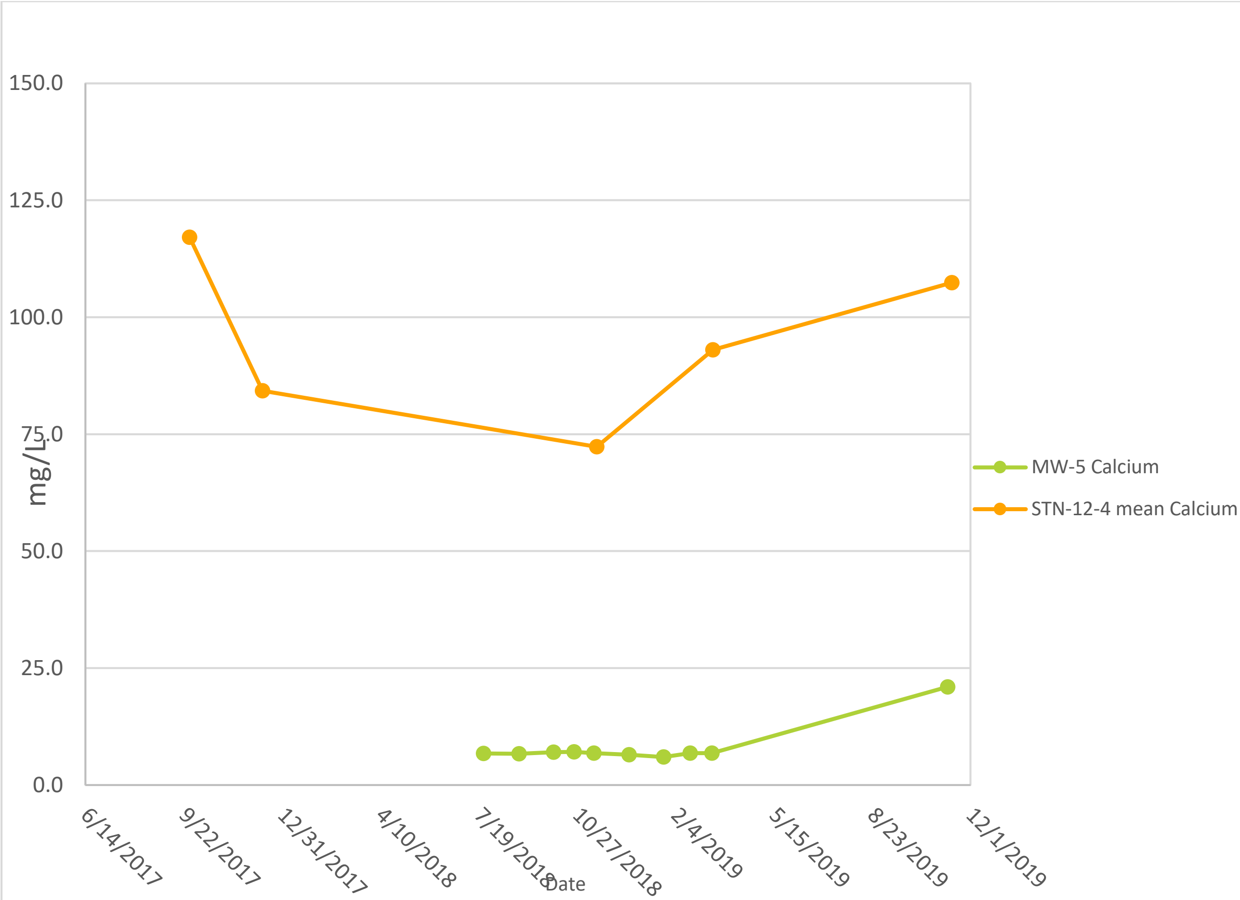

Figure 3-4 MW-5 Calcium Concentrations

Calcium concentrations in MW-5 have remained relatively constant up until the November 2019 groundwater monitoring event (geometric mean = 6.7 mg Ca/L). In November 2019, groundwater sampled from MW-5 reported a calcium concentration of 21 mg/L, approximately three times higher than previous sampling events, but this concentration of calcium in MW-5 is approximately 20 times lower than the concentrations reported in the JAFAP porewater (**Figure 3-4**). The sodium concentration reported from groundwater at this location was approximately 100 mg/L lower than previous sampling events. The relative changes in calcium and sodium suggests mixing between different groundwater types with distinct aqueous Ca/Na ratios set through ion exchange reactions with distinctive rock types or secondary minerals within formations.

The increase in dissolved calcium and sulfate may be attributed to a change in the proportion of mixing between sodium chloride and sodium bicarbonate water types; with the November 2019 result reflecting a higher proportion of more Ca- and SO_4-rich, low TDS sodium bicarbonate water type. Groundwater in the vicinity of MW-5 is identified as a sodium chloride water type (further discussed in **Section 3.1.1**) and the elevation of the screened section of MW-5 is very close to the expected mixing interface between sodium bicarbonate and sodium chloride (connate brine) water types, as discussed in **Section 2.3**. External influences such as pumping rates or intense and extended rainfall events can perturb the transition between the connate aquifer and the overlying sodium bicarbonate aquifer.

Boron, another primary indicator, has historically fluctuated in MW-5 between 0.22 to 0.32 mg/L, whereas the November 2019 concentration was notably lower at 0.18 mg/L (**Figure 3-5**). Boron is typically elevated in groundwater that has contacted aquifer rock for extended periods of time or that has experienced elevated temperatures; therefore, elevated boron in connate brine is expected. The observation of decreased boron during the November 2019 sampling event supports dilution by a younger sodium bicarbonate water type in MW-5.

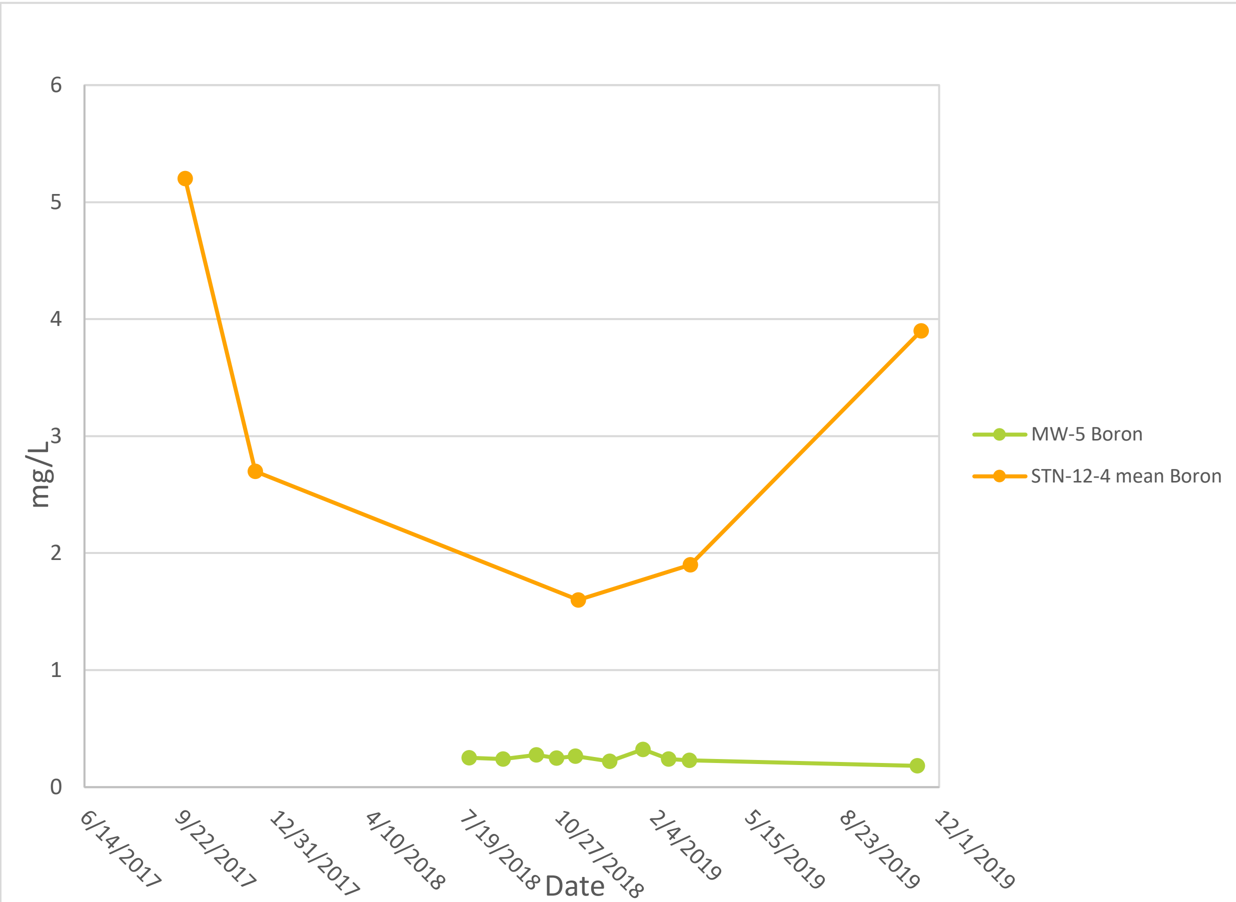

Figure 3-5 MW-5 Boron Concentrations

Temporal plots for potential indicators bromide, fluoride, molybdenum, potassium, and sodium reported in groundwater monitoring well MW-5 are provided in **Figure 3-6** to **Figure 3-10**, respectively, with geometrical mean data for the JAFAP porewater presented for comparison. Molybdenum and potassium are present in groundwater at concentrations below the concentrations within the JAFAP for MW-5. For MW-5, bromide, fluoride and sodium concentrations in groundwater are elevated in comparison to the JAFAP.

