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2019 ANNUAL GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT

COFFEEN LANDFILL, COFFEEN POWER STATION

**2019 ANNUAL GROUNDWATER MONITORING AND
CORRECTIVE ACTION REPORT
COFFEEN LANDFILL, COFFEEN POWER STATION**

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CONTENTS

EXECUTIVE SUMMARY	3
1. Introduction	4
2. Monitoring and Corrective Action Program Status	5
3. Key Actions Completed in 2019	6
4. Problems Encountered and Actions to Resolve the Problems	8
5. Key Activities Planned for 2020	9
6. References	10

TABLES

Table A	2018–2019 Detection Monitoring Program Summary (in text)
Table 1	2019 Analytical Results – Groundwater Elevation and Appendix III Parameters
Table 2	Statistical Background Values

FIGURES

Figure 1	Monitoring Well Location Map
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APPENDICES

Appendix A	Alternate Source Demonstrations
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ACRONYMS AND ABBREVIATIONS

ASD	Alternate Source Demonstration
CCR	Coal Combustion Residuals
LF	Landfill
SAP	Sampling and Analysis Plan
SSI	Statistically Significant Increase

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EXECUTIVE SUMMARY

This report has been prepared to provide the information required by Title 40 of the Code of Federal Regulations (40 C.F.R.) § 257.90(e) for the Coffeen Landfill (LF) located at Coffeen Power Station near Coffeen, Illinois.

Groundwater is being monitored at Coffeen LF in accordance with the Detection Monitoring Program requirements specified in 40 C.F.R. § 257.94.

No changes were made to the monitoring system in 2019 (no wells were installed or decommissioned).

The following Statistically Significant Increases (SSIs) of 40 C.F.R. Part 257 Appendix III parameter concentrations greater than background concentrations were determined during one or more sampling events in 2019:

- Chloride at well G120
- Fluoride at well T127

Alternate Source Demonstrations (ASDs) were completed for the SSIs referenced above and Coffeen LF remains in the Detection Monitoring Program.

1. INTRODUCTION

This report has been prepared by Ramboll on behalf of Illinois Power Generating Company, to provide the information required by 40 C.F.R. § 257.90(e) for Coffeen LF located at Coffeen Power Station near Coffeen, Illinois.

In accordance with 40 C.F.R. § 257.90(e), the owner or operator of a Coal Combustion Residuals (CCR) unit must prepare an Annual Groundwater Monitoring and Corrective Action Report for the preceding calendar year that documents the status of the Groundwater Monitoring and Corrective Action Program for the CCR unit, summarizes key actions completed, describes any problems encountered, discusses actions to resolve the problems, and projects key activities for the upcoming year. At a minimum, the Annual Report must contain the following information, to the extent available:

1. A map, aerial image, or diagram showing the CCR unit and all background (or upgradient) and downgradient monitoring wells, to include the well identification numbers, that are part of the groundwater monitoring program for the CCR unit.
2. Identification of any monitoring wells that were installed or decommissioned during the preceding year, along with a narrative description of why those actions were taken.
3. In addition to all the monitoring data obtained under §§ 257.90 through 257.98, a summary including the number of groundwater samples that were collected for analysis for each background and downgradient well, the dates the samples were collected, and whether the sample was required by the Detection Monitoring or Assessment Monitoring Programs.
4. A narrative discussion of any transition between monitoring programs (e.g., the date and circumstances for transitioning from Detection Monitoring to Assessment Monitoring in addition to identifying the constituent(s) detected at a Statistically Significant Increase relative to background levels).
5. Other information required to be included in the Annual Report as specified in §§ 257.90 through 257.98.

This report provides the required information for Coffeen LF for calendar year 2019.

2. MONITORING AND CORRECTIVE ACTION PROGRAM STATUS

No changes have occurred to the monitoring program status in calendar year 2019, and Coffeen LF remains in the Detection Monitoring Program in accordance with 40 C.F.R. § 257.94.

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3. KEY ACTIONS COMPLETED IN 2019

The Detection Monitoring Program is summarized in Table A. The groundwater monitoring system, including the CCR unit and all background and downgradient monitoring wells, is presented in Figure 1. No changes were made to the monitoring system in 2019 (no wells were installed or decommissioned). In general, one groundwater sample was collected from each background and downgradient well during each monitoring event.¹ All samples were collected and analyzed in accordance with the Sampling and Analysis Plan (SAP) (NRT/OBG, 2017a). All monitoring data obtained under 40 C.F.R. §§ 257.90 through 257.98 (as applicable) in 2019 are presented in Table 1. Analytical data were evaluated in accordance with the Statistical Analysis Plan (NRT/OBG, 2017b) to determine any SSIs of Appendix III parameters relative to background concentrations.

Statistical background values are provided in Table 2.

Analytical results for the October/November 2018 sampling event were provided in the 2018 Annual Groundwater Monitoring and Corrective Action Report.

Potential alternate sources were evaluated as outlined in the 40 C.F.R. § 257.94(e)(2). ASDs were completed and certified by a qualified professional engineer. The dates the ASDs were completed are provided in Table A. The ASDs completed in 2019 are included in Appendix A.

¹ Sampling was limited to T127 during the May 2019 sampling event to confirm Appendix III parameters initially detected at concentrations greater than statistical background values in the preceding sampling event to confirm SSIs, as allowed by the Statistical Analysis Plan.

Table A – 2018–2019 Detection Monitoring Program Summary

Sampling Date	Analytical Data Receipt Date	Parameters Collected	SSI(s)	SSI(s) Determination Date	ASD Completion Date
October 24-26, 2018 and November 2, 2018	January 16, 2019	Appendix III	Chloride (G120), Fluoride (T127)	April 15, 2019	July 15, 2019
January 16-18 and 23, 2019	April 15, 2019	Appendix III	Fluoride (T127)	July 15, 2019	October 14, 2019
May 3, 2019	April 15, 2019	Appendix III Greater than Background ¹	NA	NA	NA
August 12-13, 2019	October 15, 2019	Appendix III	TBD	TBD	TBD

Notes:

NA: Not Applicable

TBD: To Be Determined

1. To confirm SSIs, as allowed by the Statistical Analysis Plan, groundwater samples were collected and analyzed for Appendix III parameters initially detected at concentrations greater than statistical background values in the preceding sampling event.

4. PROBLEMS ENCOUNTERED AND ACTIONS TO RESOLVE THE PROBLEMS

No problems were encountered with the Groundwater Monitoring Program during 2019. Groundwater samples were collected and analyzed in accordance with the SAP (NRT/OBG, 2017a), and all data were accepted.

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5. KEY ACTIVITIES PLANNED FOR 2020

The following key activities are planned for 2020:

- Continuation of the Detection Monitoring Program with semi-annual sampling scheduled for the first and third quarters of 2020.
- Complete evaluation of analytical data from the downgradient wells, using background data to determine whether an SSI of Appendix III parameters detected at concentrations greater than background concentrations has occurred.
- If an SSI is identified, potential alternate sources (i.e., a source other than the CCR unit caused the SSI or that that SSI resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality) will be evaluated.
 - If an alternate source is demonstrated to be the cause of the SSI, a written demonstration will be completed within 90 days of SSI determination and included in the 2020 Annual Groundwater Monitoring and Corrective Action Report.
 - If an alternate source(s) is not identified to be the cause of the SSI, the applicable requirements of 40 C.F.R. §§ 257.94 through 257.98 as may apply in 2020 (e.g., Assessment Monitoring) will be met, including associated recordkeeping/notifications required by 40 C.F.R. §§ 257.105 through 257.108.

6. REFERENCES

Natural Resource Technology, an OBG Company (NRT/OBG), 2017a, Sampling and Analysis Plan, Coffeen Landfill, Coffeen Power Station, Coffeen, Illinois, Project No. 2285, Revision 0, October 17, 2017.

