2018 ANNUAL GROUNDWATER MONITORING REPORT

FEDERAL CCR RULE

CARDINAL PLANT – RESIDUAL SOLID WASTE LANDFILL
BRILLIANT, OHIO

Submitted to

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January 2019

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OHIO'S ELECTRIC COOPERATIVES
Your Touchstone Energy® Cooperatives
BUCKEYE POWER, INC.
OHIO RURAL ELECTRIC COOPERATIVES, INC.

February 11, 2019

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

Subject: FAR I RSW Landfill CCR Annual Groundwater Report Addendum

This addendum is intended to be added to the 2018 CCR Annual Groundwater Report for the FAR I RSW Landfill, completed on January 31, 2019. On February 5th, 2019 it was determined that Table 3 and Table 4 contained an incorrect intrawell UPL value for boron at monitoring well S-1. The UPL boron concentration was presented to be 0.969 ug/L, but the correct value is 0.959 ug/L.

A boron concentration from monitoring well S-7 was omitted from Table 1. The sample collected from S-7 on November 19th, 2018 had a boron concentration of 1.88 mg/L. Additionally, the field and laboratory data for samples collected on December 5, 2018 were omitted from Table 1. The reported pH value at S-1 was 6.95 SU. The reported boron concentrations at S-1 and S-10 were 0.961 mg/L and 1.88 mg/L, respectively.

Since these errors were discovered after the Annual Groundwater Report was uploaded to the Operating Record on January 31st, 2019, this addendum will be uploaded to the Operating Record on February 12th, 2019, and will be inserted behind the title page, when the annual groundwater report is published to Buckeye Power's CCR Compliance Data and Information internet site.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ATTACHMENTS

LIST OF ACRONYMS AND ABBREVIATIONS

ASD	Alternate Source Demonstration
CCR	Coal Combustion Residuals
CFR	Code of Federal Regulations
ESP	Electrostatic Precipitator
FAR	Fly Ash Reservoir
FGD	Flue Gas Desulfurization
LPL	Lower Prediction Limit
MW	Megawatt
RSW	Residual Solid Waste
SCR	Selective Catalytic Reduction
SSI	Statistically Significant Increase
UPL	Upper Prediction Limit
USEPA	United States Environmental Protection Agency

1. INTRODUCTION

The Federal Coal Combustion Residuals (CCR) Rule (40 Code of Federal Regulations [CFR] Part 257.90(e)) (USEPA, 2015) requires owners and/or operators of existing CCR landfills and surface impoundments to prepare a Groundwater Monitoring and Corrective Action Report (Report) no later than January 31, 2019. Geosyntec Consultants (Geosyntec) has prepared this Report for the former Fly Ash Reservoir I Residual Solid Waste Landfill (RSW Landfill) at the Cardinal Plant in Brilliant, Ohio (Site). This Report summarizes the groundwater monitoring activities conducted pursuant to the CCR Rule through December 31, 2018.

2. SITE DESCRIPTION

2.1 Site Description

The Site is located one mile south of Brilliant, Ohio in Jefferson County (**Figure 1**) and is operated by Buckeye Power, Inc. (Buckeye Power). Located along the Ohio River, the generating station consists of three coal-powered units with an 1,800 megawatt (MW) capacity and annual coal use of 5.2 million tons (Geosyntec, 2017). Units 1 and 2 began operation in 1967 and Unit 3 began operation in 1977. As of 2012, all three units were equipped with an electrostatic precipitator (ESP), a selective catalytic reduction (SCR) system, and a flue gas desulfurization (FGD) system.

The Fly Ash Reservoir (FAR) I RSW Landfill unit is a dry landfill disposal facility located approximately one mile north of the plant site in a portion of Blockhouse Hollow (also referred to as Blockhouse Run in references and drawings) that was formerly surface mined for the Pittsburgh No. 8 coal. The footprint of the RSW Landfill overlies approximately 75 acres of the former FAR I. The FAR I RSW Landfill is an existing, active CCR landfill which receives gypsum waste and solid waste from the Bottom Ash Pond (BAP). Two of the six cells of the RSW Landfill were in operation at the time the CCR rule became effective. Construction of future cells would be considered lateral expansions. The RSW Landfill uses FAR II as its leachate and stormwater collection pond (Geosyntec, 2016). Site features and locations are shown in **Figure 2**.

2.2 Regional Physiographic Setting

The Site is underlain by horizontal sequences of lower Permian and upper Pennsylvanian sedimentary rock. The Conemaugh Group, 500 feet (ft) thick in Jefferson County, consists of shale, sandstone, limestone, claystone, and coal. The Conemaugh Group includes the Morgantown Sandstone underlain by the Elk Lick Limestone, the Skelly Limestone and Shale, the Ames Limestone, and the Cow Run Sandstone (Geosyntec, 2016). Above the current grade of the RSW Landfill lies the Monongahela Group, which consists of shale, sandstone, limestone, coal, claystone, and siltstone. Overlying the Monongahela Group, approximately 1,250 feet in elevation, is the Permian-age Dunkard Group.

The uppermost aquifer at the Site lies within unconsolidated mine waste, the Connellsville Sandstone, Summerfield Limestone, and Bellaire Sandstone. These units are underlain by a shale aquitard, underlain by the Morgantown Sandstone. Groundwater in the uppermost aquifer generally flows southeast towards the Ohio River with hydraulic conductivity from 1×10^{-1} to 1×10^{-4} centimeters per second (cm/s). The hydraulic conductivity of the confining shale layer ranges from 1×10^{-7} to 1×10^{-9} cm/s (AEP, 2006).

3. GROUNDWATER MONITORING SYSTEM

The RSW Landfill's groundwater monitoring network was designed to comply with 40 CFR 257.91. The groundwater monitoring network utilizes monitoring wells initially installed as part of a separate site-wide hydrogeologic investigation and is used monitor groundwater quality in the uppermost aquifer at the Site. Monitoring well construction and soil boring logs were provided in *Groundwater Monitoring Network Design Report* (Geosyntec, 2016).

The RSW Landfill ground water monitoring network consists of sixteen monitoring wells, shown in **Figure 2**. Nine upgradient monitoring wells (0AE 2005 10C, CA-0623A, S-2, S-GS-3, S-4, S-5, S-6, S-17, and S-19A) are used to establish background conditions and seven downgradient monitoring wells (S-GS-1, S-GS-2, S-1, S-7, S-10, S-18, and S-20) are used as compliance wells. Network monitoring wells S-2 and S-19A were switched from compliance monitoring wells to upgradient monitoring wells in January 2018 based on a better understanding of groundwater flow behavior at the Site.

4. CCR RULE GROUNDWATER KEY ACTIVITIES

Eight background monitoring events were conducted between October 2016 and July 2017. Following the eight background monitoring events, the RSW Landfill progressed into detection monitoring. The first detection monitoring event was conducted in September 2017 and January 2018. The unit remained in detection monitoring following the results of the first detection monitoring event. The second detection monitoring event was completed in May and October 2018. Analytical results from the 2018 sampling events are summarized in **Table 1**.

4.1 Groundwater Elevation and Flow Velocities

Prior to sampling, a synoptic round of groundwater measurements was collected from the compliance and background monitoring wells. Potentiometric surface maps based on groundwater elevations measured during the May and October 2018 detection monitoring sampling events are presented in **Figure 3 and Figure 4**. The potentiometric maps show overall groundwater around the RSW Landfill flows from northwest to southeast, towards the Ohio River. The groundwater residence times within the wells at the RSW Landfill ranged from 3.4 days at well S-7 to 40 days at S-GS-1. A summary of hydraulic gradients and groundwater residence times at the RSW Landfill is provided in **Table 2**.

4.2 Data Usability

Upon receipt of laboratory analytical reports, the data were evaluated for usability. Analytical data were checked for the following:

- Samples were analyzed within the method specified hold times;
- Samples were received within holding temperature;
- The chain of custody form was complete;
- Precision was within control limits using relative percent differences of blind duplicate samples;
- Matrix spike and matrix spike duplicate recoveries and laboratory control samples were within the control limits; and
- Potential for positive bias was evaluated using method blanks.

Upon completion of the data usability assessment, the data were qualified as needed and added to the data tables. All data received during 2018 were considered complete and usable.

4.3 Background Statistical Evaluation

In accordance with 40 CFR 257.94(b), groundwater samples collected during the background groundwater monitoring period were analyzed for 40 CFR 257 Appendix III and Appendix IV list parameters. The results were used to statistically determine upper prediction limits (UPLs) for all Appendix III parameters and a lower prediction limit (LPL) for pH. The *Statistical Analysis Summary-Landfill* report (Geosyntec, 2018a) summarizes the analysis and results of the background statistical evaluation.

4.4 Detection Monitoring Program

Detection monitoring events at the RSW Landfill were conducted in accordance with 40 CFR 257.94(a) of the CCR Rule. Samples were analyzed for Appendix III parameters only. A statistical analysis was performed following the first detection monitoring event. Detection monitoring data was compared to the calculated UPLs and LPL, developed from background monitoring data, to identify statistically significant increases (SSIs) at the CCR Unit.

The first detection monitoring event at the RSW Landfill was conducted in September 2017 and January 2018 and is described in the *Annual Groundwater Monitoring Report* (AEP, 2018). An evaluation of the first detection monitoring sampling analytical results are shown in **Table 3**. Boron was detected above the UPL at compliance well S-7 using a 1-of-3 retesting procedure. An alternate source was identified for this SSI, an alternate source demonstration (ASD) was prepared, and the CCR unit remained in detection monitoring.

The second detection monitoring event was conducted in May 2018. An evaluation of the second detection monitoring sampling analytical results are shown in **Table 4**. Boron was detected above

the UPL at compliance well S-7, a second ASD was prepared for the SSI, and the CCR unit remained in detection monitoring.

The third detection monitoring event began in October and November 2018. The third detection monitoring event is ongoing and will be completed outside of the timeframe of this report. Following the completion of the detection monitoring event, Appendix III parameters will be tested for potential SSIs over calculated UPLs and below LPL for pH.

4.5 Alternate Source Demonstration

Following the first detection monitoring event in January 2018, an SSI was identified for boron at compliance well S-7. An ASD was prepared in June 2018 to document that the observed boron SSI could be attributed to a Type V alternate source. A hydrological connection between FAR II and groundwater near S-7 created backflow from the FAR II impoundment, elevating boron concentrations at well S-7 (Geosyntec, 2018b). The certified ASD is provided as **Attachment A**.

Following the completion of the second detection monitoring event, an ASD memorandum was prepared in November 2018 to document that elevated boron concentrations observed at compliance well S-7 could be attributed to a Type V alternate source. Similar to the first event, elevated concentrations of boron at well S-7 were shown to be a result of the hydraulic connectivity between FAR II and the groundwater near RSW Landfill (Geosyntec, 2018c). This ASD is provided as **Attachment B**.

5. PROBLEMS ENCOUNTERED AND RESOLUTIONS

No problems were encountered during 2018 which were related to detection monitoring activities at the RSW Landfill. No monitoring wells were gauged dry, abandoned, or added to the well network during 2018. All analytical data received were deemed to be of acceptable quality.

6. STATUS OF MONITORING PROGRAM

The Site was in the detection monitoring program from September 2017 through December 2018. The RSW Landfill's monitoring status will be evaluated after the completion of the ongoing detection monitoring event.

7. PLANNED KEY ACTIVITIES FOR 2019

The following activities are planned for 2019 at the RSW Landfill.

- The 2018 Annual Groundwater Monitoring Report will be entered into the facility's operating record and posted to the public internet site;

- Assuming the unit remains in detection monitoring, two semi-annual groundwater detection monitoring program events will be conducted and tested for an SSI over background. The RSW Landfill's monitoring status will be confirmed following the SSI evaluation;

- Revision of the detection monitoring statistics will occur following the fourth semi-annual detection monitoring event.; and

- The 2019 Annual Groundwater Monitoring Report will be prepared for submittal in January 2020.

8. REFERENCES

American Electric Power (AEP) and Geosyntec Consultants, Inc. May 2006. Hydrogeological Investigation Report.

American Electric Power (AEP) Service Corporation. 2018. Annual Groundwater Monitoring Report, Cardinal Operating Company, Cardinal Plant, FAR I RSW Landfill, January.

