2019 ANNUAL GROUNDWATER MONITORING REPORT

FEDERAL CCR RULE

CARDINAL PLANT
RESIDUAL SOLID WASTE LANDFILL
BRILLIANT, OHIO

Submitted to

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

Submitted by

Geosyntec consultants
engineers | scientists | innovators

941 Chatham Lane, Suite 103
Columbus, Ohio 43221

January 13, 2020

CHA8468

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, annually. Geosyntec Consultants (Geosyntec) has prepared this Report for the former Fly Ash Reservoir (FAR) 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, 2019.

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, 2016). 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 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. 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, at 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, the Summerfield Limestone, and the Bellaire Sandstone. These units are underlain by a shale aquitard, which is 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 the *Groundwater Monitoring Network Evaluation* (Geosyntec, 2016).

The RSW Landfill groundwater 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.

4. CCR RULE GROUNDWATER KEY ACTIVITIES

The RSW Landfill remained in detection monitoring during 2019. The second semi-annual detection monitoring event of 2018 was completed in January and February 2019. The first semi-annual detection monitoring event of 2019 was completed in March and May 2019 and the second semi-annual detection monitoring event of 2019 was completed in October and November 2019. Following the first semi-annual detection monitoring event of 2019, updated background statistics were calculated as discussed in **Section 4.4**. Analytical results from the 2019 sampling events are summarized in **Table 1**.

4.1 Groundwater Elevation and Flow Velocities

Prior to sampling, a synoptic round of groundwater level measurements was collected from the compliance and background monitoring wells. Potentiometric surface maps based on groundwater elevations measured during the March and October 2019 detection monitoring sampling events are presented in **Figure 3 and Figure 4**, respectively. 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 1.2 days at well S-1 to 19.6 days at S-17. 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;
- Chain of custody forms were 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.

All data received during 2019 were considered complete and usable.

4.3 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, with results provided in **Table 1**.

4.3.1 2018 Detection Monitoring Program

The second semi-annual detection monitoring event of 2018 at the RSW Landfill was conducted in October and November 2018 and January and February 2019. An evaluation of sampling analytical results for this detection monitoring event are shown in **Table 3**. Boron was detected above the upper prediction limit (UPL) at compliance well S-7 using a 1-of-3 retesting procedure resulting in a statistically significant increase (SSI) for boron. Following the SSI for boron, an alternate source demonstration (ASD) memorandum was prepared and the RSW Landfill remained in detection monitoring.

4.3.2 Alternate Source Demonstration

Following completion of the second semi-annual detection monitoring event of 2018, conducted from October 2018 through February 2019, an ASD memorandum was prepared in April 2019 to document that elevated boron concentrations observed at compliance well S-7 could be attributed to communication with reservoir water. Similar to the first two detection monitoring events, elevated concentrations of boron at well S-7 were shown to be a result of the hydraulic connectivity between FAR II and groundwater near the RSW Landfill (Geosyntec, 2019a). This ASD is provided as **Attachment A**.

4.3.3 2019 Detection Monitoring Program

The first semi-annual detection monitoring event of 2019 was conducted in March and May 2019. An evaluation of the first semi-annual detection monitoring sampling analytical results are shown in **Table 4**. No SSIs were identified for this detection monitoring event.

The second semi-annual detection monitoring event was conducted in October and November 2019. Analytical results were compared to the revised UPLs, as described in **Section 4.4**, and are shown in **Table 5**. No SSIs were identified for this detection monitoring event.

4.4 Background Statistical Calculation Update

Background statistics were updated following the first semi-annual detection monitoring event of 2019 in accordance with 40 CFR 257.94(b), the United States Environmental Protection Agency (USEPA's) *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities – Unified Guidance* (Unified Guidance; USEPA, 2009), and the Site's Statistical Analysis Plan (Geosyntec, 2017).

Groundwater samples collected during the first four detection monitoring events, between August 2017 and May 2019, were analyzed for 40 CFR 257 Appendix III parameters. The results from these four semi-annual detection monitoring events were evaluated for inclusion in the background dataset through several validation tests to identify the usability of the data, Mann-Whitney test to identify inclusion in the background dataset, and a review of outliers prior to updating prediction limits.

Mann-Whitney (Wilcoxon rank-sum) tests were used to compare the medians of historical data to the new compliance samples. Where no significant difference was found, the new compliance data were added to the background dataset. Where a statistically significant difference was found, the data was reviewed to evaluate the cause of the difference to determine if replacing the background dataset with the newer data or continuing to use the existing background dataset was most appropriate. Where appropriate, the updated background datasets were updated and used to recalculate UPLs and lower prediction limits (LPLs) for Appendix III parameters.

Based on the updated background dataset, intrawell testing using a one-of-two retesting procedure was selected for all Appendix III parameters. The *Statistical Analysis Summary-Background Update Calculations-Landfill* report (Geosyntec, 2019b) summarizes the analysis and results of the updated background statistical calculations.

5. PROBLEMS ENCOUNTERED AND RESOLUTIONS

Problems with low water levels at monitoring wells during detection monitoring in 2019 were encountered at the RSW Landfill. Monitoring wells S-1, S-2, S-4, S-5, S-6, and S-7 were purged dry during low-flow sampling in both the first and second semi-annual detection monitoring

events. Wells that were purged dry during low-flow sampling were allowed to recharge, and grab samples were collected approximately 24 hours later. Field parameters were not obtained for S-2 and S-7 during the first semi-annual detection monitoring.

Upgradient monitoring well S-17 was purged dry during sampling in the second semi-annual detection monitoring event. A sample was not collected from S-17 during for the second semi-annual monitoring event.

No monitoring wells were abandoned or added to the network during 2019. All analytical data received were deemed to be of acceptable quality.

6. STATUS OF MONITORING PROGRAM

The Site remained in the detection monitoring program through December 2019. It is anticipated the RSW Landfill will remain in detection monitoring in 2020.

7. PLANNED KEY ACTIVITIES FOR 2020

The following activities are planned for 2020 at the RSW Landfill:

- The 2019 Annual Groundwater Monitoring Report will be entered into the facility's operating record and posted to the public internet site;
- Two semi-annual groundwater detection monitoring program events will be conducted and tested for SSIs over background. The RSW Landfill's monitoring status will be confirmed following the SSI evaluation;
- The 2020 Annual Groundwater Monitoring Report will be prepared for submittal in January 2021.

8. REFERENCES

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

Geosyntec Consultants, Inc. 2016. Groundwater Monitoring Network Evaluation, Cardinal Site – Former Fly Ash Reservoir I – Residual Solid Waste Landfill, August.

Geosyntec Consultants, Inc. 2017. Statistical Analysis Plan. January.