Natural Resource Technology, an OBG Company (NRT/OBG), 2017b. Statistical Analysis Plan, Coffeen Power Station, Newton Power Station, Illinois Power Generating Company, October 17, 2017.

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TABLES

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TABLE 1.
2019 ANALYTICAL RESULTS - GROUNDWATER ELEVATION AND APPENDIX III PARAMETERS
2019 ANNUAL GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT
 COFFEEN POWER STATION
 UNIT ID 105 - COFFEEN LANDFILL
 COFFEEN, ILLINOIS
 DETECTION MONITORING PROGRAM

Well Identification Number	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)	Date & Time Sampled	Depth to Groundwater (ft) ¹	Groundwater Elevation (ft NAVD88)	40 C.F.R. Part 257 Appendix III						
						Boron, total (mg/L)	Calcium, total (mg/L)	Chloride, total (mg/L)	Fluoride, total (mg/L)	pH (field) (S.U.)	Sulfate, total (mg/L)	Total Dissolved Solids (mg/L)
						6020A ²	6020A ²	9251 ²	9214 ²	SM 4500 H+B ²	9036 ²	SM 2540C ²
Background / Upgradient Monitoring Wells												
G102	39.071389	-89.398986	1/17/2019 12:32	8.96	622.00	0.015	78	47	0.323	7.2	130	560
			5/3/2019 NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
			8/12/2019 15:04	8.19	622.77	0.022	93	22	0.402	7.2	86	420
G200	39.075139	-89.395014	1/16/2019 10:01	3.96	621.98	0.048	350	54	0.386	7.1	110	700
			5/3/2019 NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
			8/12/2019 13:07	3.90	622.04	<0.010	92	58	0.405	7.0	110	540
R201	39.075139	-89.397847	1/16/2019 11:04	4.17	622.17	<0.010	100	48	0.341	7.1	150	790
			5/3/2019 NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
			8/12/2019 14:02	3.99	622.35	<0.010	120	71	0.466	7.1	220	760
Downgradient Monitoring Wells												
G106	39.067528	-89.399083	1/17/2019 16:22	9.52	621.63	0.058	110	35	0.453	6.9	78	480
			5/3/2019 NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
			8/13/2019 7:55	10.57	620.58	0.029	94	44	0.468	6.9	36	520
G110	39.067167	-89.400708	1/23/2019 9:57	9.69	619.96	0.020	110	49	0.455	6.9	88	740
			5/3/2019 NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
			8/13/2019 8:46	9.00	620.65	<0.010	98	47	0.476	7.2	85	530
G120	39.069483	-89.401228	1/18/2019 11:25	19.00	612.87	0.017	96	100	0.381	7.1	38	540
			5/3/2019 13:03	13.72	618.15	NA	NA	94	NA	7.6	NA	NA
			8/13/2019 11:25	17.60	614.27	0.028	120	95	0.426	7.1	36	520
G125	39.071	-89.401236	1/18/2019 8:00	14.50	619.01	<0.010	71	93	0.482	7.1	70	590
			5/3/2019 NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
			8/13/2019 15:25	14.65	618.86	<0.010	76	89	0.472	7.1	70	540
T127	39.068124	-89.401222	1/18/2019 13:52	15.83	615.13	0.033	110	43	0.526	7.1	93	680
			5/3/2019 13:48	13.70	617.26	NA	NA	NA	0.508	7.5	NA	NA
			8/13/2019 9:36	15.81	615.15	0.015	78	40	0.525	7.0	92	520

[O: RAB 12/10/19, C: KLT 12/23/19]

Notes:

40 C.F.R. = Title 40 of the Code of Federal Regulations

ft = foot/feet

mg/L = milligrams per liter

NA = Not Analyzed

NAVD88 = North American Vertical Datum of 1988

NS = Not Sampled

S.U. = Standard Units

< = concentration is less than the concentration shown, which corresponds to the reporting limit for the method; estimated concentrations below the reporting limit and associated qualifiers are not provided since not utilized in statistics to determine Statistically Significant Increases (SSIs) over background.

¹All depths to groundwater were measured on the first day of the sampling event.

²4-digit numbers represent SW-846 analytical methods.

TABLE 2.
STATISTICAL BACKGROUND VALUES
2019 ANNUAL GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT
 COFFEEN POWER STATION
 UNIT ID 105 - COFFEEN LANDFILL
 COFFEEN, ILLINOIS
 DETECTION MONITORING PROGRAM

Parameter	Statistical Background Value (UPL)
40 C.F.R. Part 257 Appendix III	
Boron (mg/L)	0.39
Calcium (mg/L)	140
Chloride (mg/L)	96
Fluoride (mg/L)	0.5
pH (S.U.)	6.9 / 7.4
Sulfate (mg/L)	329.4
Total Dissolved Solids (mg/L)	891

[O: RAB 12/19/19, C: KLT 12/23/19]

Notes:

40 C.F.R. = Title 40 of the Code of Federal Regulations

mg/L = milligrams per liter

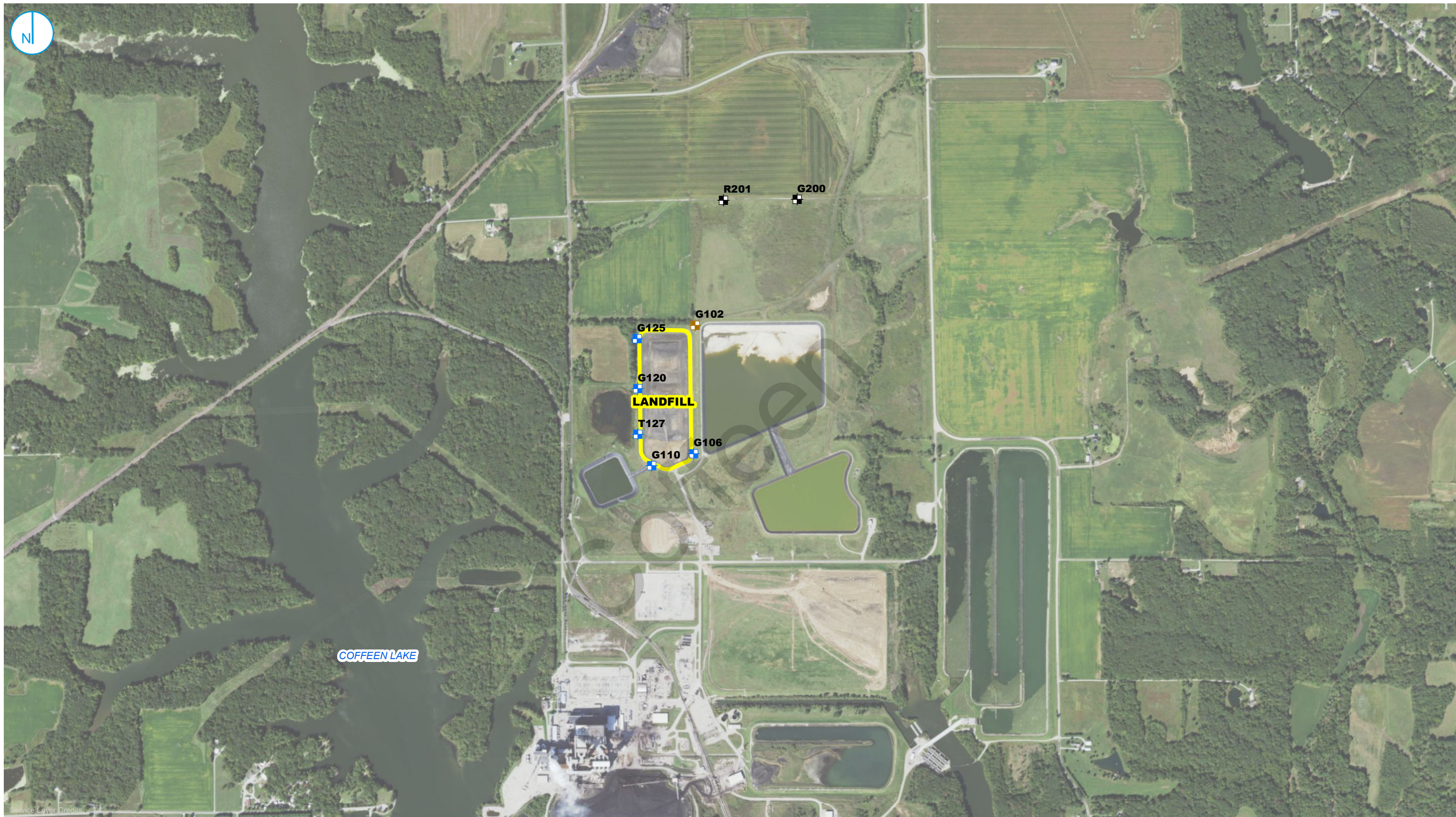
S.U. = Standard Units

UPL = Upper Prediction Limit

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FIGURES

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- UPGRADIENT MONITORING WELL LOCATION
- DOWNGRADIENT MONITORING WELL LOCATION
- BACKGROUND MONITORING WELL LOCATION
- CCR MONITORED UNIT

0 500 1,000 Feet

MONITORING WELL LOCATION MAP COFFEEN LANDFILL UNIT ID:105

2019 ANNUAL GROUNDWATER MONITORING AND CORRECTIVE ACTION REPORT
VISTRA CCR RULE GROUNDWATER MONITORING
COFFEEN POWER STATION
COFFEEN, ILLINOIS

FIGURE 1

O'BRIEN & GERE ENGINEERS, INC.
A RAMBOLL COMPANY

RAMBOLL

APPENDIX A
ALTERNATE SOURCE DEMONSTRATIONS

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**40 C.F.R. § 257.94(e)(2): ALTERNATE SOURCE DEMONSTRATION
COFFEEN LANDFILL
JULY 15, 2019**

Coffeen

July 15, 2019

Title 40 of the Code of Federal Regulations (C.F.R.) § 257.94(e)(2) allows the owner or operator of a Coal Combustion Residuals (CCR) unit 90 days from the date of determination of Statistically Significant Increases (SSIs) over background for groundwater constituents listed in Appendix III of 40 C.F.R. Part 257 to complete a written demonstration that a source other than the CCR unit being monitored caused the SSI(s), or that the SSI(s) resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality (Alternate Source Demonstration [ASD]).

This ASD has been prepared on behalf of Illinois Power Generating Company by O'Brien & Gere Engineers, Inc., part of Ramboll (OBG) to provide pertinent information pursuant to 40 C.F.R. § 257.94(e)(2) for the Coffeen Landfill, located near Coffeen, Illinois.

The third semi-annual detection monitoring samples (Detection Monitoring Round 3 [D3]) were collected on October 24-26 and November 2, 2018 and analytical data were received on January 16, 2019. In accordance with 40 C.F.R. § 257.93(h)(2), statistical analysis of the data to identify SSIs of 40 C.F.R. Part 257 Appendix III parameters over background concentrations was completed by April 15, 2019, within 90 days of receipt of the analytical data. The statistical determination identified the following SSIs at downgradient monitoring wells:

- Chloride at well G120
- Fluoride at wells G110 and T127
- pH less than the background lower prediction limit at wells G106 and G110

Because Detection Monitoring Round 4 (D4) samples were collected on January 16-18 and 23, 2019, prior to the SSIs referenced above being determined for D3, results from D4 were used to confirm the D3 SSIs in accordance with the Statistical Analysis Plan¹. Following evaluation of analytical data from D4, the following SSIs were confirmed for D3:

- Chloride at well G120
- Fluoride at well T127

Pursuant to 40 C.F.R. § 257.94(e)(2), the following demonstrates that sources other than the Coffeen Landfill were the cause of the SSIs listed above. This ASD was completed by July 15, 2019, within 90 days of determination of the SSIs, as required by 40 C.F.R. § 257.94(e)(2).

ALTERNATE SOURCE DEMONSTRATION: LINES OF EVIDENCE

Lines of evidence supporting this ASD include the following:

1. Landfill Design.
2. The ionic composition of landfill leachate is different from the ionic composition of groundwater.
3. Chloride concentrations in groundwater at G120 have not increased since CCR was first placed in the Landfill.

¹ Natural Resource Technology, an OBG Company, *Statistical Analysis Plan, Coffeen Power Station, Newton Power Station*, Illinois Power Generating Company, October 17, 2017.

4. Concentrations of boron and sulfate, common indicators for CCR impacts to groundwater, are at or below background concentrations and are stable in the downgradient wells.

These lines of evidence are described and supported in greater detail below. Monitoring well locations, leachate sample locations, and groundwater flow direction are shown on Figure 1.

The groundwater elevation contours shown on Figure 1 were measured on October 23, 2018, the first day of a combined sampling event at Coffeen Power Station for the five CCR units located there and for multiple monitoring programs required by both federal and state regulatory agencies. As noted above, groundwater sampling for D3 occurred on October 24-26 and November 2, 2018.

LINE OF EVIDENCE #1: LANDFILL DESIGN

The Coffeen Landfill was constructed in 2010. The constructed landfill liner includes the following design components:

- A 60-mil high-density polyethylene (HDPE) geomembrane
- Three-foot-thick layer of recompacted, low-permeability soil having a maximum hydraulic conductivity of 1×10^{-7} centimeters per second (cm/s)

The Illinois Environmental Protection Agency (IEPA)-approved Coffeen Landfill liner system exceeds the design criteria for a composite liner for new CCR landfills established by 40 C.F.R. § 257.70.

LINE OF EVIDENCE #2: THE IONIC COMPOSITION OF LANDFILL LEACHATE IS DIFFERENT FROM THE IONIC COMPOSITION OF GROUNDWATER

Piper diagrams graphically represent ionic composition of aqueous solutions. A Piper diagram displays the position of water samples relative to their major cation and anion content, providing the information needed to identify compositional categories or groupings. Figure 2, below, is a Piper diagram that displays the ionic composition of samples from the background and downgradient monitoring wells associated with the Landfill, as well as leachate samples collected during Quarter 2 2015, Quarter 4 2016, and Quarter 3 2017. The ionic compositional groupings identified are shown in the green and black ellipses on the diamond portion of the Piper diagram. These are summarized in Table 1 and discussed in more detail below.

The ionic compositions plotted on the Piper diagrams can be categorized into two distinct groups. Samples of background and downgradient groundwater from the Landfill wells (enclosed within a black ellipse) are tightly clustered, have no dominant cation, and have high percentages of carbonate-bicarbonate anions. The Landfill leachate samples (enclosed within a green ellipse) are compositionally distinct from the groundwater and have moderate to high percentages of sodium-potassium cations and moderate to high percentages of sulfate anions. The dissimilar ionic composition between the groundwater and leachate indicate that the leachate is not the source of CCR constituents detected in groundwater.