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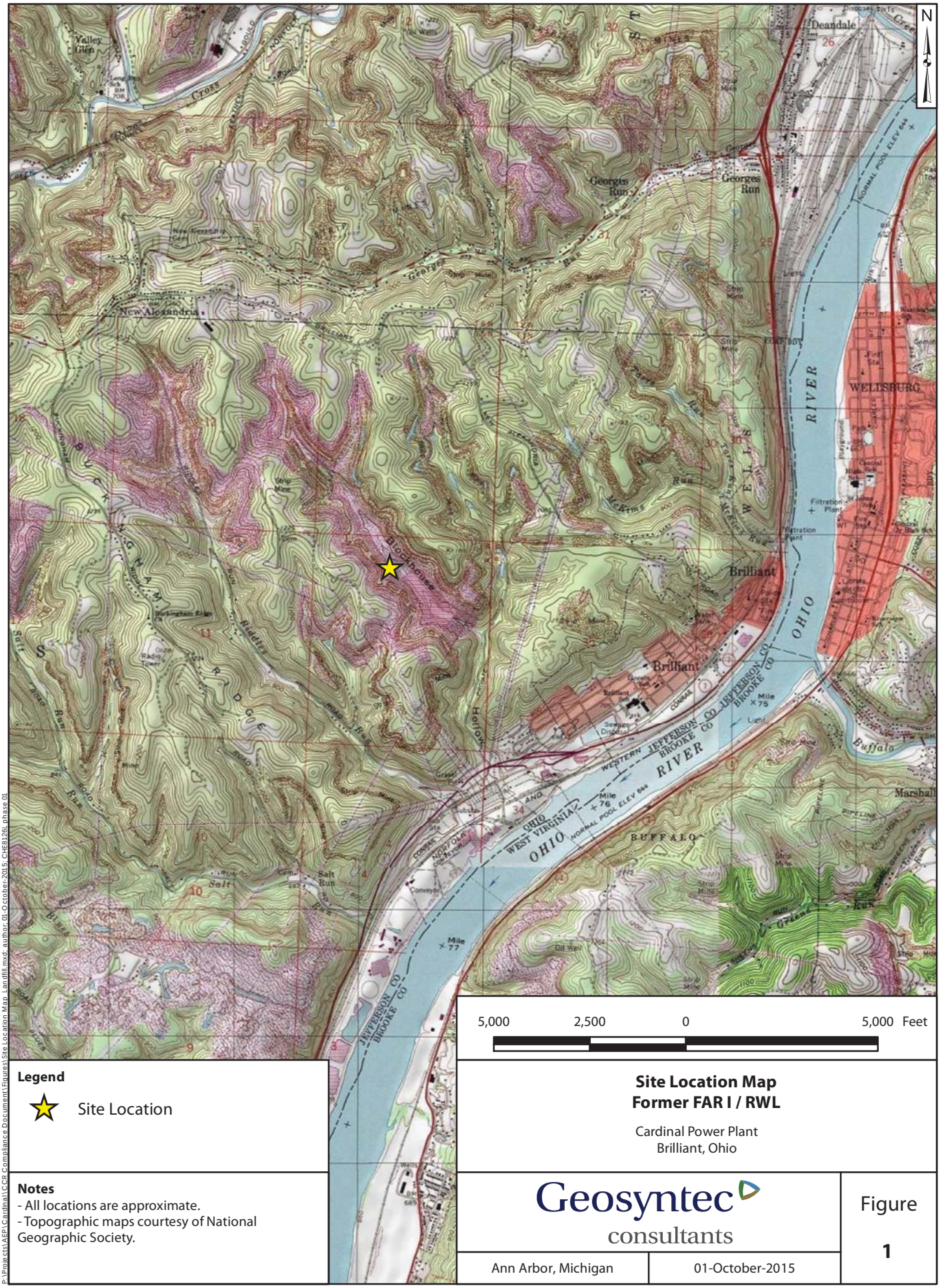
United States Environmental Protection Agency (USEPA). 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities - Unified Guidance. March.

United States Environmental Protection Agency (USEPA). 2015. Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities (Final Rule). Fed. Reg. 80 FR 21301, pp. 21301-21501, 40 CFR Parts 257 and 261, April.

FIGURES



Legend

Site Location

Notes
- All locations are approximate.
- Topographic maps courtesy of National Geographic Society.

Site Location Map
Former FAR I / RWL

Cardinal Power Plant
Brilliant, Ohio

Geosyntec consultants

Ann Arbor, Michigan | 01-October-2015

Figure 1

P:\Projects\AEP\Cardinal\CCR Compliance Document\Figures\Site Location Map_Landfill.mxd; author: 01-October-2015; CHE8126I; phase 01

Monitoring Well Network

- Background Sampling Location
- Compliance Sampling Location
- Residual Solid Waste (RSW) Landfill

Notes

- Monitoring well coordinates provided by Buckeye Power.
- Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Former Fly Ash Reservoir I - Residual Solid Waste Landfill (Geosyntec, 2016) provided by Buckeye Power.

1,000 500 0 1,000 Feet

Site Layout
Residual Solid Waste Landfill

Buckeye Power Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2019/01/16

Figure **2**

P:\Projects\AEP\Groundwater Statistical Evaluation - CHA8423\Groundwater Mapping\GIS Files\Mike's GIS Files\Cardinal\MXDs\FAR_I\AEP-Cardinal_RSW_Site_Layout.mxd. ARevezzo. 1/16/2019. CHA8423/01/08.

Legend

- Groundwater Monitoring Well
- Groundwater Elevation Contour
- Approximate Groundwater Flow Direction

Notes

- Monitoring well coordinates and water level data (collected May 14, 2018) provided by Buckeye Power.
- Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Former Fly Ash Reservoir I - Residual Solid Waste Landfill (Geosyntec, 2016) provided by Buckeye Power.
- Groundwater elevation units are feet above mean sea level.

1,000 500 0 1,000 Feet

Potentiometric Surface Map - Shallow Water Table
Former Fly Ash Reservoir I RSW Landfill
May 2018

Buckeye Power Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2019/01/10

Figure **3**

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Legend

- Groundwater Monitoring Well
- Groundwater Elevation Contour
- Approximate Groundwater Flow Direction

Notes

- Monitoring well coordinates and water level data (collected October 8-16, 2018) provided by Buckeye Power.
- Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Former Fly Ash Reservoir I - Residual Solid Waste Landfill (Geosyntec, 2016) provided by Buckeye Power.
- Groundwater elevation units are feet above mean sea level.

1,000 500 0 1,000 Feet

Potentiometric Surface Map - Shallow Water Table
Former Fly Ash Reservoir I RSW Landfill
October 2018

Buckeye Power, Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2018/12/24

Figure **4**

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TABLES

Table 1: Groundwater Data Summary
Cardinal Plant - Landfill

Geosyntec Consultants, Inc.

Parameter	Unit	CA-0623A		OAE-2005-10-C		S-1			S-2	
		5/15/2018	10/16/2018	5/15/2018	10/16/2018	5/16/2018	10/9/2018	11/19/2018	5/16/2018	10/9/2018
		2018-D1	2018-D2	2018-D1	2018-D2	2018-D1	2018-D2	2018-D2-V1	2018-21	2018-D2
Boron	mg/L	0.546	0.513	0.476	0.502	0.888	0.97	0.961	1.09	2.5
Calcium	mg/L	1.64	1.18	6.3	5.44	315	321	-	271	385
Chloride	mg/L	14.1	20.7	9.69	12	5.42	6.4	-	8.09	5.6
Fluoride	mg/L	2.08	2.3	1.09	1.1	0.19	0.23	-	0.42	0.2
pH	SU	8.59	8.72	8.37	8.55	6.84	7.46	-	7.54	7.53
Total Dissolved Solids	mg/L	609	642	1410	1410	1880	1840	-	2110	3060
Sulfate	mg/L	33.1	30.9	357	377	1030	1020	-	1340	1840

Parameter	Unit	S-4		S-5		S-6		S-7				
		5/16/2018	10/12/2018	5/16/2018	10/12/2018	5/16/2018	10/12/2018	1/24/2018	2/15/2018	5/16/2018	10/9/2018	11/19/2018
		2018-D1	2018-D2	2018-D1	2018-D2	2018-D1	2018-D2	2017-D1-V1	2017-D1-V1	2018-D1	2018-D2	2018-D2-V1
Boron	mg/L	0.255	0.307	0.051	0.0222	1.57	1.73	1.90	2.12	1.93	2.16	-
Calcium	mg/L	593	459	268	258	209	236	-	-	251	263	-
Chloride	mg/L	5.37	6	6.95	8.1	30.9	34.7	-	-	34.7	38.4	31.9
Fluoride	mg/L	0.27	0.27	0.11	0.13	0.28	0.25	-	-	0.18	0.17	-
pH	SU	6.92	7.94	7.37	8.77	7.23	8.02	-	-	7.1	7.61	-
Total Dissolved Solids	mg/L	3260	606	1260	1280	1950	2040	-	-	1870	1890	-
Sulfate	mg/L	1580	1600	704	743	1100	1200	-	-	1090	1080	-

Notes:
mg/L: milligrams per liter
SU: standard unit
J: Estimated value. Parameter was detected in concentrations below the reporting limit
-: Not sampled
2017-D1-V1: Verification sampling for initial detection monitoring event (initial detection event occurred in 2017)
2018-D1: First semi-annual detection monitoring event of 2018
2018-D1-V1: Verification sampling, first semi-annual detection monitoring event
2018-D2: Second semi-annual detection monitoring event of 2018
2018-D2-V1: Verification sampling, second semi-annual detection monitoring event

Table 1: Groundwater Data Summary
Cardinal Plant - Landfill

Geosyntec Consultants, Inc.

Parameter	Unit	S-10					S-17		S-18		
		1/24/2018	5/22/2018	8/7/2018	10/15/2018	11/19/2018	5/15/2018	10/16/2018	5/15/2018	10/8/2018	11/19/2018
		2017-D1-V1	2018-D1	2018-D1-V1	2018-D2	2018-D2-V1	2018-D1	2018-D2	2018-D1	2018-D2	2018-D2-V1
Boron	mg/L	-	1.87	1.37	1.74	1.88	0.229	0.212	0.573	0.586	-
Calcium	mg/L	-	196	-	178	-	143	140	172	164	-
Chloride	mg/L	-	25.1	-	22.8	-	3.21	5.7	1.64	2.9	1.7
Fluoride	mg/L	-	0.100 J	-	0.16	-	0.23	0.28	0.36	0.39	0.36
pH	SU	-	7.27	-	7.18	-	6.87	7.13	7.05	7.05	-
Total Dissolved Solids	mg/L	-	1450	-	1480	-	1210	514	1320	1250	-
Sulfate	mg/L	894	849	-	834	-	671	775	743	772	-

Parameter	Unit	S-19A		S-20				SGS-1			SGS-2		SGS-3	
		5/15/2018	10/16/2018	5/17/2018	8/7/2018	10/8/2018	11/19/2018	5/22/2018	8/7/2018	10/15/2018	5/22/2018	10/15/2018	5/15/2018	10/15/2018
		2018-D1	2018-D2	2018-D1	2018-D1-V1	2018-D2	2018-D2-V1	2018-D1	2018-D1-V1	2018-D2	2018-D1	2018-D2	2018-D1	2018-D2
Boron	mg/L	0.398	0.409	0.34	0.264	0.267	-	0.923	-	0.911	0.556	0.55	0.418	0.319
Calcium	mg/L	419	385	315	-	319	-	118	-	107	9.96	7.94	5.3	5
Chloride	mg/L	3.57	3.6	2.93	-	3.9	2.7	23.8	-	23.2	91.2	99.7	375	401
Fluoride	mg/L	0.40	0.35	0.27	-	0.31	0.22	0.72	0.62	0.64	2.75	2.6	2.08	1.9
pH	SU	6.94	7.26	6.75	-	6.83	-	7.23	-	7.17	7.98	7.98	8.05	8.19
Total Dissolved Solids	mg/L	3210	3100	1480	-	1860	-	1800	-	1820	1700	1700	1750	1900
Sulfate	mg/L	2080	2080	1040	-	1060	-	906	-	935	81.1	73.8	123	126

Notes:
mg/L: milligrams per liter
SU: standard unit
J: Estimated value. Parameter was detected in concentrations below the reporting limit
-: Not sampled
2017-D1-V1: Verification sampling for initial detection monitoring event (initial detection event occurred in 2017)
2018-D1: First semi-annual detection monitoring event of 2018
2018-D1-V1: Verification sampling, first semi-annual detection monitoring event
2018-D2: Second semi-annual detection monitoring event of 2018
2018-D2-V1: Verification sampling, second semi-annual detection monitoring event

Table 2: Residence Time Calculation Summary
Cardinal Plant - Landfill

Geosyntec Consultants, Inc.

CCR Management Unit	Monitoring Well	Well Diameter (inches)	2018-05		2018-10	
			Groundwater Velocity (ft/year)	Groundwater Residence Time (days)	Groundwater Velocity (ft/year)	Groundwater Residence Time (days)
Residual Solid Waste Landfill	OAE-2005-10C [1]	2.0	NC	NC	NC	NC
	CA-0623A [1]	2.0	3.9	15.6	3.9	15.7
	S-1 [2]	1.25	11.0	3.5	9.3	4.1
	S-10 [2]	2.0	10.0	6.1	4.1	15.0
	S-17 [1]	2.0	2.7	22.8	3.0	20.3
	S-18 [2]	2.0	2.3	26.0	2.8	21.5
	S-19 [2]	2.0	2.2	28.0	3.3	18.6
	S-2 [2]	1.25	9.6	4.0	9.3	4.1
	S-20 [2]	2.0	13.2	4.6	13.4	4.6
	S-4 [1]	1.0	2.1	14.3	2.1	14.3
	S-5 [1]	1.0	2.3	13.3	2.2	13.8
	S-6 [1]	1.0	1.9	15.6	1.6	18.9
	S-7 [2]	1.0	9.0	3.4	6.2	4.9
	S-GS-1 [2]	2.0	1.5	40.0	1.6	38.6
	S-GS-2 [2]	2.0	4.6	13.2	4.3	14.3
	S-GS-3 [1]	2.0	5.3	11.4	5.5	11.0

Notes:

[1] - Background Well

[2] - Compliance Well

NC - Groundwater residence time could not be calculated.

Table 3: Detection Monitoring Data Evaluation - 2017 Event
Cardinal Plant - Landfill

Geosyntec Consultants, Inc.