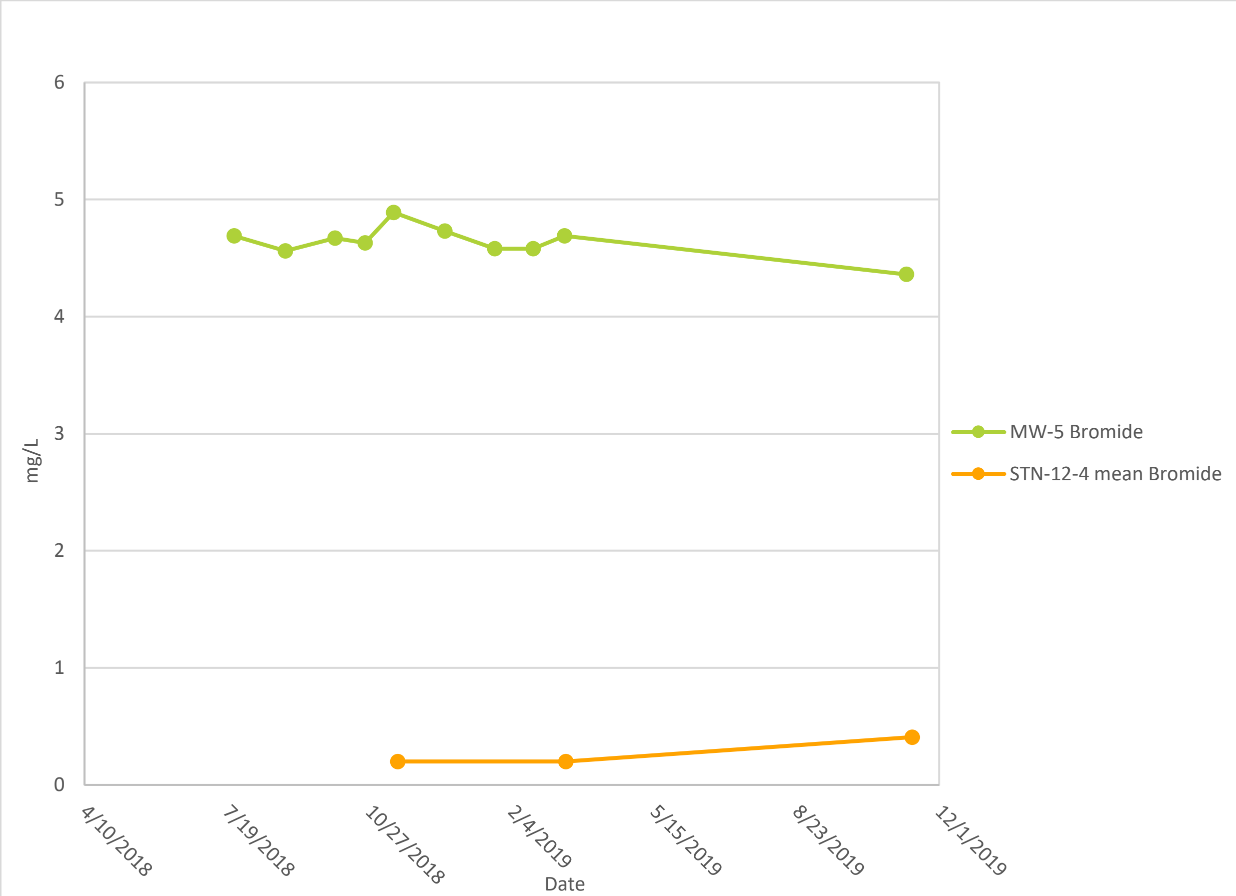

Figure 3-6 MW-5 Bromide Concentrations

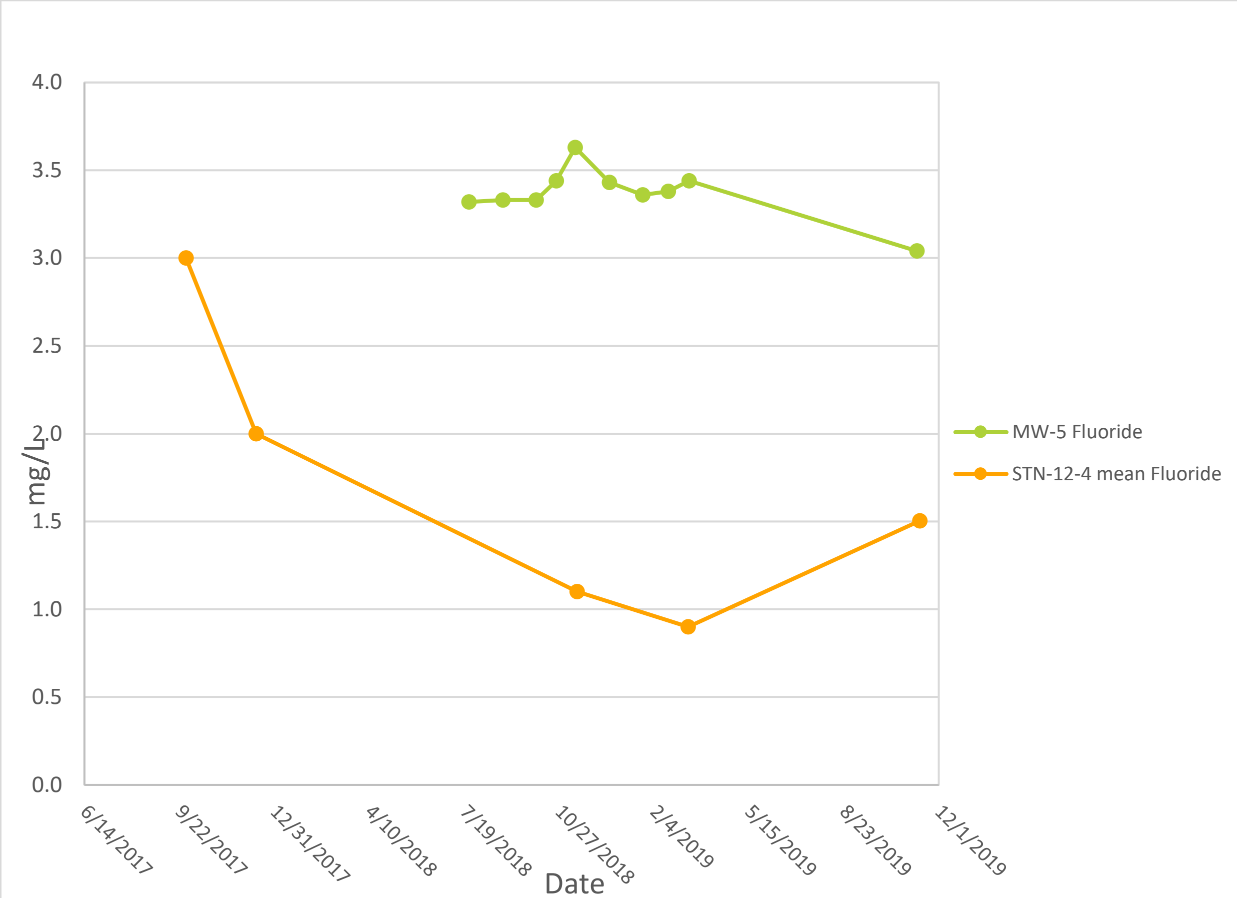

Figure 3-7 MW-5 Fluoride Concentrations

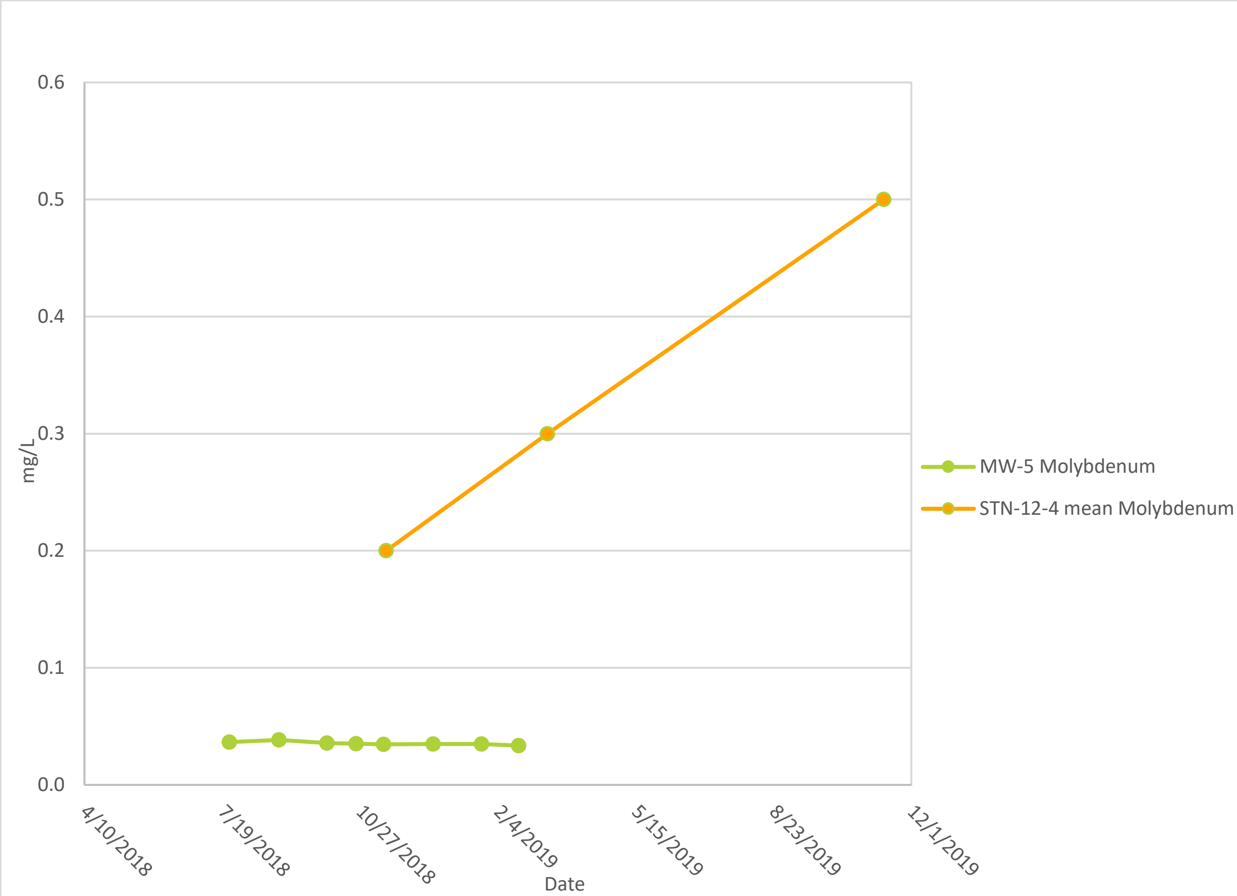

Figure 3-8 MW-5 Molybdenum Concentrations

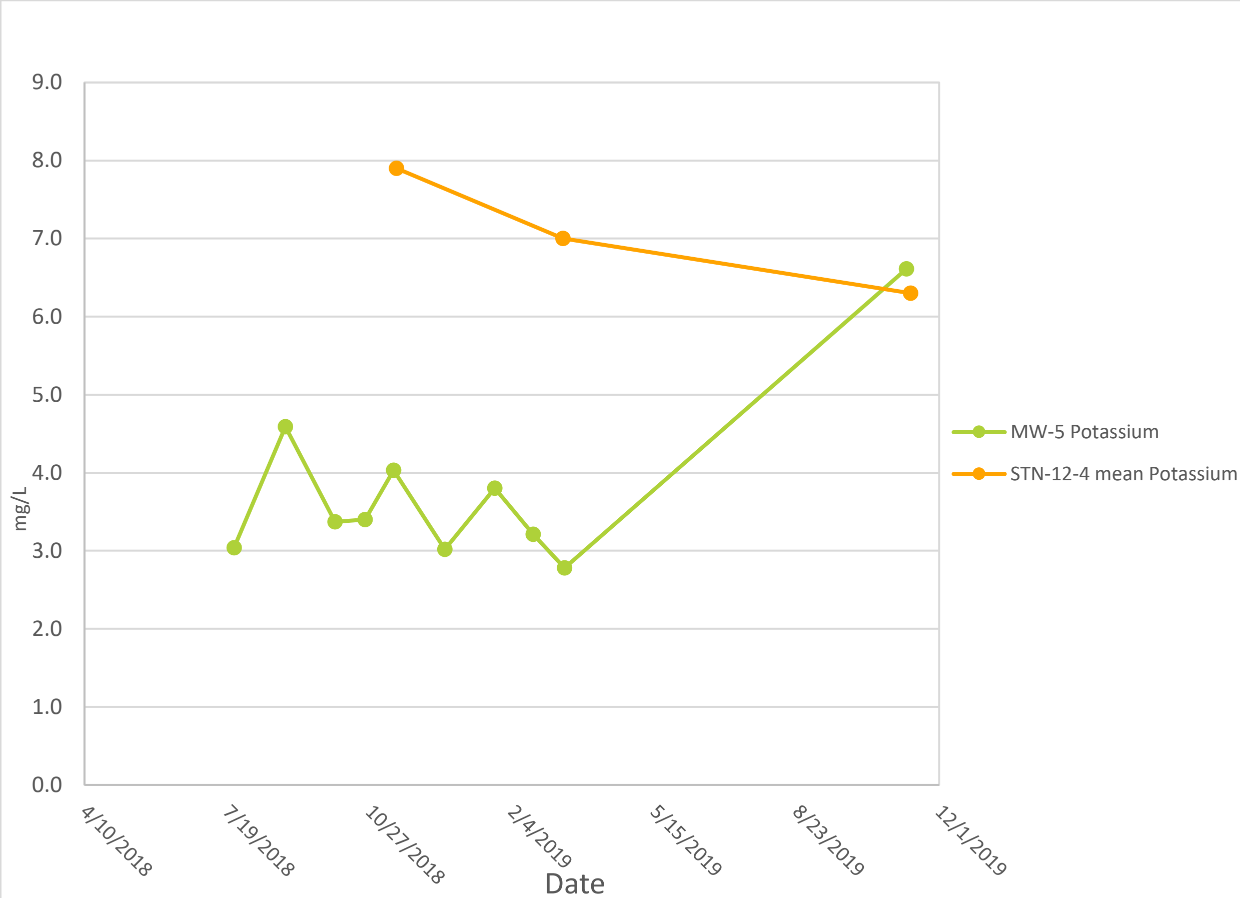

Figure 3-9 MW-5 Potassium Concentrations

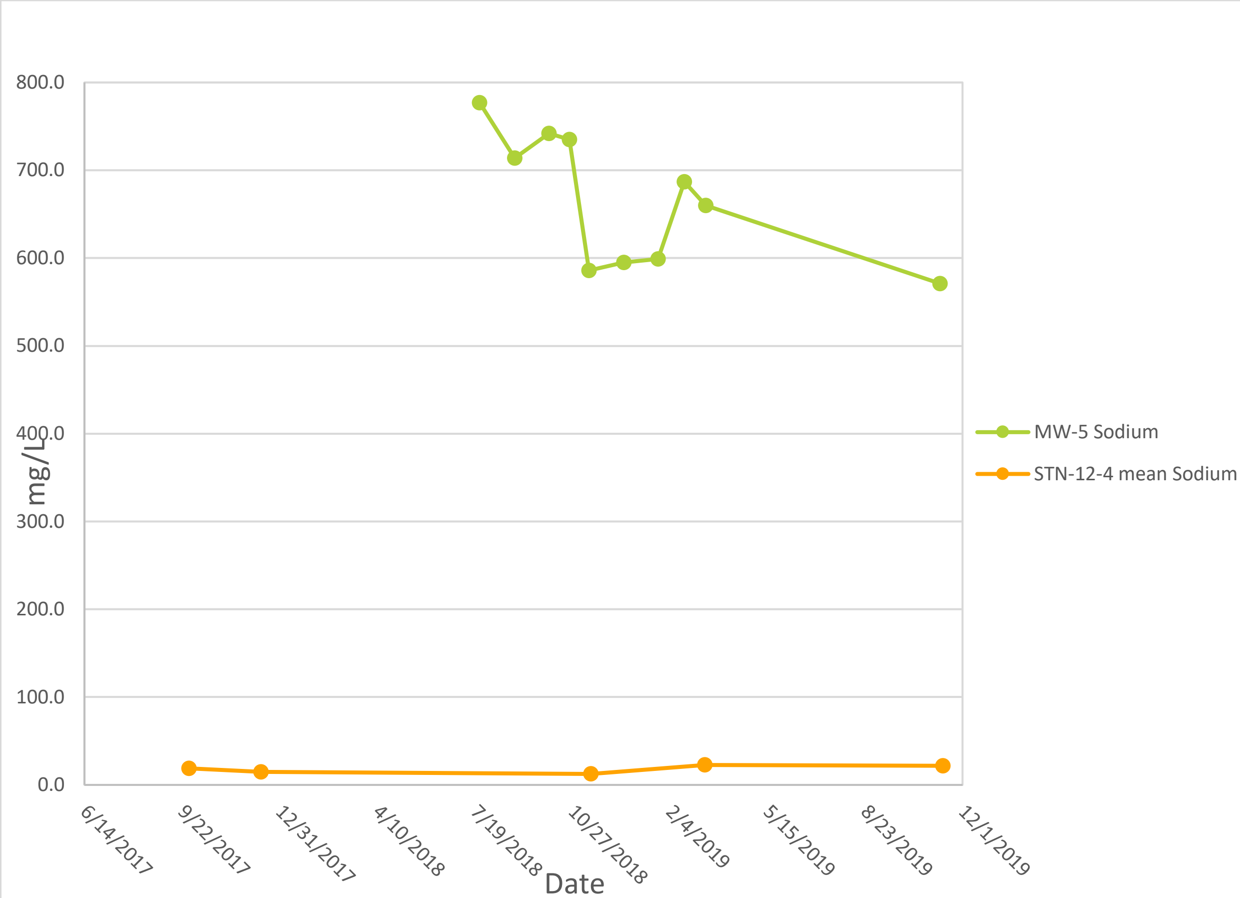

Figure 3-10 MW-5 Sodium Concentrations

3.1.3 MW-1804A Evaluation

Temporal plots for the primary indicators sulfate and chloride in MW-1804A are provided in **Figure 3-11** and **Figure 3-12**, respectively. Sulfate and chloride concentration data for STN-12-4 Intervals 1 and 2, which represent JAFAP porewater at a higher or similar elevation to the MW-1804A sand pack and screen, for each sampling event is presented for comparison.

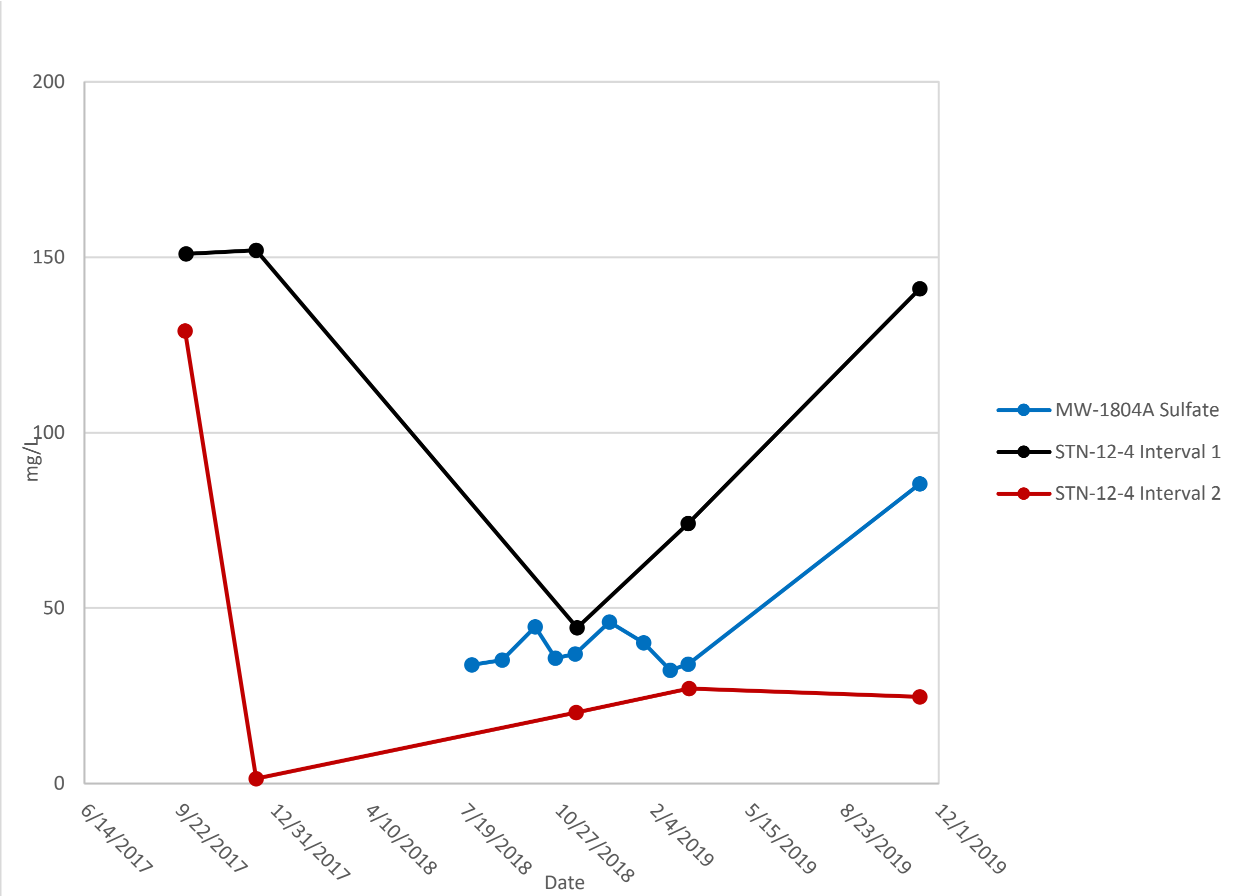

Figure 3-11 MW-1804A Sulfate concentrations

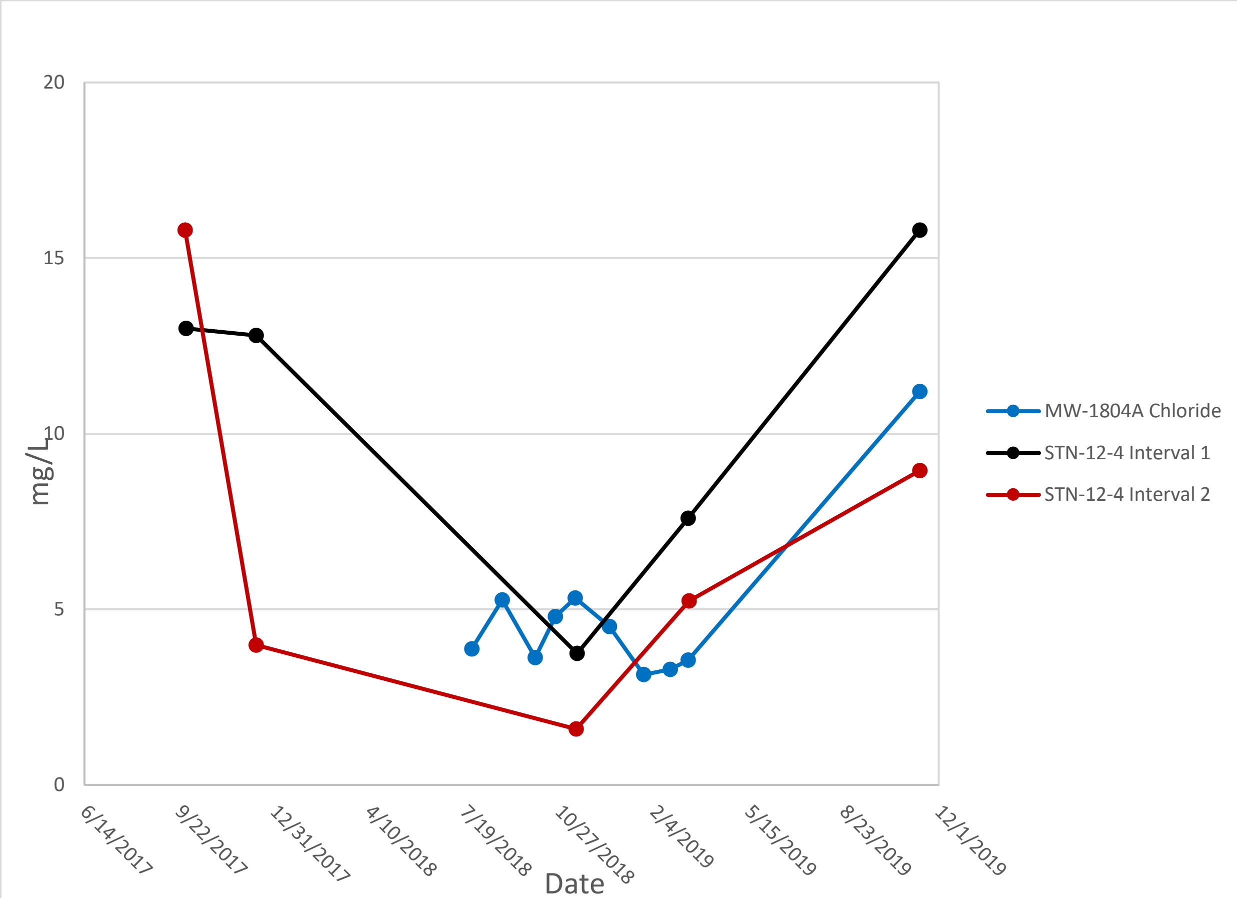

Figure 3-12 MW-1804A Chloride concentrations

Sulfate and chloride concentrations in MW-1804A have remained relatively constant historically, within the range 32.3 mg/L to 46 mg/L (geometric mean = 40.6 mg SO_4/L) and 3.14 mg/L to 5.32 mg/L (geometric mean = 4.5 mg Cl/L), respectively, over the monitoring period from July 2018 through March 2019 (eight background events and initial detection monitoring event). In November 2019, sulfate concentrations were reported as 85.4 mg/L and chloride concentrations as 11.2 mg/L.

Gypsum ($CaSO_4$) dissolution could lead to elevated sulfate concentrations. Calcite and dolomite are often encountered in aquifer rocks. Calcite has been identified in borehole logs for both MW-5 and MW-1804A. If gypsum dissolution occurs (**Equation 1**), increasing calcium ion concentrations ultimately cause calcite to precipitate (**Equation 2**). As calcite precipitates bicarbonate concentrations decrease and initiates the dissolution of dolomite which causes an increase in magnesium concentrations (Equation 3):

$CaSO_4 \rightarrow Ca^{2+} + SO_4^{2-}$ Equation 1

$Ca^{2+} + HCO_3^{2-} \rightarrow CaCO_3 + H^+$ Equation 2

$Ca^{2+} + CaMg(CO_3)_2 \rightarrow CaCO_3 + Mg^{2+}$ Equation 3

$$CaSO_4 + CaMg(CO_3)_2 \rightarrow CaCO_3 + Ca^{2+} + SO_4^{2-} + Mg^{2+} \quad \text{Equation 4}$$

Overall, calcium, magnesium and sulfate concentrations would be expected to increase and there would be a corresponding decrease in bicarbonate (**Equation 4**). Although acidity is released in **Equation 2**, the buffering provided by calcite likely prevents changes in pH.

While the increase in sulfate could be related to gypsum dissolution, chloride is unlikely sourced from mineral dissolution or water-rock interactions as it is present at only trace concentrations in common rock-forming minerals. Concentration changes in chloride, a conservative ion in groundwater, typically reflects evaporation, dilution, or mixing between distinct water types. Notably, the November 2019 chloride concentration in MW-1804A is almost identical to the concentration in MW-1806A, the only other site well with a sand pack and screen that extend over the same three geologic formations (**Table 1**) providing an indication that this variation in MW-1804A chloride is likely driven by conditions within the formation and not the JAFAP porewater.

Other primary indicators such as boron report a stable concentration over time in MW-1804A, with a historical concentration range from 0.568 to 0.779 mg/L (**Figure 3-13**). The November 2019 event (0.73 mg/L) is within this historical range. Comparing the boron concentrations in MW-1804A groundwater to the upper section of the JAFAP (STN-12-4 Intervals 1 and 2) is complicated by a wide range in this data (with five rounds ranging from 0.145 mg/L to 0.955 and five rounds ranging from 2 mg/L to 10.1 mg/L).