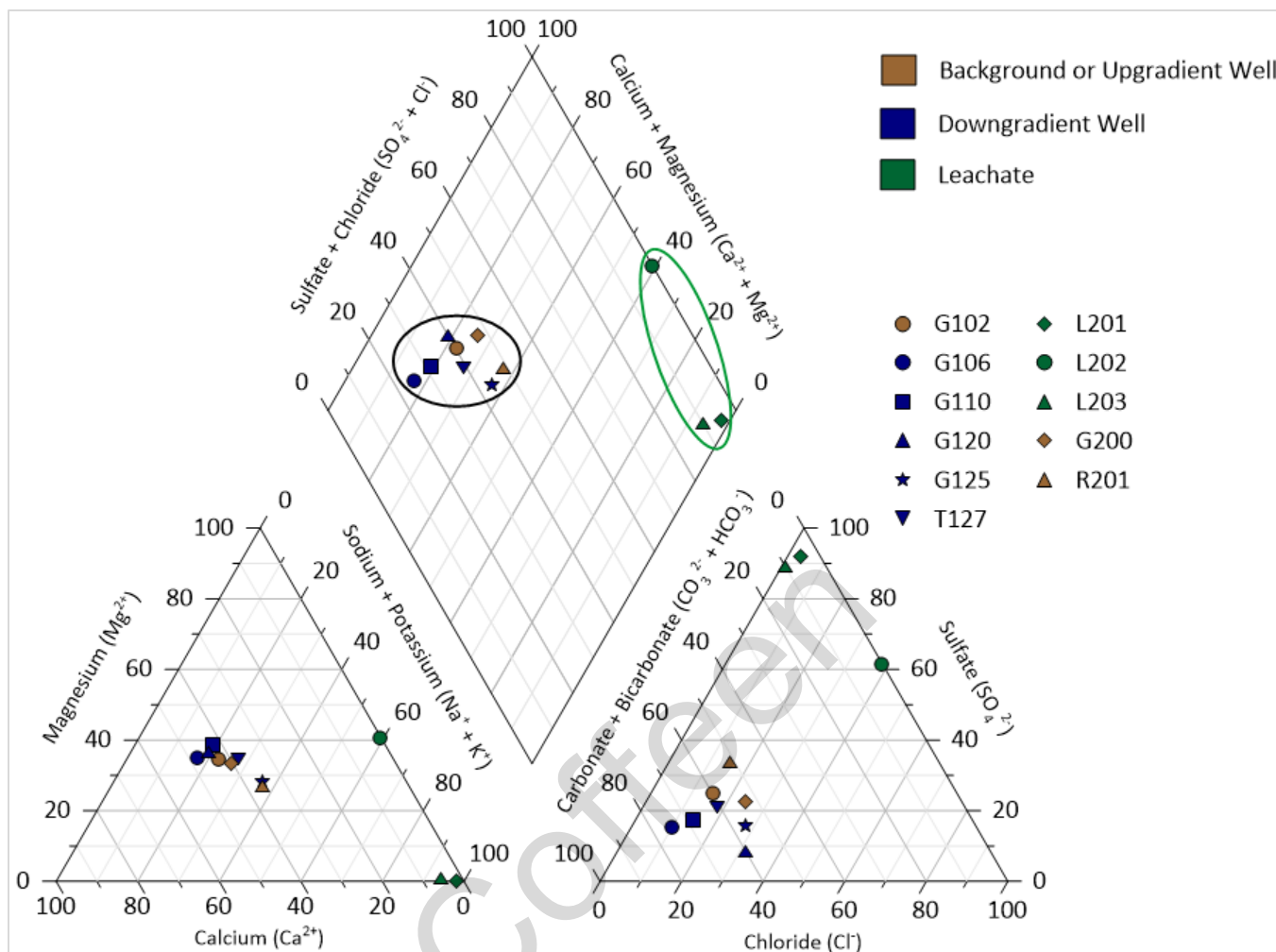


Figure 2. Piper Diagram Showing Ionic Composition of Samples of Background and Downgradient Groundwater and Landfill Leachate.

The ionic characteristics of these samples are provided in Table 1 below:

Grouping	Black	Green
Locations	Landfill Wells Groundwater	Landfill Leachate
Dominant Cation	No dominant cation	Moderate to High Sodium-Potassium
Dominant Anion	High Carbonate-Bicarbonate	Moderate to High Sulfate

Table 1. Summary of Ionic Classification.

LINE OF EVIDENCE #3: CHLORIDE CONCENTRATIONS IN GROUNDWATER AT G120 HAVE NOT INCREASED SINCE CCR WAS FIRST PLACED IN THE LANDFILL

The time series presented in Figure 3 displays dissolved chloride concentrations in samples of groundwater collected from G120 and Coffeen Landfill leachate, both collected since 2010, and total chloride concentrations in samples of groundwater collected from G120 since 2015.

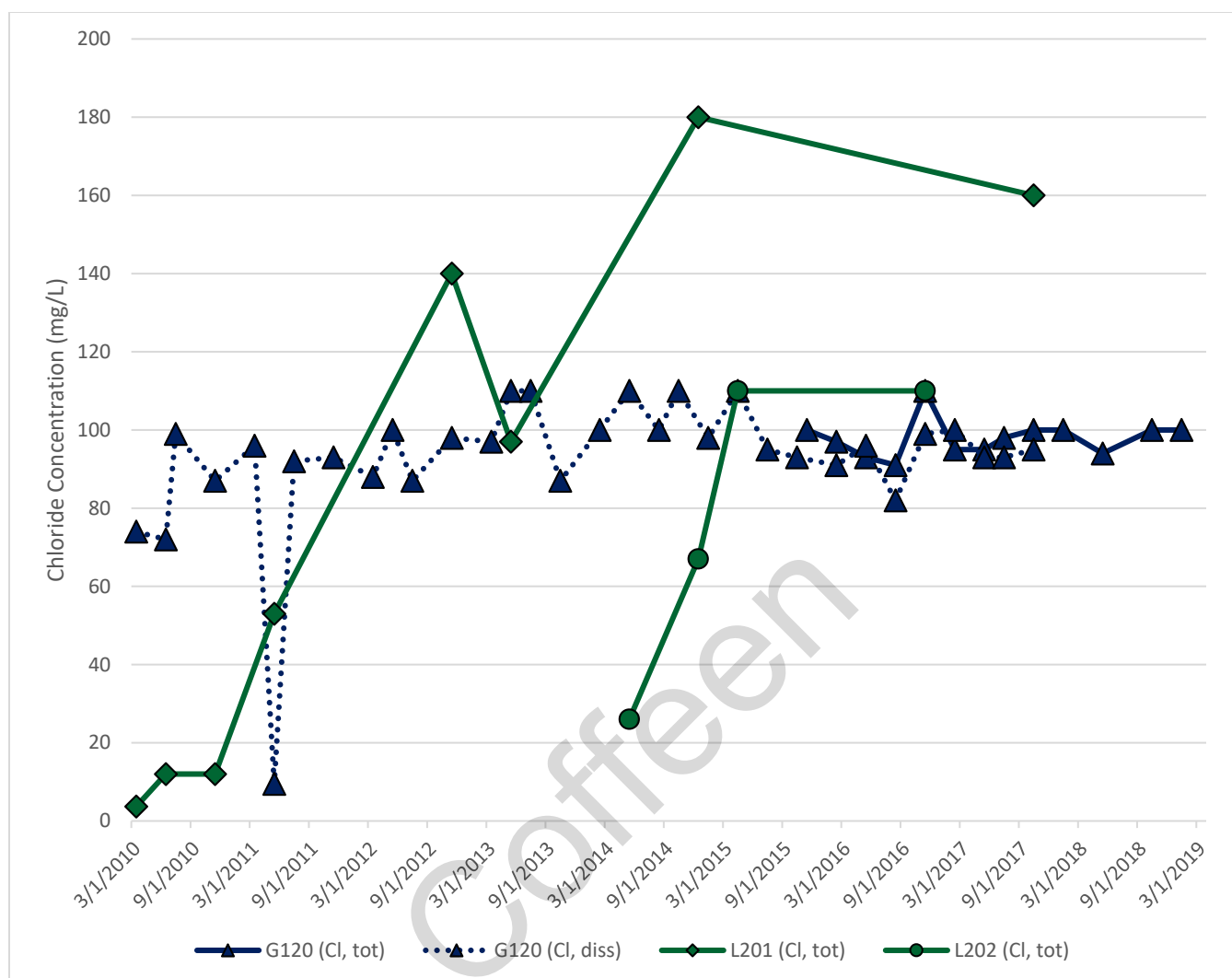


Figure 3. Time Series with Total and Dissolved Chloride Concentrations in Groundwater Samples Collected from G120 and Leachate Samples Collected from L201 and L202.