Parameter	Units	Description	S-1	S-7			S-10		S-18	S-20	SGS-1	SGS-2
			10/4/2017	10/4/2017	1/24/2018	2/15/2018	9/26/2017	1/24/2018	10/3/2017	9/26/2017	10/4/2017	10/4/2017
Boron	mg/L	Intrawell Background Value (UPL)	0.969	1.86			1.691		0.663	0.313	1.118	0.977
	mg/L	Detection Monitoring Result	0.839	**1.88**	**1.9**	**2.12**	0.825	-	0.556	0.293	0.934	0.67
Calcium	mg/L	Intrawell Background Value (UPL)	345	273			306		238	387	197	106
	mg/L	Detection Monitoring Result	306	244	-	-	295	-	178	339	110	13
Chloride	mg/L	Intrawell Background Value (UPL)	6.46	36.5			29.5		2.54	3.02	28.6	120
	mg/L	Detection Monitoring Result	5.39	36.5	-	-	24.6	-	1.18	2.53	23.4	62.2
Fluoride	mg/L	Intrawell Background Value (UPL)	0.24	0.19			0.24		0.38	0.27	0.66	2.84
	mg/L	Detection Monitoring Result	0.155	0.1	-	-	0.17	-	0.29	0.26	0.55	2.33
pH	SU	Intrawell Background Value (UPL)	7.36	7.75			7.19		7.33	7.77	8.73	8.85
	SU	Intrawell Background Value (LPL)	6.67	6.75			6.79		6.63	5.90	5.92	7.19
	SU	Detection Monitoring Result	7.08	7.41	7.70	-	**7.74**	7.08	7.12	7.74	7.99	8.28
Total Dissolved Solids	mg/L	Intrawell Background Value (UPL)	1944	1948			1737		1749	2127	1984	2103
	mg/L	Detection Monitoring Result	1830	1860	-	-	1730	-	1520	1950	1800	1700
Sulfate	mg/L	Interwell Background Value (UPL)	1107	1156			1050		1032	1232	1049	993
	mg/L	Detection Monitoring Result	985.5	1020	-	-	**1060**	894	799	1180	922	131

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

Table 4: Detection Monitoring Data Evaluation - 2018 First Semi-Annual Event
Cardinal Plant - Landfill

Geosyntec Consultants, Inc.

Parameter	Units	Description	S-1	S-7	S-10		S-18	S-20		SGS-1		SGS-2
			5/16/2018	5/16/2018	5/22/2018	8/9/2018	5/15/2018	5/17/2018	8/9/2018	5/22/2018	8/10/2018	5/22/2018
Boron	mg/L	Intrawell Background Value (UPL)	0.969	1.86	1.69		0.663	0.313		1.118		0.977
	mg/L	Detection Monitoring Result	0.888	**1.93**	**1.87**	1.37	0.573	**0.34**	0.264	0.923	-	0.556
Calcium	mg/L	Intrawell Background Value (UPL)	345	273	306		238	387		197		106
	mg/L	Detection Monitoring Result	315	251	196	-	172	315	-	118	-	9.96
Chloride	mg/L	Intrawell Background Value (UPL)	6.46	36.5	29.5		2.54	3.02		28.6		120
	mg/L	Detection Monitoring Result	5.42	34.7	25.1	-	1.64	2.93	-	23.8	-	91.2
Fluoride	mg/L	Intrawell Background Value (UPL)	0.24	0.19	0.24		0.38	0.27		0.66		2.84
	mg/L	Detection Monitoring Result	0.19	0.18	0.1	-	0.36	0.27	-	**0.72**	0.62	2.75
pH	SU	Intrawell Background Value (UPL)	7.36	7.75	7.19		7.33	7.77		8.73		8.85
	SU	Intrawell Background Value (LPL)	6.67	6.75	6.79		6.63	5.90		5.92		7.19
	SU	Detection Monitoring Result	6.84	7.10	**7.27**	7.09	7.05	6.75	6.7	7.23	7.13	7.98
Total Dissolved Solids	mg/L	Intrawell Background Value (UPL)	1944	1948	1737		1749	2127		1984		2103
	mg/L	Detection Monitoring Result	1880	1870	1450	-	1320	1480	-	1800	--	1700
Sulfate	mg/L	Intrawell Background Value (UPL)	1107	1156	1050		1032	1232		1049		993
	mg/L	Detection Monitoring Result	1030	1090	849	-	743	1040	-	906	--	81.1

Notes:
UPL: Upper prediction limit
LPL: Lower prediction limit
-: Not Sampled
Well S-7 was not resampled after 5/16/2018, because the SSI is consistent with the proposed alternative source.
Bold values exceed the background value.
Background values are shaded gray.

ATTACHEMENT A

Alternate Source Demonstration – June 2018

ALTERNATIVE SOURCE DEMONSTRATION REPORT FEDERAL CCR RULE

Cardinal Plant
Residual Solid Waste Landfill
Brilliant, Ohio

Submitted to

BUCKEYE POWER, INC.
OHIO'S ELECTRIC COOPERATIVES
Your Touchstone Energy® Cooperatives

Buckeye Power
6677 Busch Blvd.
Columbus, Ohio 43229

Submitted by

Geosyntec consultants
engineers | scientists | innovators

150 East Wilson Bridge Road
Suite 232
Worthington, Ohio 43085

June 12, 2018

CHA8468

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ATTACHMENTS

LIST OF ACRONYMS AND ABBREVIATIONS

ASD	Alternative Source Demonstration
CCR	Coal Combustion Residuals
CFR	Code of Federal Regulations
EPA	Environmental Protection Agency
LPL	Lower Prediction Limit
PHREEQC	Computer program for geochemical calculations
QA	Quality Assurance
QC	Quality Control
RSW	Residual Solid Waste
SSI	Statistically Significant Increase
UPL	Upper Prediction Limit
USEPA	United States Environmental Protection Agency

SECTION 1

INTRODUCTION AND SUMMARY

Eight background monitoring events were conducted at the Cardinal Residual Solid Waste (RSW) Landfill, and upper prediction limits (UPLs) were calculated for each Appendix III parameter to represent background values. Lower prediction limits (LPL) were also calculated for pH. Prediction limits were calculated based on a one-of-three retesting procedure. With this procedure, a statistically significant increase (SSI) is only concluded if all of the samples in a series of three exceeds the UPL. In practice, if the initial result did not exceed the UPL, a second sample was not collected or analyzed. Following three detection monitoring events at the Landfill, an SSI was identified for the boron at monitoring well S-7 by intrawell analysis. No other SSIs were identified.

A summary of the detection monitoring analytical results and the calculated prediction limits to which they were compared is provided in Table 1.

Pursuant to the coal combustion residuals (CCR) Rule, Geosyntec Consultants, Inc. (Geosyntec) has prepared this Alternative Source Demonstration (ASD) report, which documents that the SSI cited above should not be attributed to the Cardinal RSW Landfill.

1.1 CCR Rule Requirements

In accordance with the United States Environmental Protection Agency (USEPA) regulations regarding the disposal of CCR in landfills and surface impoundments, Rule 40 CFR 257.94(e)(2) states the following:

> *The owner or operator may demonstrate that a source other than the CCR unit caused the statistically significant increase over background levels for a constituent or that the statistically significant increase resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality. The owner or operator must complete the written demonstration within 90 days of detecting a statistically significant increase over background levels to include obtaining a certification from a qualified professional engineer verifying the accuracy of the information in the report.*

Detection monitoring events were conducted on October 4, 2017, January 24, 2018, and February 15, 2018 at the Cardinal RSW Landfill, which resulted in an SSI over background limits for boron at well S-7. The CCR Rule allows the owner or operator to demonstrate that the SSI resulted from a source other than the regulated CCR unit, such as an error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality.

1.2 Demonstration of Alternative Sources

An evaluation was completed to assess possible alternative sources to which identified SSIs could be attributed. Alternative sources were identified amongst five types, based on methodology provided by EPRI (2017):

- ASD Type I: Sampling Causes;
- ASD Type II: Laboratory Causes;
- ASD Type III: Statistical Evaluation Causes;
- ASD Type IV: Natural Variation; and
- ASD Type V: Alternative Sources.

A demonstration was conducted to show that the increases in constituent concentrations were based on a Type V cause and not by a release from the Cardinal RSW Landfill.

SECTION 2

ALTERNATIVE SOURCE DEMONSTRATION

An SSI for boron at well S-7 at the Cardinal RSW Landfill was observed in detection monitoring events which occurred on October 4, 2017, January 24, 2018, and February 15, 2018. The CCR Rule allows the owner or operator to demonstrate that a source other than the CCR unit caused the SSI. Identified SSIs, evaluation methodology, and the proposed alternative source are described below.

2.1 Proposed Alternative Source

Initial review of site geochemistry, site historical data, and laboratory QA/QC did not identify ASDs due to Type I, Type II, Type III or Type IV issues. A Type V ASD associated with an increase in water levels from the Fly Ash Reservoir (FAR) II impoundment was identified.

As shown in the well network map (Figure 1), well S-7 is located between the RSW Landfill and the FAR II impoundment. While the pond level has been raised many times since the impoundment was constructed, groundwater elevations at well S-7 began to track closely with the reservoir level after the two most recent increases (Figure 2a and 2b). One such increase was in March 2014, when the reservoir level increased from 956.4 to 962.7 ft above mean sea level (amsl), and another was in October 2017, when the reservoir level increased from 963.2 to 968 ft amsl. These concurrent increases in S-7 groundwater elevation and the pond level indicate a hydrologic connection between well S-7 and the FAR II reservoir.

Since August 2014 water levels at well S-7 typically have been less than two feet above the impoundment (Figure 2b). Several times the head difference between the groundwater and pond was less than one foot and occasionally the groundwater was below the level of the impoundment. For example, on February 14, 2017, the water levels at S-7 abruptly decreased by approximately one foot, which caused the level to fall below that of the FAR II pond elevation (Figure 2b). Such events typically signify flow reversals. In this situation backflow from the reservoir would have migrated into the surrounding geologic formation. Because monitoring events are spaced on the order of weeks or months, it is possible that backflow conditions occurred at other times which were not captured by monitoring events. In generally, water levels in the well network were not monitored on the same schedule as the reservoir elevation. Consequently, transient changes in pond elevation due to perturbations such as rain events, evaporation (during summer months), time lapses, and barometric pressure changes (diurnal and weather-related) could have induced backflow from the reservoir which would have gone undetected in the absence synoptic water level data.

The water elevation in the impoundment reached the screen elevation at well S-7 (939.9 ft amsl) in early 2007, based on available data (Figure 2a). Given that well S-7 was installed in very fine-grained sandstone below a sequence of clayshales and silty sandstones (Attachment A), backflow from the reservoir may have started shortly after the impoundment elevation reached the well

screen. When backflow conditions existed, the reservoir water would have mixed with groundwater introducing boron and other constituents into the aquifer.

The boring log for S-7 noted a limestone formation at approximately 978-982 ft amsl (Attachment A), which is slightly above the present water level of 968 ft amsl in the FAR II impoundment (Figure 3). The limestone could interfere with the water level rise at S-7, possibly contributing to the backflow from the impoundment into the aquifer.

While well S-10 is roughly the same distance from the FAR II impoundment as S-7 (Figure 1) and screened in the same formation, water level measurements suggest the direction of groundwater flow at S-10 has always been towards the impoundment (Figure 2b). If the Landfill had been the source of boron, then well S-10 would have detected a release before S-7 because of its closer proximity to the Landfill boundary. While well S-10 is clearly hydraulically connected to S-7 (evident in Figure 2b, which shows that the one-foot drop in water level at S-7 coincides with a two-foot drop at S-10 in February 2017), well S-10 has had lower concentrations of boron than S-7 throughout its monitoring history.

As noted above the reservoir level rose to the elevation of the screened interval for well S-7 in December 2006 (Figure 2a). Since August 2014 the height of the reservoir has been no more than one to two feet above well S-7 (Figure 2b). Therefore, the pond water may have entered the aquifer by S-7 as early as 2007 and hydraulic communication between the aquifer and reservoir was complete in August 2014. This can be further demonstrated by the four-foot rise in groundwater level at S-7 on 11/1/2016 (Figure 4), which parallels the change in reservoir level (Figure 2b). The change in aquifer level was significant and occurred one year before the first of three detection events confirmed the SSI for boron. This emphasizes the connection between reservoir elevation and aquifer conditions.

Based on available data (Table 2), which show higher concentrations of boron in the FAR II impoundment compared to the groundwater, backflow from the impoundment could feasibly contribute to rising boron concentrations in the aquifer (Figure 5). The calculated UPL for boron at well S-7 was 1.86 mg/L. Results for boron in the three detection events were 1.88, 1.90 and 2.12 mg/L. The boron concentration in the reservoir was roughly twice that of S-7 during background sampling. A similar pattern is observed between chloride and groundwater elevation at S-7, using analytical data gathered for the state monitoring program. Since the impoundment elevation has reached the screened elevation at S-7, the chloride concentration has consistently increased (Figure 6). Chloride concentrations in the FAR II impoundment are consistently higher than the values observed in groundwater. This provides further evidence that backflow from the impoundment is affecting the concentration of mobile constituents such as boron and chloride.

Other than the small increase in boron which resulted in an SSI, the composition of S-7 groundwater has not varied since the first background sample was collected. In contrast the pond water chemistry has been more variable, which is typical for surface water (Figure 7). Compared to the aquifer, the impoundment contains higher concentrations of highly soluble species, such as sodium and chloride, and lower concentrations of dissolved mineral mater like calcium,

magnesium, and bicarbonate. A geochemical modeling code (PHREEQC) was used to compare the aquifer and impoundment water for saturation with respect to common mineral phases (Parkhurst, 1999). Results indicate that the groundwater aquifer is at equilibrium with calcite ($CaCO_3$) and dolomite [$CaMg(CO_3)_2$] (Table 3), which probably formed during sedimentation by precipitation or recrystallization. The table also shows that magnesium carbonate (magnesite) and sulfate minerals (gypsum and epsomite) are undersaturated and not likely to exist in the aquifer.