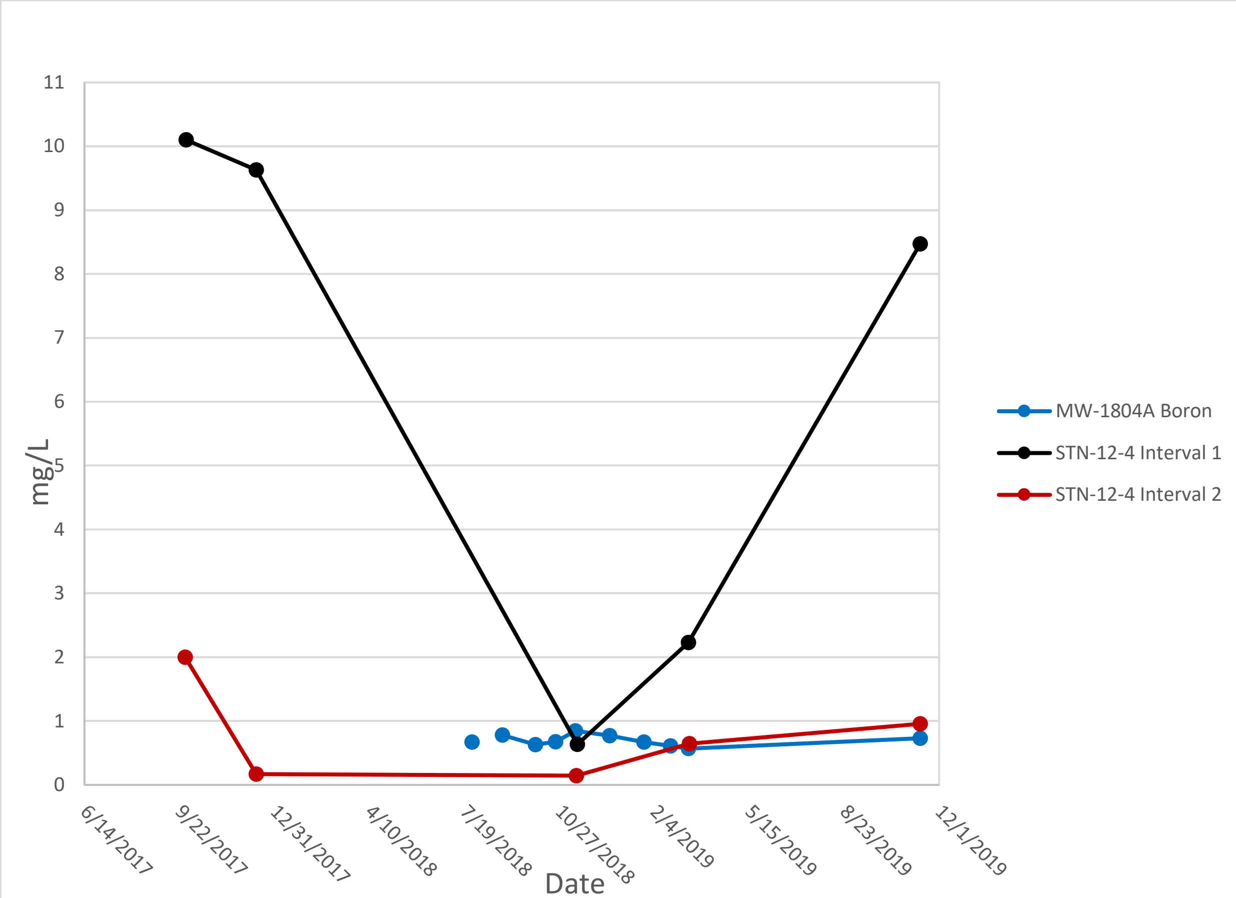

Figure 3-13 MW-1804A Boron Concentrations

Groundwater (**Table 3**) and upper JAFAP porewater data (**Table 4**) were compared for potential indicators bromide, fluoride, molybdenum (not analyzed in March or November 2019 detection monitoring events at MW-1804A), potassium, and sodium. Of these five potential indicators, sodium is the only one where its November 2019 concentration is higher in MW-1804A groundwater than the upper JAFAP porewater (STN-12-4 Intervals 1 and 2), as shown in temporal plot **Figure 3-14** (molybdenum data from the October 2018 background sampling event also had higher concentrations than JAFAP water at that time). These higher concentrations in groundwater indicate this groundwater is being affected by another source within the formation, and likely not being influenced by the JAFAP porewater.

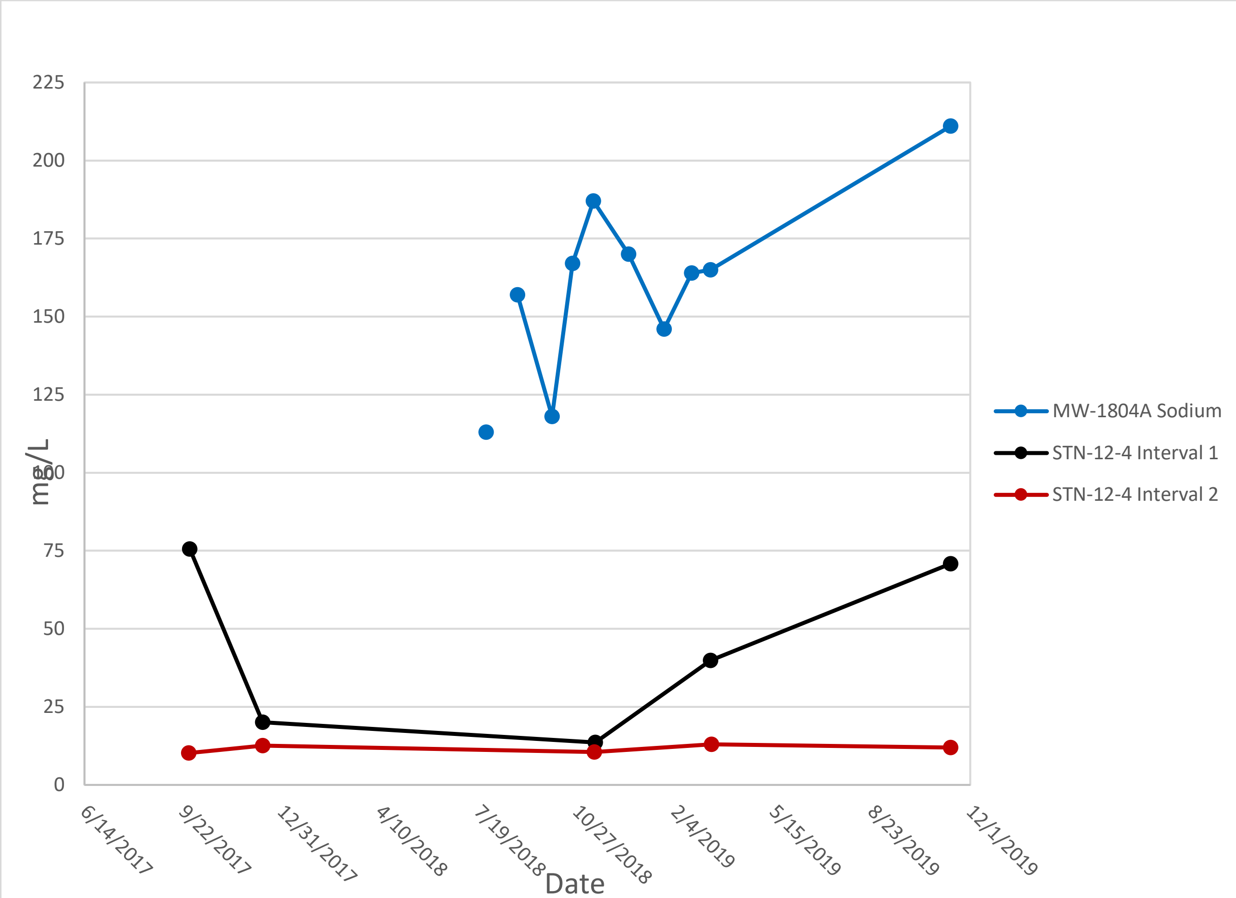

Figure 3-14 MW-1804A Sodium Concentrations

3.2 Statistical Evaluation

Mann Kendall analysis was used to compare the temporal variation in MW-5 sulfate and calcium and MW-1804A sulfate and chloride. Results for two datasets for these analytes were investigated by reviewing the entire 2018/2019 dataset and the dataset omitting the November 2019 groundwater monitoring results (**Table 3-1**).

Table 3-1 Mann Kendall Statistics

Series	Monitoring Well ID	Type	Trend 2018/2019	Trend (excluding Nov 2019)
GW	MW-5	Sulfate	No trend	Decreasing
GW	MW-1804A	Sulfate	No trend	No trend
GW	MW-5	Calcium	No trend	Stable
GW	MW-1804A	Chloride	Stable	Stable

Trends for the entire dataset were either stable or did not have a trend. When the November 2019 set of results were omitted, MW-1804A (sulfate and chloride) still reported a ‘no trend’ and a ‘stable trend’, respectively, while in MW-5 sulfate reported a decreasing trend and calcium a stable trend. Based on the trend analysis, the set of results which triggered the SSI evaluation, do not appear to be contributing towards any significant temporal changes in sulfate, chloride, or calcium concentrations.

3.3 Ion Ratios and Conservative Ion Binary Plots

3.3.1 Ion Ratios

EPRI (2012) recommends the use of ion ratios to identify source waters, or to determine that an additional source water is being added along a flow path. The premise is that the concentration of two constituents in groundwater is maintained unless mixing with a water source that has different ion concentration ratios occurs. Care must be taken to select unreactive constituents (conservative ions) to support this analysis. Conservative ions are generally not volatile, largely do not participate in ion exchange or redox reactions, generally form minerals with high solubilities, and are not typically leached from or incorporated into reactive minerals along groundwater paths in appreciable concentrations. These characteristics result in preservation of conservative ion ratios through binary mixing, dilution, and evaporation processes. Sulfate should be assessed with caution using the conservative ion ratio approach, since sulfate is typically a conservative ion in oxygenated waters, however, oxidation of sulfide or reduction of sulfate on mixing between anoxic and oxygenated waters can shift the sulfate concentration substantially from an expected binary mixing result.

Ion ratios for key constituents in groundwater and JAFAP porewater samples from the November 2019 sampling round are provided in **Table 4**. Notably, the SO_4/Cl and F/Cl ratios for most groundwater samples are indistinguishable from JAFAP porewater; therefore, these SO_4/Cl and F/Cl ratios are not useful for distinguishing JAFAP porewater influence for the majority of locations in the monitoring network. In more detail, SO_4/Cl and F/Cl ratios for JAFAP pore water wells MW-1804A and MW-1806A (**Figure 3-16**) show temporal variability at each sampling point. When coupled with the distinctive B/Cl and Ca/Cl ratios, this supports lack of mixing between JAFAP pore water and MW-1804A/MW-1806A, and external control by an overall common source. The common source may be attributed to local groundwater that ultimately ends up in the well screens and JAFAP pores, and varies with precipitation levels, water levels, and the mineralogy of rocks along the flow paths that ultimately intercept the sampling points. The exception is for wells MW-5, MW-2 and MW-8, which have distinct SO_4/Cl and F/Cl ratios that likely reflect a connate brine component. In contrast, Ca/Cl and B/Cl ion ratios are distinct for most groundwater and JAFAP porewater samples and provide useful indicators of mixing relationships between different water types. To better assess mixing relationships based on ion ratios, ion ratio plots were developed following the method and rationale described below.

Ion ratio plots were developed from historical and current data for MW-5 (**Figure 3-15**) and MW-1804A (**Figure 3-16**). These plots illustrate SSI benchmark exceedances in November 2019 in the context of historical and current JAFAP porewater samples. Ion ratio plots for MW-5 show that the water in both historical and the November 2019 samples show a distinct ion composition compared to shallower co-located wells (MW-1 and MW-6) and JAFAP porewater. This result supports an Appalachian Plateau connate brine origin. Indeed, the composition of MW-5 groundwater on these plots is sufficiently unique that no clear mixing relationship between the November 2019 sampling result and other water sources is clear based on ion ratios. For this reason, absolute conservative ion concentrations (not ratios) are used to better assess mixing between MW-5 and alternative sources, as discussed below (**Section 3.3.2**).

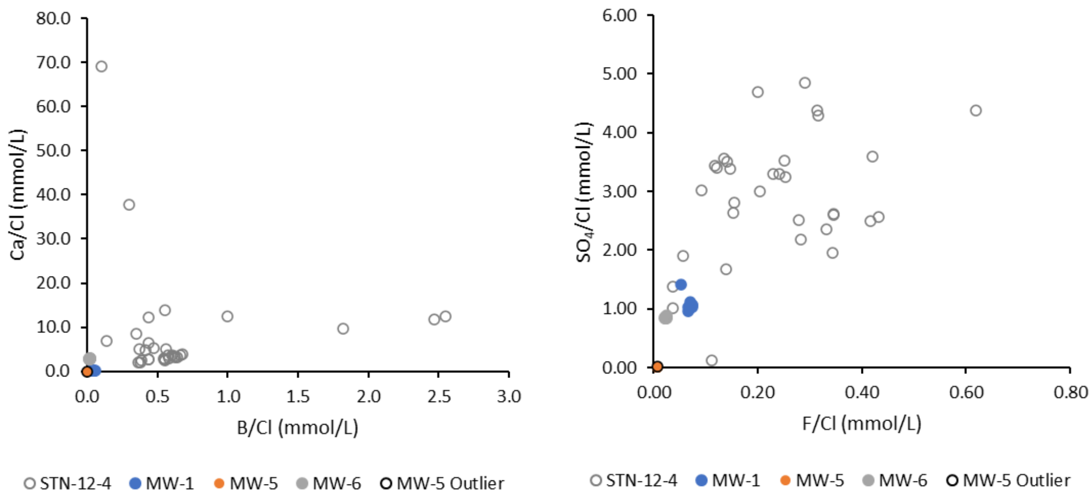

Figure 3-15 Ion Ratio Plots of Historical and Current Data from MW-5, MW-1 and MW-6, and STN-12-4 JAFAP Porewater. Note: the MW-5 outlier plots in the same location as historical MW-5 data.

An ion ratio (Ca/Cl vs. B/Cl) plot for MW-1804A shows that the November 2019 sampling result is intermediate between the composition of historical results from MW-1804A and MW-1806A, which is screened in the same formation over a similar well screen elevation range. The MW-1804A and MW-1806A SO_4/Cl vs. F/Cl ion ratio plot illustrates that these ion ratios are of limited use for distinguishing JAFAP porewater mixing in this formation, as there is substantial overlap between these ion ratios in groundwater and JAFAP porewater. Overall, the plots suggest that the anomalous November 2019 sample from MW-1804A is best attributed to groundwater compositional variations within the Upper Connellsville Sandstone unit rather than mixing with JAFAP porewater.

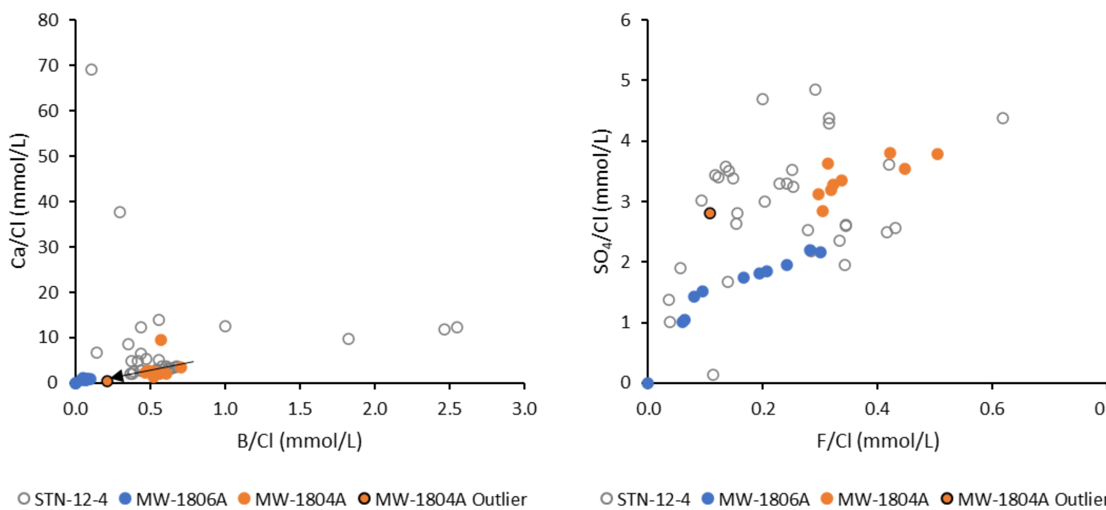

Figure 3-16 Ion Ratio Plots of Historic and Current Data from MW-1804A and well MW-1806A, and STN-12-4 JAFAP Porewater.

3.3.2 Conservative Ion binary plots

Binary plots of the molar concentrations of conservative ions in waters that have undergone binary mixing or dilution trace a straight line between the mixing endmembers, and the intermediate (resulting) water falls on the mixing line. Molal concentrations are preferred in this type of diagram as mineral precipitation effects are more readily apparent. Dissolved elements broadly considered as conservative for this purpose include the halides (e.g. chloride and fluoride) and boron.

Binary conservative ion plots (B-Cl, F-Cl, and B-F) were constructed for MW-5 (**Figure 3-17**) and MW-1804A (**Figure 3-18**). Data for each well from nine sampling events between July 2018 and March 2019 were compared to the data points showing SSI exceedances from November 2019. Data for JAFAP porewater from the seven ports in multilevel well STN-12-4 from September 2017 through November 2019, representing JAFAP porewater, were included on the charts as a possible mixing endmember. For MW-5, co-located and shallower wells MW-1 and MW-6 were included as a possible mixing endmember, whereas well MW-1806A was included with the plots for MW-1804A for comparison, as it is screened in the same formation (Upper Connellsville Sandstone) and at a similar elevation.

For well MW-5, the November 2019 sample falls on a mixing line between historical MW-5 waters and $NaHCO_3$-type waters in the shallower co-located wells MW-1 and MW-6 for all conservative ion plots, and does not indicate mixing with JAFAP porewater (**Figure 3-17**). This relationship indicates that mixing between Appalachian Plateau NaCl-type connate water and overlying more dilute $NaHCO_3$-type water best explains the November 2019 sampling result and mixing with JAFAP porewater is not supported.

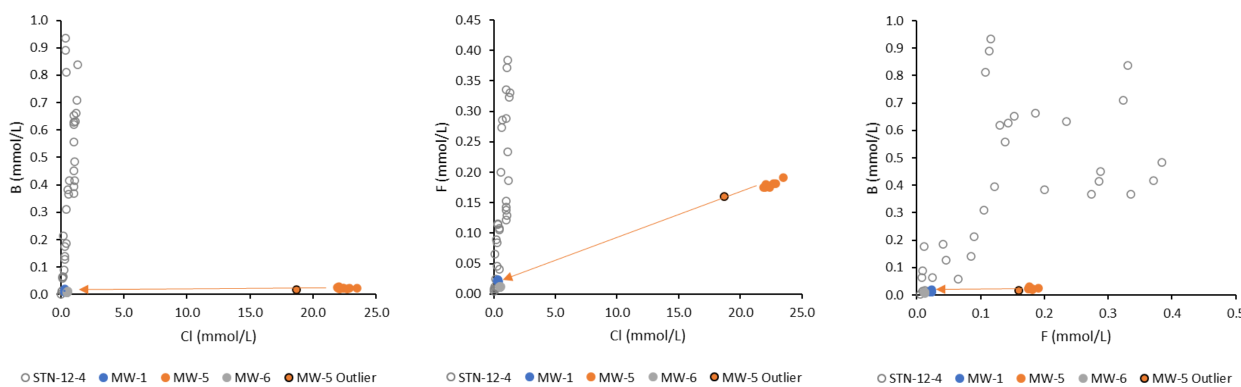

Figure 3-17. Conservative Ion Binary Plots for MW-5.

The B and Cl concentrations in the November 2019 sample from MW-1804A show that Cl increased relative to historical data for the well with no concomitant increase in B, whereas JAFAP porewater results show a distinct linear correlation between Cl and B concentrations (**Figure 3-18**). The Cl and F concentrations in the November 2019 MW-1804A sample also show increasing Cl with no concomitant increase in F compared to historical data from the well along a mixing path defined by historical F and Cl concentrations observed in groundwater samples from MW-1806A and is distinct from the pathway expected for mixing between MW-1804A and JAFAP porewater. The B and F concentrations plotted against each other do not reveal any mixing relationships but do show the broad compositional similarity between groundwater in MW-1804A and MW-1806A.