Figure 3 demonstrates the following:

- Total chloride concentrations in samples of groundwater collected from G120 from 2015-2019 are similar to the dissolved concentrations in samples collected during that timeframe, indicating that dissolved concentrations are representative of total concentrations in samples collected prior to 2015.
- Chloride concentrations in samples of groundwater collected from G120 have remained stable relative to chloride concentrations in leachate samples collected since 2010 when CCR disposal at the Coffeen Landfill commenced. A trend analysis (linear regression) was performed (Attachment A) to confirm that the chloride concentrations in groundwater at G120 are neither increasing or decreasing. An increasing trend in chloride concentrations in groundwater would be expected if leachate was being released from the Coffeen Landfill to groundwater due to the increasing trend in chloride concentrations in leachate.
- The stable chloride concentration trends in groundwater indicate that the Landfill is not impacting groundwater.

LINE OF EVIDENCE #4: CONCENTRATIONS OF BORON AND SULFATE, COMMON INDICATORS FOR CCR IMPACTS TO GROUNDWATER, ARE AT OR BELOW BACKGROUND CONCENTRATIONS AND ARE STABLE IN THE DOWNGRAIDENT WELLS

Boron and sulfate are common indicators of CCR impacts to groundwater due to their leachability from CCR and mobility in groundwater; however, downgradient concentrations of both are at or below concentrations in background wells (and upper prediction limits [UPLs]) as shown in Figures 4 and 5.

Boron

Boron concentrations are very near or below analytical method reporting limits. As listed in the statistical summary provided in Attachment B (rightmost column), boron was not detected in 75 to 92 percent (%) of the samples at each downgradient well. Only 12 of 60 downgradient water samples had a detected boron concentration. Boron was not detected in 33 to 67% of the samples at each background well. The background wells have lower percentages of non-detects than the downgradient wells.

Sulfate

Sulfate concentrations in downgradient wells versus background wells are shown on Figure 4. All sulfate concentrations in downgradient wells are below the Upper Prediction Limit (UPL) of 329.4 milligrams per liter (mg/L), determined from concentrations in background monitoring wells G200 and R201. Maximum sulfate concentrations measured in groundwater at each downgradient well between 2015 and 2019 ranged from 47 mg/L to 110 mg/L.

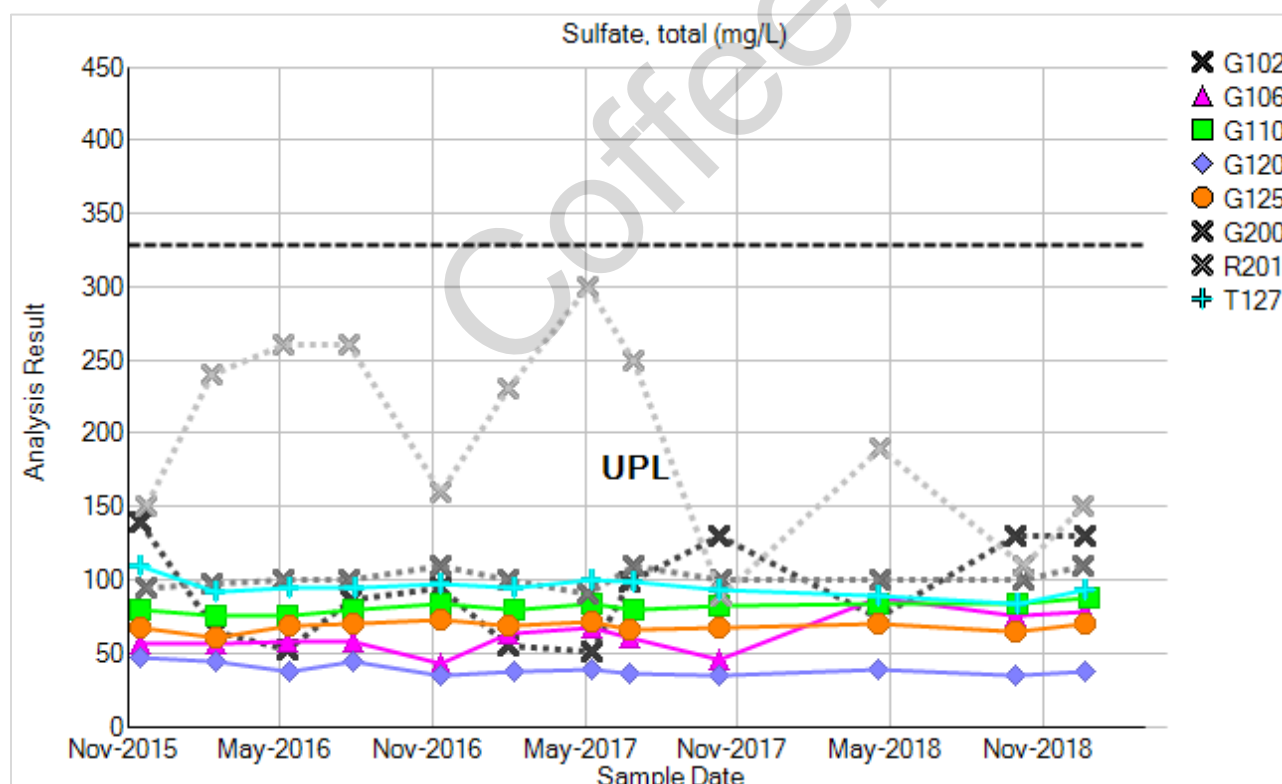


Figure 4. Sulfate Time Series.