These results can be explained by mixing of the FAR II impoundment water with groundwater. As more pond water enters the aquifer, mixing with aquifer water naturally takes place. This results in a change in characteristic from the native groundwater. However, chemical principles indicate that following a perturbation (intrusion of reservoir water) equilibrium with respect to groundwater and aquifer minerals must be restored. The result is that the concentrations of major constituents such as calcium, magnesium and bicarbonate don't change to the extent that simple mixing would imply. Mixing of impoundment water in the aquifer results in limited dissolution of calcite and dolomite, causing calcium, magnesium and bicarbonate concentrations to increase toward their previous levels. Similarly, simple mixing would tend to increase the concentration of sodium in the aquifer. However, it is common for clay minerals present in sedimentary rock to take up sodium by cation exchange reactions and replace them by species such as calcium. This results in no appreciable change in sodium concentration in groundwater. Sulfate levels are comparable between the impoundment and groundwater, so mixing would not affect the concentration of sulfate in the aquifer.

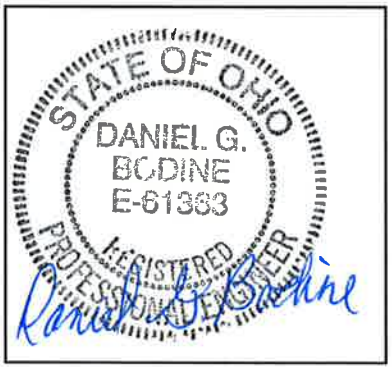
In contrast with metal species, boron and chloride in aquifer groundwater are affected by mixing with water from the reservoir because neither is not attenuated by common geochemical mechanisms such as precipitation, ion exchange, and sorption. The increase in chloride over time at well S-7 correlates with increases in reservoir water level (Figure 6). Boron is regarded as a highly conservative species because it can travel by advection nearly at the groundwater seepage rate. Therefore, mixing of reservoir water with native groundwater can result in higher levels of boron without a proportional increase in all other constituents. In addition, periodic backflow from the reservoir into the aquifer hastens the mixing process due to the effects of dispersion and molecular-scale diffusion. In summary, flow of water from the impoundment into the aquifer provides a reasonable explanation for the increase in boron at well S-7 which triggered an SSI.

2.2 Sampling Requirements

As the ASD described above supports the position that the identified SSIs are not due to a release from the Cardinal RSW Landfill, the unit will remain in the detection monitoring program. Groundwater at the unit will be sampled for Appendix III parameters on a semi-annual basis.

2.3 Certification by a Qualified Professional Engineer

I certify that the selected and above described alternative source demonstration is appropriate for evaluating the groundwater monitoring data for the Cardinal RSW Landfill CCR management area and that the requirements of 40 CFR 257.94(e)(2) have been met.



Daniel G. Bodine
Printed Name of Licensed Professional Engineer

Daniel G. Bodine
Signature

61363	Ohio	June 12, 2018
License Number	Licensing State	Date

SECTION 3

CONCLUSIONS AND RECOMMENDATIONS

The preceding information serves as the ASD prepared in accordance with 40 CFR 257.94(e)(2) and supports the position that the SSIs in Appendix III detection monitoring constituents are not due to a release from the Cardinal RSW Landfill during the October 2017, January 2018, and February 2018 sampling events. An investigation into the hydrological connection between S-7 and the FAR II impoundments suggests backflow from the impoundment is the most likely source for the observed boron SSI. Therefore, no further action is warranted and the Cardinal RSW Landfill will remain in the detection monitoring program.

SECTION 4

REFERENCES

EPRI, 2017. Guidelines for Development of Alternative Source Demonstrations at Coal Combustion Residual Site. 3002010920. October.

Parkhurst, D. L., Appelo, C.A.J. 1999. User's Guide to PHREEQC (Version 2) – A Computer Program for Speciation, Batch-Reaction, One-Dimensional Transport, and Inverse Geochemical Calculations. Water-Resources Investigations Report 99-4259.

U.S. EPA, 2015. Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities (Final Rule). Fed. Reg. 80 FR 21301, pp. 21301-21501, 40 CFR Parts 257 and 261, April.

TABLES

Table 1: Detection Monitoring Data Evaluation
Cardinal Plant - Landfill

Geosyntec Consultants, Inc.

Parameter	Units	Description	S-1	S-7			S-10		S-18	S-20	SGS-1	SGS-2
			10/4/2017	10/4/2017	1/24/2018	2/15/2018	9/26/2017	1/24/2018	10/3/2017	9/26/2017	10/4/2017	10/4/2017
Boron	mg/L	Intrawell Background Value (UPL)	0.969	1.86			1.691		0.663	0.313	1.118	0.977
	mg/L	Detection Monitoring Result	0.839	**1.88**	**1.9**	**2.12**	0.825	-	0.556	0.293	0.934	0.67
Calcium	mg/L	Intrawell Background Value (UPL)	345	273			306		238	387	197	106
	mg/L	Detection Monitoring Result	306	244	-	-	295	-	178	339	110	13
Chloride	mg/L	Intrawell Background Value (UPL)	6.46	36.5			29.5		2.54	3.02	28.6	120
	mg/L	Detection Monitoring Result	5.39	36.5	-	-	24.6	-	1.18	2.53	23.4	62.2
Fluoride	mg/L	Intrawell Background Value (UPL)	0.24	0.19			0.24		0.38	0.27	0.66	2.84
	mg/L	Detection Monitoring Result	0.155	0.1	-	-	0.17	-	0.29	0.26	0.55	2.33
pH	SU	Intrawell Background Value (UPL)	7.36	7.75			7.19		7.33	7.77	8.73	8.85
	SU	Intrawell Background Value (LPL)	6.67	6.75			6.79		6.63	5.90	5.92	7.19
	SU	Detection Monitoring Result	7.08	7.41	7.70	-	**7.74**	7.08	7.12	7.74	7.99	8.28
Total Dissolved Solids	mg/L	Intrawell Background Value (UPL)	1944	1948			1737		1749	2127	1984	2103
	mg/L	Detection Monitoring Result	1830	1860	-	-	1730	-	1520	1950	1800	1700
Sulfate	mg/L	Interwell Background Value (UPL)	1107	1156			1050		1032	1232	1049	993
	mg/L	Detection Monitoring Result	985.5	1020	-	-	**1060**	894	799	1180	922	131

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

Table 2: Boron Analytical Data - FAR II Impoundment
Cardinal Residual Solid Waste Landfill

Sample Date	Boron Concentration
10/6/2009	2.80
5/25/2010	2.43
10/18/2010	3.19
12/16/2010	2.48
3/22/2011	1.80
8/3/2011	3.81
4/25/2012	2.39
10/17/2012	4.22
3/27/2014	5.27
10/4/2014	3.41
4/30/2015	5.89
11/5/2015	3.89
5/11/2016	4.48
10/12/2016	4.05
4/27/2017	3.44
10/5/2017	4.32

Notes:
All values are in milligrams per liter (mg/L).

Table 3: Calculated Saturation Indices at Well S-7
Cardinal Residual Solid Waste Landfill

Date	Calculated Saturation Index				
	Calcite $CaCO_3$	Dolomite $CaMg(CO_3)_2$	Gypsum $CaSO_4$	Epsomite $MgSO_4$	Magnesite $MgCO_3$
10/11/2016	0.31	0.46	-0.47	-3.07	-0.74
01/11/2017	0.23	0.21	-0.44	-3.00	-0.69
05/24/2017	0.09	-0.01	-0.46	-3.06	-0.93
06/21/2017	0.10	0.14	-0.47	-3.09	-1.02
07/26/2017	0.14	0.23	-0.46	-3.12	-1.04

Notes:
Calculated saturation indices (SIs) greater than -0.20 suggest saturation of the mineral and are shaded in red with red text.

FIGURES

Monitoring Well Network

- Background Sampling Location
- Compliance Sampling Location
- Residual Solid Waste (RSW) Landfill

Notes

- Monitoring well coordinates provided by AEP.
-Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Former Fly Ash Reservoir I - Residual Solid Waste Landfill (Geosyntec, 2016) provided by AEP.

1,000 500 0 1,000 Feet

Site Layout
Residual Solid Waste Landfill

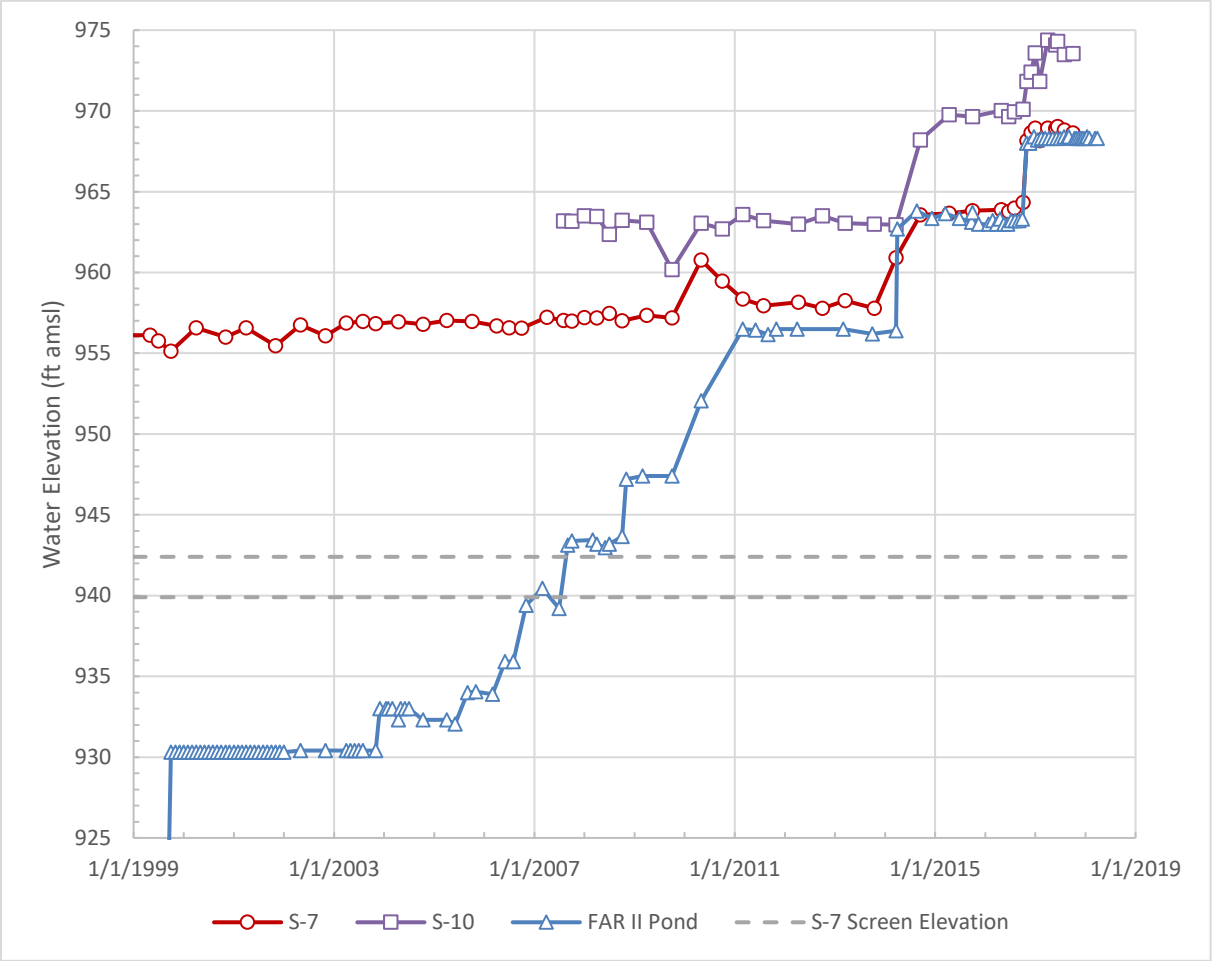
AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2018/01/25

Figure **1**

C:\Users\mmuenich\Documents\local_projects\AEP_GIS\Cardinal\MXDs\FAR_I\AEP-Cardinal_RSW_Site_Layout.mxd. MMuenich. 1/25/2018. CHA8423/01/08.



Notes: The dashed line represent the upper (942.4 feet above mean sea level (amsl) and lower limits (939.9 ft amsl) of the screened interval at S-7.