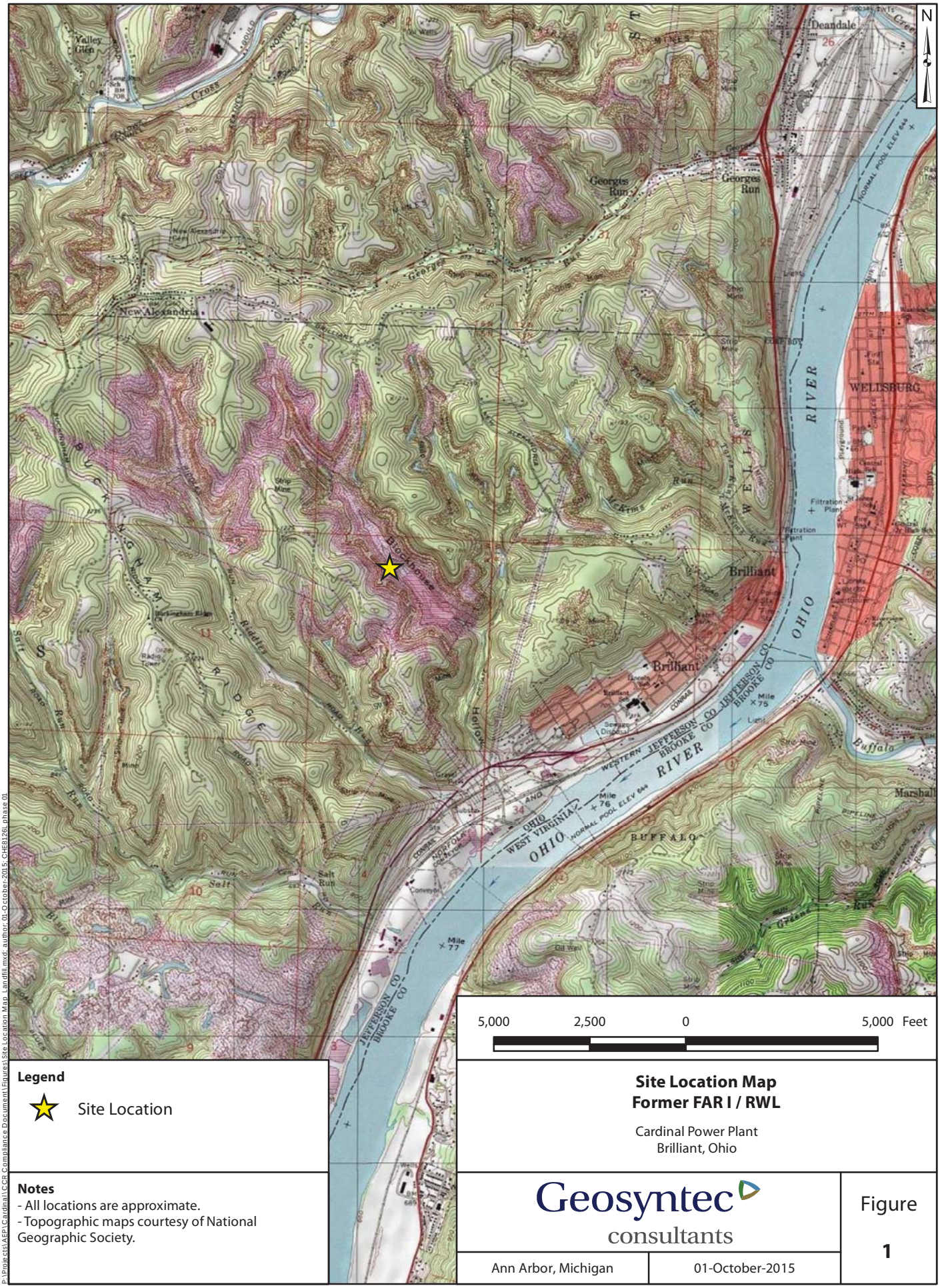
Geosyntec Consultants, Inc. 2019a. Cardinal Plant RSW Landfill Alternate Source Demonstration, April.

Geosyntec Consultants, Inc. 2019b. Statistical Analysis Summary – Background Update Calculations – Landfill, Cardinal Plant. December.

United States Environmental Protection Agency (USEPA). 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities - Unified Guidance. EPA 530/R-09-007. 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

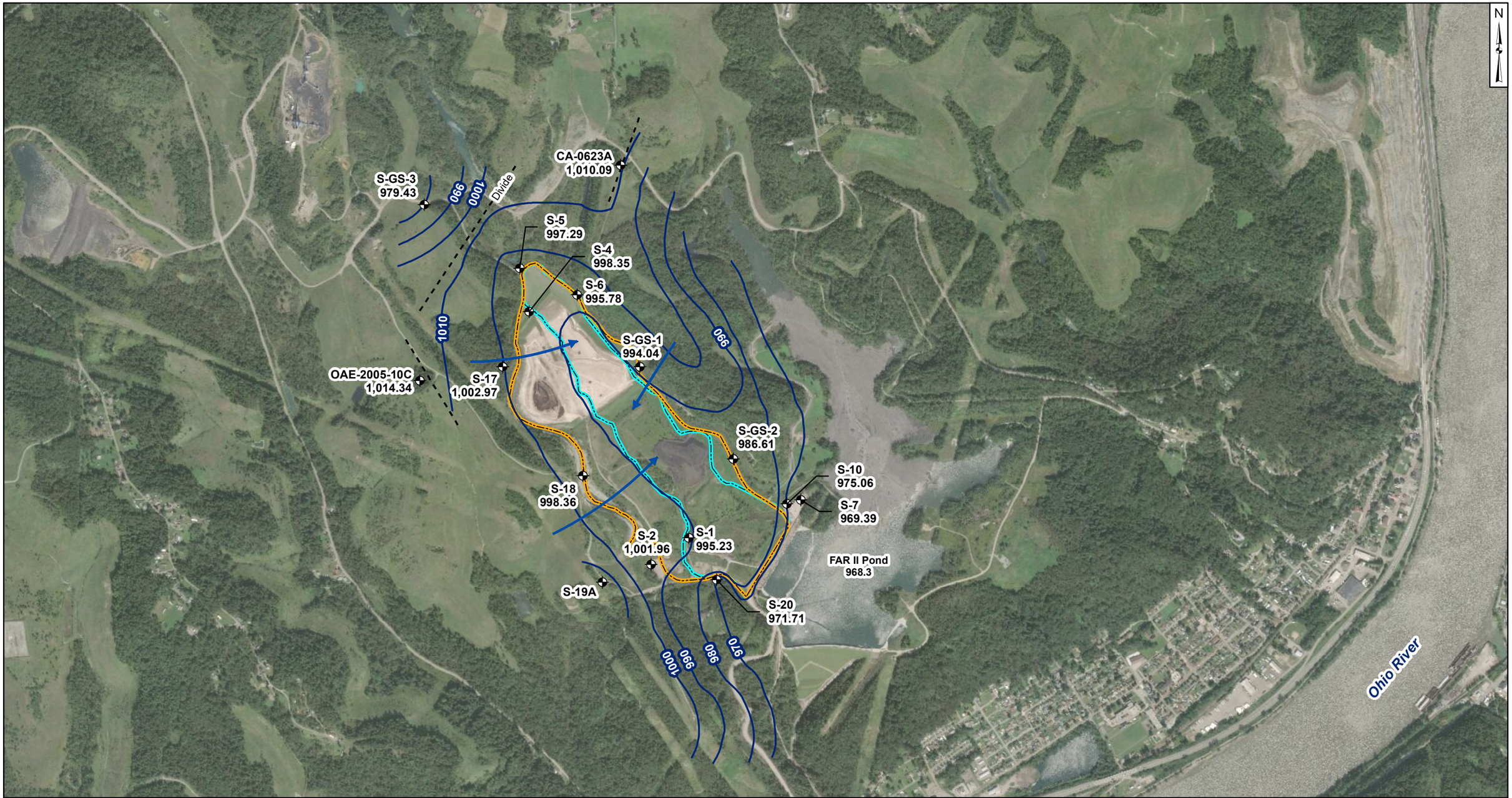
Buckeye Power Cardinal Generating Plant
Brilliant, Ohio

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
- Residual Solid Waste (RSW) Landfill
- Former Fly Ash Reservoir (FAR) I

Notes

- Monitoring well coordinates and water level data (collected on March 21, 2019) 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 AEP.
- MW-19A was not gauged during March 2019.
- Groundwater elevation units are feet above mean sea level.

1,000 500 0 1,000 Feet

Potentiometric Surface Map - Shallow Water Table
Former FAR I & RSW Landfill
March 2019