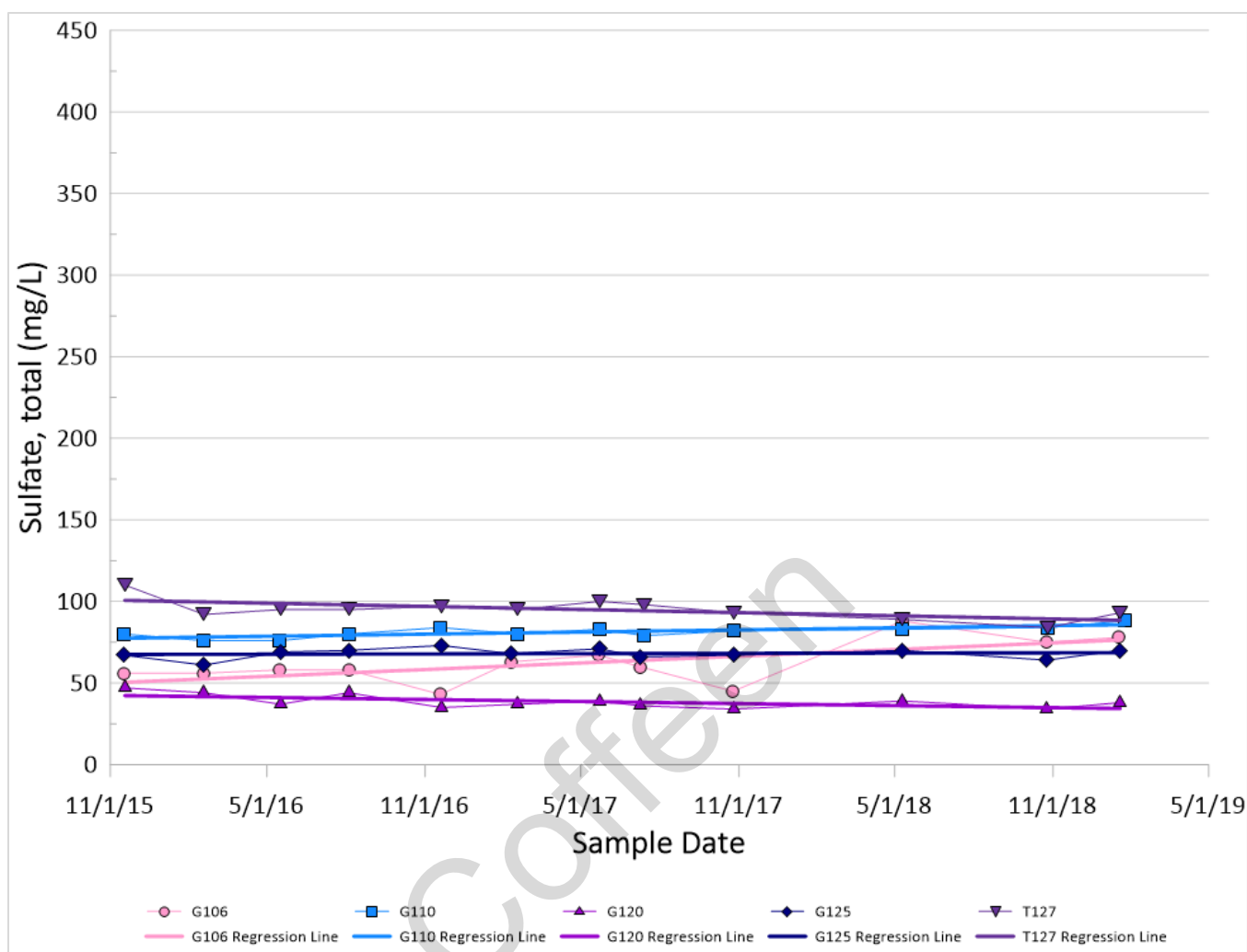


Figure 5. Downgradient Wells Sulfate Trends with Linear Regression Lines.

Sulfate is stable in downgradient wells. Linear regression lines calculated for the data at each monitoring well (straight lines as shown on Figure 5) show that concentrations from 2015 to 2019 have slight upward or downward slopes, meaning that concentrations over time may be increasing or decreasing. Mann-Kendall trend analysis tests were performed (Attachment B) to determine if sulfate concentrations at each well is increasing, decreasing or stable (i.e., no statistically significant upward or downward trend). If the Mann-Kendall test did not identify a trend, the coefficient of variation (CV) was calculated (Attachment C) to determine if the concentrations are stable (i.e., CV less than or equal to 1). If a trend was identified, the CV was calculated to indicate whether data used to establish the trend are suggestive of a low or high magnitude trend. Data with a CV less than or equal to 1 suggest a low magnitude trend.

Sulfate concentrations were stable in background wells G102, G200, and R201, and downgradient wells G125, G200, and T127. A statistically significant downward trend was identified in downgradient well G120. Statistically significant upward trends were identified in downgradient monitoring wells G106 and G110. Although the sulfate trends at G106, G110, and G120 were determined to be significant based on the Mann-Kendall tests, the concentrations demonstrated low variability (CV less than or equal to 1), suggesting a low magnitude trend. Table 2 provides summary statistics, including CV and trend per well.

The limited detections of boron, the concentrations of boron and sulfate near or below background levels, and the relative stability of the concentrations, support the conclusion that the Landfill is not the source of CCR constituents detected in the downgradient groundwater monitoring wells.

Monitoring Well	Sulfate (mg/L)					Trend	CV
	Minimum	Maximum	Median	Standard Deviation			
G102	51	140	90.5	33.6		stable	0.36
G106	43	88	59	13.1		upward	0.21
G110	76	88	81	3.5		upward	0.04
G120	34	47	37.5	4.2		downward	0.11
G125	61	73	68.5	3.3		stable	0.05
G200	90	110	100	6.3		stable	0.06
R201	89	300	210	67.0		stable	0.34
T127	84	110	95	6.3		stable	0.07

Table 2. Minimum, Maximum, Median, Standard Deviation, Trend, and Coefficient of Variation of Sulfate in Groundwater.

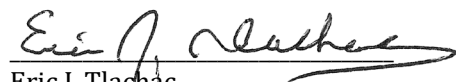
Based on these four lines of evidence, it has been demonstrated that the Coffeen Landfill is not the source of the chloride SSI in G120 or fluoride SSI in T127.

This information serves as the written ASD prepared in accordance with 40 C.F.R. § 257.94(e)(2) that the SSIs observed during D3 was not due to the Landfill. Therefore, an assessment monitoring program is not required and the Coffeen Landfill will remain in detection monitoring.

Attachments

- Figure 1 Monitoring Well and Leachate Location Map
- Attachment A Chloride Trend Analysis, Monitoring Well G120
- Attachment B Boron Statistical Summary for Landfill Monitoring Wells
- Attachment C Mann-Kendall Trend Analyses
- Attachment D Coefficient of Variation Evaluation

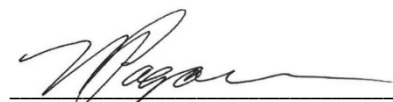
I, Eric J. Tlachac, a qualified professional engineer in good standing in the State of Illinois, certify that the information in this report is accurate as of the date of my signature below. The content of this report is not to be used for other than its intended purpose and meaning, or for extrapolations beyond the interpretations contained herein.



Eric J. Tlachac
Qualified Professional Engineer
062-063091
Illinois
O'Brien & Gere Engineers, Inc., a Ramboll Company
Date: July 15, 2019



I, Nicole M. Pagano, a professional geologist in good standing in the State of Illinois, certify that the information in this report is accurate as of the date of my signature below. The content of this report is not to be used for other than its intended purpose and meaning, or for extrapolations beyond the interpretations contained herein.