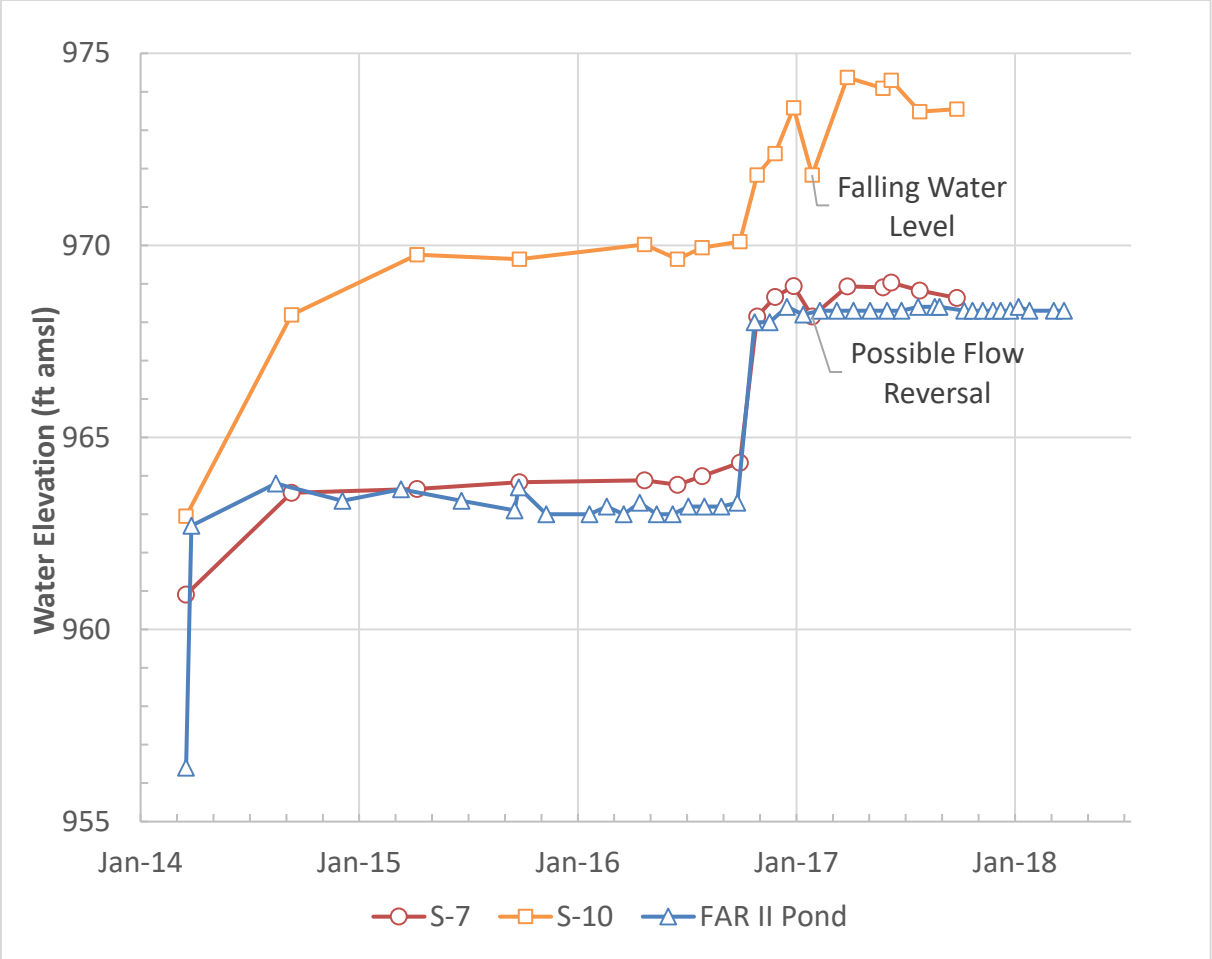
Water Level Time Series Graph
Cardinal RSW Landfill

Geosyntec consultants

Columbus, Ohio | 02-Jun-2018

Figure **2a**

internal info: path, date revised, author



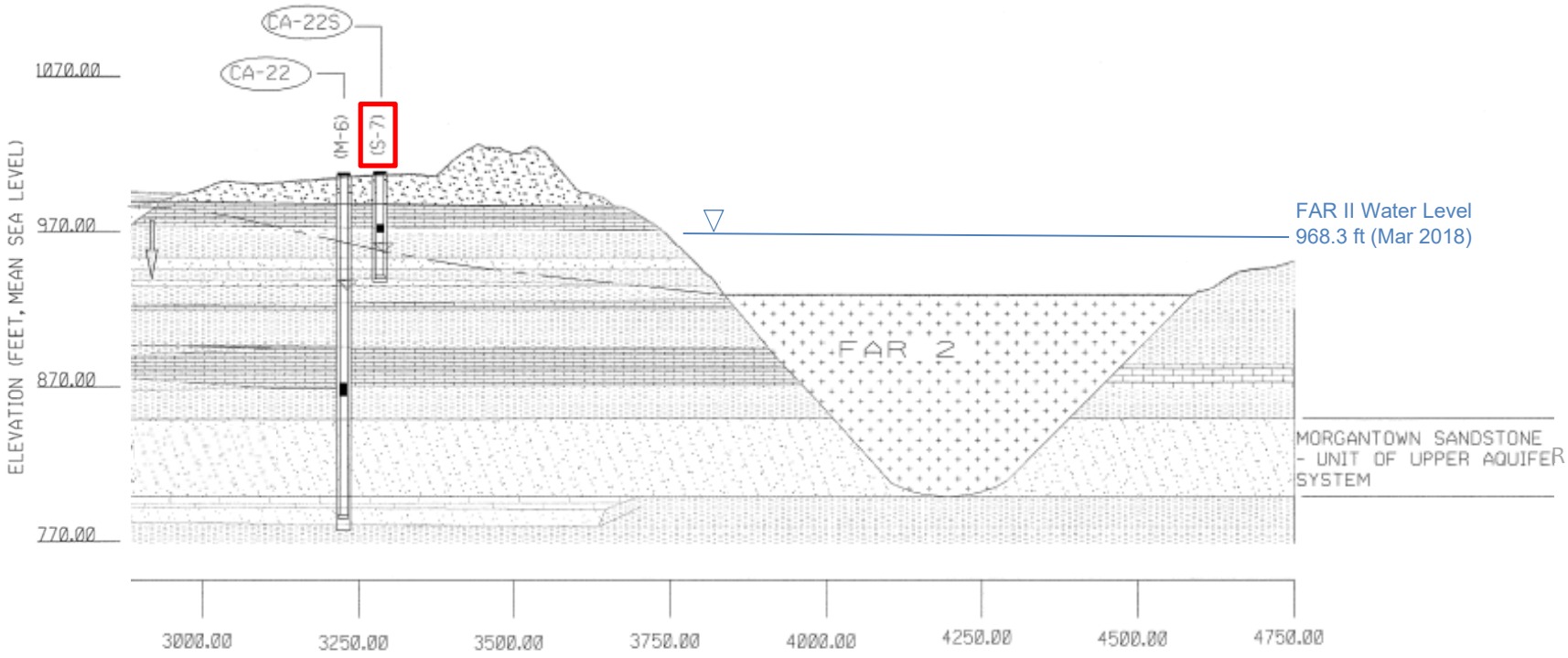
Water Level Time Series Graph
Cardinal RSW Landfill

Geosyntec consultants

Figure **2b**

Columbus, Ohio | 02-Jun-2018

internal info: path, date revised, author



Note:
Cross-Section from Groundwater Monitoring Network Evaluation, Cardinal Site – Former Fly Ash Reservoir I – Residual Solid Waste Landfill (Geosyntec, 2016) provided by AEP. The original figure is dated October 2005 and depicts a FAR II impoundment elevation of approximately 933 feet above median sea level.

S-7 and Surrounding Area Cross-Section

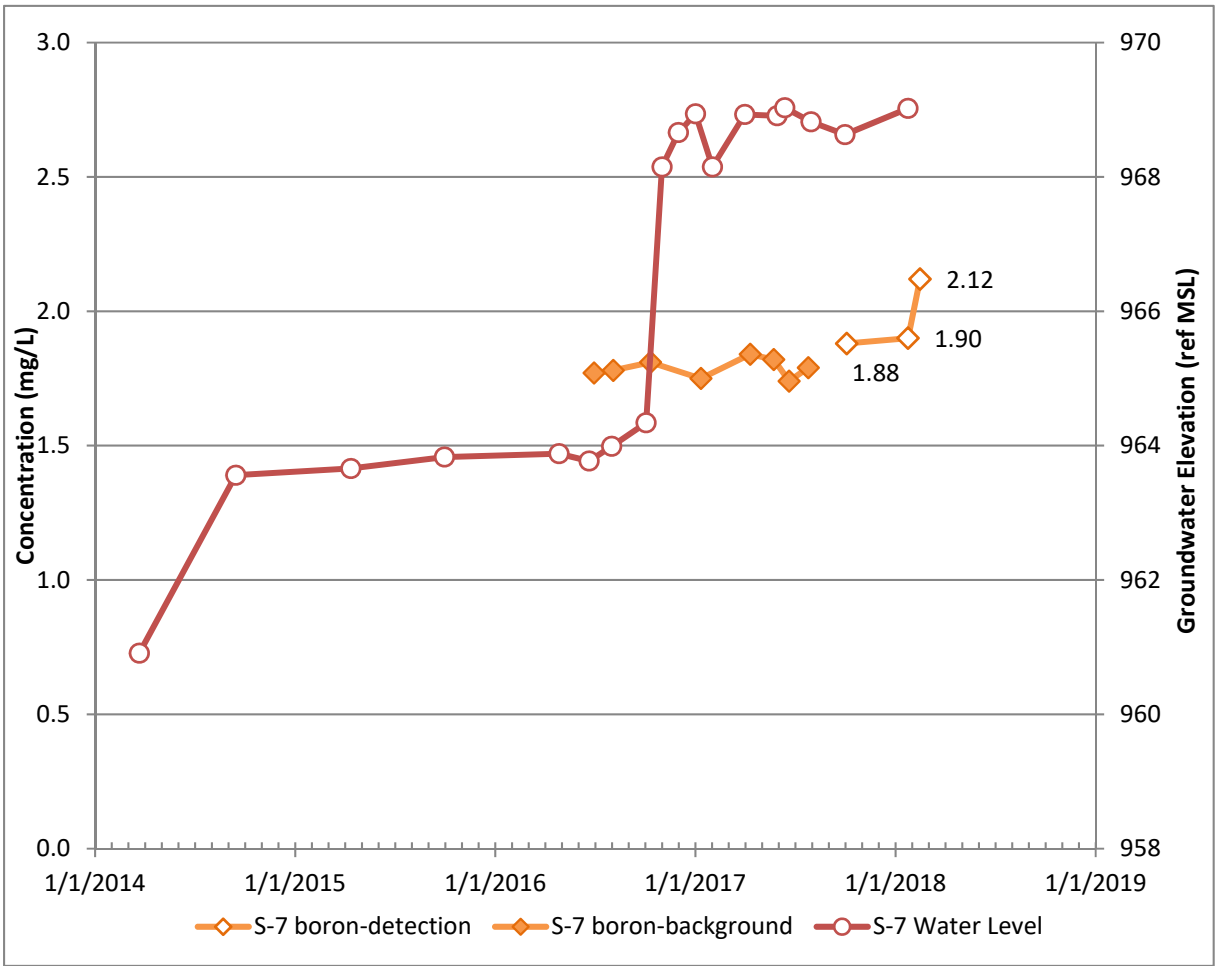
Cardinal Plant
Residual Solid Waste Landfill
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | June 2018

Figure 3

P:\Projects\Buckeye Power\ASD Report\Figure 3 - S-7 CrossSection.docx, alicia revezzo, 6/5/2018 4:05:00 PM



S-7 Boron and Water Level Time Series Graphs

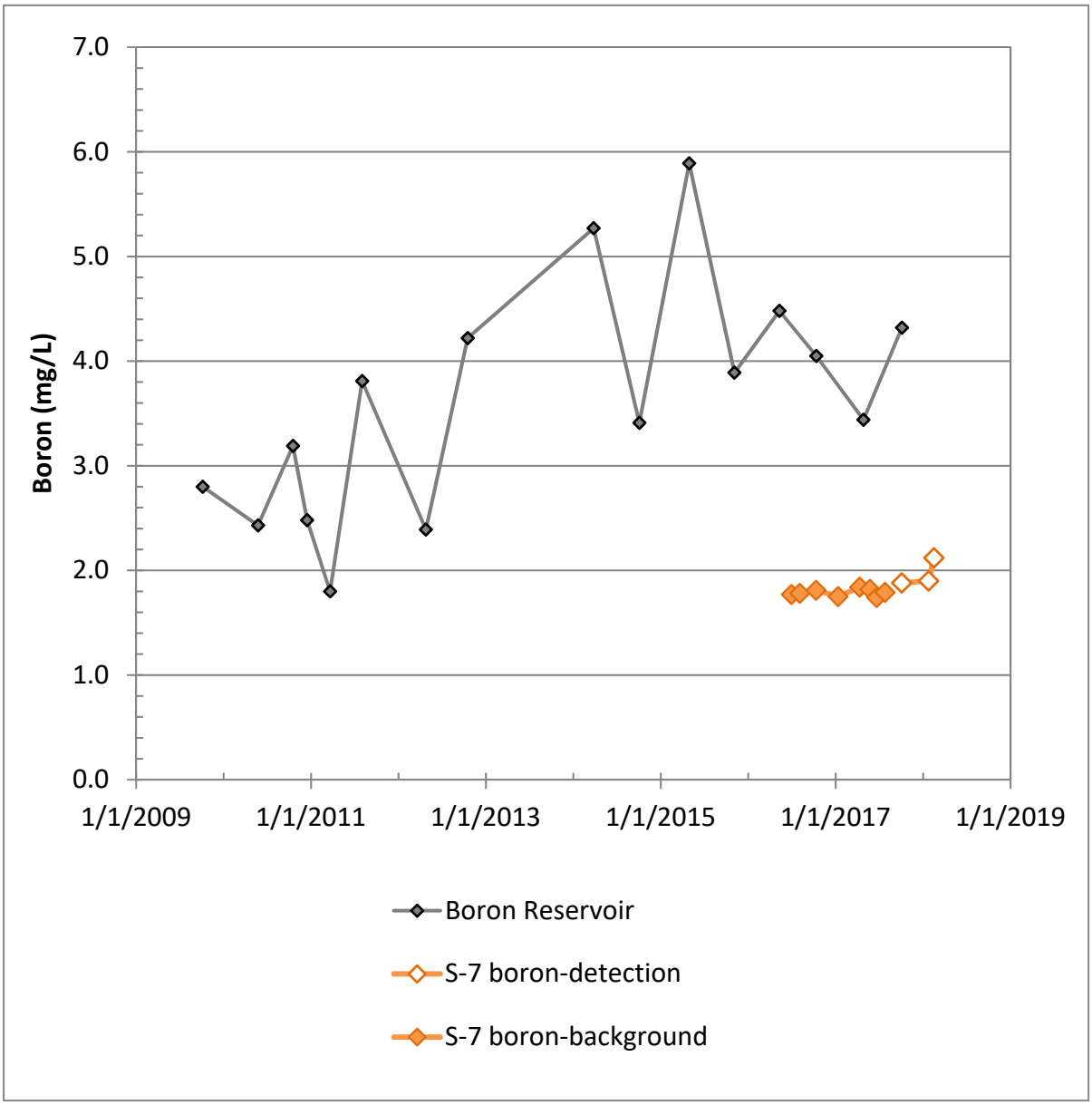
Cardinal RSW Landfill

Geosyntec consultants

Columbus, Ohio | 02-Jun-2018

Figure **4**

internal info: path, date revised, author



Notes: 'Boron Reservoir' data represents the reported boron concentration in the FAR II impoundment.