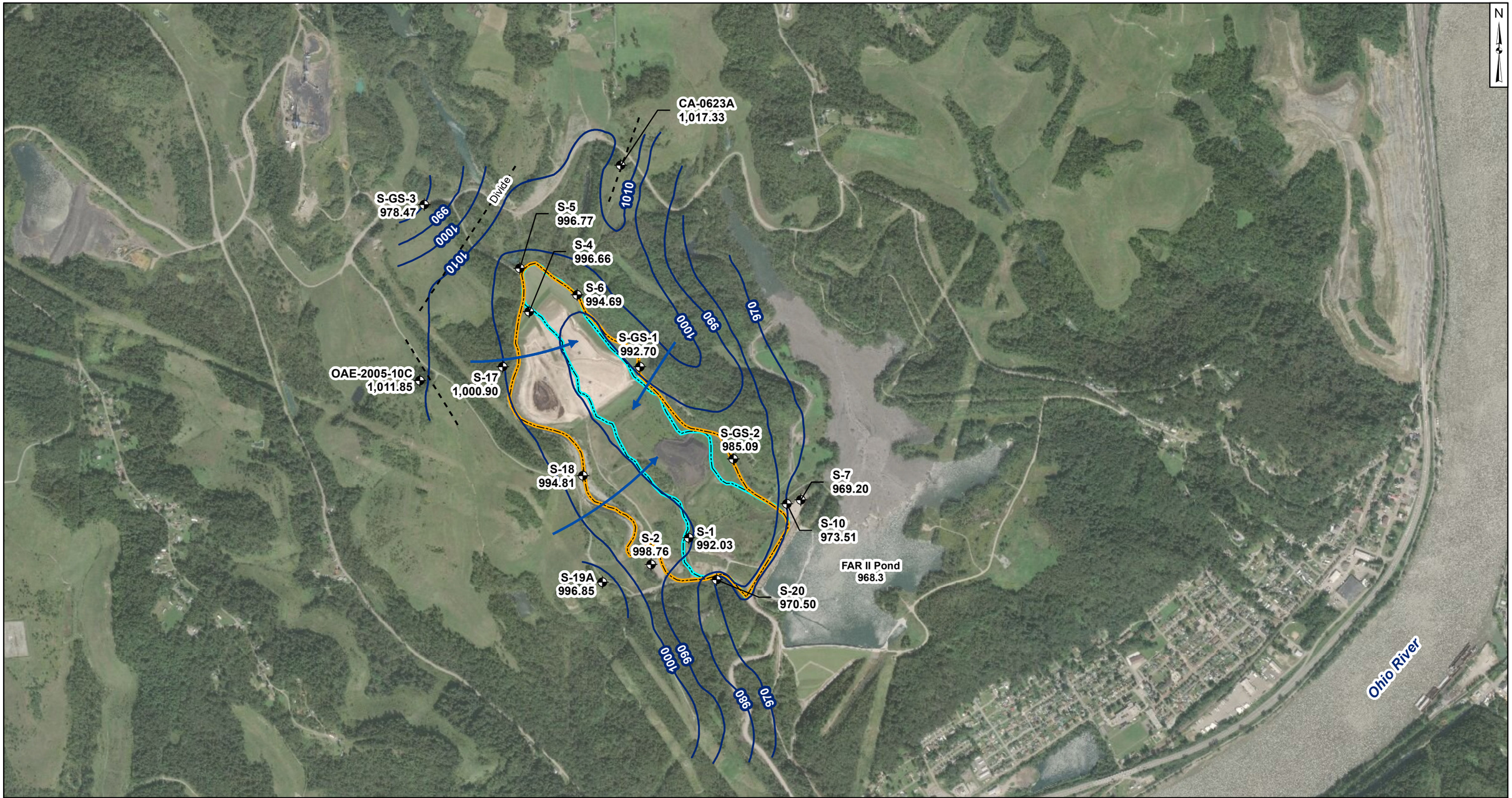
AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2020/01/08

Figure **3**

P:\Projects\Buckeye Power\GIS\MXDs\FAR I\Buckeye-Cardinal_FAR I_GW_2019-03Mar_REV.mxd. ARevezzo. 1/8/2020. CHA8423/01/08.



Legend

- Groundwater Monitoring Well
- Groundwater Elevation Contour
- Inferred Groundwater Elevation Contour
- Approximate Groundwater Flow Direction
- Residual Solid Waste (RSW) Landfill
- Former Fly Ash Reservoir (FAR) I

Notes

- Monitoring well coordinates and water level data (collected on October 26 , 2019) 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 AEP.
- Groundwater elevation units are feet above mean sea level.

1,000 500 0 1,000
Feet

Potentiometric Surface Map - Shallow Water Table
Former FAR I & RSW Landfill
October 2019

AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2020/01/08

Figure **4**

P:\Projects\Buckeye Power\GIS\MXDs\FAR I\Buckeye-Cardinal_FAR I_GW_2019-10.mxd. ARevezzo. 1/8/2020. CHA8423/01/08.

TABLES

Table 1 - Groundwater Data Summary
Cardinal Plant - Landfill and Fly Ash Reservoir I

Geosyntec Consultants, Inc.

Parameter	Unit	CA-0623A		OAE-2005-10-C		S-1				S-2		S-4	
		3/26/2019	10/1/2019	4/2/2019	10/7/2019	2/7/2019	3/29/2019	5/1/2019	10/3/2019	3/29/2019	10/3/2019	3/29/2019	10/9/2019
		2019-D1	2019-D2	2019-D1	2019-D2	2018-D2-R2	2019-D1	2019-D1-R1	2019-D2	2019-D1	2019-D2	2019-D1	2019-D2
Boron	µg/L	441	440	468	489	960	938	-	834	1,280	2,590	312	263
Calcium	µg/L	929	1,070	4,850	6,180	-	333,000	-	341,000	318,000	404,000	499,000	478,000
Chloride	mg/L	11.9	19.9	12.6	19.3	-	5.00	-	4.50	6.70	4.50	4.40	4.30
Fluoride	mg/L	2.10	2.00	1.10	1.10	-	0.110	-	0.120	0.370	0.290	0.190	0.240
Total Dissolved Solids	mg/L	632	646	1,440	1,350	-	1,800	-	1,790	2,400	2,930	2,130	2,560
Sulfate	mg/L	32.1	18.7	363	421	-	1,400	940	992	1,290	1,910	1,400	1,440
pH	SU	8.76	8.71	7.80	7.61	7.19	7.19	7.11	7.43	7.05	7.37	7.34	7.60

Parameter	Unit	S-5		S-6		S-7					S-10			
		3/28/2019	10/9/2019	3/28/2019	10/3/2019	1/7/2019	3/28/2019	5/1/2019	5/22/2019	10/3/2019	1/7/2019	3/28/2019	5/1/2019	9/30/2019
		2019-D1	2019-D2	2019-D1	2019-D2	2018-D2-R2	2019-D1	2019-D1-R1	2019-D1-R2	2019-D2	2018-D2-R2	2019-D1	2019-D1-R1	2019-D2
Boron	µg/L	22.2	20.5	1,510	2,190	1,900	1,980	1,940	1,860	2,000	1,600	1,080	-	608
Calcium	µg/L	302,000	287,000	182,000	418,000	-	252,000	-	-	255,000	-	268,000	-	278,000
Chloride	mg/L	6.90	7.20	27.1	37.6	29.9	32.1	-	-	31.4	19.8	23.1	-	19.4
Fluoride	mg/L	0.210	0.110	0.370	0.0720	-	0.260	0.0910	-	0.0880	-	0.290	0.0950	0.200
Total Dissolved Solids	mg/L	1,280	1,240	1,780	2,500	-	1,870	-	-	1,930	-	1,580	-	1,710
Sulfate	mg/L	739	689	973	1,360	-	1,100	-	-	984	-	966	-	946
pH	SU	8.11	7.93	7.59	7.00	7.48	7.72	7.42	7.22	7.68	7.40	7.23	7.16	7.03

Notes:
µg/L: micrograms per liter
mg/L: milligrams per liter
SU: standard unit
J: Estimated value. Parameter was detected in concentrations below the reporting limit
-: Not sampled
2018-D2-R2: Second verification sampling, second semi-annual detection monitoring event of 2018
2019-D1: First semi-annual detection monitoring event of 2019
2019-D1-R1: Verification sampling, first semi-annual detection monitoring event
2019-D1-R2: Second verification sampling, first semi-annual detection event of 2019
2019-D2: Second semi-annual detection monitoring event of 2019
2019-D2-R1: Verification sampling, second semi-annual detection monitoring event

Table 1 - Groundwater Data Summary
Cardinal Plant - Landfill and Fly Ash Reservoir I

Parameter	Unit	S-17	S-18				S-19A		S-20		
		4/2/2019	4/2/2019	5/9/2019	10/7/2019	11/21/2019	3/28/2019	10/8/2019	3/28/2019	5/1/2019	10/3/2019
		2019-D1	2019-D1	2019-D1-R1	2019-D2	2019-D2-R1	2019-D1	2019-D2	2019-D1	2019-D1-R1	2019-D2
Boron	µg/L	182	558	-	549	-	388	381	253	-	287
Calcium	µg/L	159,000	112,000	-	146,000	-	457,000	452,000	361,000	-	304,000
Chloride	mg/L	4.20	2.60	2.10	1.80	-	3.00	3.30	2.70	-	2.70
Fluoride	mg/L	0.190	0.300	-	0.300	-	0.460	0.270	0.370	0.150	0.220
Total Dissolved Solids	mg/L	1,270	938	-	1,070	-	3,200	3,180	1,830	-	1,750
Sulfate	mg/L	644	444	-	688	-	2,090	2,180	1,130	-	1,120
pH	SU	7.03	7.08	-	6.63	6.99	7.07	6.95	6.65	7.08	6.75

Parameter	Unit	SGS-1			SGS-2		SGS-3	
		3/28/2019	5/9/2019	10/2/2019	3/28/2019	10/2/2019	3/26/2019	10/2/2019
		2019-D1	2019-D1-R1	2019-D2	2019-D1	2019-D2	2019-D1	2019-D2
Boron	µg/L	870	-	855	502	473	302	288
Calcium	µg/L	111,000	-	110,000	6,920	6,380	5,600	5,540
Chloride	mg/L	23.1	-	22.7	90.9	93.2	404	363
Fluoride	mg/L	0.750	0.610	0.620	2.80	2.80	2.10	1.90
Total Dissolved Solids	mg/L	1,760	-	1,780	1,620	1,600	1,880	1,950
Sulfate	mg/L	954	-	991	58.3	38.1	174	184
pH	SU	7.36	-	7.45	8.02	8.02	8.40	8.21

Notes:
µg/L: micrograms per liter
mg/L: milligrams per liter
SU: standard unit
J: Estimated value. Parameter was detected in concentrations below the reporting limit
-: Not sampled
2018-D2-R2: Second verification sampling, second semi-annual detection monitoring event of 2018
2019-D1: First semi-annual detection monitoring event of 2019
2019-D1-R1: Verification sampling, first semi-annual detection monitoring event
2019-D1-R2: Second verification sampling, first semi-annual detection event of 2019
2019-D2: Second semi-annual detection monitoring event of 2019
2019-D2-R1: Verification sampling, second semi-annual detection monitoring event

Table 2: Residence Time Calculation Summary
Cardinal Plant - RSW Landfill

Geosyntec Consultants, Inc.