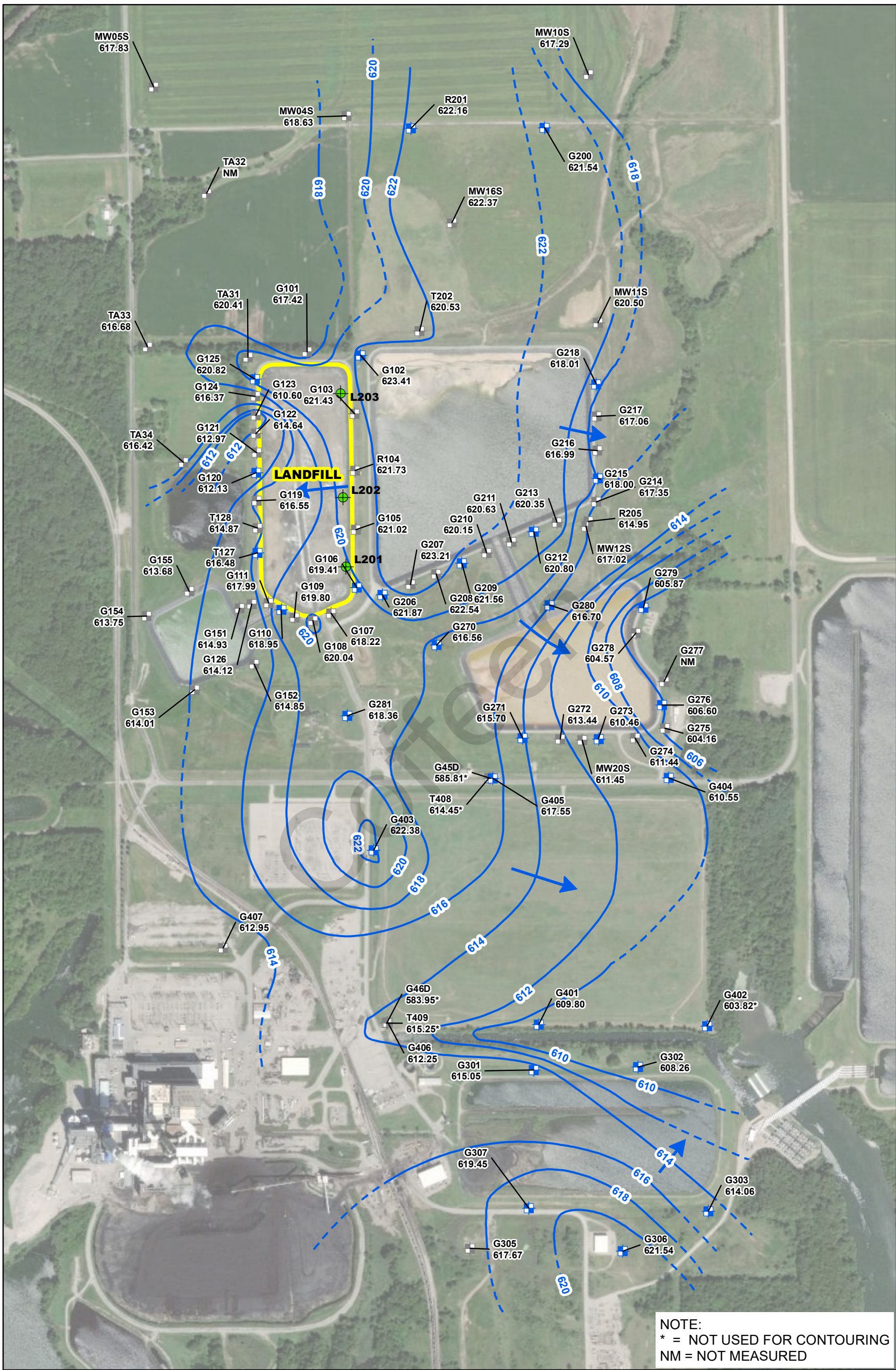
Nicole M. Pagano
Professional Geologist
196-000750
O'Brien & Gere Engineers, Inc., a Ramboll Company
Date: July 15, 2019



Figure

Coffeen

Y:\Mapping\Projects\22\2285\MXD\Alt_Source_Dem\Coffeen\Figure 1_R2018_3Q_Coffeen_GW_Contours.mxd



- CCR RULE MONITORING WELL LOCATION
- NON-CCR RULE MONITORING WELL LOCATION
- LEACHATE WELL LOCATION
- GROUNDWATER ELEVATION CONTOUR (2-FT CONTOUR INTERVAL, NAVD88)
- INFERRED GROUNDWATER ELEVATION CONTOUR
- GROUNDWATER FLOW DIRECTION
- CCR MONITORED UNIT

ALTERNATE SOURCE DEMONSTRATION
COFFEEN POWER STATION
COFFEEN, ILLINOIS

MONITORING WELL AND
LEACHATE LOCATION MAP
COFFEEN LANDFILL



O'BRIEN & GERE ENGINEERS, INC.

Attachment A
**Chloride Trend Analysis,
Monitoring Well G120**

Coffeen

Coffeen
Linear Regression of Conc vs. Time

User Supplied Information

Date Range:	11/16/2015 to 03/31/2019	Option for LT Pts:	x 1.00
Confidence Level:	95.00%	Slope Test:	slope < 0
Compliance Locations:	G120		

<u>Location:</u> G120	<u>B1 Year</u>	<u>Type:</u>	<u>Class:</u>	Based on equation $c = b0 + b1 * t$		
<u>Parameter</u>	<u>Code</u>	<u>Units</u>	<u>Number of Samples</u>	<u>Time Units</u>		
Chloride, total	00940	mg/L	13	year		
<u>Intercept, b0</u>	<u>Slope, b1</u>	<u>R square</u>	<u>Test statistic for slope, Ts</u>	<u>Critical Value, Tcr</u>	<u>P level of test</u>	
19.556	0.66759	0.020	0.4733	-1.7959	0.3226	

Test Results: The test hypothesis of slope (slope < 0) is rejected.

Coffeen
Linear Regression of Conc vs. Time

User Supplied Information

Date Range:	11/16/2015 to 03/31/2019	Option for LT Pts:	x 1.00
Confidence Level:	95.00%	Slope Test:	slope > 0
Compliance Locations:	G120		

<u>Location:</u> G120	<u>B1 Year</u>	<u>Type:</u>	<u>Class:</u>	Based on equation $c = b0 + b1 * t$		
<u>Parameter</u>	<u>Code</u>	<u>Units</u>	<u>Number of Samples</u>	<u>Time Units</u>		
Chloride, total	00940	mg/L	13	year		
<u>Intercept, b0</u>	<u>Slope, b1</u>	<u>R square</u>	<u>Test statistic for slope, Ts</u>	<u>Critical Value, Tcr</u>	<u>P level of test</u>	
19.556	0.66759	0.020	0.4733	1.7959	0.6774	

Test Results: The test hypothesis of slope (slope > 0) is rejected.

Attachment B
Boron Statistical Summary
for Downgradient
Monitoring Wells

Coffeen
Statistical Summary for Multiple Parameters (100)

User Supplied Information

Date Range: 11/16/2015 to 03/31/2019

Option for LT Pts:

x 1.00

Locations:

G106,G110,G120,G125,T127

Parameter

Units

B, tot

mg/L

Location	Class	Count	Mean	Median	Maximum	Minimum	Std Dev	Sen Slope Units/yr	Normal / Log Normal	% of Non-Detects
T127	Compliance	12	0.013	0.010	0.033	0.010	0.007	0.00	No / No	75.00
G125	Compliance	12	0.011	0.010	0.018	0.010	0.002	0.00	No / No	91.67
G120	Compliance	12	0.012	0.010	0.028	0.010	0.005	0.00	No / No	75.00
G110	Compliance	12	0.012	0.010	0.025	0.010	0.005	0.00	No / No	83.33
G106	Compliance	12	0.015	0.010	0.058	0.010	0.014	0.00	No / No	75.00

Attachment C
Mann-Kendall Trend
Analyses

Coffeen

Coffeen
Mann-Kendall Trend Analysis

User Supplied Information

Location ID:	G102	Parameter Code:	00945
Location Class:		Parameter:	SO4, tot
Location Type:		Units:	mg/L
Confidence Level:	95.00%	Period Length:	1 month(s)
Date Range:	11/16/2015 to 03/31/2019	Limit Name:	
		Averaged:	No

Trend Analysis

Trend of the least squares straight line

Slope (fitted to data):	0.030930	mg/L per day
R-Squared error of fit:	0.120877	

Sen's Non-parametric estimate of the slope (One-Sided Test)

Median Slope:	0.043059	mg/L per day
Lower Confidence Limit of Slope, M1:	-0.013577	mg/L per day
Upper Confidence Limit of Slope, M2+1:	0.085995	mg/L per day

Non-parametric Mann-Kendall Test for Trend

S Statistic:	0.968
Z test:	1.645
At the 95.0 % Confidence Level (One-Sided Test):	None

Coffeen
Mann-Kendall Trend Analysis

User Supplied Information

Location ID:	G106	Parameter Code:	00945
Location Class:		Parameter:	SO4, tot
Location Type:		Units:	mg/L
Confidence Level:	95.00%	Period Length:	1 month(s)
Date Range:	11/16/2015 to 03/31/2019	Limit Name:	
		Averaged:	No

Trend Analysis

Trend of the least squares straight line

Slope (fitted to data):	0.022411	mg/L per day
R-Squared error of fit:	0.416921	

Sen's Non-parametric estimate of the slope (One-Sided Test)

Median Slope:	0.019340	mg/L per day
Lower Confidence Limit of Slope, M1:	0.006729	mg/L per day
Upper Confidence Limit of Slope, M2+1:	0.030646	mg/L per day