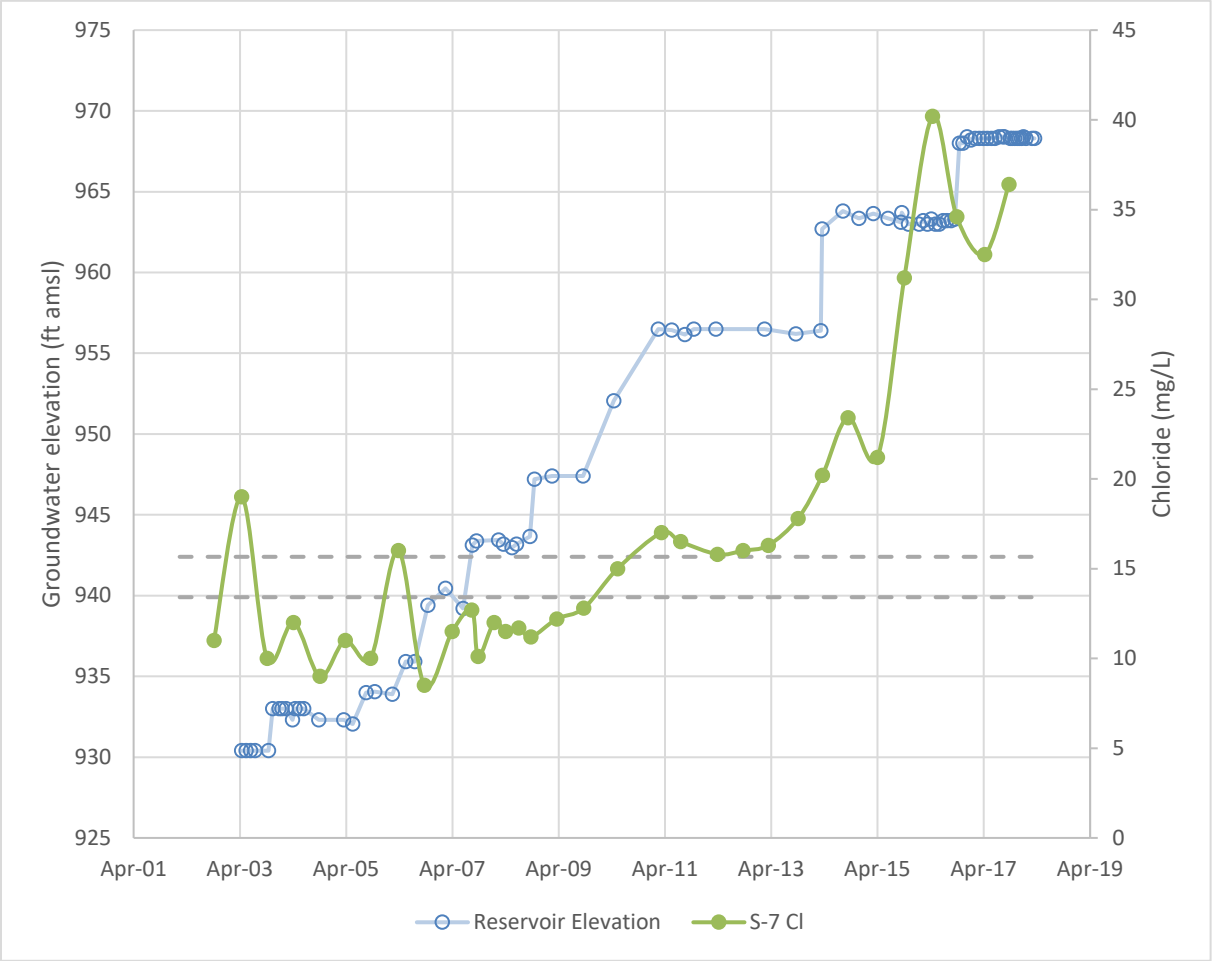
Boron Time Series Graph
Cardinal RSW Landfill

Geosyntec consultants

Columbus, Ohio | 02-Jun-2018

Figure **5**

internal info: path, date revised, author



Notes: Chloride data were collected for the state monitoring program and were not collected for compliance with the Federal CCR Rule. The dashed lines represent the upper (942.4 feet above mean sea level (amsl) and lower limits (939.9 ft amsl) of the screened interval at S-7.

S-7 Chloride and Water Level Time Series Graphs

Cardinal RSW Landfill

Geosyntec consultants

Figure **6**

Columbus, Ohio	02-Jun-2018

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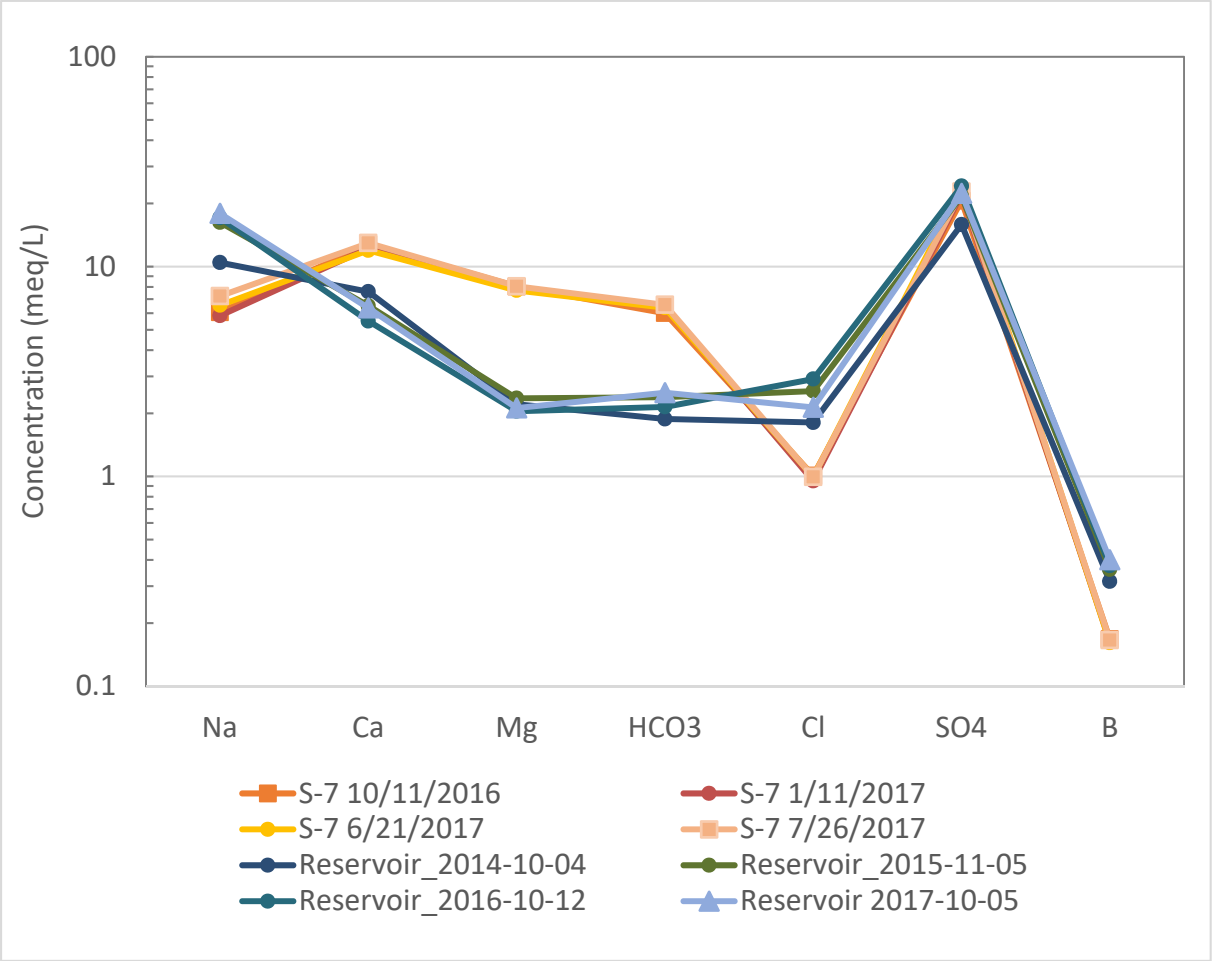


Notes: Selected data represent typical groundwater concentrations for S-7 and the FAR II impoundment.

Schoeller Diagram
Cardinal RSW Landfill

Geosyntec consultants

Figure **7**

Columbus, Ohio | 02-Jun-2018

internal info: path, date revised, author

ATTACHMENT A

S-7 Boring Log

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER _____

COMPANY **OHIO POWER COMPANY**

PROJECT **TIDD ASH POND SITE INVESTIGATION**

COORDINATES **N 831,920.2 E 2,516,676.4**

GROUND ELEVATION **1008.5** SYSTEM **STATE PLANE**

WATER LEVEL	▽ 52.7	▼	▼
TIME			
DATE			

BORING NO. **90CA22-S** DATE _____ SHEET **1** OF **2**

BORING START **08/13/90** BORING FINISH **08/14/90**

PIEZOMETER TYPE _____ WELL TYPE **GM**

HGT. RISER ABOVE GROUND **1.94** DIA **1.0**

DEPTH TO TOP OF WELL SCREEN **66.2** BOTTOM **68.2**

WELL DEVELOPMENT _____ BACKFILL **BENSEAL**

FIELD PARTY **MCR-JF** RIG **B-61**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPH LOG	USCS	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							5			NO SPT SAMPLES TAKEN SEATED CASING AT 18.1. LOST WATER DRILL NW CASING AT 9.7. NO WATER RETURN DURING DRILLING. NOT A GOOD SEAL AT CASING ROCK INTERFACE.		
							10					
							15					
1	NQ	18.1	25.6		5.0		20			GRAY SILTY CLAYSHALE Calcareous, vertical cracks 20.8-21.1, 21.6-21.8		
										GRAY SHALEY LIMESTONE Hard.		
2	NQ	25.6	28.6		2.6	0	25			GRAY SILTY SANDSTONE V-fine grain.		
3	NQ	28.6	35.6		7.0	80				GRAY LIMESTONE Hard, stain on joints and vertical cracks.		
							30			GRAY TO BLACK CLAYSHALE		
										GRAY SILTY SANDSTONE F-fine grain.		33.1 TOP OF SEAL.
4	NQ	35.6	45.6		?		35			vertical cracks		
							40			GRAY LIGHT GRAY CLAYSHALE Slightly sandy, calcareous.		38.6 TOP OF SAND.
										LIGHT GRAY SANDSTONE Silt crossbedding throughout, thin bedding at 43.1		
							45			GRAY TO LIGHT TO DARK GRAY CLAYSHALE Broken slightly calcareous.		
5	NQ	45.6	50.6		?					LIGHT GRAY LIMESTONE Vertical fracture from 46.0-46.9, calcite filled.		
										GRAY SANDY CLAYSHALE Broken, silty,		

Continued Next Page

TYPE OF CASING USED

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

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 **JD**

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER _____

COMPANY **OHIO POWER COMPANY** BORING NO. **90CA22-S** DATE _____ SHEET **2** OF **2**

PROJECT **TIDD ASH POND SITE INVESTIGATION** BORING START **08/13/90** BORING FINISH **08/14/90**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPH LOG	USCS	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
6	NQ	50.6	52.0		1.1	31				slightly calcareous.		
7	NQ	52.0	57.0		4.6	58				**DEEP MAROON PURPLE CLAYSHALE** Blocky, slightly calcareous, slightly weathered.		PLUGGED OFF.
							55			**LIGHT GREEN TO LIGHT GRAY CLAYSHALE** Slightly broken.		
8	NQ	57.0	65.6		8.6	100				**LIGHT TAN TO LIGHT GRAY SANDSTONE** Fine grain, silt bedding throughout.		PLUGGED OFF. AFTER PULLING NQ RODS SWL 52.7.
							60					
										RUST BROWN CLAYSHALE Iron precipitate staining throughout, broken, slightly sandy to very sandy, fine grained sand.		
9	NQ	65.6	70.6		5.0	43	65					66.0 CHECK VALVE. 66.6 TOP OF SCREEN. 68.6 BOTTOM OF SCREEN
										LIGHT GRAY SANDSTONE Very fine grain, silt partings and cross bedding throughout.		
							70					

ATTACHEMENT B

Alternate Source Demonstration – November 2018

941 Chatham Lane, Suite 103
Columbus, Ohio 43221
PH 614.468.0415
FAX 614.468.0416
www.geosyntec.com

Memorandum

Date: November 5, 2018

To: Nicholas Kasper, Ohio Electric Cooperative

From: Dan Bodine, P.E.