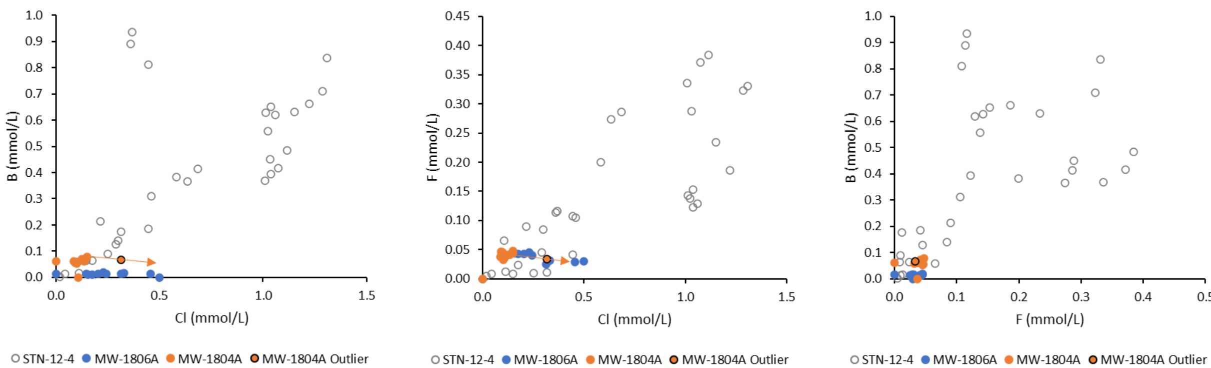

Figure 3-18. Conservative Ion Binary Plots for MW-1804A.

In summary, F and B concentrations plotted against Cl suggest mixing between different groundwater compositions within the Upper Connellsville Sandstone unit best explain the MW-1804A sample result from November 2019 and that mixing with JAFAP porewater is not expected.

3.4 Tier II Evaluation - Geochemical Evaluation

A simple analysis of primary and potential indicator constituents (as performed in **Section 3.1**) may not provide the lines of evidence required for a robust ASD investigation. It is recognized that naturally occurring indicator constituents and upgradient sources may have an additional influence on groundwater quality. Spatially across a site, groundwater quality may be observed to change due to chemical interactions with the aquifer matrix. EPRI (2012) recommended more sophisticated methods that can be used for multiple parameters over multiple locations.

Piper plots are used to classify groundwater types based on the major ion ratios of calcium, magnesium, sodium (and potassium), alkalinity, chloride, and sulfate. They can be used to visually illustrate ion exchange and mixing between different water chemistries.

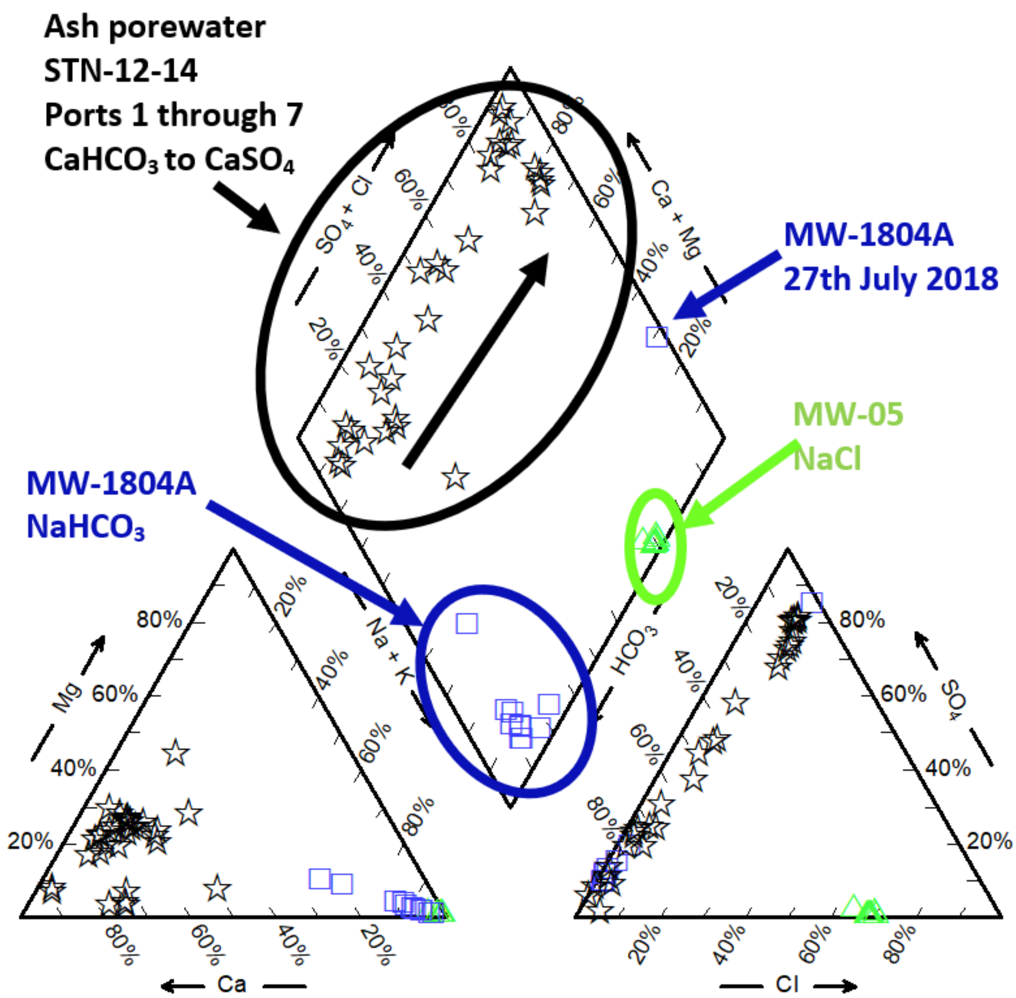

Figure 3-19 **JAFAP and Groundwater Piper Plot (water types)**

Ash porewater and groundwater are represented by different water types. In **Figure 3-19** above, the water types related to the JAFAP porewater are dominated by calcium, bicarbonate, and sulfate. Bicarbonate is associated with both ash porewater and MW-1804A, which is likely related to infiltrating rainwater. MW-1804A reports one event (July 27, 2018) with an alkalinity less than 1 mg/L. Groundwater samples collected in the vicinity of MW-1804A between August 2018 and November 2019 consistently report a sodium bicarbonate water type. The initial groundwater analysis conducted in July 2018 is potentially anomalous (with respect to alkalinity) when compared to the remainder of the historical dataset. During this event, total alkalinity (as $CaCO_3$) was reported as <1 mg/L and a field pH 7.5. Subsequent alkalinity results have ranged from 329 mg/L to 446 mg/L. At this pH, a carbonate alkalinity would be expected to report below 1 mg/L and total alkalinity would be represented by bicarbonate alkalinity only. It is suggested that the laboratory inadvertently reported carbonate alkalinity instead of total (or bicarbonate) alkalinity. The November 2019 sample falls partway along the regional evolution line where less evolved Ca-HCO_3 undergoes Na/Ca ion exchange with clay minerals along the flow path resulting in the Na-HCO_3 water type. The November 2019 sample may be considered a less evolved water that was sampled due to a combination of factors discussed in **Section 3.5** and **Section 3.7.**

The groundwater of MW-5 is distinct from MW-1804A and has a sodium chloride water type. Groundwater samples collected in the vicinity of MW-5 between July 2018 and November 2019 consistently report a sodium chloride water type. This water type is typically indicative of connate brines with a marine component that are relict within the aquifer. This groundwater monitoring location intersects a deeper section of the bedrock aquifer as discussed in **Section 2.3**.

In summary, based on the geochemical evaluation there is insufficient evidence to support the presence of CCR constituents, as derived from the JAFAP, in groundwater sampled in the vicinity of MW-5 and MW-1804A. The Piper plots do not support mixing between groundwater and JAFAP water at any of the groundwater monitoring locations reviewed. The JAFAP water type is calcium bicarbonate (shallow porewater) and calcium sulfate (deeper porewater). Only four other groundwater locations report these two water types – MW-1801A and MW-6 (calcium bicarbonate); and MW-1807A and MW1809A (calcium sulfate). Bicarbonate concentrations are generally more elevated in groundwater in comparison to JAFAP porewater. Sulfate concentrations are mostly higher within groundwater compared to JAFAP, except for MW-6. Additionally, In MW-1804A groundwater, sodium is elevated in concentration compared to JAFAP water and bromide, fluoride and sodium are all present at higher concentrations in MW-5 groundwater compared to the JAFAP water. These concentration imbalances indicate an alternate source of these constituents within the formation. Based on this evidence, it is considered that porewater from JAFAP is unlikely to be influencing the surrounding groundwater chemistry in MW-5 and MW-1804A where the November 2019 SSIs were identified.

3.5 ASD Type I – Natural Variation due to Sampling Causes

EPRI (2012) describes sampling anomalies as a defensible cause for an SSI. Review of field documents indicates a notable change in the sampling technique at MW-5 and MW-1804A during the November sampling and the eight background monitoring events, in that the maximum purge rate was between one half and one quarter the rate used historically (**Figure 3-20** and **Figure 3-21**). Additionally, the total volume purged during November 2019 sampling at MW-5 and MW-1804A was lower than all previous instances (except the October 2018 event in MW-1804A) (**Figure 3-20** and **Figure 3-21**).

Sampling events used to establish benchmark values for evaluating SSIs were formulated through statisitical analysis of the historical samples that were collected at higher purge rates and purge volumes. In the case of MW-5, the excess pumping in the associated low-yield formation during SSI benchmark calibration sampling is expected to result in incursion of reducing, low sulfate, high TDS NaCl-type connate water into the well screen. Subsequent sampling at a lower purge rate and purge volume on November 2019 is expected to have minimized connate water incursion into the well and facilitated sampling of low TDS and sulfate bearing water with elevated Ca from above the connate water mixng interface.

Similar to MW-5, lower purge rates and volumes at MW-1804 during November 2019 sampling is expected to draw groundwater from portions of the formation not typically sampled during the background sampling events. The SSI exceedance can be attributed in part to a substantially lower purge rate and volume than used during background sampling to establish SSI benchmarks. The screen and sand pack extends across the Conemaugh Shale, Upper Connellsville Sandstone, and an unnamed shale/siltstone unit, which conceivably have variable groundwater geochemistry. Notably, MW-1806A is the only other Site well with a sand pack that extends across the same combination of units and a substantial interval of the Conemaugh Shale. Conceivably, differences in the purge rate during sampling affected the relative contributions of different water bearing zones to the well, which resulted in groundwater geochemistry differences.

For MW-1804A, this is supported by the outcome of the Tier II geochemical evaluation (**Section 4.4**) that provides multiple lines of evidence to support the November 2019 MW-1804A groundwater sample has a simlar origin to groundwater sampled from other wells screened over simlar elevation ranges in the Conemaugh Shale/Upper Connellsville Sandstone, and that mixing with JAFAP porewater is not supported.

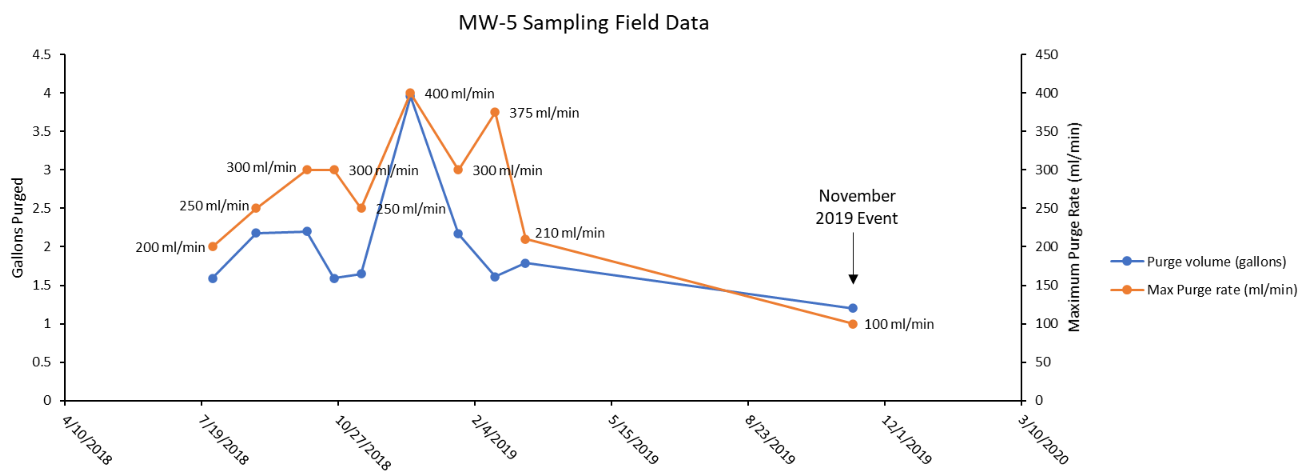

Figure 3-20. Historical Well Purge Rates and Volume Purged for MW-5.

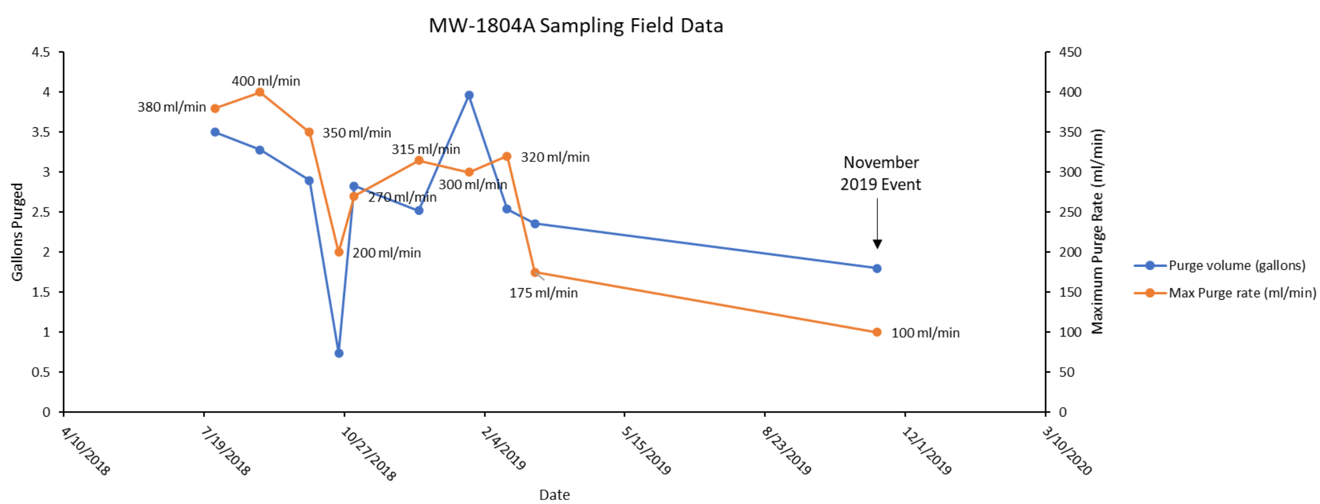

Figure 3-21. Historical Well Purge Rates and Volume Purged for MW-1804A.

3.6 ASD Type III – Statistical Evaluation Causes

Samples to establish SSI benchmarks were obtained over a seven month period between July 25, 2018 to February 18, 2019. For this reason, benchmark statistical calulations are qualified with "Insufficient data to test for seasonality: data were not deseasonalized" (AEP, 2020). Additionally, annual variations owing to high rainfall years (**Section 3.7**) are not accounted for, as detection monitoring began immediately following the establishment of SSI benchmarks. Therefore, periodic SSI exceedences related to seasonal and/or annual weather variations should be expected until a broader dataset is available that incorporates seasonal and annual weather patterns.

3.7 ASD Type IV – Natural Variation

The year highest annual rainfall ever recorded in West Virigina (67.05 inches) occurred in 2018 (NOAA, 2020), which coincides with the time period when 75 percent of the data to support the SSI benchmarks was collected. Historical water level records only extend back to the period where SSI benchmark data was collected for MW-1804A. In addition, the conceptual time-frame for recharge water to infiltrate to the MW-1804A screened zone is on the order of days to weeks (**Figure 2-2**), consistent with the expected response time between precitiation and sampling at MW-1804A during the high rainfall period. The anomalous rainfall is not expected to influence MW-5, as the conceptual time for recharge water to infiltrate the MW-5 screened zone is on the order of years to centuries (**Figure 2-2**).The November 2019 water level elevation (841.72 ft mean sea level) was the lowest measured to date. In comparison, the water level ranged between 842.01 and 846.00 ft during the earlier eight quarters of sampling used to establish SSI benchmarks, an elevation range that spans the overburden/bedrock interface (**Figure 3-22**). The water level measured in November 2019 was nearly 2.5 feet lower than the overburden/bedrock interface and approached the top of a sandstone interbed within the Conemaugh Shale. Variable water level elevations in MW-1804A support potential changes in the relative contributions from different water-bearing zones to the November 2019 sample. Additionally, the lowest historical water level in November 2019 conceivably reflects relaxation of the water table back to typical levels with concomitant changes in groundwater geochemistry, thus, may be more reflective of typical conditions.

It is expected that a combination of a historically low water levels and a notably lower purge rate during the November 2019 sampling event contributed to concentrations outside the range used to establish SSI benchmark exceedances. The variable concentrations in MW-1804A may be attributed to natural variations in the water chemistry at this location.

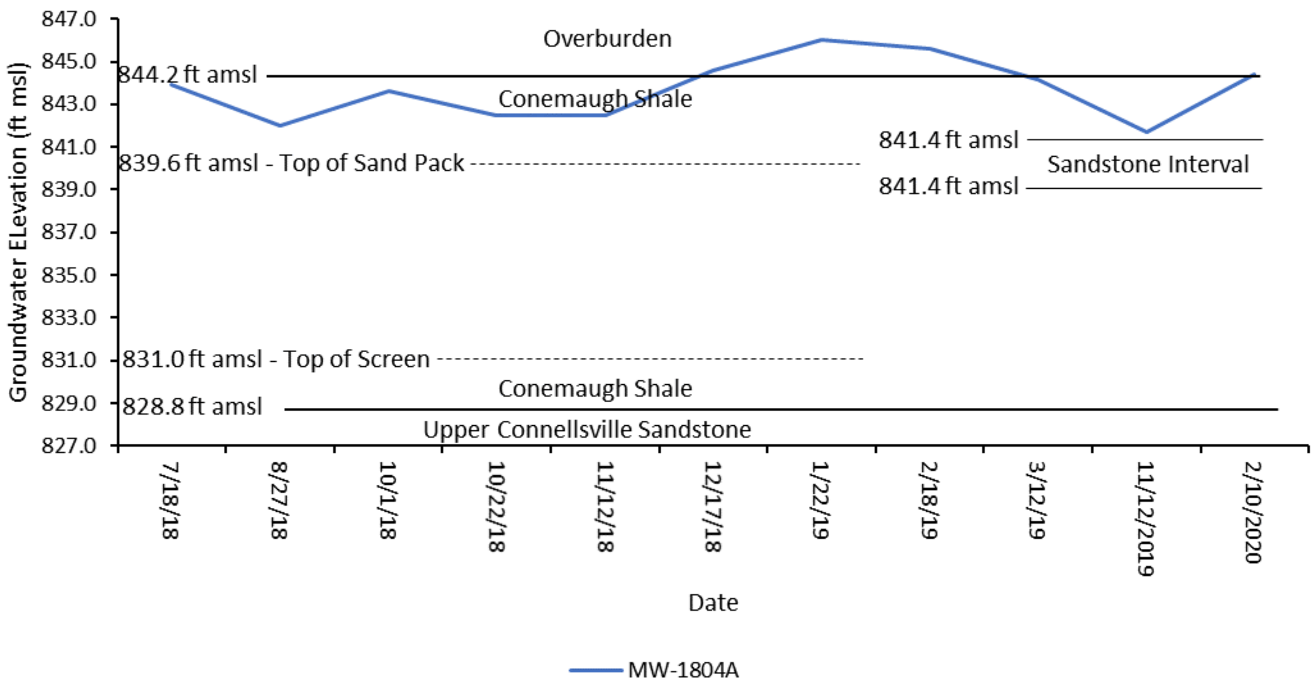

Figure 3-22. Hydrograph for MW-1804A Relative to Geological Observations Over the Screen Interval.

4 Summary and Conclusions

Table 5-1 (Table 6-1 in EPRI, 2017) highlights the potential causes of SSIs at MW-5 and MW-1804A during the November 2019 detection monitoring event that have been identified during this ASD investigation.