CCR Management Unit	Monitoring Well	Well Diameter (inches)	2019-03		2019-10	
			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	20.6	3.0	5.7	10.6
	CA-0623A [1]	2.0	9.5	6.4	16.4	3.7
	S-1 [2]	1.25	33.0	1.2	12.8	3.0
	S-10 [2]	2.0	13.9	4.4	18.2	3.3
	S-17 [1]	2.0	3.1	19.6	4.0	15.2
	S-18 [2]	2.0	4.7	12.9	6.0	10.1
	S-19 [2]	2.0	NC	NC	16.5	3.7
	S-2 [2]	1.25	15.0	2.5	11.0	3.5
	S-20 [2]	2.0	28.6	2.1	32.8	1.9
	S-4 [1]	1.0	5.9	5.1	4.7	6.4
	S-5 [1]	1.0	3.1	9.7	3.8	8.1
	S-6 [1]	1.0	8.5	3.6	6.9	4.4
	S-7 [2]	1.0	11.8	2.6	12.0	2.5
	S-GS-1 [2]	2.0	16.0	3.8	10.7	5.7
	S-GS-2 [2]	2.0	4.1	14.9	3.1	19.4
	S-GS-3 [1]	2.0	13.2	4.6	14.3	4.2

Notes:

[1] - Background Well

[2] - Compliance Well

NC - Groundwater residence time could not be calculated.

Table 3: Detection Monitoring Data Evalation
Second Semi-Annual Event of 2018
Cardinal Plant - Landfill

Geosyntec Consultants, Inc.

Parameter	Unit	Description	S-1			S-7			S-10		
			10/9/2018	12/5/2018	2/7/2019	10/9/2018	11/19/2018	1/7/2019	10/15/2018	12/5/2018	1/7/2019
Boron	mg/L	Intrawell Background Value (UPL)	0.959			1.86			1.69		
	mg/L	Detection Monitoring Result	**0.970**	**0.961**	0.911	**2.16**	**1.88**	**1.90**	**1.74**	**1.88**	1.60
Calcium	mg/L	Intrawell Background Value (UPL)	345			273			306		
	mg/L	Detection Monitoring Result	321	-	-	263	-	-	178	-	-
Chloride	mg/L	Intrawell Background Value (UPL)	6.46			36.5			29.5		
	mg/L	Detection Monitoring Result	6.40	-	-	**38.4**	31.9	29.9	22.8	-	19.8
Fluoride	mg/L	Intrawell Background Value (UPL)	0.245			0.190			0.238		
	mg/L	Detection Monitoring Result	0.23	-	-	0.17	-	-	0.16	-	-
pH	SU	Intrawell Background Value (UPL)	7.36			7.75			7.19		
	SU	Intrawell Background Value (LPL)	6.67			6.75			6.79		
	SU	Detection Monitoring Result	**7.46**	6.95	-	7.61	-	7.48	7.18	-	**7.40**
Sulfate	mg/L	Intrawell Background Value (UPL)	1107			1156			1050		
	mg/L	Detection Monitoring Result	1020	-	-	1080	-	-	834	-	-
Total Dissolved Solids	mg/L	Intrawell Background Value (UPL)	1944			1948			1737		
	mg/L	Detection Monitoring Result	1840	-	-	1890	-	-	1480	-	-

Parameter	Unit	Description	S-18		S-20		SGS-1	SGS-2
			10/8/2018	11/19/2018	10/8/2018	11/19/2018	10/15/2018	10/15/2018
Boron	mg/L	Intrawell Background Value (UPL)	0.663		0.313		1.12	0.977
	mg/L	Detection Monitoring Result	0.586	-	0.267	-	0.911	0.550
Calcium	mg/L	Intrawell Background Value (UPL)	238		386		197	106
	mg/L	Detection Monitoring Result	164	-	319	-	107	7.94
Chloride	mg/L	Intrawell Background Value (UPL)	2.54		3.02		28.6	120
	mg/L	Detection Monitoring Result	**2.9**	1.7	**3.9**	2.7	23.2	99.7
Fluoride	mg/L	Intrawell Background Value (UPL)	0.383		0.274		0.659	2.84
	mg/L	Detection Monitoring Result	**0.39**	0.36	**0.31**	0.22	0.64	2.6
pH	SU	Intrawell Background Value (UPL)	7.33		7.77		8.73	8.85
	SU	Intrawell Background Value (LPL)	6.63		5.90		5.92	7.19
	SU	Detection Monitoring Result	7.05	-	6.83	-	7.17	7.98
Sulfate	mg/L	Intrawell Background Value (UPL)	1032		1232		1049	993
	mg/L	Detection Monitoring Result	772	-	1060	-	935	73.8
Total Dissolved Solids	mg/L	Intrawell Background Value (UPL)	1749		2127		1984	2103
	mg/L	Detection Monitoring Result	1250	-	1860	-	1820	1700

Notes:
UPL: Upper prediction limit
LPL: Lower prediction limit
Bold values exceed the background value.
Background values are shaded gray.
Based on a 1-of-3 resampling for boron and 1-of-2 resampling for remaining Appendix III parameters, a statistically significant increase (SSI) is only identified when all samples in the detection monitoring period are above the calculated background value.

Table 4: Detection Monitoring Data Evaluation
First Semi-Annual Event of 2019
Cardinal Plant - Landfill

Geosyntec Consultants, Inc.

Parameter	Units	Description	S-1	S-10	S-18	S-20	S-7		SGS-1	SGS-2
			3/29/2019	3/28/2019	4/2/2019	3/28/2019	3/28/2019	5/22/2019	3/28/2019	3/28/2019
Boron	mg/L	Intrawell Background Value	0.959		0.663	0.313			1.12	0.977
	mg/L	Analytical Data	0.938	1.08	0.558	0.253	1.98	1.86	0.870	0.502
Calcium	mg/L	Intrawell Background Value	345		238	386			197	106
	mg/L	Analytical Data	333	268	112	361	252	-	111	6.92
Chloride	mg/L	Intrawell Background Value	6.46		2.54	3.02			28.6	120
	mg/L	Analytical Data	5.00	23.1	2.60	2.70	32.1	-	23.1	90.9
Fluoride	mg/L	Intrawell Background Value	0.245		0.383	0.274			0.659	2.84
	mg/L	Analytical Data	0.110	0.290	0.300	0.370	0.260	-	0.750	2.80
pH	SU	Intrawell Background Value	7.4		7.3	7.8			8.7	8.8
	SU	Intrawell Background LPL	6.7		6.6	5.9			5.9	7.2
	SU	Analytical Data	7.2	7.2	7.1	6.7	-	7.2	7.4	8.0
Sulfate	mg/L	Intrawell Background Value	1107		1032	1232			1049	993
	mg/L	Analytical Data	1400	966	444	1130	1100	-	954	58.3
Total Dissolved Solids	mg/L	Intrawell Background Value	1944		1749	2127			1984	2103
	mg/L	Analytical Data	1800	1580	938	1830	1870	-	1760	1620

Notes:
UPL: Upper prediction limit LPL: Lower prediction limit
Bold values exceed the background value.
Background values are shaded gray.
Based on a 1-of-3 resampling for boron and 1-of-2 resampling for remaining Appendix III parameters, a statistically significant increase (SSI) is only identified when all samples in the detection monitoring period are above the calculated background value.

Table 5: Detection Monitoring Data Evalation
Second Semi-Annual Event of 2019
Cardinal Plant - Landfill

Geosyntec Consultants, Inc.