Subject: Cardinal Plant RSW Landfill Alternate Source Demonstration

In accordance with the Coal Combustion Residual (CCR) Rule [40CFR257.94], a semi-annual detection monitoring event was recently completed at the Cardinal Plant Residual Solid Waste (RSW) Landfill. The results of this event (Table 1) were compared to previously calculated upper prediction limits (UPLs) for each Appendix III parameter. In addition, the reported pH values were also compared to previously calculated lower prediction limits (LPLs). A statistically significant increase (SSI) was noted for boron at well S-7 during the previous annual detection monitoring events and the semi-annual events. No other SSIs were noted in the well network during the semi-annual detection monitoring event (Table 1).

DEMONSTRATION OF AN ALTERNATIVE SOURCE

Geosyntec Consultants, Inc. (Geosyntec) prepared an alternative source demonstration (ASD) report for the Landfill in June 2018 (Geosyntec, 2018), to evaluate the SSI for boron at Landfill well S-7. The SSI was concluded after the intrawell background UPL for boron was exceeded after each of three consecutive sampling events (October 4, 2017, January 24, 2018, and February 15, 2018). Following EPRI guidance an investigation was conducted in which five possible types of alternative sources were considered (EPRI, 2017). Hydrologic and geochemical data pointed to a hydrological connection between the Fly Ash Reservoir (FAR) II reservoir and groundwater near the well. Using EPRI (2017) nomenclature, the SSI for boron at well S-7 was determined to be a Type V alternative source.

A semi-annual detection monitoring event took place in May 16-22, 2018, in which seven wells were sampled. Resamples were collected on August 8-9, 2018 to verify if SSIs were identified for additional parameters. Well S-7 was not resampled after May 16, 2018, because the SSI is consistent with the proposed alternative source. In addition, no other exceedances were verified

in the RSW Landfill network, leaving boron at S-7 as the only SSI during the semi-annual detection monitoring event.

Hydrologic and geochemical conditions during May and August 2018, have remained consistent during with those presented in the June ASD. Therefore, the argument presented in the June ASD in which hydraulic communication between the well and FAR II reservoir was shown to be the cause for the SSI, continues to support the reservoir as the source of boron at S-7.

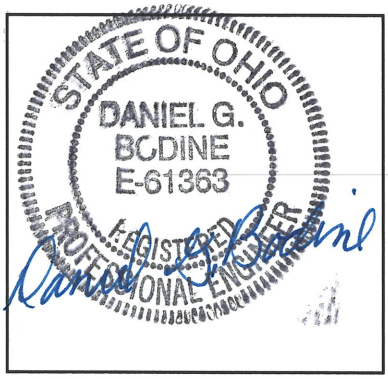
Figures in the previous ASD were updated to include the May semi-annual detection monitoring data. Figures 1a and 1b show groundwater elevation at S-7, which continues to track closely with the reservoir elevation, which is a key indicator of hydraulic communication. Figure 2 compares boron concentrations in the reservoir with those at S-7. This figure shows that the reservoir has higher boron concentrations than S-7, which is consistent with mixing. Figure 3 shows the concentration of boron at S-7, which is slowly increasing, and the groundwater elevation at S-7, which changes with the reservoir elevation. Figure 4 shows that the concentration of chloride at S-7 (collected under the state program) has been increasing in a manner that is consistent with the rise in water level in the reservoir. The updated figures support the arguments presented in the ASD and in this memorandum.

The flow of water from the reservoir into the aquifer provides an explanation for the increase in boron at well S-7 which triggered an SSI. Therefore, no further action is warranted and the Cardinal RSW Landfill will remain in detection monitoring. The preceding information serves as the ASD prepared in accordance with 40 CFR 257.94(e)(2) and in agreement with the previous ASD prepared for this unit (Geosyntec, 2018).

(Continued on next page)

CERTIFICATION BY A QUALIFIED PROFESSIONAL ENGINEER

I certify that the selected and above described alternative source demonstration is appropriate for evaluating the groundwater monitoring data for the Cardinal RSW Landfill CCR management area and that the requirements of 40 CFR 257.94(e)(2) have been met.



Daniel G. Bodine
Printed Name of Licensed Professional Engineer

Daniel G. Bodine
Signature

61363 — License Number
Ohio — Licensing State
5 Nov. 2018 — Date

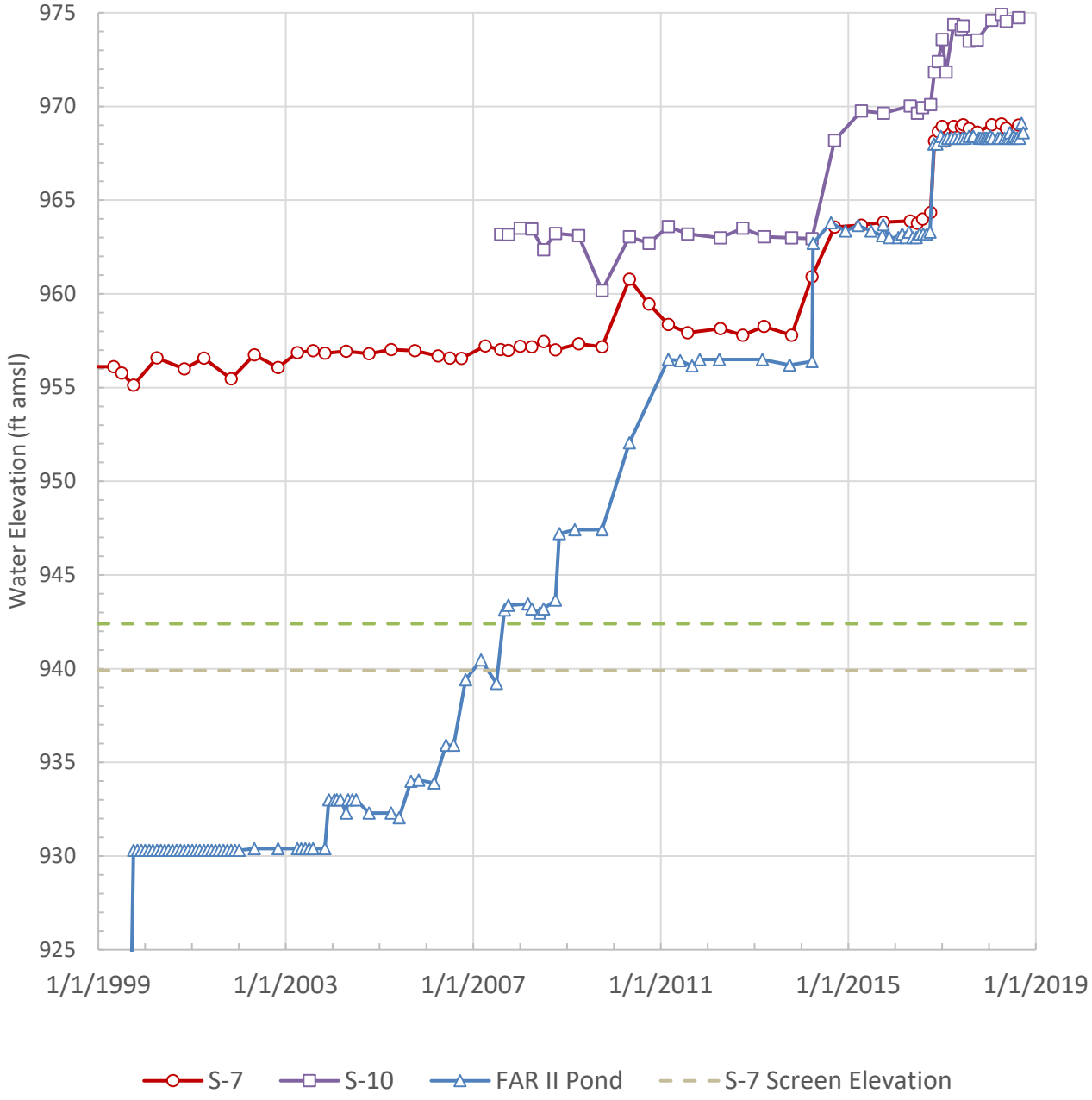
* * * * *

Table 1: Detection Monitoring Data Evaluation
Cardinal Plant - Landfill

Geosyntec Consultants, Inc.

Parameter	Units	Description	S-1	S-7	S-10		S-18	S-20		SGS-1		SGS-2
			5/16/2018	5/16/2018	5/22/2018	8/9/2018	5/15/2018	5/17/2018	8/9/2018	5/22/2018	8/10/2018	5/22/2018
Boron	mg/L	Intrawell Background Value (UPL)	0.969	1.86	1.69		0.663	0.313		1.118		0.977
	mg/L	Detection Monitoring Result	0.888	**1.93**	**1.87**	1.37	0.573	**0.34**	0.264	0.923	-	0.556
Calcium	mg/L	Intrawell Background Value (UPL)	345	273	306		238	387		197		106
	mg/L	Detection Monitoring Result	315	251	196	-	172	315	-	118	-	9.96
Chloride	mg/L	Intrawell Background Value (UPL)	6.46	36.5	29.5		2.54	3.02		28.6		120
	mg/L	Detection Monitoring Result	5.42	34.7	25.1	-	1.64	2.93	-	23.8	-	91.2
Fluoride	mg/L	Intrawell Background Value (UPL)	0.24	0.19	0.24		0.38	0.27		0.66		2.84
	mg/L	Detection Monitoring Result	0.19	0.18	0.1	-	0.36	0.27	-	**0.72**	0.62	2.75
pH	SU	Intrawell Background Value (UPL)	7.36	7.75	7.19		7.33	7.77		8.73		8.85
	SU	Intrawell Background Value (LPL)	6.67	6.75	6.79		6.63	5.90		5.92		7.19
	SU	Detection Monitoring Result	6.84	7.10	**7.27**	7.09	7.05	6.75	6.7	7.23	7.13	7.98
Total Dissolved Solids	mg/L	Intrawell Background Value (UPL)	1944	1948	1737		1749	2127		1984		2103
	mg/L	Detection Monitoring Result	1880	1870	1450	-	1320	1480	-	1800	--	1700
Sulfate	mg/L	Intrawell Background Value (UPL)	1107	1156	1050		1032	1232		1049		993
	mg/L	Detection Monitoring Result	1030	1090	849	-	743	1040	-	906	--	81.1

Notes:
UPL: Upper prediction limit
LPL: Lower prediction limit
-: Not Sampled
Well S-7 was not resampled after 5/16/2018, because the SSI is consistent with the proposed alternative source.
Bold values exceed the background value.
Background values are shaded gray.



Notes: The dashed line represent the upper (942.4 feet above mean sea level (amsl) and lower limits (939.9 ft amsl) of the screened interval at S-7.

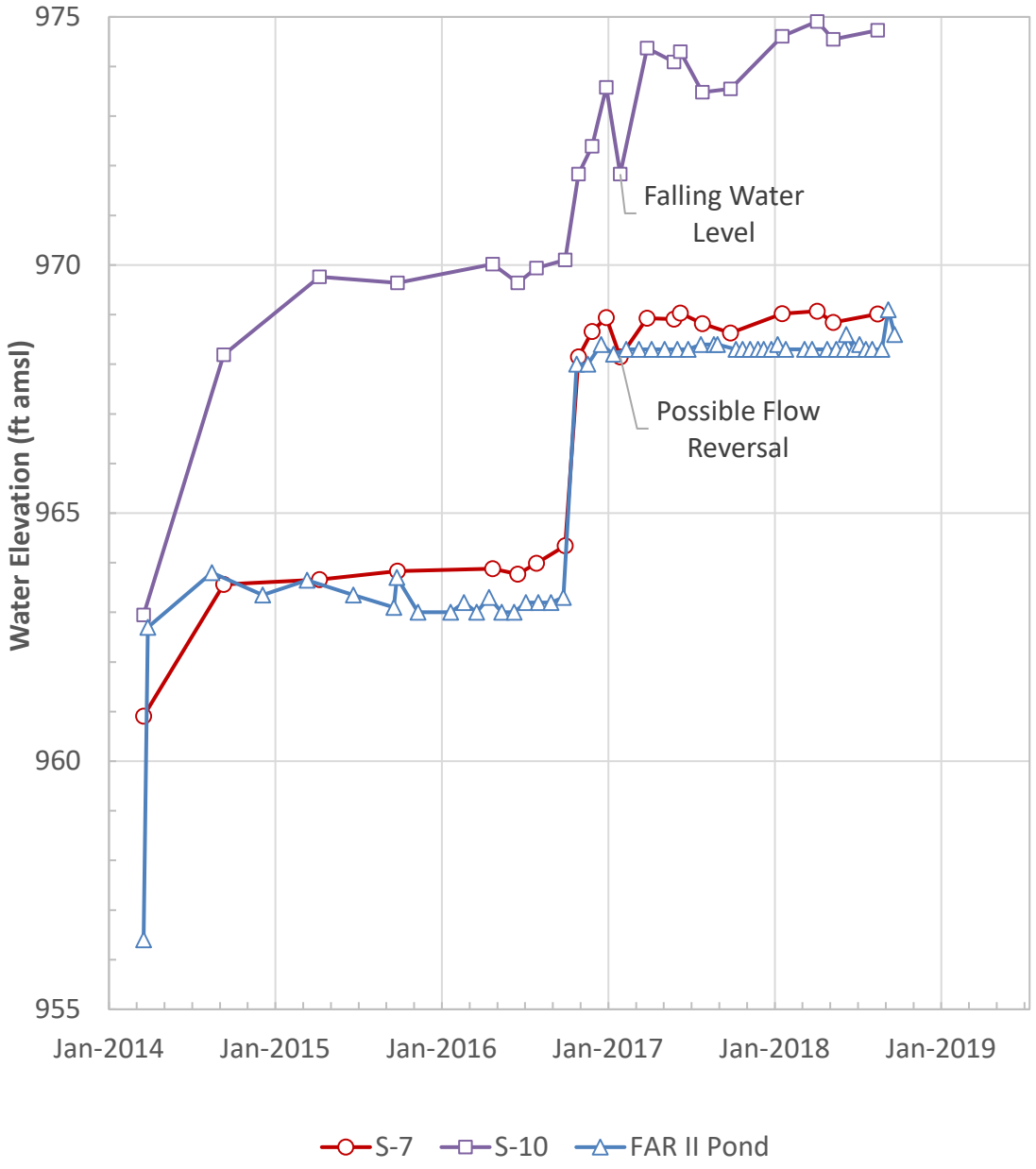
Water Level Time Series Graph
Cardinal RSW Landfill