Table 5-1 Summary of Potential Causes Identified by ASD Investigation

Table 6-1
Potential Causes for an SSI/SSL

Sampling Causes (ASD Type I)	Laboratory Causes (ASD Type II)	Statistical Evaluation Causes (ASD Type III)	Natural Variation (ASD Type IV)	Alternative Sources (ASD Type V - Natural and Anthropogenic)
• Sample mislabeling • Contamination • Change in technique • Excessive suspended solids or turbidity • Other sampling anomalies	• Analytical method • Calibration • Analytical technique • Contamination • Interference • Recording • Dilution errors • Digestion methods	• Lack of statistical independence • Outliers • Trends • Non-detect Processing • False positives • New background data	• Geology • Precipitation • Seasonality • Water level • Changes in pH and/or ORP • Biological activity • Time of travel	• See Appendix A, Tables A-3 and A-4

Using the EPRI (2017) guidance for completing an ASD, the conclusions that are based on the lines of evidence presented and discussed within **Sections 3** indicate that groundwater in the vicinity of the JAFAP is not being influenced by CCR constituents from the JAFAP. Concentrations of the constituents calcium and sulfate in MW-5 and chloride and sulfate in MW-1804A that lead to SSIs in November 2019 are primarily caused by a change in the sampling procedure (ASD Type I – Sampling Causes), leading to a difference in where sampled water originated in the formation, as detailed in **Table 5-2.** Additionally, ASD Type III – Statistical Evaluation Causes, ASD Type IV Natural Variation Causes at MW-1804A and Type V – Alternatives Source Causes at MW-5 were identified, as discussed below.

Table 5-2 Evidence of ASD for SSIs at the John Amos Fly Ash Pond

MW-5 Evidence	MW-1804A Evidence
MW-5: Calcium SSI	MW-1804A: Chloride SSI
1. High purge rates and purge volumes during background sampling resulted in intrusion of sodium chloride water, setting an unrealistically low calcium SSI value for future comparison. 2. Mixing of shallower calcium-rich groundwater occurred during the November 2019 sampling event due to a substantially lower purge rate and volume, which led to the SSI as evidenced by: a. Calcium was 2.7 times lower in MW-5 than calcium in the shallower, co-located well MW-6. b. Shallow groundwater mixing is supported by Ca/Cl and B/Cl ratios in MW-5 similar to shallow groundwater and notably different than JAFAP porewater. c. Shallow groundwater mixing with brine is supported by conservative element (B, Cl, F) concentrations.	1. The SSI exceedance can be attributed to a substantially lower purge rate and volume than used during background sampling to establish SSI benchmarks. The screen and sand pack extends across the Conemaugh Shale, Upper Connellsville Sandstone, and an unnamed shale/siltstone unit, which conceivably have variable groundwater geochemistry. Variable groundwater chemistry in the different units is supported by the subtle geochemical differences in background data for other Site wells screened over only one or two of these units. Conceivably, differences in the purge rate during sampling affects the relative contributions of different water bearing zones to the well, which results in groundwater geochemistry differences. 2. November 2019 data, obtained with the lower purge rate, is likely due to natural groundwater variation within the screened formations and not the JAFAP, as evidenced by: a. Chloride in MW-1804A (11.2 mg/L) was essentially identical to MW-1806A (11.1 mg/L), which is screened in the same formation and over a similar elevation range. b. Ca/Cl and B/Cl ratios indicate that chloride in MW-1804A cannot be attributed to mixing with JAFAP porewater. c. Mixing between historical MW-1804A groundwater with MW-1806A groundwater is supported by conservative element (B, Cl, F) concentrations. d. The water level in MW-1804A in November 2019 was the lowest previously recorded.

MW-5 Evidence	MW-1804A Evidence
MW-5: Sulfate SSI	MW-1804A: Sulfate SSI
1. High purge rates and purge volumes during background sampling resulted in intrusion of sodium chloride water, with essentially no sulfate, setting an unrealistically low SSI value for future comparison (sulfate SSI benchmark is over 100 times lower than typical groundwater sulfate concentrations due to incursion of reducing, sulfide-bearing and sulfate-free brine) 2. Mixing of shallower sulfate-rich groundwater occurred during the November 2019 sampling event due to a substantially lower purge rate and volume, as evidenced by: a. Sulfate in MW-5 was lower than in co-located and shallower wells MW-1 and MW-6. b. SO_4/Cl ratios were substantially lower than JAFAP porewater and closer to those in shallow groundwater wells. 3. The November 2019 sulfate concentration should be considered an anomaly since it is two orders of magnitude higher than historical data.	1. The SSI exceedance can be attributed to a substantially lower purge rate and volume than used during background sampling to establish SSI benchmarks. 2. November 2019 data, obtained with the lower purge rate, combined with a low groundwater table elevation, is likely due to natural variation within the Upper Connellsville Sandstone formation and not the JAFAP, as evidenced by: a. Ca/Cl and B/Cl ratios indicate the 11/11/2019 sample from MW-1804A cannot be explained by mixing with JAFAP porewater and is best explained by natural variation within the Upper Connellsville Sandstone/SRF aquifer. b. Mixing between historical MW-1804A groundwater with groundwater of a composition similar to MW-1806A is supported by conservative element (B, Cl, F) concentrations. 3. The November 2019 sulfate concentration should be considered an anomaly since the anomalous concentration does not correspond to increases in other elements that would suggest mixing with JAFAP porewater.

An ASD Type III – Statistical evaluation cause could also be the reason for SSIs in the November 2019 detection monitoring event. SSI benchmarks were established over approximately a seven-month period preceding two quarters of detection monitoring. The November 2019 event was the second of two monitoring events following establishment of SSI benchmark values. The eight-month period does not fully capture seasonal and annual weather variations, and future reevaluation of benchmarks may be required to ensure a background data set which accurately reflects the natural variation in groundwater chemistry across the hydrogeologic units surrounding the JAFAP.

In addition to ASD Type I – Sampling Causes and ASD Type III – Statistical Evaluation Causes, the following potential contributing alternative sources were identified:

MW-5

- ASD Type V – Alternative sources (Natural). Historical groundwater geochemistry data for MW-5 show that it is screened close to a mixing zone between low TDS and comparatively young recharge water and high TDS and comparatively ancient connate brine. Regionally, the mixing interface between these two disparate water types is known to be only a few feet thick. The two water types constitute two natural groundwater sources with distinct groundwater geochemistry that may periodically contribute water to the saturated zone within the MW-5 screen/sand pack zone.

MW-1804A

- ASD Type IV – Natural Variation (precipitation and geology). The highest rainfall on record for West Virginia occurred during 2018, which coincides with the period where 75 percent of the values were obtained to establish SSI benchmarks and when water levels were first measured in MW-1804A.
  - Water levels in MW-1804A collected during establishment of SSI benchmarks spanned the overburden-bedrock interface.
  - The lowest water level on record for MW-1804A occurred during November 2019 and was nearly 2.5 feet lower than the overburden/bedrock interface.
  - Water quality variations associated with different water bearing zones exposed to the saturated zone in MW-1804A conceivably contributed to differences in groundwater geochemistry during the November 2019 sampling event compared to the eight background events sampled during a seven month period during the wettest year on record in West Virginia.

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Tables

Table 1
Screened Interval of Monitoring Wells
Fly Ash Pond Alternative Source Demonstration Investigation
AEP, John E. Amos Plant, Winfield, WV
November 2019

Well/ Boring	Hydraulic Location	Hydrolitho-stratigraphic Unit	Surface Elevation (ft amsl)	Screened Interval (ft amsl)	Sand Pack Interval (ft amsl)	Geologic Formation
MW-1807A	Upgradient/ Background	SRF	861.99	766.99 – 746.99	745.99 – 769.99	Unnamed clay shale/ Lower Connellsville SS
MW-1808A	Upgradient/ Background	SRF	857.55	733.73 – 748.35	746.55 – 776.55	Unnamed clay shale/ Lower Connellsville SS
MW-1809A	Upgradient/ Background	SRF	738.09	666.09 – 681.09	664.09 – 683.69	Clarksburg Shale
MW-1810A	Upgradient/ Background	SRF	735.26	655.26 – 675.26	653.26 – 681.26	Clarksburg Shale
MW-1	Downgradient	SRF	647.57	587.57 – 606.47	569.47 – 609.57	Birmingham Shale
MW-2	Downgradient	SRF	645.20	540.20 – 549.10	534.20 – 560.50	Birmingham Shale
MW-5	Downgradient	SRF	648.03	537.03 – 546.43	535.93 – 557.03	Birmingham Shale /Grafton SS
MW-6	Downgradient	SRF	647.50	614.00 – 619.00	613.30 – 620.30	Morgantown SS/ Birmingham Shale
MW-7	Downgradient	U/SRF	953.00	823.00 – 843.00	820.50 – 845.00	Conemaugh Shale/ Upper Connellsville SS
MW-8	Downgradient	U/SRF	963.01	800.01 – 819.01	797.01 – 821.21	Conemaugh Shale/ Upper Connellsville SS
MW-9	Downgradient	U/SRF	944.66	805.56 – 824.56	804.56 – 824.56	Conemaugh Shale/ Upper Connellsville SS
MW-1801A	Downgradient	U/SRF	901.12	826.12 – 846.12	824.12 – 849.12	Conemaugh Shale/ Upper Connellsville SS
MW-1804A	Downgradient	U/SRF	858.53	811.03 – 831.03	809.53 – 838.63	Conemaugh Shale/ Upper Connellsville SS/ Unnamed clay shale
MW-1806A	Downgradient	U/SRF	889.63	809.23 – 829.23	808.63 – 832.63	Conemaugh Shale/ Upper Connellsville SS/ Unnamed clay shale

--- = Boring advanced below the coal interval
~ = Approximate
ft = feet
amsl = above mean sea level
U=Upper Connellsville Sandstone
SRF=Stress Relief Fracture System
SS=Sandstone

Table 2
Multi-Port Piezometer STN-12-4 Water Quality Data
Fly Ash Pond Alternative Source Demonstration Investigation
AEP, John E. Amos Plant, Winfield, WV
November 2019

Multi-Port Interval	Sampling Date	Major Ions					Minor Ions							
		Bicarbonate	Calcium	Chloride	Magnesium	Sulfate	Boron	Bromide	Fluoride	Molybdenum	Potassium	Sodium	TDS	pH
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	SU
1	9/29/2017	630	182	13	41.7	151	10.1	--	2.2	--	--	75.6	810	--
2	9/28/2017	181	84.9	15.8	23.1	129	2	--	0.78	--	--	10.2	394	--
3	9/28/2017	108	69.2	16.3	11.9	146	3.36	--	2	--	--	16.1	344	--
4	9/28/2017	187	103	24.3	25.3	164	4.48	--	5.43	--	--	23.5	458	--
5	9/28/2017	62	122	39.5	22.9	280	5.23	--	7.3	--	--	15.7	582	--
6	9/28/2017	44	134	35.9	3.59	341	6.79	--	2.71	--	--	38.5	612	--
7	9/28/2017	51	168	46.4	29.3	409	9.05	--	6.28	--	--	19.9	740	--
GeoMean	September 2017	118.1	117.1	24.5	18.3	210.3	5.2	--	3.0	--	--	23.1	539.2	--
1	12/12/2017	597	170	12.8	22.6	152	9.63	--	2.16	--	--	20.1	816	--
2	12/12/2017	122	30.7	3.98	19.9	1.4	0.169	--	0.24	--	--	12.6	174	--
3	12/12/2017	102	34.5	6.18	3.06	28.1	0.698	--	0.46	--	--	33.7	224	--
4	12/11/2017	185	91.9	22.5	25.1	156	3.98	--	5.2	--	--	16.2	446	--
5	12/11/2017	67.1	105	38.1	38.5	268	4.5	--	7.05	--	--	66.6	550	--
6	12/11/2017	50.6	122	36.3	6.36	351	6.02	--	2.62	--	--	6.01	608	--
7	12/11/2017	49.6	143	45.6	6.81	435	7.67	--	6.14	--	--	7.42	774	--
GeoMean	December 2017	112.7	84.3	17.2	12.8	87.1	2.7	--	2.0	--	--	17.0	448.9	--
1	11/15/2018	360	58.5	3.74	15.3	44.4	0.634	0.1	1.24	0.0375	8.76	13.6	406	7.57
2	11/14/2018	289	67.9	1.59	17.4	20.2	0.145	0.1	0.17	0.0158	7.36	10.5	320	7.32
3	11/15/2018	181	50	0.64	12.6	8.4	<0.02	0.1	0.1	0.00892	7.6	7.78	217	7.47
4	11/15/2018	229	63.6	10.6	15.1	62.8	1.52	0.2	1.61	0.231	8.26	12.1	330	4.48
5	11/15/2018	80.4	86	35.8	17.9	229	3.98	0.508	6.38	1.62	6.34	10.6	440	7.65
6	11/15/2018	38.7	82.7	36.8	4.82	342	4.27	0.5	2.32	2.52	10.8	22.2	840	8.92
7	11/16/2018	55.8	115	40.8	19.3	332	6.83	0.502	4.45	3.17	7.83	16.1	600	8.01
GeoMean	November 2018	133.3	72.3	8.0	13.6	74.1	1.6	0.2	1.1	0.2	8.0	12.6	413.4	7.2
1	3/12/2019	392	107	7.59	26.8	74.1	2.23	0.1	1.71	0.0924	8.47	39.9	508	7.76
2	3/13/2019	281	73	5.24	19.1	27.1	0.643	<0.1	0.16	0.101	5.43	13	314	7.28
5	3/14/2019	213	75.3	10.3	19	78.2	1.25	<0.1	0.86	0.45	4.67	13.6	346	7.26
6	3/15/2019	47.4	127	37.6	3.98	346	6.67	0.548	2.46	2.5	11.2	37.8	628	9.52
GeoMean	March 2019	182.6	93.0	11.1	14.0	85.9	1.9	0.2	0.9	0.3	7.0	22.7	431.5	7.9
1	11/11/2019	627	173	15.8	36.8	141	8.47	0.311	2.05	0.146	10.4	70.8	816	7.55
2	11/11/2019	314	86.5	8.95	19.5	24.7	0.955	0.224	0.18	0.0714	6.14	12	361	7.25
3	11/11/2019	211	64.6	11.2	13.8	41.8	1.72	0.263	0.22	0.114	4.9	13.4	285	7.46
4	11/11/2019	201	83.4	20.6	20.5	109	3.95	0.423	3.79	0.551	6.01	20.4	391	7.68
5	11/11/2019	75.7	114	36.6	21.6	250	4.88	0.634	5.47	1.69	3.86	12.3	512	7.82
6	11/12/2019	47.7	132	36.8	3.7	337	7.05	0.584	2.91	2.68	10	42	632	9.26
7	11/12/2019	62	136	43.3	19.5	310	6.67	0.657	3.54	2.81	5.58	18.7	625	7.64
GeoMean	November 2019	151.9	107.4	21.2	16.4	122.5	3.9	0.4	1.5	0.5	6.3	21.7	488.5	7.8

Notes:
mg/L : milligrams per Liter
TDS : total dissolved solids
SU : standard units
- - : not analyzed
< : value less than reporting limit

Table 3
Monitoring Well Water Quality Data
Fly Ash Pond Alternative Source Demonstration Investigation
AEP, John E. Amos, Winfield, WV
November 2019

	Collection Date	Monitoring Program	Boron	Bromide	Calcium	Chloride	Fluoride	Molybdenum	Potasium	Sodium	Sulfate	pH	TDS
			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	s.u.	mg/L
MW-1	7/24/2018	Background	0.182	0.106	2.83	11.7	0.42	1.94	1.75	159	30.6	8.2	473
MW-1	8/28/2018	Background	0.135	0.121	2.80	11.3	0.45	1.48	1.63	168	31.6	8.5	435
MW-1	10/3/2018	Background	0.138	0.100	2.95	11.1	0.40	1.00	1.40	172	30.8	8.3	457
MW-1	10/22/2018	Background	0.180	0.100	2.36	11.4	0.42	1.00	1.49	170	30.7	8.3	434
MW-1	11/13/2018	Background	0.209	0.100	3.03	11.5	0.45	1.00	2.27	159	32.2	8.0	444
MW-1	12/19/2018	Background	0.117	0.0900	2.71	10.7	0.43	1.00	1.31	162	30.9	8.1	428
MW-1	1/23/2019	Background	0.115	0.0400	2.29	14.6	0.41	1.00	1.41	148	55.9	8.2	453
MW-1	2/19/2019	Background	0.126	0.0900	2.36	10.9	0.44	1.00	1.22	175	31.3	8.5	457
MW-1	**MW-1 Intrawell Prediction Limit**		**0.261**	- -	**3.58**	**14.6**	**4.85**	- -	- -	- -	**55.9**	**8.8**	**536**
MW-1	3/12/2019	Detection	0.110	0.080	2.60	11.0	0.43	- -	1.14	170.0	31.6	8.2	458
MW-1	11/8/2019	Detection	0.114	0.100	2.38	11.2	0.42	- -	1.42	165.0	33.7	8.2	461
MW-2	07/27/2018	Background	0.259	2.60	4.24	471	3.08	27.2	1.97	427	2.40	8.4	1260
MW-2	08/29/2018	Background	0.249	2.49	3.98	443	2.99	34.5	3.05	426	17.4	8.6	1310
MW-2	10/04/2018	Background	0.256	2.55	4.31	435	2.99	30.8	2.33	532	14.8	8.5	1280
MW-2	10/23/2018	Background	0.262	2.41	3.95	438	3.08	26.1	2.47	516	7.40	8.5	1250
MW-2	11/15/2018	Background	0.328	2.67	4.07	469	3.30	29.2	2.69	482	13.5	8.5	1250
MW-2	12/19/2018	Background	0.225	2.34	3.81	430	3.03	25.5	2.03	443	6.40	8.5	1250
MW-2	01/23/2019	Background	0.318	2.22	3.67	441	3.00	29.2	2.40	447	6.40	8.2	1310
MW-2	02/22/2019	Background	0.237	2.26	3.95	447	3.06	21.9	2.02	461	2.30	8.7	1310
MW-2	**MW-2 Intrawell Prediction Limit**		**0.382**	- -	**4.66**	**495**	**3.39**	- -	- -	- -	**26.7**	**8.9**	**1410**
MW-2	3/13/2019	Detection	2.300	2.38	3.98	441	3.02	26.2	1.86	470	1.8	8.7	1300
MW-2	11/8/2019	Detection	0.265	2.39	4.77	426	2.73	- -	2.91	481	20.1	8.5	1340
MW-2	2/11/2020	Verification	- -	- -	4.31	- -	- -	- -	- -	- -	- -	- -	- -
MW-5	7/24/2018	Background	0.252	4.69	6.75	793	3.32	36.5	3.04	777	0.2	8.1	1890
MW-5	8/29/2018	Background	0.240	4.56	6.71	780	3.33	38.4	4.59	714	0.2	8.2	1880
MW-5	10/3/2018	Background	0.276	4.67	7.03	776	3.33	35.7	3.37	742	0.1	8.1	1860
MW-5	10/24/2018	Background	0.249	4.63	7.09	811	3.44	35.1	3.40	735	<0.06	8.1	1840
MW-5	11/13/2018	Background	0.264	4.89	6.79	832	3.63	34.7	4.03	586	0.1	8.0	1880
MW-5	12/19/2018	Background	0.221	4.73	6.48	783	3.43	34.8	3.02	595	<0.06	7.9	1890
MW-5	1/23/2019	Background	0.323	4.58	5.98	782	3.36	35.0	3.80	599	<0.06	8.1	1910
MW-5	2/19/2019	Background	0.239	4.58	6.79	793	3.38	33.6	3.21	687	<0.06	8.2	1920
MW-5	**MW-5 Intrawell Prediction Limit**		**0.355**	- -	**7.79**	**853**	**3.72**	- -	- -	- -	**0.2**	**7.8**	**1980**
MW-5	3/13/2019	Detection	0.229	4.690	6.85	804	3.44	- -	2.78	660	0.08	8.0	1930
MW-5	11/8/2019	Detection	0.182	4.360	21.00	663	3.04	- -	6.61	571	32	8.0	1840
MW-5	2/11/2020	Verification	- -	- -	11.30	713	- -	- -	- -	- -	18.6	7.8	- -