Parameter	Unit	Description	S-1	S-7	S-10	S-18		S-20	SGS-1	SGS-2
			10/3/2019	10/3/2019	9/30/2019	10/7/2019	11/21/2019	10/3/2019	10/2/2019	10/2/2019
Boron	mg/L	Intrawell Background Value (UPL)	1.01	2.15	2.13	0.659		0.360	1.11	0.980
		Detection Monitoring Result	0.834	2.00	0.608	0.549	--	0.287	0.855	0.473
Calcium	mg/L	Intrawell Background Value (UPL)	353	275	342	246		390	198	32.6
		Detection Monitoring Result	341	255	278	146	--	304	110	6.38
Chloride	mg/L	Intrawell Background Value (UPL)	6.83	39.2	30.5	3.07		3.90	28.6	125
		Detection Monitoring Result	4.50	31.4	19.4	1.80	--	2.70	22.7	93.2
Fluoride	mg/L	Intrawell Background Value (UPL)	0.267	0.258	0.293	0.411		0.362	0.788	3.23
		Detection Monitoring Result	0.120	0.088	0.200	0.300	--	0.220	0.620	2.80
pH	SU	Intrawell Background Value (UPL)	7.5	7.9	7.7	7.4		7.9	8.8	8.8
		Intrawell Background Value (LPL)	6.6	6.7	6.6	6.7		6.3	5.9	7.2
		Detection Monitoring Result	7.4	7.7	7.0	**6.6**	7.0	6.8	7.5	8.0
Sulfate	mg/L	Intrawell Background Value (UPL)	1400	1178	1098	1192		1257	1045	488
		Detection Monitoring Result	992	984	946	688	--	1120	991	38.1
Total Dissolved Solids	mg/L	Intrawell Background Value (UPL)	1961	1957	1828	1982		2248	1982	2125
		Detection Monitoring Result	1790	1930	1710	1070	--	1750	1780	1600

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

ATTACHMENT A

Alternate Source Demonstration Memorandum
April 2019

Geosyntec consultants

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

Memorandum

Date: April 10, 2019

To: Nicholas Kasper, Ohio Electric Cooperative

From: Dan Bodine, P.E.

Subject: Cardinal Plant RSW Landfill Alternative 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 this detection monitoring event. No other SSIs were observed in the well network during this semi-annual detection monitoring event (Table 1).

DEMONSTRATION OF AN ALTERNATIVE SOURCE

SSIs for boron were also identified at well S-7 for two previous detection monitoring events (October 2017 and May 2018). In both instances, an alternative source demonstrations (ASD) was prepared (Geosyntec, 2018a; Geosyntec, 2018b).

For the current semi-annual detection monitoring event, the SSI was concluded after the intrawell background UPL for boron was exceeded in three consecutive sampling events (October 9, 2018, November 19, 2018, and January 7, 2019). An investigation was conducted in which five possible types of alternative sources were considered in accordance with guidance by the Electric Power Research Institute (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 on October 8-15, 2018, in which seven downgradient wells were sampled. Resamples were collected on either November 19, 2018 or December 5, 2018 to verify if any possible SSIs were confirmed. Additional sampling was completed on either January 7, 2019 or February 7, 2019 to verify if any remaining possible SSIs were confirmed. Following the third event, 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 this sampling period (October 2018 through February 2019), have remained consistent with those presented in the prior ASDs. In September 2018, the water levels in the reservoir temporarily rose by almost one foot, before returning to its previous level about two months later. For a brief period. the reservoir elevation was approximately equal to the groundwater elevation at S-7. Under these conditions, reverse flow from the reservoir to S-7 could have occurred, which would have led to formation water moving back toward S-7. Therefore, the argument presented in the prior ASDs, in which water with elevated boron from the reservoir mixing with formation water at S-7 due to hydraulic communication between the well and FAR II reservoir, remains as the likely cause for the SSI for boron at S-7.

Figures 1a and 1b show the groundwater elevation at S-7 over both the past 20 years and in the more recent time period. The data show that the groundwater level at S-7 continues to track closely with the reservoir elevation once the latter was raised above 960 ft above mean sea level (amsl) in April 2014. This is a strong indicator of hydraulic communication between the reservoir and S-7. Figure 2 compares boron concentrations in the reservoir with those at S-7. This figure shows that the groundwater at S-7 has lower boron concentrations that the reservoir, which is consistent with mixing between the reservoir and native groundwater.

Figure 3 shows the concentration of boron at S-7, which is increasing over time since 2003, and the groundwater elevation at S-7, which tracks closely with the reservoir elevation. Chloride is a conservative species, similar to boron, and is also a good indicator of mixing. 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. This correlation, in addition to the higher concentrations of chloride in the reservoir (Figure 5), suggests that chloride at S-7 is also impacted by mixing with reservoir water. The updated figures support the arguments presented in the previous ASDs and in this memorandum.

As the elevation of water in the FAR II reservoir has increased above 960 ft amsl, the resulting migration of water from the reservoir into the aquifer provides an explanation for the increase in boron at well S-7. 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 ASDs prepared for this unit (Geosyntec, 2018a; Geosyntec, 2018b). Certification of this ASD by a qualified professional engineer is provided in Attachment A.

******

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

Geosyntec, 2018a. Alternative Source Demonstration Report – Federal CCR Rule. June.

Geosyntec, 2018b. Memorandum – Cardinal Plant RSW Landfill Alternate Source Demonstration. October.

TABLES

Table 1: Detection Monitoring Data Evalation
Cardinal Plant - Landfill

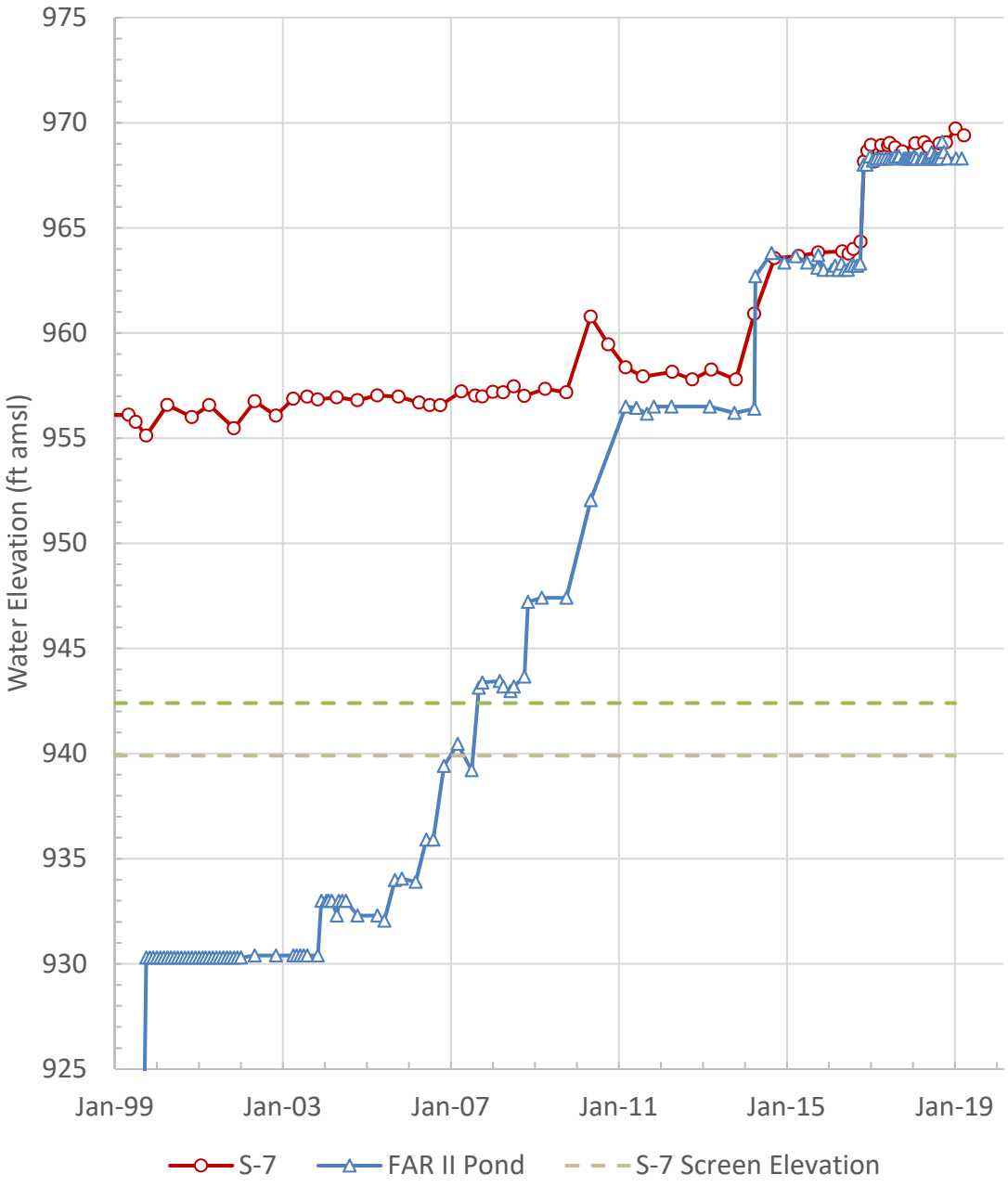
Geosyntec Consultants, Inc.