Geosyntec consultants

Columbus, Ohio | 22-Oct-2018

Figure **1a**

internal info: path, date revised, author

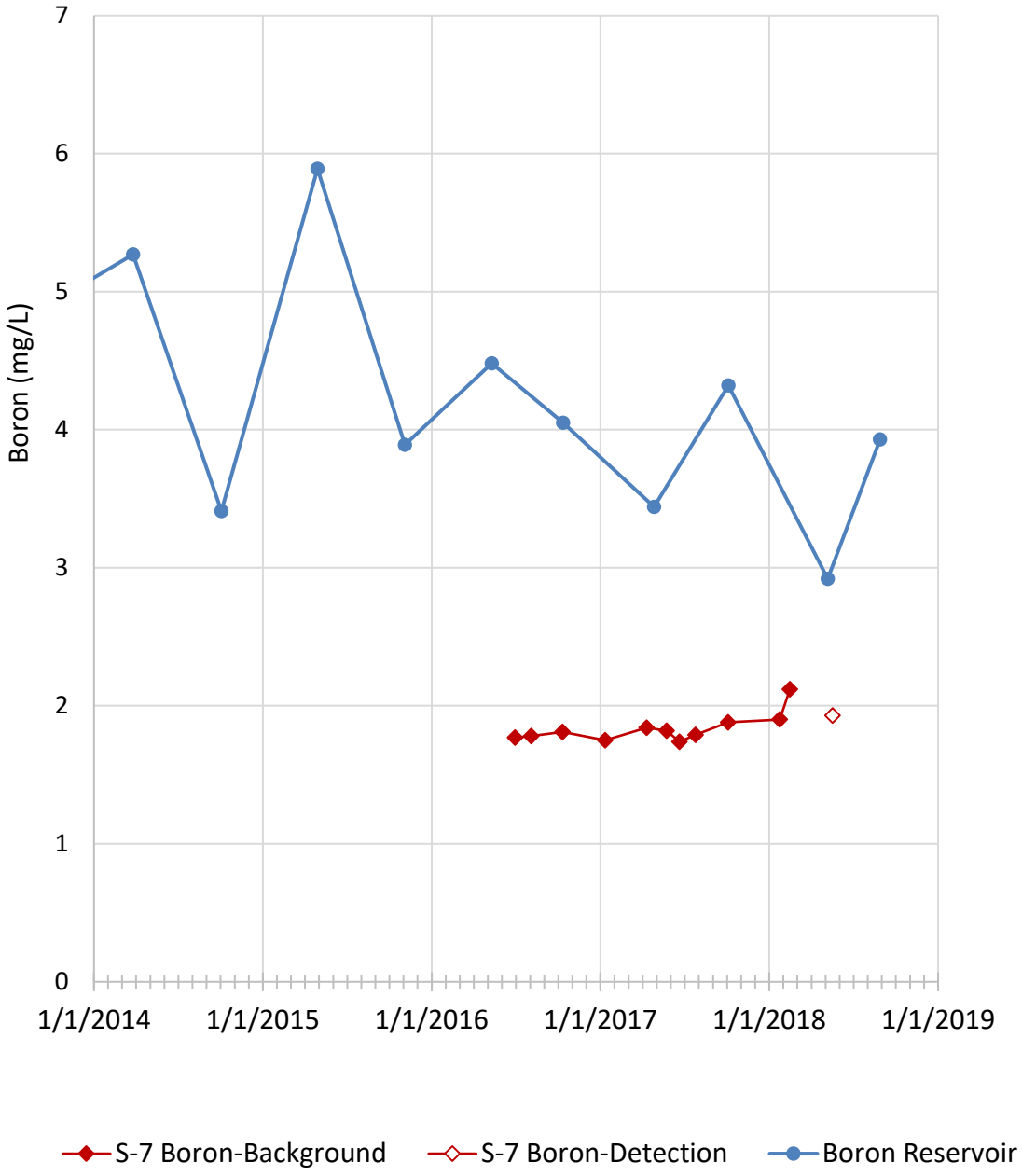


Water Level Time Series Graph
Cardinal RSW Landfill

Geosyntec consultants

Figure **1b**

Columbus, Ohio | 22-Oct-2018



Notes: 'Boron Reservoir' data represents the reported boron concentration in the FAR II impoundment.

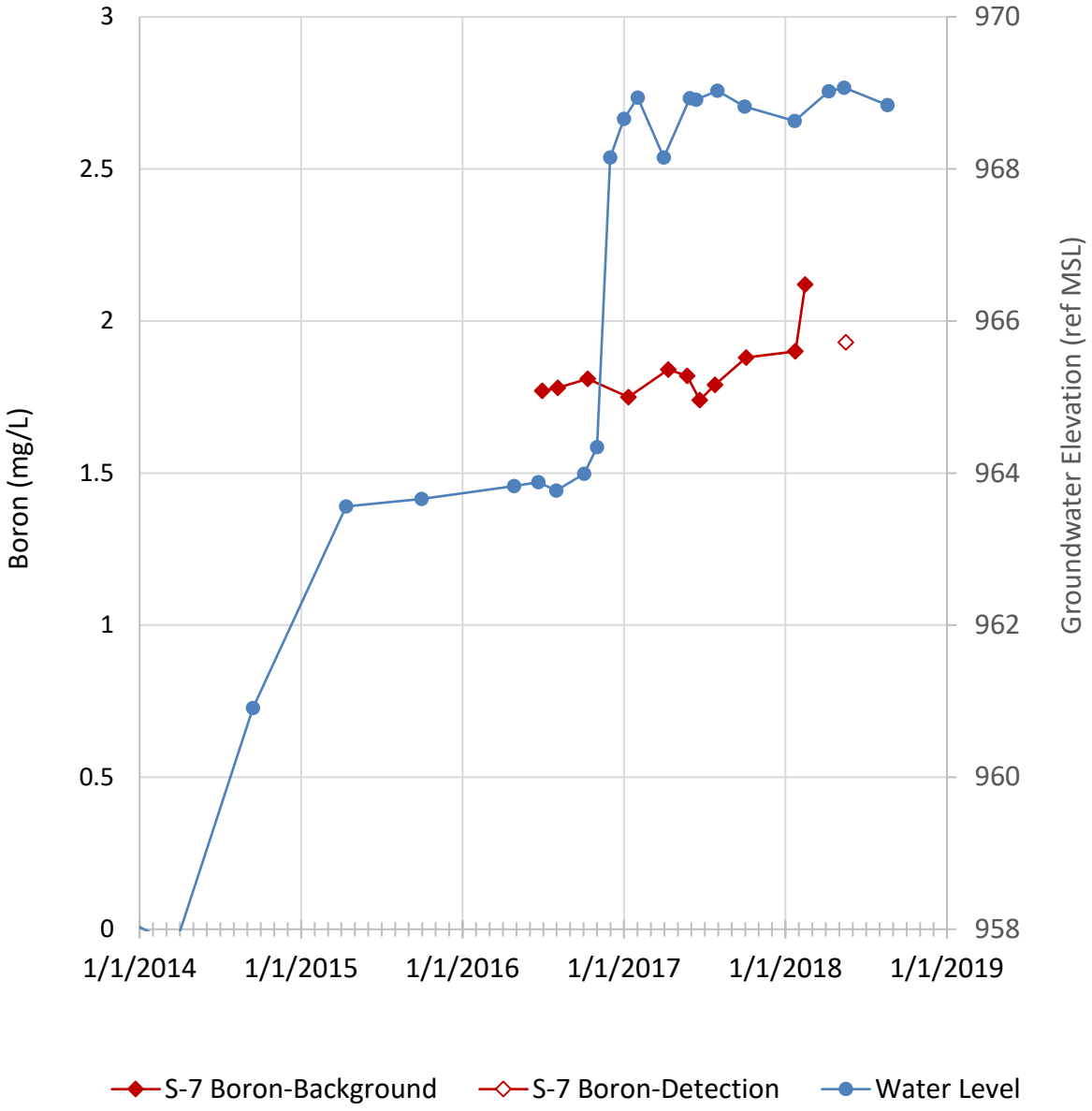
Boron Time Series Graph
Cardinal RSW Landfill

Geosyntec consultants

Figure **2**

Columbus, Ohio | 22-Oct-2018

internal info: path, date revised, author



Notes: Boron concentrations and groundwater levels at S-7. The screened interval at S-7 (940.0 to 942.4 ft amsl) is not shown in this figure.

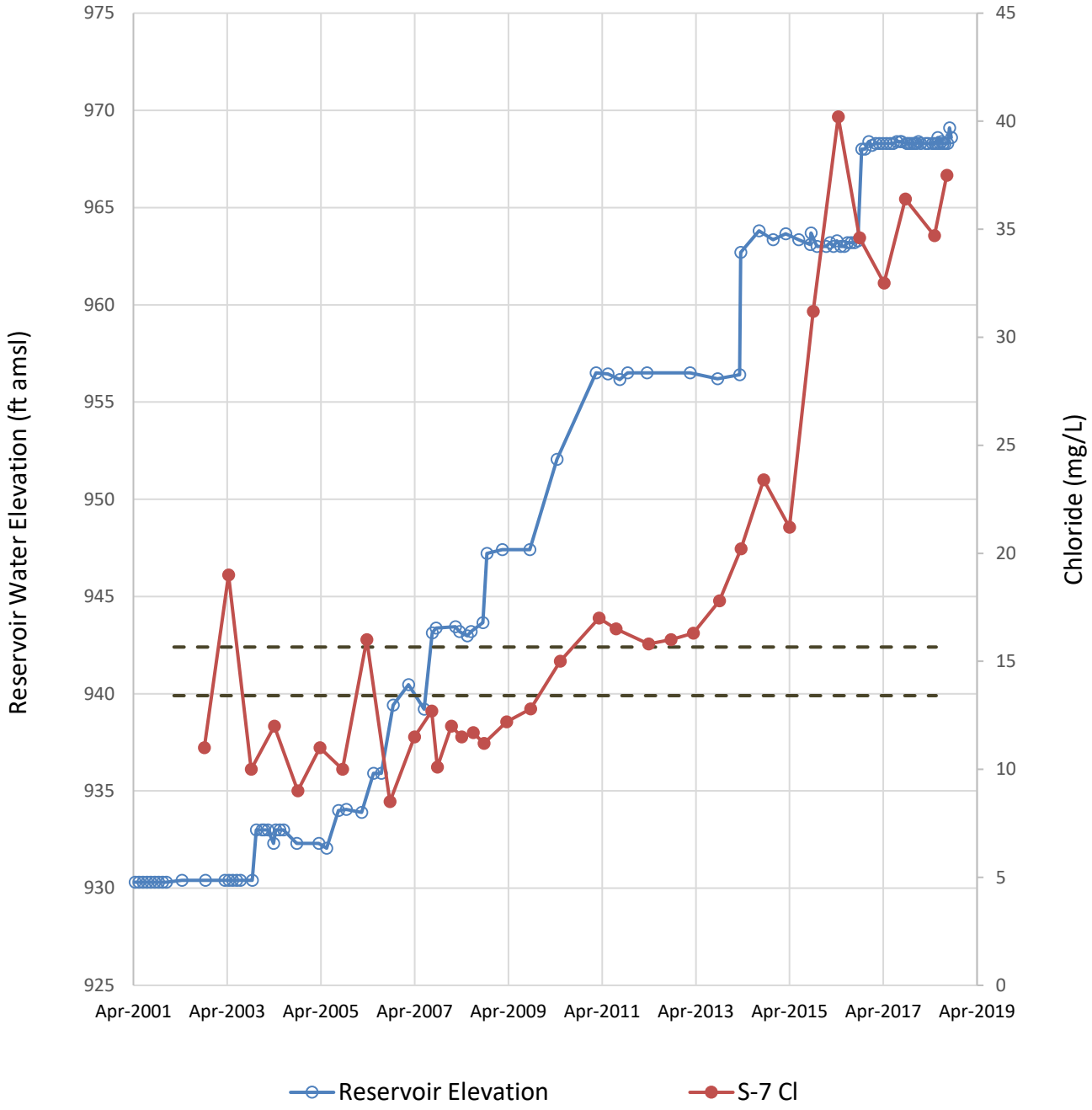
S-7 Boron and Water Level Time Series Graphs
Cardinal RSW Landfill

Geosyntec consultants

Columbus, Ohio | 22-Oct-2018

Figure **3**

internal info: path, date revised, author



Notes: Chloride data were collected for the state monitoring program and were not collected for compliance with the Federal CCR Rule. The dashed lines represent the upper (942.4 feet above mean sea level (amsl) and lower limits (939.9 ft amsl) of the screened interval at S-7.

S-7 Chloride and Water Level Time Series Graphs

Cardinal RSW Landfill

Geosyntec consultants

Columbus, Ohio | 22-Oct-2018

Figure **4**

internal info: path, date revised, author