Table 3
Monitoring Well Water Quality Data
Fly Ash Pond Alternative Source Demonstration Investigation
AEP, John E. Amos, Winfield, WV
November 2019

	Collection Date	Monitoring Program	Boron	Bromide	Calcium	Chloride	Fluoride	Molybdenum	Potasium	Sodium	Sulfate	pH	TDS
			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	s.u.	mg/L
MW-6	7/24/2018	Background	0.120	0.168	61.0	19.3	0.22	0.580	2.73	59.0	44.4	6.9	392
	8/28/2018	Background	0.096	0.203	59.7	19.4	0.24	0.600	2.87	60.8	44.6	6.9	398
	10/3/2018	Background	0.125	0.200	60.7	18.9	0.21	0.500	2.72	62.5	43.4	6.8	402
	10/24/2018	Background	0.1	0.200	61.5	18.4	0.23	0.600	2.76	68.3	42.0	6.9	400
	11/13/2018	Background	0.111	0.200	64.9	19.8	0.24	0.700	3.24	57.4	44.6	6.7	390
	12/19/2018	Background	0.07	0.100	55.8	17.7	0.23	0.700	2.80	57.4	41.7	6.7	376
	1/23/2019	Background	0.08	0.100	54.1	17.8	0.22	0.600	2.77	54.8	41.3	6.6	411
	2/19/2019	Background	0.09	0.100	55.8	17.3	0.24	0.600	2.92	67.4	40.4	7.0	406
	MW-6 Intrawell Prediction Limit		**0.159**	- -	**70.6**	**21.4**	**0.26**	- -	- -	- -	**48.0**	**6.3**	**424**
	3/12/2019	Detection	0.08	0.1	57.9	17.4	0.23	- -	2.69	65.5	39.8	6.9	390
	11/8/2019	Detection	0.079	0.201	56.6	17.2	0.24	- -	2.84	66.1	41.7	6.9	368
MW-7	07/26/2018	Background	0.0870	0.0960	1.33	5.41	0.270	1.12	0.590	138	32.0	8.53	368
	08/29/2018	Background	0.112	0.0900	1.29	5.32	0.270	1.06	1.15	133	31.5	8.75	387
	10/03/2018	Background	0.156	0.100	1.44	5.23	0.260	<1.00	0.910	147	31.8	8.75	376
	10/24/2018	Background	0.0900	0.100	1.40	5.37	0.270	<1.00	0.940	154	31.7	8.82	344
	11/13/2018	Background	0.192	0.100	1.49	5.65	0.290	<1.00	1.45	135	33.2	8.36	379
	12/17/2018	Background	0.100	0.0900	1.24	5.29	0.270	<1.00	0.730	155	32.0	8.62	387
	01/23/2019	Background	0.127	0.0800	1.41	5.18	0.250	<1.00	1.04	128	32.0	8.44	389
	02/18/2019	Background	0.0600	0.0900	1.37	5.39	0.260	<1.00	0.780	154	32.1	8.96	401
	MW-7 Intrawell Prediction Limit		**0.248**	- -	**1.63**	**5.80**	**0.34**	- -	- -	- -	**33.6**	**9.3**	**458**
	3/13/2019	Detection	0.060	0.090	1,47	5.5	0.270	- -	0.650	162	32.5		385
	11/8/2019	Detection	0.066	0.100	2.18	5.4	0.250	- -	1.760	139	32.3	8.7	390
	2/11/2020	Verification	- -	- -	1.39	- -	- -	- -	- -	- -	- -	- -	- -
MW-1804A	7/27/2018	Background	0.672	0.5	28.1	- -	- -	136	2.45	113	- -	- -	- -
	8/1/2018	Background	- -	0.0400	- -	3.87	0.70	- -	- -	- -	35.2	7.4	423
	8/28/2018	Background	0.779	0.0800	15.9	5.27	0.84	136	2.82	157	44.7	8.3	452
	10/2/2018	Background	0.629	0.0400	38.8	3.63	0.61	111	3.18	118	35.7	7.9	458
	10/23/2018	Background	0.675	0.0500	12.9	4.79	0.78	116	1.90	167	36.9	7.6	452
	11/13/2018	Background	0.846	0.0600	8.90	5.32	0.91	129	1.58	187	46	7.8	498
	12/19/2018	Background	0.772	0.0400	10.1	4.51	0.78	130	1.91	170	40.1	7.9	433
	1/24/2019	Background	0.673	0.04	12.1	3.14	0.71	110	1.86	146	32.3	7.4	414
	2/21/2019	Background	0.611	0.04	7.43	3.29	0.89	115	1.29	164	33.8	8.0	461
	MW-1804A Intrawell Prediction Limit		**0.965**	- -	**51.20**	**6.93**	**1.10**	- -	- -	- -	**53.9**	**6.8**	**599**
	3/12/2019	Detection	0.568	<0.04	10.2	3.55	0.85	- -	1.37	165.0	34.0	7.9	411
	11/11/2019	Detection	0.730	0.203	6.8	11.20	0.64	- -	0.80	211.0	85.4	8.0	582
	2/12/2020	Verification	- -	- -	- -	9.59	- -	- -	- -	- -	69	7.8	- -

EHS Support

Table 3
Monitoring Well Water Quality Data
Fly Ash Pond Alternative Source Demonstration Investigation
AEP, John E. Amos, Winfield, WV
November 2019

	Collection Date	Monitoring Program	Boron	Bromide	Calcium	Chloride	Fluoride	Molybdenum	Potasium	Sodium	Sulfate	pH	TDS
			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	s.u.	mg/L
MW-1806A	7/27/2018	Background	0.164	0.0700	12.9	- -	- -	17	1.63	129	- -	- -	- -
	8/1/2018	Background	- -	0.0600	- -	17.7	0.56	- -	- -	- -	48.4	7.6	426
	8/29/2018	Background	0.162	0.0630	12.0	16.2	0.55	14.2	2.01	139	45.6	8.0	445
	10/2/2018	Background	0.15	0.04	5.81	7.21	0.80	7.73	1.31	160	36.2	8.5	435
	10/23/2018	Background	0.158	0.04	7.43	8.62	0.77	6.66	1.30	158	40.8	8.4	423
	11/13/2018	Background	0.213	0.04	7.51	8.15	0.85	7.44	1.32	159	40.1	8.1	442
	12/19/2018	Background	0.162	0.04	5.14	5.29	0.85	6.02	1.20	161	30.9	8.5	409
	1/24/2019	Background	0.168	0.0500	12.2	11.7	0.59	5.62	2.17	153	48.1	8.1	445
	2/18/2019	Background	0.133	0.04	5.67	6.24	0.81	4.74	1.14	159	33.0	8.6	460
	MW-1806A Intrawell Prediction Limit		**0.235**	- -	**18.80**	**24.60**	**1.14**	- -	- -	- -	**61.4**	**7.2**	**485**
	3/12/2019	Detection	0.130	0.040	4.98	5.51	0.83	- -	0.98	180.0	32.9	8.8	430
	11/12/2019	Detection	0.156	0.100	13.50	11.10	0.48	- -	1.78	149.0	42.8	7.9	423

Notes:

Intrawell Prediction Limits are "Lower" for pH and "Upper" for all other consitutents (AEP, 2020)

- - : not analyzed

TDS : total disolved solids

mg/L : milligrams per Liter

s.u. : standard units

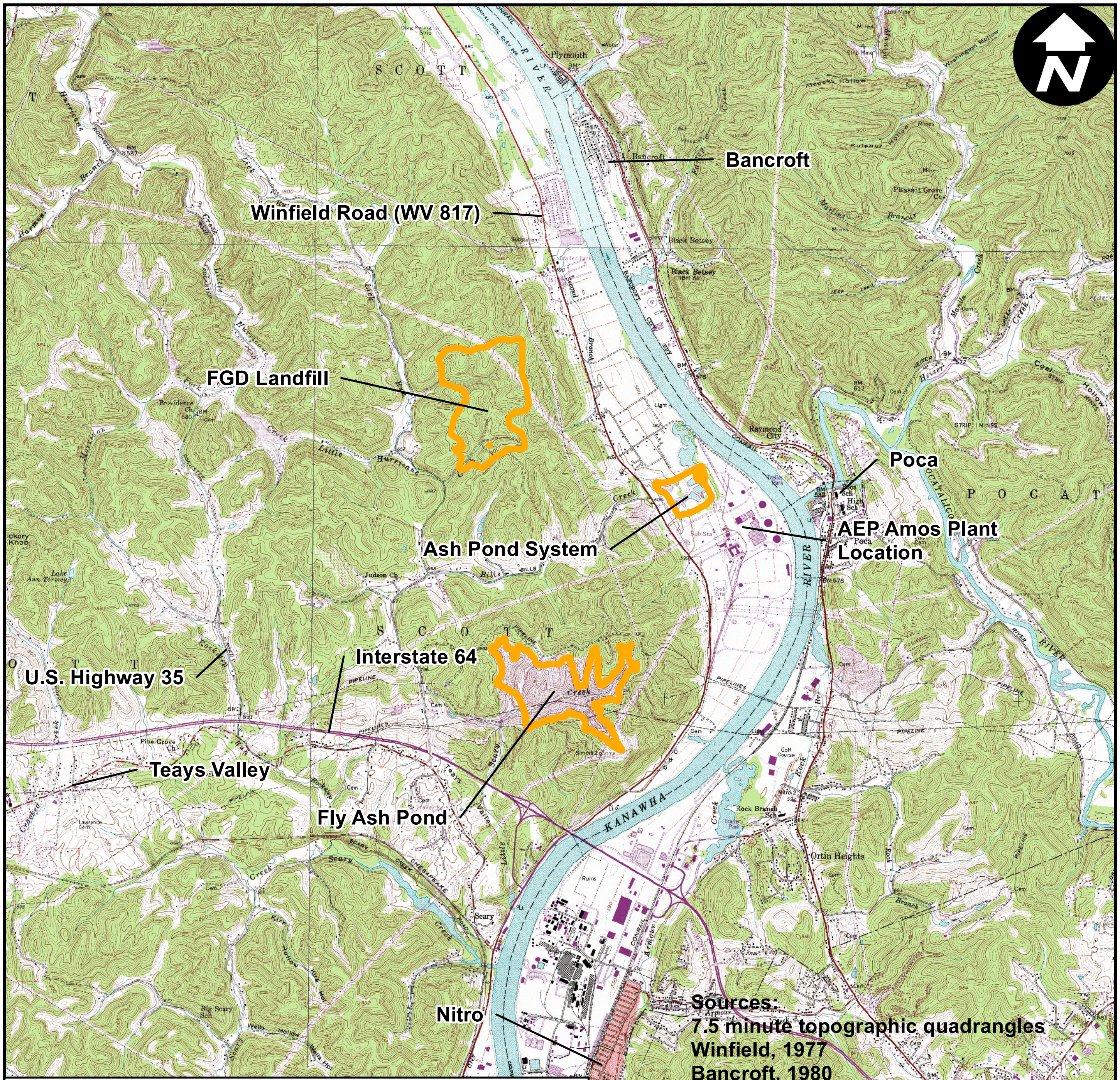
< - Non-detect value, less than the Method Detection Limit

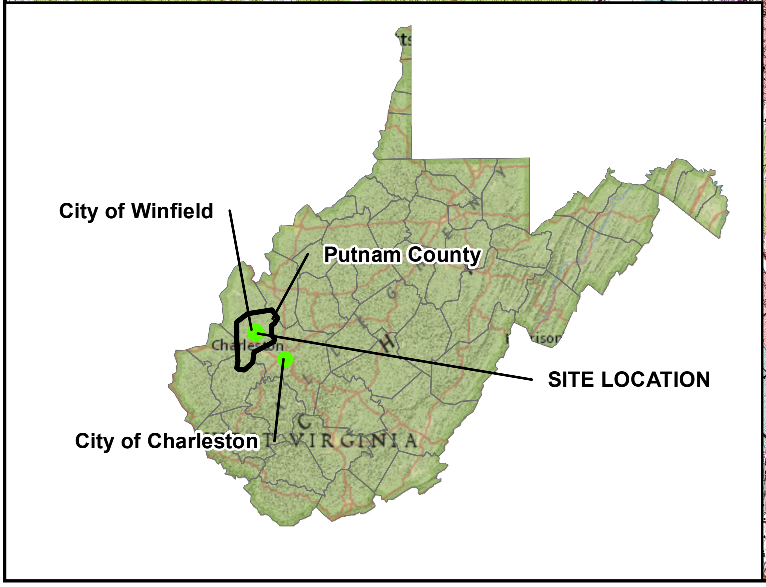
Table 4
Ion Ratios for Key Constituents in Groundwater
Fly Ash Pond Alternative Source Demonstration Investigation
AEP, John E. Amos Plant, Winfield, WV
November 2019

	Collection Date	Monitoring Program	Boron	Calcium	Chloride	Fluoride	Sulfate	B/Cl *100	Ca/Cl	F/Cl *1000	SO_4/Cl *1000
			mg/L	mg/L	mg/L	mg/L	mg/L				
JAFAP Pore Water											
STN-12-4 Port 1	11/11/2019	Fly Ash	8.78	173	15.8	2.05	141	556	10.9	0.13	8924
STN-12-4 Port 2	11/11/2019	Fly Ash	0.959	86.5	8.95	0.18	24.7	107	9.7	0.02	2760
STN-12-4 Port 3	11/11/2019	Fly Ash	1.9	64.6	11.2	0.22	41.8	170	5.8	0.02	3732
STN-12-4 Port 4	11/11/2019	Fly Ash	4.15	83.4	20.6	3.79	109	201	4.0	0.18	5291
STN-12-4 Port 5	11/11/2019	Fly Ash	4.88	114	36.6	5.47	250	133	3.1	0.15	6831
STN-12-4 Port 6	11/12/2019	Fly Ash	7.05	132	36.8	2.91	337	192	3.6	0.08	9158
STN-12-4 Port 7	11/12/2019	Fly Ash	7.16	136	43.3	3.54	310	165	3.1	0.08	7159
Benchmark SSI Exceedences											
MW-5	11/8/2019	Detection	0.182	**21.00**	663	3.04	**32**	0.3	0.03	0.005	48
MW-1804A	11/11/2019	Detection	0.730	6.8	**11.20**	0.64	**85.4**	65	0.6	0.06	7625
Downgradient Wells											
MW-1	11/8/2019	Detection	0.114	2.38	11.2	0.42	33.7	10	0.2	0.04	3009
MW-2	11/12/2019	Detection	0.265	4.77	426	2.73	20.1	1	0.01	0.01	47
MW-6	11/8/2019	Detection	0.079	56.6	17.2	0.24	41.7	5	3.3	0.01	2424
MW-7	11/11/2019	Detection	0.066	2.2	5.4	0.25	32	12	0.4	0.05	6026
MW-8	11/8/2019	Detection	0.197	2.0	109	2.97	22.5	2	0.0	0.03	206
MW-9	11/8/2019	Detection	0.133	1.0	7.7	0.83	19.1	17	0.1	0.11	2474
MW-1801A	11/11/2019	Detection	0.229	61.6	9.76	0.12	45.3	23	6.3	0.01	4641
MW-1806A	11/12/2019	Detection	0.156	13.50	11.10	0.48	42.8	14	1.2	0.04	3856

Notes:
mg/L : milligrams per Liter
B/Cl : Boron/Chloride
Ca/Cl : Calcium/Chloride
F/Cl : Fluoride/Chloride
SO_4/Cl : Sulfate/Chloride

Appendix A Site Maps





AEP AMOS GENERATING PLANT - FLY ASH POND
WINFIELD ROAD
WINFIELD, WEST VIRGINIA

SITE LOCATION MAP

ARCADIS Design & Consultancy for natural and built assets

FIGURE 1

Document Path: Z:\GISProjects_ENV\AEP\Amos\mxd\Impoundment\Report\F1_ site map.mxd

LEGEND:

- Coal Combustion Residual (CCR) Unit
- Rivers and Streams
- Streamflow Direction

NOTES:
1. 2016 AERIAL IMAGERY OBTAINED FROM ESRI IMAGE SERVICE.
2. 2018 SITE SPECIFIC AERIAL IMAGERY OBTAINED FROM AEP.
3. WEST VIRGINIA 1983 STATE PLANAR COORDINATES

0 3,000 6,000 Feet

GRAPHIC SCALE

AEP AMOS GENERATING PLANT - FLY ASH POND
WINFIELD ROAD
WINFIELD, WEST VIRGINIA

PLANT AND CCR UNIT LOCATION MAP

ARCADIS Design & Consultancy for natural and built assets

FIGURE
2

City: CITRIX Div/Group: IM/DV Created By: K.Ives Last Saved By: webb
OH015976.0009.00001 (Mountaineer Ash Pond)
Z:\GISProjects_ENV\AEP\Amos\mxd\ImpoundmentReport\F2_AmosRegionalMap.mxd 1/14/2019 9:27:48 AM

Well Identifiers

A – uppermost aquifer (Upper Connellsville sandstone/stress relief fracture system)

B – intermediate secondary groundwater-bearing zone (Clarksburg disconformity and fissile shale)

C – deep secondary groundwater-bearing zone (Morgantown sandstone – upper and basal disconformity contacts)

LEGEND:

- CCR Unit Boundary
- 2014 Soil and Rock Boring Location
- Oil & Gas Well
- 2008 Soil Boring and/or Rock Core
- Dewatering Well Converted to Piezometer
- Dewatering Well - Abandoned
- Downgradient Monitoring Well
- Upgradient or Background Monitoring Well
- 2012 Direct Push Boring with Cone Penetration Test (SCPTU)
- 2012 Direct Push Boring
- Piezometer
- 2012 Direct Push Soil Boring with Undisturbed (Shelby) Tube Samples and/or Standard Penetration Tests
- 2012 Direct Push Soil Boring with Undisturbed (Shelby) Tube Samples and/or Standard Penetration Tests and Piezometer
- 2012 Soil Boring with Standard Penetration Tests and Rock Core
- Rivers and Streams
- Stream Flow Direction
- Access Road

NOTES:

1. 2018 aerial imagery obtained from AEP.
2. FAP monitor well, STN boring, B-1401, and B-1402 coordinate source: AEP Drawing No. 13-30702-1
3. FAP piezometer and 2008 soil boring coordinate source: AEP-provided boring logs
4. Oil and gas well coordinate source: WVDEP Oil and Gas Well Database
5. West Virginia 1983 State Planar Coordinates