Parameter	Unit	Description	S-1			S-7			S-10		
			10/9/2018	12/5/2018	2/7/2019	10/9/2018	11/19/2018	1/7/2019	10/15/2018	12/5/2018	1/7/2019
Boron	mg/L	Intrawell Background Value (UPL)		0.959			1.86			1.69	
	mg/L	Detection Monitoring Result	**0.970**	**0.961**	0.911	**2.16**	**1.88**	**1.90**	**1.74**	**1.88**	1.60
Calcium	mg/L	Intrawell Background Value (UPL)		345			273			306	
	mg/L	Detection Monitoring Result	321	-	-	263	-	-	178	-	-
Chloride	mg/L	Intrawell Background Value (UPL)		6.46			36.5			29.5	
	mg/L	Detection Monitoring Result	6.40	-	-	**38.4**	31.9	29.9	22.8	-	19.8
Fluoride	mg/L	Intrawell Background Value (UPL)		0.245			0.190			0.238	
	mg/L	Detection Monitoring Result	0.23	-	-	0.17	-	-	0.16	-	-
pH	SU	Intrawell Background Value (UPL)		7.36			7.75			7.19	
	SU	Intrawell Background Value (LPL)		6.67			6.75			6.79	
	SU	Detection Monitoring Result	**7.46**	6.95	-	7.61	-	7.48	7.18	-	**7.40**
Sulfate	mg/L	Intrawell Background Value (UPL)		1107			1156			1050	
	mg/L	Detection Monitoring Result	1020	-	-	1080	-	-	834	-	-
Total Dissolved Solids	mg/L	Intrawell Background Value (UPL)		1944			1948			1737	
	mg/L	Detection Monitoring Result	1840	-	-	1890	-	-	1480	-	-

Parameter	Unit	Description	S-18		S-20		SGS-1	SGS-2
			10/8/2018	11/19/2018	10/8/2018	11/19/2018	10/15/2018	10/15/2018
Boron	mg/L	Intrawell Background Value (UPL)	0.663		0.313		1.12	0.977
	mg/L	Detection Monitoring Result	0.586	-	0.267	-	0.911	0.550
Calcium	mg/L	Intrawell Background Value (UPL)	238		386		197	106
	mg/L	Detection Monitoring Result	164	-	319	-	107	7.94
Chloride	mg/L	Intrawell Background Value (UPL)	2.54		3.02		28.6	120
	mg/L	Detection Monitoring Result	**2.9**	1.7	**3.9**	2.7	23.2	99.7
Fluoride	mg/L	Intrawell Background Value (UPL)	0.383		0.274		0.659	2.84
	mg/L	Detection Monitoring Result	**0.39**	0.36	**0.31**	0.22	0.64	2.6
pH	SU	Intrawell Background Value (UPL)	7.33		7.77		8.73	8.85
	SU	Intrawell Background Value (LPL)	6.63		5.90		5.92	7.19
	SU	Detection Monitoring Result	7.05	-	6.83	-	7.17	7.98
Sulfate	mg/L	Intrawell Background Value (UPL)	1032		1232		1049	993
	mg/L	Detection Monitoring Result	772	-	1060	-	935	73.8
Total Dissolved Solids	mg/L	Intrawell Background Value (UPL)	1749		2127		1984	2103
	mg/L	Detection Monitoring Result	1250	-	1860	-	1820	1700

Notes:
UPL: Upper prediction limit
LPL: Lower prediction limit
Bold values exceed the background value.
Background values are shaded gray.
Based on a 1-of-3 resampling for boron and 1-of-2 resampling for remaining Appendix III parameters, a statistically significant increase (SSI) is only identified when all samples in the detection monitoring period are above the calculated background value.

FIGURES



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

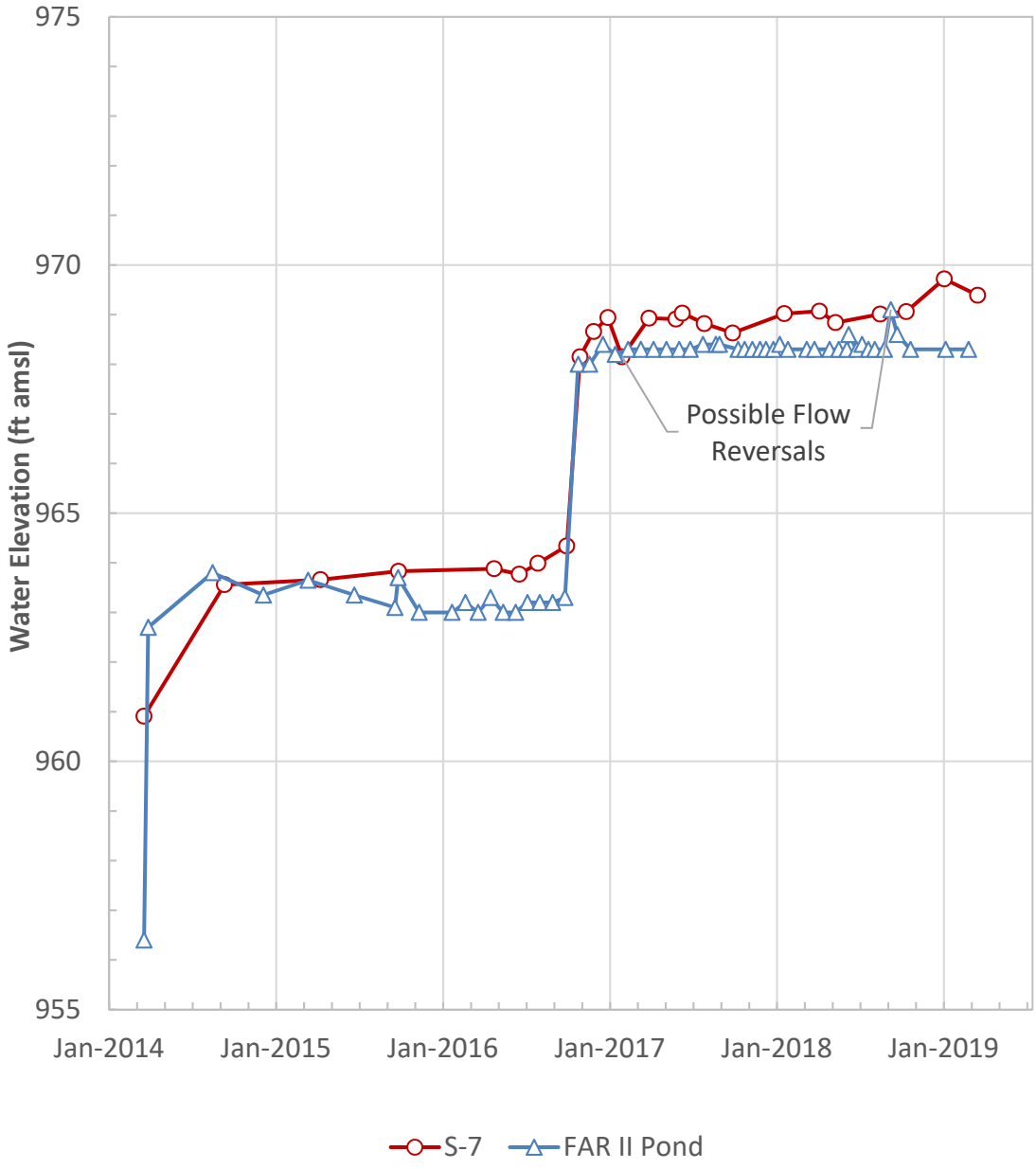
Water Level Time Series Graph
Cardinal RSW Landfill