0 600 1,200 Feet

GRAPHIC SCALE

AEP AMOS GENERATING PLANT - FLY ASH POND
WINFIELD ROAD
WINFIELD, WEST VIRGINIA

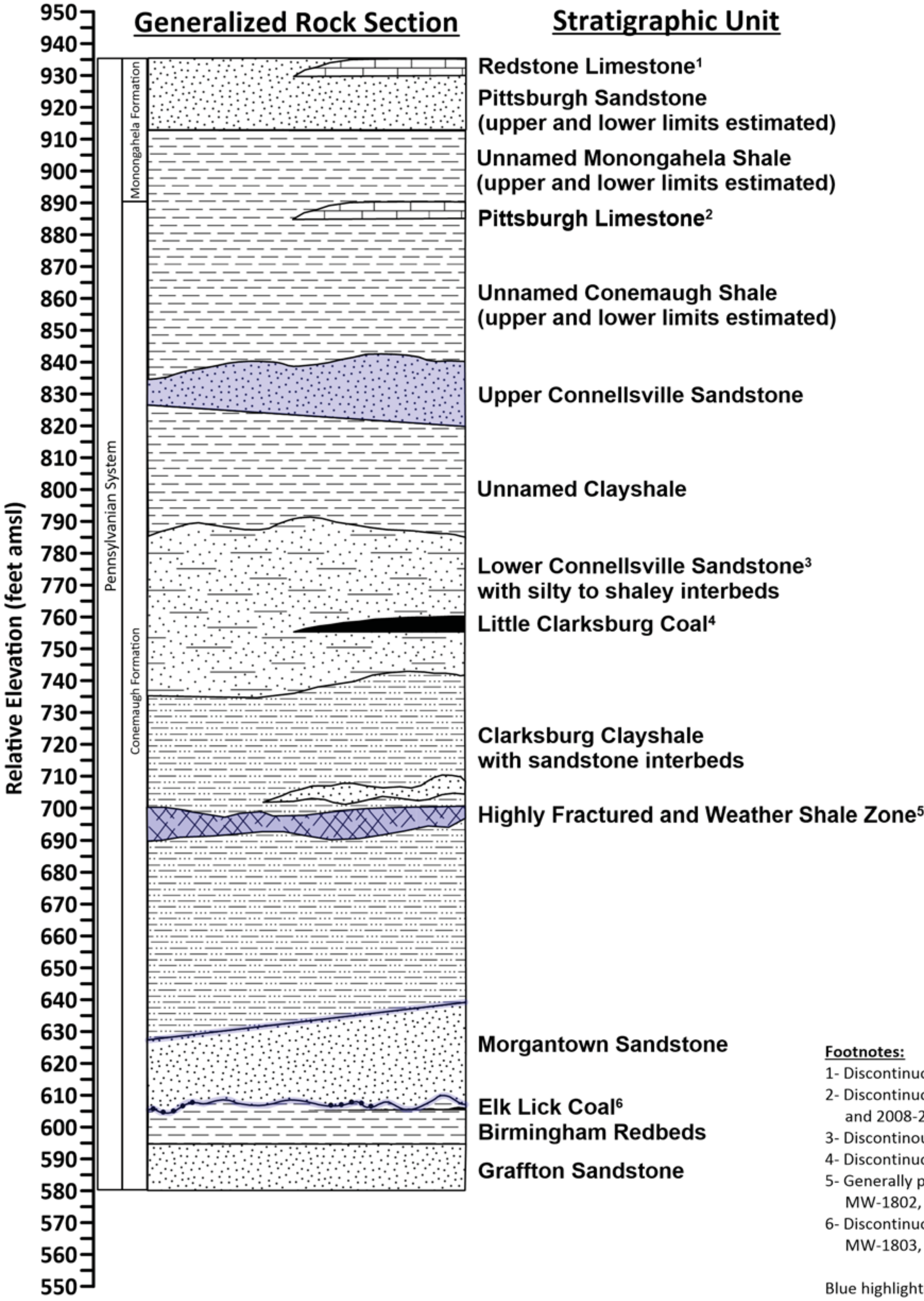
FLY ASH POND LAYOUT AND WELL LOCATIONS MAP

ARCADIS Design & Consultancy for natural and built assets

FIGURE 3

City: Div/Group: Created By: Last Saved By: acarlone
Project (Project #)
Z:\GISProjects_ENV\AEP\Amos\mxd\ImpoundmentReport\F3_Layout_WellLocations_v4.mxd 4/11/2019 10:36:50 AM

Appendix B Geologic Cross-Sections



Footnotes:

1- Discontinuous - only present at boring MW-3
2- Discontinuous - only present at borings MW-3 and 2008-26
3- Discontinous - interbeds of sandstone
4- Discontinuous - only present at boring B-0608
5- Generally present at borings MW-1801, MW-1802, MW-1803, and MW-1805
6- Discontinuous and thin - present at MW-1802, MW-1803, MW-1805

Blue highlighted areas designate groundwater-bearing fracture zones

References:

- Site stratigraphic and geophysics from current data collection and historical reports.
- Cross, A.T and M.P. Shemel. 1956. *Geology and Economic Resources of the Ohio River Valley in West Virginia, Part I Geology.* West Virginia Geological Survey Volume XXII.
- Latimer, W.J., et al. 1911. *Jackson, Mason and Putnam Counties, Volume 1, County Reports and Maps*. Wheeling News Litho. Company.
- Orsborn, N.P. 2008. *Deposition and Structural Features of the Basal Morgantown Sandstone of the Casselman Formation (Pennsylvanian) of the Greater Pittsburgh Region*. MS Thesis.
- Reger, D.B., et al. 1918. *Barbour and Upshur Counties and Western Portion of Randolph, Volume 1, County Reports and Maps.* Wheeling News Litho. Company.

AEP AMOS GENERATING PLANT - FLY ASH POND
WINFIELD ROAD
WINFIELD, WEST VIRGINIA

GENERALIZED STRATIGRAPHIC COLUMN

ARCADIS Design & Consultancy for natural and built assets

FIGURE
4

LEGEND:

- CCR Unit Boundary
- Stormwater Pond
- 2014 Soil and Rock Boring Location
- Oil & Gas Well
- 2008 Soil Boring and/or Rock Core
- Dewatering Well Converted to Piezometer
- Dewatering Well - Abandoned
- Downgradient Monitoring Well
- Upgradient or Background Monitoring Well
- Monitoring wells for the Ash Pond CCR Unit
- 2012 Direct Push Boring with Cone Penetration Test (SCPTU)
- 2012 Direct Push Boring
- Piezometer
- 2012 Direct Push Soil Boring with Undisturbed (Shelby) Tube Samples and/or Standard Penetration Tests
- 2012 Direct Push Soil Boring with Undisturbed (Shelby) Tube Samples and/or Standard Penetration Tests and Piezometer
- 2012 Soil Boring with Standard Penetration Tests and Rock Core
- Rivers and Streams
- Stream Flow Direction
- Access Road
- Cross Section Location

NOTES:

1. Topography from AEP dwg no. 13-30705-0 and 3dAMtopo_FAP11_aerial05.dgn. Contour Interval: 10 feet (2 feet within CCR unit boundary)
2. FAP monitor well, STN boring, B-1401, and B-1402 coordinate source: AEP Drawing No. 13-30702-1
3. FAP piezometer and 2008 soil boring coordinate source: AEP-provided boring logs
4. Oil and gas well coordinate source: WVDEP Oil and Gas Well Database
5. Amos Generating Plant monitor well, piezometer, and soil boring coordinate source: June 2016 AEP survey and EPRI, April 1999, Groundwater Quality at the John E. Amos Power Plant, Putnam County, West Virginia
6. West Virginia 1983 State Planar Coordinates
7. CSM = Conceptual Site Model

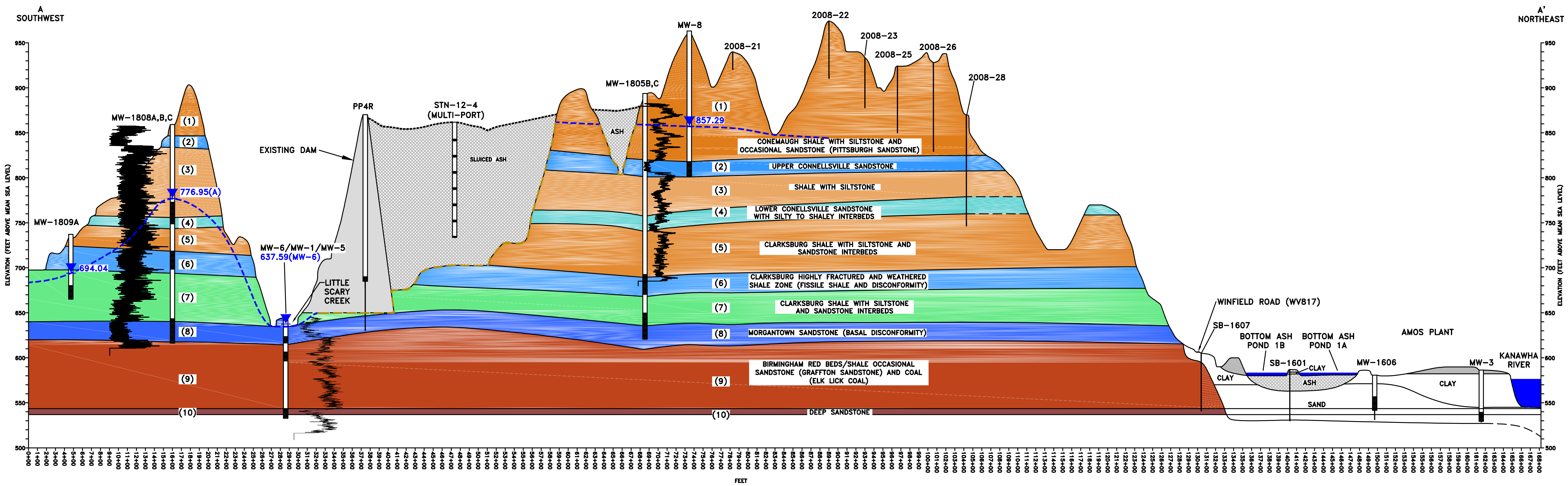
AEP AMOS GENERATING PLANT - FLY ASH POND
WINFIELD ROAD
WINFIELD, WEST VIRGINIA

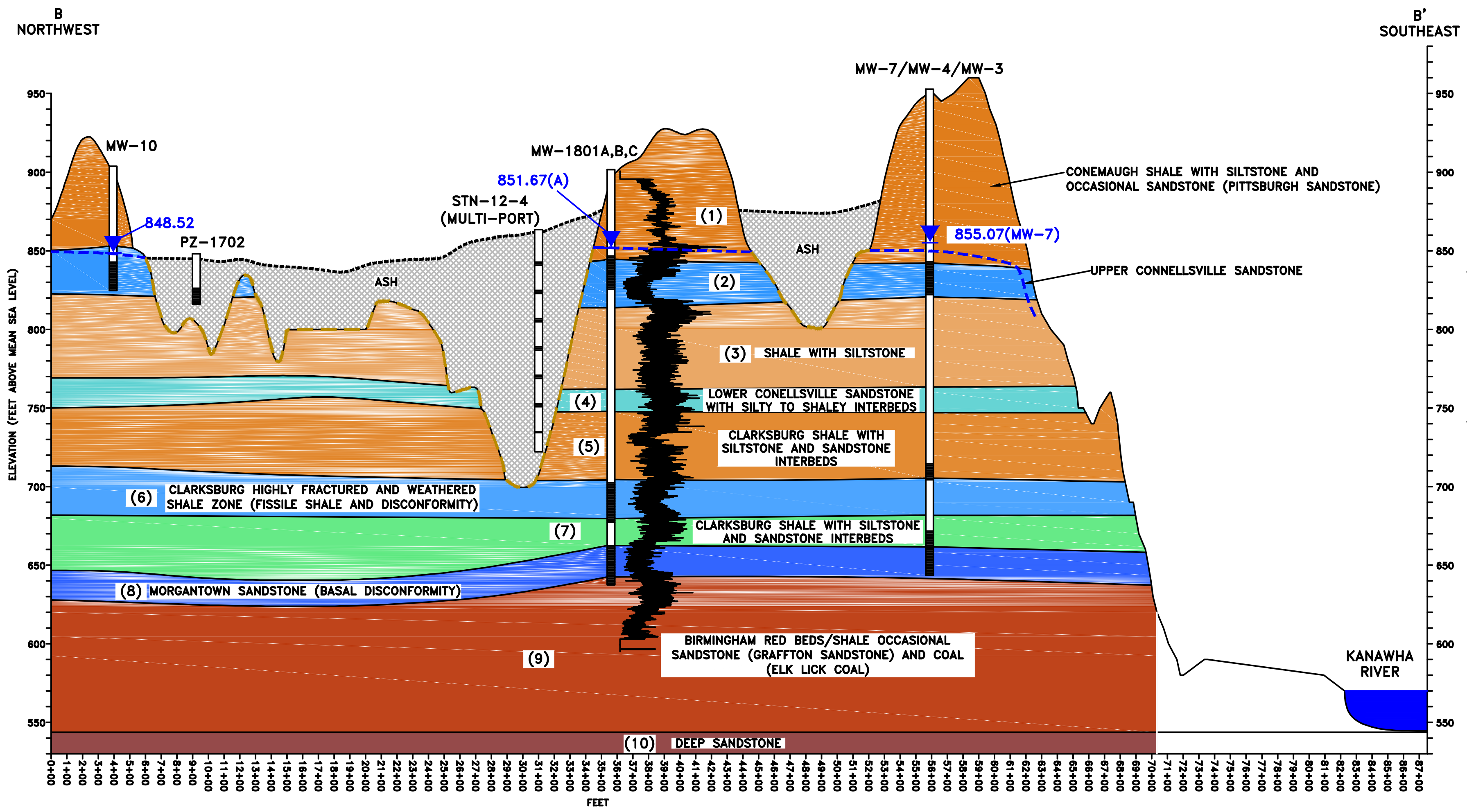
CROSS SECTION LOCATION MAP

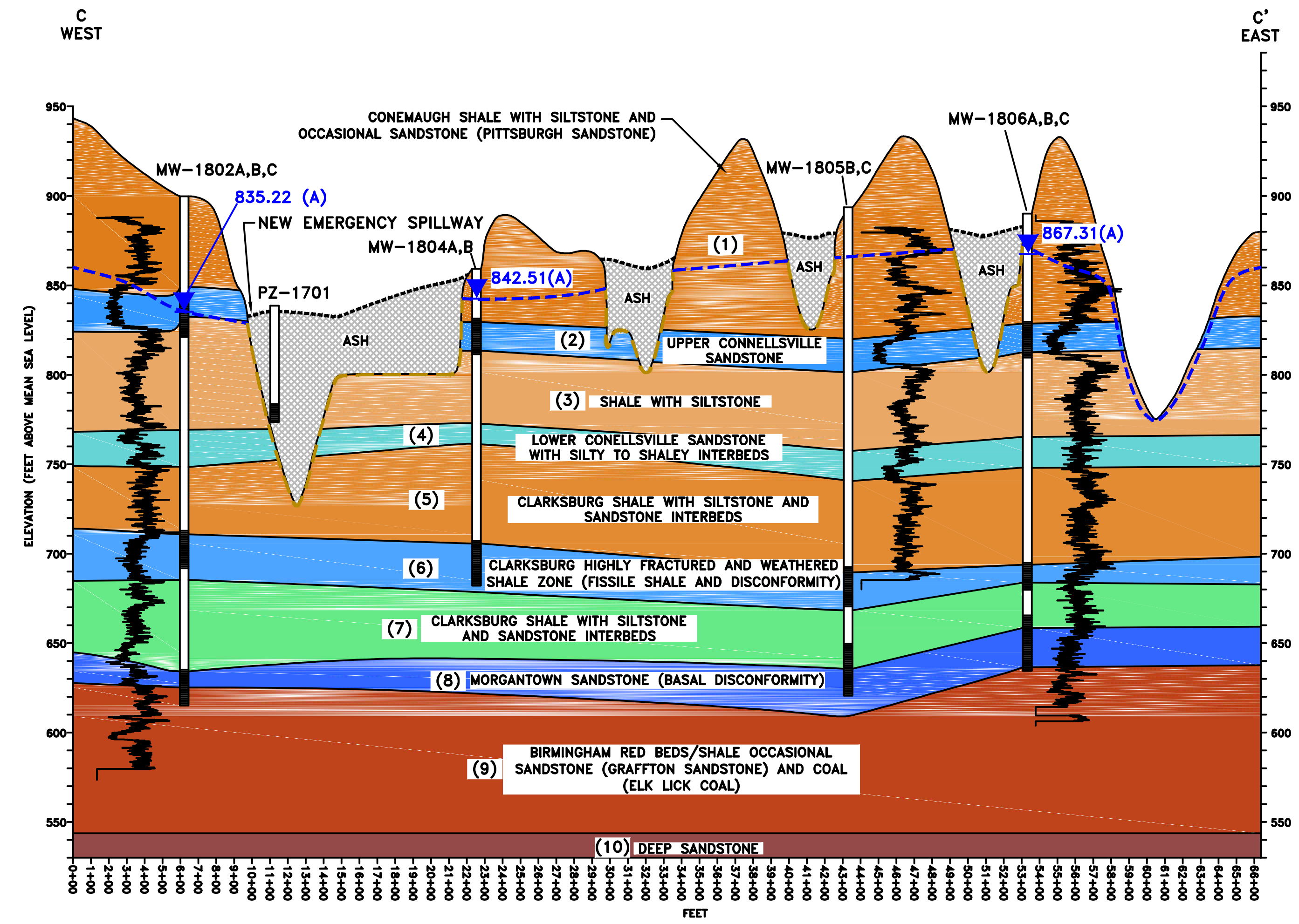
ARCADIS Design & Consultancy for natural and built assets

FIGURE 5

City: Div/Group: Created By: Last Saved By: akens
Project (Project #)
Z:\GISProjects_ENV\AEP\Amos\mxd\ImpoundmentReport\F5_Layout_CrossSectionLocationRevJan2019.mxd 3/29/2019 7:44:22 AM







LEGEND

MW-9 — WELL OR BORING IDENTIFICATION

- WELL
- WELL SCREEN
- BORING

CAP CONSTRUCTION (BOTTOM TO TOP):

- SUBGRADE PREPARATION (IN-PLACE FLY ASH AND ONSITE BORROW MATERIAL DEWATERING, EXCAVATING, GRADING)
- 40-MIL LINEAR LOW-DENSITY POLYETHYLENE (LLDPE) FLEXIBLE MEMBRANE LINER
- 8oz. GEOTEXTILE CUSHION LAYER
- 18 INCHES OF PROTECTIVE SOIL COVER LAYER
- 6 INCHES OF VEGETATIVE COVER LAYER
- DRAINAGE STRUCTURES
- SEEDING AND MULCHING

UPPERMOST AQUIFER (UPPER CONNELLSVILLE SANDSTONE AND SRF) MONITORING WELL WATER LEVEL OCTOBER 22, 2018

UPPERMOST AQUIFER (UPPER CONNELLSVILLE SANDSTONE AND SRF) POTENTIOMETRIC SURFACE

UPPERMOST AQUIFER (UPPER CONNELLSVILLE SANDSTONE AND SRF) TOP BELOW SATURATED ASH

NATURAL GAMMA LOG

0 100 200 300 COUNTS PER SECOND

(1) CONEMAUGH SHALE WITH SILTSTONE AND OCCASIONAL SANDSTONE (PITTSBURGH SANDSTONE)
(2) UPPER CONNELLSVILLE SANDSTONE
(3) SHALE WITH SILTSTONE
(4) LOWER CONNELLSVILLE SANDSTONE WITH SILTY TO SHALEY INTERBEDS
(5) CLARKSBURG SHALE WITH SILTSTONE AND SANDSTONE INTERBEDS
(6) CLARKSBURG HIGHLY FRACTURED AND WEATHERED SHALE ZONE (FISSILE SHALE AND DISCONFORMITY)
(7) CLARKSBURG SHALE WITH SILTSTONE AND SANDSTONE INTERBEDS
(8) MORGANTOWN SANDSTONE (BASAL DISCONFORMITY)
(9) BIRMINGHAM RED BEDS/SHALE OCCASIONAL SANDSTONE (GRAFFTON SANDSTONE) AND COAL (ELK LICK COAL)
(10) DEEP SANDSTONE

VERTICAL SCALE: 1" = 100'
HORIZONTAL SCALE: 1" = 1000'

AEP AMOS GENERATING PLANT - FLY ASH POND
WINFIELD ROAD
WINFIELD, WEST VIRGINIA

CROSS SECTIONS A-A', B-B' AND C-C'

ARCADIS Design & Consultancy for natural and built assets

FIGURE
6

CITY:(COLUMBUS, OHIO) DIV/GROUP:(ENV) DB:(R. SMITH) LD:(Opt) PIC:(Opt) PM:(T. FORTNER) TM:(Opt) LYR:(Opt)ON=*;OFF=*REF*
C:\BIM\OneDrive - ARCADIS\BIM 360 Docs\AMERICAN ELECTRIC POWER\AEP AMOS FAP\2019\WV015976.0005\01-DWG\0001E\WV015976-0005-0001E-FAP-CS01.dwg LAYOUT: CS ALL SAVED: 2/1/2019 8:34 AM ACADVER: 21.0S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: ACAD.CTB
PLOTTED: 2/1/2019 12:57 PM BY: SMITH, BOB
XREFS:

Appendix C MW-5, MW-1804A and STN-12-4 Boring Logs

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

COMPANY

PROJECT **EPRI GROUND WATER STUDY - AMOS**

COORDINATES **N 531,282.0 E 1,724,360.0**

GROUND ELEVATION **648.0** SYSTEM **STATE PLANE**

BORING NO. **D=MW-05** DATE **8/27/07** SHEET **1** OF **5**

BORING START **7/11/95** BORING FINISH **7/26/95**

PIEZOMETER TYPE WELL TYPE **OW**

HGT. RISER ABOVE GROUND **1.9** DIA **2.0**

DEPTH TO TOP OF WELL SCREEN **101.6** BOTTOM **111.0**

WELL DEVELOPMENT **YES** BACKFILL **QUICK GROUT**

FIELD PARTY **MCR-RLY=TJH-REB** RIG **BK-81 CME-75**

Water Level, ft	▽	▼	▼
TIME			
DATE			

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	USCS	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										AUGERED TO 2'		
1	SS	2.0	3.5	??-28-19	15"				GM	**GRAY ROCK FRAGMENTS, GRAVEL, SILT,** DRY, (FILL).		
									ML	**CLAYEY SILT AND GRAVEL**, MODERATE BROWN (5YR 3\4), Moist. AUGERED TO 7.0'		
							5					
2	SS	7.0	22.0	10-9-9	7.5"				ML	**CLAYEY SILT AND GRAVEL**, MODERATE BROWN (5YR 4\8) LIGHT BROWN (5YR 5\6 AND MODERATE BROWN (5YR 3\4), TRACE FELDSPAR, MOIST. AUGERED TO 12.0'		
							10					
3	SS	12.0	13.5	13-8-5	17"				ML	**SAME AS ABOVE**		
									CL	**SILTY CLAY**, PALE YELLOWISH BROWN (12YR 6\2) AND LIGHT OLIVE GRAY (5YR 5\2), LOW TO MEDIUM PLASTICITY, MOIST. AUGERED TO 17.0'		
							15					
4	SS	17.0	18.5	3-3-3	18"				SC	**CLAYEY-SILTY FINE SAND**, DUSKY YELLOWISH BROWN (10 YR 2\2),MOIST TO WET.		
										AUGERED TO 22.0'		

TYPE OF CASING USED

X	NQ-2 ROCK CORE	
X	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
	NW CASING	3"
	SW CASING	6"
	AIR HAMMER	8"

Continued Next Page

PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER **D.BENNETT**

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER ____________

COMPANY ____________

PROJECT **EPRI GROUND WATER STUDY - AMOS**

BORING NO. **D=MW-05** DATE **8/27/07** SHEET **2** OF **5**

BORING START **7/11/95** BORING FINISH **7/26/95**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	SAMPLE DEPTH IN FEET TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	USCS	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
5	SS	22.0	23.2	7-7-50/3"	13"				SC	**SAME AS SAMPLE No. 4**		
									SW	**MEDIUM TO COARSE SAND**, LIGHT BLUISH GRAY (5B 7\1), MOIST.		
1	NQ	24.0	29.8		5.0	60				AUGERED TO 23.9' - AUGERED THROUGH OBSTRUCTION (ROCK?)		
							25			**MORGANTOWN SANDSTONE?**, GRAY. 24.0 - 25.0' Solid, light gray, (N-7) 25.0 - 26.0' Fractured, brown clay lined fractures, light gray (N-7). 26.0 - 27.0' Minimal fractures 27.0 - 27.7' Fractured, weathered, very fine dark gray (N-3) bedding. 27.7 - 29.8' Light gray (N-7) sandstone		25.0 Fracture = 8 26.0 Fracture = 3 26.5 Lost water 27.0 Fracture = 5
2	NQ	29.8	39.8		10.0	93	30			29.8 - 33.8' Light gray (N-7) sandstone		
										CLAY SHALE, MEDIUM GRAY (N4) MOIST, VERY SOFT.		
							35			**CLAY SHALE**, GRAYISH BROWN (5YR 3\2), MOIST, VERY SOFT.		35.2 Fracture = 3
										CLAY SHALE, LIGHT OLIVE GRAY (5Y 5\2) MEDIUM LIGHT GRAY (N6), SOFT, MODERATE WEATHERING.		36.3 Fracture = 3
										SHALE, MEDIUM BLUISH GRAY (5B 5\1), TRACE IRREGULAR BEDDING PLANES, SOFT.		37.3 Fracture = 2
3	NQ	39.8	49.8		9.8	67	40			**SAME AS ABOVE**		39.8 Fracture = 6
										SAME, WITH MODERATE BROWN (5YR 3\4) BEDDING PLANES, MEDIUM TO HIGHLY FRACTURED, MODERATE WEATHERING.		42.5 Fracture = 8
										SHALE, MEDIUM BLUISH GRAY 5Y 5\2), SLIGHT TO MODERATE WEATHERED		
							45			**CLAY SHALE**, PALE BROWN (5YR 5/2), TO DARK YELLOWISH BROWN (10YR 4/2) AND		44.6 numerous fractures.

Continued Next Page

JOB NUMBER ______

COMPANY ______

BORING NO. **D=MW-05** DATE **8/27/07** SHEET **3** OF **5**

PROJECT **EPRI GROUND WATER STUDY - AMOS** BORING START **7/11/95** BORING FINISH **7/26/95**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										LIGHT OLIVE GRAY (5YR 4/2), SOFT, SOME IRREGULAR BEDDING PLANES		
4	NQ	49.8	56.5		4.7	54	50					
												51.0 Regained drill water
							55					
5	NQ	56.5	59.8		2.55	50				**SAME EXCEPT VERY SOFT**		56.5 Fracture = 7
6	NQ	59.8	67.3		7.5	96	60			**CLAYEY SILT**, DARK YELLOWISH BROWN (10yr 4\2), MOIST - WET		
										SAME, VERY WEATHERED, SOFT		
										CLAY SHALE, PALE BROWN (5YR 5\2), SLIGHTLY WEATHERED		
							65					
										SAME, SOME MODERATELY WEATHERED, SOFT		
7	NQ	67.3	69.8		2.5	40				**SAME**, VERY WEATHERED, VERY SOFT		
										SAME, MODERATELY WEATHERED, SOFT		68.0 Fracture = 5
										SHALE, MEDIUM GRAY (N5), SOFT.		
8	NQ	69.8	78.8		6.8	64	70			**SAME**		
										CLAY SHALE, PALE BROWN (YR 5\2) AND		71.6 Fracture = 12

Continued Next Page

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

COMPANY

PROJECT **EPRI GROUND WATER STUDY - AMOS**

BORING NO. **D=MW-05** DATE **8/27/07** SHEET **4** OF **5**

BORING START **7/11/95** BORING FINISH **7/26/95**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										MEDIUM GRAY (N5), MODERATELY WEATHERED, SOFT.		
							75					
9	NQ	78.8	79.8		1.0	40				**SHALE**, PALE BROWN (5YR 5\2) AND LIGHT OLIVE GRAY (5Y 5\2), IRREGULAR BEDDING, WEATHERED, SOFT.		78.8 numerous fracture.
10	NQ	79.8	87.8		6.3	48	80			**SAME**, SOME SEDIMENT FILLED FRACTURES		
							85					86.0 Top of seal.
11	NQ	87.8	89.8		2.0	75				**SHALE**, GRAYISH OLIVE (10 YR 4\2) AND MODERATE BROWN (5YR 3\4), INTERBEDDED LAYERS, SOFT, SLIGHTLY WEATHERED.		
12	NQ	89.8	90.8		.75	0	90			**SAME**, EXCEPT WEATHERED		
13	NQ	90.8	99.8		9.0	100				**SHALE**, MEDIUM BLUISH GRAY (5B 5\1), WITH SOME INTERBEDDED BROWNISH GRAY (5YR 4\1) COLOR, SLIGHTLY WEATHERED, SOFT		91.0 Top sand.
							95					

Continued Next Page

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER ______________________

COMPANY ______________________

PROJECT **EPRI GROUND WATER STUDY - AMOS**

BORING NO. **D=MW-05** DATE **8/27/07** SHEET **5** OF **5**

BORING START **7/11/95** BORING FINISH **7/26/95**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
14	NQ	99.8	100.3		.25	0	100			**SAME**, EXCEPT WEATHERED		Lost water return on run #14.
15	NQ	100.3	109.8		9.5	95				**SHALE**, MEDIUM BLUISH GRAY 5B 5\1), SLIGHTLY WEATHERED, SOFT		101.6 Top of screen.
										SANDSTONE, MEDIUM BLUISH GRAY (5B 5\1), SLIGHTLY WEATHERED AT 104', SOFT.		
							105					
16	NQ	109.8	114.8		4.4	40	110			**SAME**, SOFT		
										SHALE, MEDIUM BLUISH GRAY (5B 5\1), SOFT.		111.0 Bottom of screen.
										SHALE, MEDIUM DARK GRAY, SOFT, WEATHERED, VERY FRACTURED.		112.0 Fracture = 7 112.1 Bottom of sand.
										CLAY SHALE, GRAYISH BROWN (5YB 3\2), WEATHERED, SOFT TO VERY SOFT, FRACTURED.		
										114.8 BOTTOM OF HOLE		114.7 Bottom of seal.

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER **WV015976.0005**

COMPANY **American Electric Power**

PROJECT **Amos Fly Ash Pond**

COORDINATES **N 533,349.8 E 1,725,662.5**

GROUND ELEVATION **858.5** SYSTEM **NAD83/NAVD88**

BORING NO. **MW-1804A** DATE **1/11/19** SHEET **1** OF **3**

BORING START **5/21/18** BORING FINISH **5/23/18**

PIEZOMETER TYPE **NA** WELL TYPE **OW**

HGT. RISER ABOVE GROUND **3.32** DIA **2"**

DEPTH TO TOP OF WELL SCREEN **27.5** BOTTOM **47.5**

WELL DEVELOPMENT **Surge/Purge** BACKFILL **Bentonite Grout**

FIELD PARTY **Zachary Racer (AEP)** RIG **Direct Circulation - Wireline Core**

Water Level, ft	▽ 17.9	▼	▼
TIME			
DATE	7/18/2018		

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	USCS	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
0	NR	0.0	14.3		0		5, 10		CL ML	0-14.3': No recovery - Silty CLAY overburden.		0-27.50': Riser; 7-18.90': Bentonite Seal
1	RC	14.3	24.3		120	14	15			14.3-17.1': SHALE; weak field strength; GLEY 4/N (Dark Gray); fine-grained texture; thinly bedded; highly decomposed; moderately disintegrated, mottling; intensely fractured.		
										17.1-19.2': SANDSTONE; moderate to strong field strength; GLEY 6/N (Gray); fine-grained texture; thinly bedded; slightly decomposed; slightly fractured.	▽	
										19.2-26.5': SHALE; weak field strength; GLEY 4/N (Dark Gray); fine-grained texture; thinly		18.90-19.90': Secondary Sand

TYPE OF CASING USED

X	NQ-2 ROCK CORE	
NA	6" x 3.25 HSA	
NA	9" x 6.25 HSA	
NA	HW CASING ADVANCER	4"
NA	NW CASING	3"
NA	SW CASING	6"
NA	AIR HAMMER	8"

Continued Next Page

PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER **A. Gillespie**

AEP - AEP.GDT - 1/11/19 13:55 - C:\USERS\LWOODS\DESKTOP\FOR NICOLE BORING LOGS GINT FILES\AEP MOUNTAINEER.GPJ

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER **WV015976.0005**

COMPANY **American Electric Power**

PROJECT **Amos Fly Ash Pond**

BORING NO. **MW-1804A** DATE **1/11/19**

BORING START **5/21/18** BORING FINISH **5/23/18**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	USCS	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
1	RC	14.3	24.3		120	14				bedded; moderately decomposed; moderately disintegrated, iron staining in bedded intervals and vertical fractures; moderately fractured with iron-stained vertical fractures.		Pack (Global #6) 19.90-49': Primary Sand Pack (Global #5)
2	RC	24.3	34.3		120	7	25			26.5-29.7': Interbedded SHALE and SANDSTONE; moderate field strength; GLEY 4/N (Dark Gray); fine-grained texture; thinly bedded; slightly decomposed in some bedded intervals in the top 3' of the interval; slightly disintegrated; slightly to moderately fractured.		27.50-47.50': Slotted PVC (20-slot) Screen
							30			29.7-34.3': SANDSTONE; strong field strength; GLEY 6/N (Gray); fine-grained texture; thinly bedded; fresh; competent; unfractured.		
3	RC	34.3	44.3			NR	35			34.3-45.3': SANDSTONE; strong field strength; GLEY 6/N (Gray); fine-grained texture; thinly bedded; fresh; competent; unfractured.		
							40					
4	RC	44.4	54.4			NR	45					

Continued Next Page

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

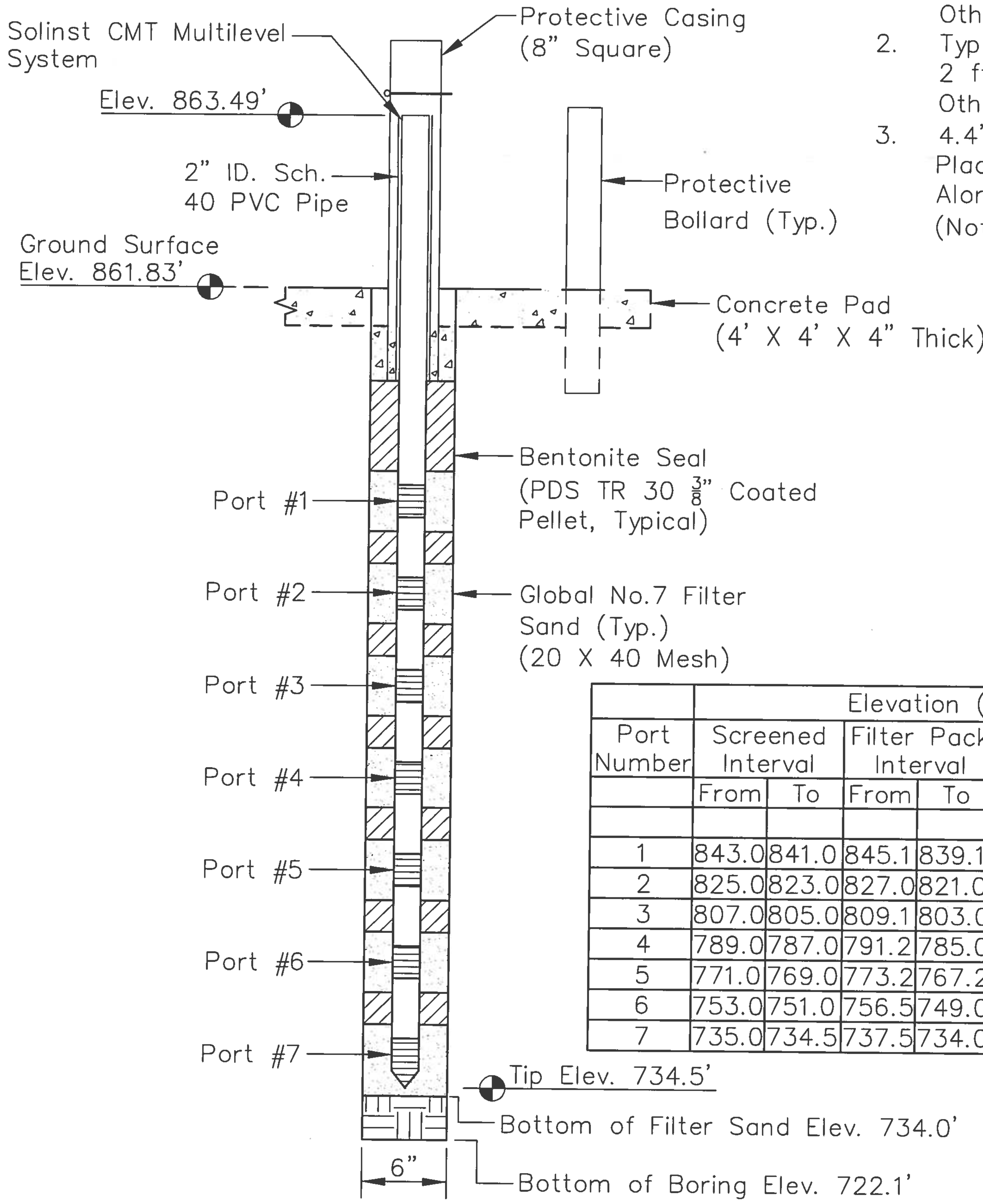
JOB NUMBER **WV015976.0005**

COMPANY **American Electric Power** BORING NO. **MW-1804A** DATE **1/11/19** SHEET **3** OF **3**

PROJECT **Amos Fly Ash Pond** BORING START **5/21/18** BORING FINISH **5/23/18**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
4	RC	44.4	54.4			NR				45.3-49': SHALE; GLEY 4/N (Dark Gray); fine-grained texture; thinly bedded; moderately decomposed; slightly to moderately disintegrated, calcite layer from 46.8-46.9' bgs; moderately fractured.		
							50					
							55					
							60					
							65					
							70					

AEP - AEP.GDT - 1/11/19 13:55 - C:\USERS\LWOODS\DESKTOP\FOR NICOLE BORING LOGS GINT FILES\AEP MOUNTAINEER.GPJ



NOTES:

1. All Units Are in Feet Unless Noted Otherwise.
2. Typical Port Length is 2 ft. Unless Noted Otherwise.
3. 4.4" Dia. Centralizers Placed at 10ft. Spacing Along Well Tubing (Not Shown).

Port Number	Elevation (ft.)					
	Screened Interval		Filter Pack Interval		Bentonite Seal Interval	
	From	To	From	To	From	To
					861.5	845.1
1	843.0	841.0	845.1	839.1	839.1	827.0
2	825.0	823.0	827.0	821.0	821.0	809.1
3	807.0	805.0	809.1	803.0	803.0	791.2
4	789.0	787.0	791.2	785.0	785.0	773.2
5	771.0	769.0	773.2	767.2	767.2	756.5
6	753.0	751.0	756.5	749.0	749.4	737.5
7	735.0	734.5	737.5	734.0		

PLOT DATE: 04/27/2012 USER: JENNINGS, MATTHEW
U:\1756\175661014\ENVIRONMENTAL\DRAWING\SHEET_FILES\MONITORING WELLS\STN-12-4-WELL-LOG.DWG

LOCATION:

Northing: 531,882.29
Easting: 1,726,127.18
Ground Elevation: 861.83'
Installation Date: 3/8/12
Horizontal Datum: NAD 83 WV. South
Vertical Datum: NAVD 88

PIEZOMETER DETAIL
AEP AMOS POWER PLANT, FLY ASH DAM COMPLEX
STN-12-4, WEST VIRGINIA WELL ID WV00054-0003-12

Stantec

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Cincinnati, Ohio
45241-2012
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DRAWN BY	MSJ	DATE	4/25/12	REVISED		SHEET
CHECKED BY	JMM	PROJ. NO.	175661014	1.	3.	1 OF 1
CHECKED BY	JSD	SCALE	NTS	2.	4.	

APPENDIX 4

Not applicable.

APPENDIX 5

Not applicable.