Geosyntec consultants

Columbus, Ohio | 01-Apr-2019

Figure **1a**

internal info: path, date revised, author

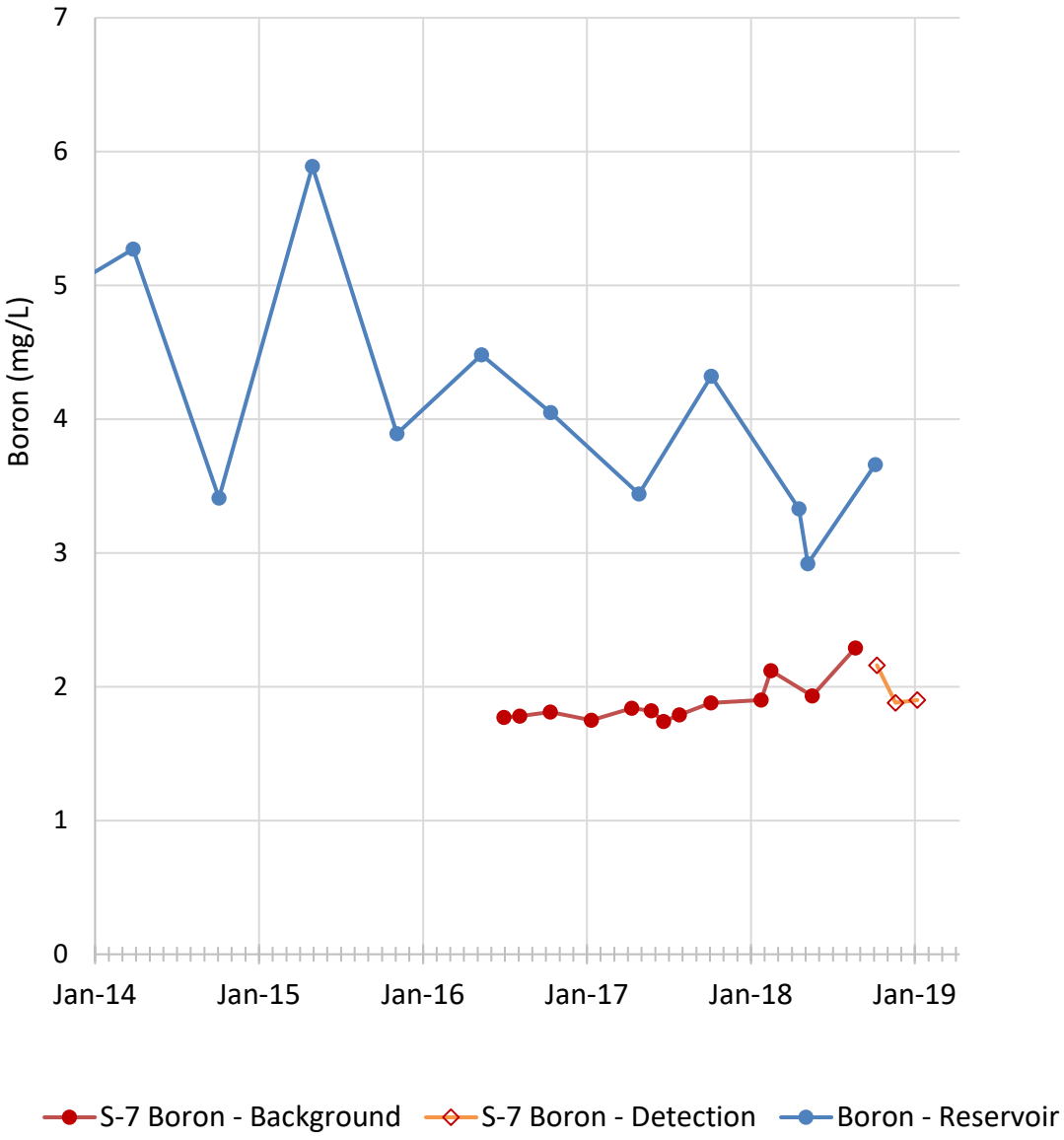


Water Level Time Series Graph
Cardinal RSW Landfill

Geosyntec consultants

Figure **1b**

Columbus, Ohio | 01-Apr-2019



Notes: 'S-7 Boron – Background' data represents all samples collected for the Federal CCR Rule in advance of this detection monitoring event. 'Boron Reservoir' data represents the reported dissolved boron concentration in the FAR II reservoir.

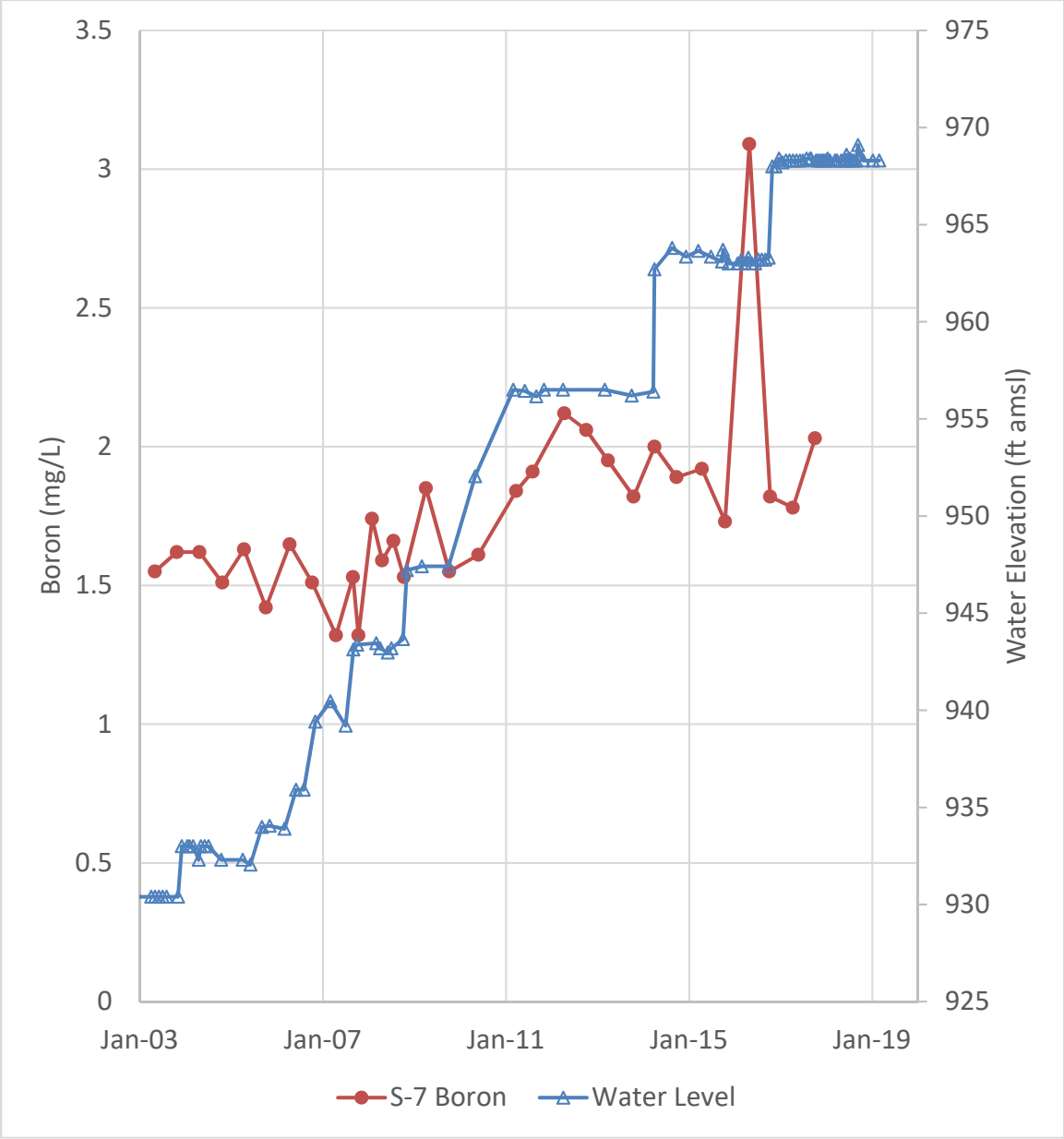
Boron Time Series Graph
Cardinal RSW Landfill

Geosyntec consultants

Figure **2**

Columbus, Ohio | 01-Apr-2019

internal info: path, date revised, author



Notes: Boron data shown here were collected for the state monitoring program and were not collected for compliance with the Federal CCR Rule.

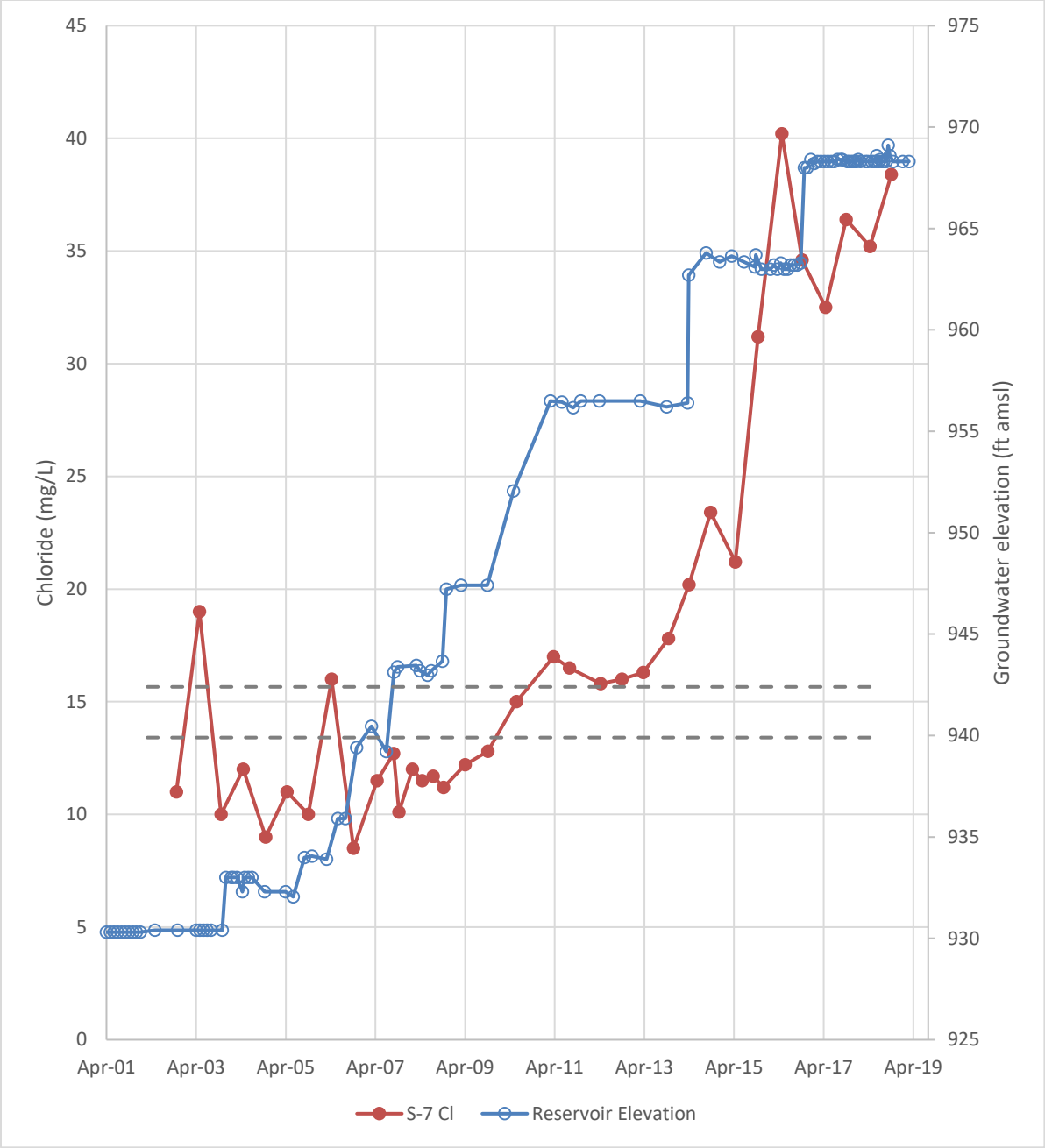
S-7 Boron and Water Level Time Series Graph
Cardinal RSW Landfill

Geosyntec consultants

Figure **3**

Columbus, Ohio	01-Apr-2019

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 [ft amsl]) and lower limits (939.9 ft amsl) of the screened interval at S-7.

S-7 Chloride and Water Level Time Series Graph

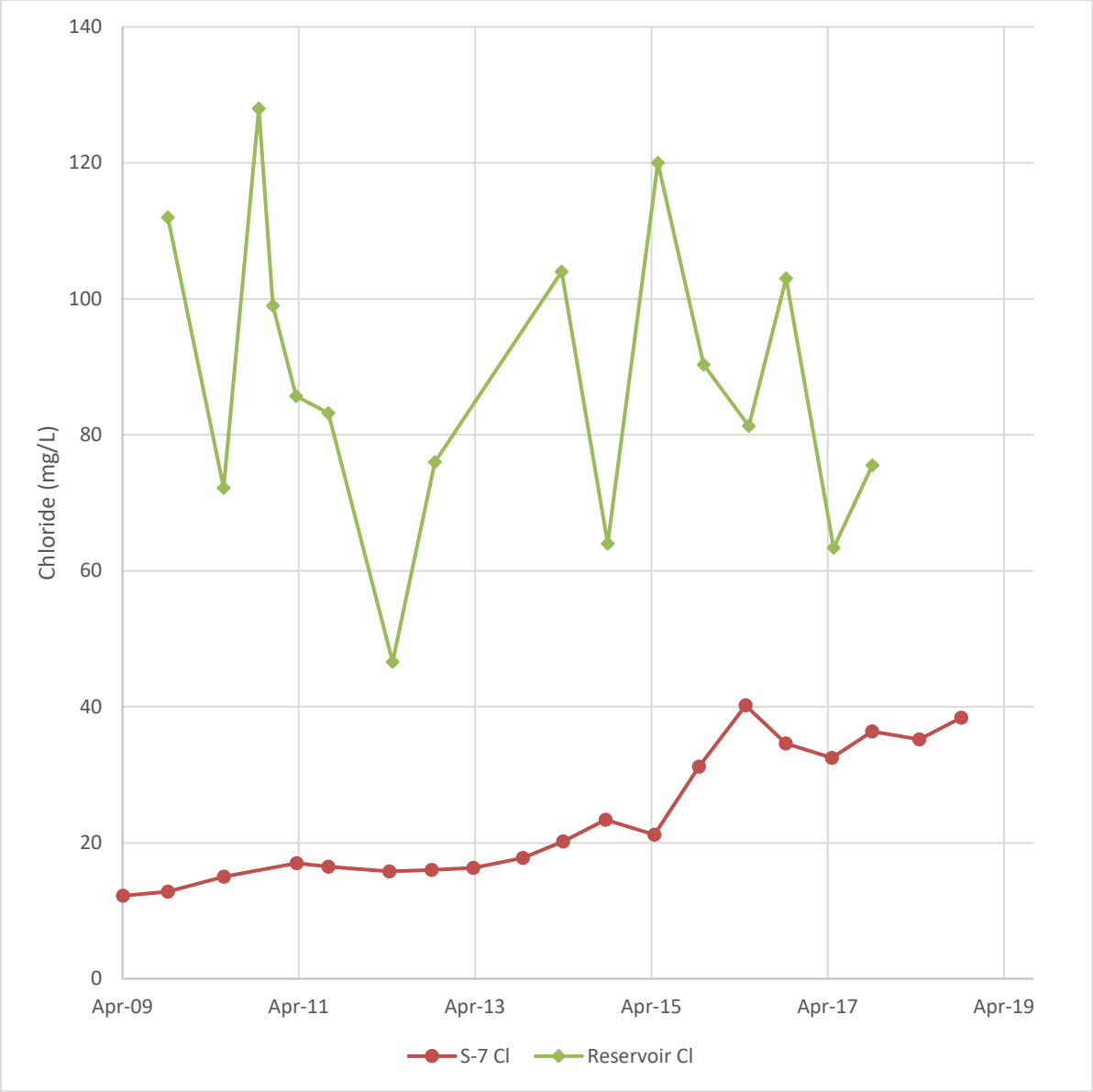
Cardinal RSW Landfill

Geosyntec consultants

Columbus, Ohio | 01-Apr-2019

Figure **4**

internal info: path, date revised, author



Notes: Chloride data at S-7 were collected for the state monitoring program and were not collected for compliance with the Federal CCR Rule. 'Reservoir Cl' data represents the reported dissolved chloride concentration in the FAR II reservoir.

Chloride Time Series Graph
Cardinal RSW Landfill

Geosyntec consultants

Figure **5**

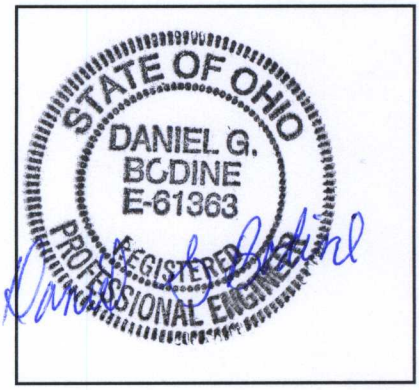
Columbus, Ohio	01-Apr-2019

internal info: path, date revised, author

ATTACHMENT A
Certification by Qualified Professional Engineer

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

E-61363	Ohio	April 10, 2019
License Number	Licensing State	Date

* * * * *