Non-parametric Mann-Kendall Test for Trend

S Statistic:	2.274
Z test:	1.645
At the 95.0 % Confidence Level (One-Sided Test):	Upward

Coffeen
Mann-Kendall Trend Analysis

User Supplied Information

Location ID:	G110	Parameter Code:	00945
Location Class:		Parameter:	SO4, tot
Location Type:		Units:	mg/L
Confidence Level:	95.00%	Period Length:	1 month(s)
Date Range:	11/16/2015 to 03/31/2019	Limit Name:	
		Averaged:	No

Trend Analysis

Trend of the least squares straight line

Slope (fitted to data):	0.007120	mg/L per day
R-Squared error of fit:	0.603315	

Sen's Non-parametric estimate of the slope (One-Sided Test)

Median Slope:	0.006795	mg/L per day
Lower Confidence Limit of Slope, M1:	0.003395	mg/L per day
Upper Confidence Limit of Slope, M2+1:	0.010829	mg/L per day

Non-parametric Mann-Kendall Test for Trend

S Statistic:	2.439
Z test:	1.645
At the 95.0 % Confidence Level (One-Sided Test):	Upward

Coffeen
Mann-Kendall Trend Analysis

User Supplied Information

Location ID:	G120	Parameter Code:	00945
Location Class:		Parameter:	SO4, tot
Location Type:		Units:	mg/L
Confidence Level:	95.00%	Period Length:	1 month(s)
Date Range:	11/16/2015 to 03/31/2019	Limit Name:	
		Averaged:	No

Trend Analysis

Trend of the least squares straight line

Slope (fitted to data):	-0.006863	mg/L per day
R-Squared error of fit:	0.374294	

Sen's Non-parametric estimate of the slope (One-Sided Test)

Median Slope:	-0.006866	mg/L per day
Lower Confidence Limit of Slope, M1:	-0.014232	mg/L per day
Upper Confidence Limit of Slope, M2+1:	-0.000170	mg/L per day

Non-parametric Mann-Kendall Test for Trend

S Statistic:	-1.869
Z test:	1.645
At the 95.0 % Confidence Level (One-Sided Test):	Downward

Coffeen
Mann-Kendall Trend Analysis

User Supplied Information

Location ID:	G125	Parameter Code:	00945
Location Class:		Parameter:	SO4, tot
Location Type:		Units:	mg/L
Confidence Level:	95.00%	Period Length:	1 month(s)
Date Range:	11/16/2015 to 03/31/2019	Limit Name:	
		Averaged:	No

Trend Analysis

Trend of the least squares straight line

Slope (fitted to data):	0.000947	mg/L per day
R-Squared error of fit:	0.011893	

Sen's Non-parametric estimate of the slope (One-Sided Test)

Median Slope:	0.000512	mg/L per day
Lower Confidence Limit of Slope, M1:	-0.004177	mg/L per day
Upper Confidence Limit of Slope, M2+1:	0.007224	mg/L per day

Non-parametric Mann-Kendall Test for Trend

S Statistic:	0.208
Z test:	1.645
At the 95.0 % Confidence Level (One-Sided Test):	None

Coffeen
Mann-Kendall Trend Analysis

User Supplied Information

Location ID:	G200	Parameter Code:	00945
Location Class:		Parameter:	SO4, tot
Location Type:		Units:	mg/L
Confidence Level:	95.00%	Period Length:	1 month(s)
Date Range:	11/16/2015 to 03/31/2019	Limit Name:	
		Averaged:	No

Trend Analysis

Trend of the least squares straight line

Slope (fitted to data):	0.006122	mg/L per day
R-Squared error of fit:	0.136179	

Sen's Non-parametric estimate of the slope (One-Sided Test)

Median Slope:	0.004235	mg/L per day
Lower Confidence Limit of Slope, M1:	0.000000	mg/L per day
Upper Confidence Limit of Slope, M2+1:	0.017806	mg/L per day

Non-parametric Mann-Kendall Test for Trend

S Statistic:	1.562
Z test:	1.645
At the 95.0 % Confidence Level (One-Sided Test):	None

Coffeen
Mann-Kendall Trend Analysis

User Supplied Information

Location ID:	R201	Parameter Code:	00945
Location Class:		Parameter:	SO4, tot
Location Type:		Units:	mg/L
Confidence Level:	95.00%	Period Length:	1 month(s)
Date Range:	11/16/2015 to 03/31/2019	Limit Name:	
		Averaged:	No

Trend Analysis

Trend of the least squares straight line

Slope (fitted to data):	-0.078691	mg/L per day
R-Squared error of fit:	0.198410	

Sen's Non-parametric estimate of the slope (One-Sided Test)

Median Slope:	-0.077109	mg/L per day
Lower Confidence Limit of Slope, M1:	-0.165212	mg/L per day
Upper Confidence Limit of Slope, M2+1:	0.054952	mg/L per day

Non-parametric Mann-Kendall Test for Trend

S Statistic:	-1.033
Z test:	1.645
At the 95.0 % Confidence Level (One-Sided Test):	None

Coffeen
Mann-Kendall Trend Analysis

User Supplied Information

Location ID:	T127	Parameter Code:	00945
Location Class:		Parameter:	SO4, tot
Location Type:		Units:	mg/L
Confidence Level:	95.00%	Period Length:	1 month(s)
Date Range:	11/16/2015 to 03/31/2019	Limit Name:	
		Averaged:	No

Trend Analysis

Trend of the least squares straight line

Slope (fitted to data):	-0.010521	mg/L per day
R-Squared error of fit:	0.396236	

Sen's Non-parametric estimate of the slope (One-Sided Test)

Median Slope:	-0.008227	mg/L per day
Lower Confidence Limit of Slope, M1:	-0.018395	mg/L per day
Upper Confidence Limit of Slope, M2+1:	0.000000	mg/L per day

Non-parametric Mann-Kendall Test for Trend

S Statistic:	-1.456
Z test:	1.645
At the 95.0 % Confidence Level (One-Sided Test):	None

Attachment D
Coefficient of Variation
Evaluation

Coffeen

Coffeen

Coefficient of Variation
Date Range: 11/10/2015 to 3/31/2019

Sulfate, total (mg/L)

Location	Count	Mean	Std Dev	% Non-Detects	CV
G102	12	92.2	33.6	0.0	0.36
G106	12	62.3	13.1	0.0	0.21
G110	12	81.3	3.5	0.0	0.04
G120	12	38.7	4.2	0.0	0.11
G125	12	68.0	3.3	0.0	0.05
G200	12	101	6.3	0.0	0.06
R201	12	199	67.0	0.0	0.34
T127	12	95.1	6.3	0.0	0.07

CV=Std Dev/ Mean

40 C.F.R. § 257.94(e)(2): ALTERNATE SOURCE DEMONSTRATION
COFFEEN LANDFILL
OCTOBER 14, 2019

Coffeen

October 14, 2019

Title 40 of the Code of Federal Regulations (C.F.R.) § 257.94(e)(2) allows the owner or operator of a Coal Combustion Residuals (CCR) unit 90 days from the date of determination of Statistically Significant Increases (SSIs) over background for groundwater constituents listed in Appendix III of 40 C.F.R. Part 257 to complete a written demonstration that a source other than the CCR unit being monitored caused the SSI(s), or that the SSI(s) resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality (Alternate Source Demonstration [ASD]).

This ASD has been prepared on behalf of Illinois Power Generating Company by O'Brien & Gere Engineers, Inc., part of Ramboll (OBG) to provide pertinent information pursuant to 40 C.F.R. § 257.94(e)(2) for the Coffeen Landfill, located near Coffeen, Illinois.

The fourth semi-annual detection monitoring samples (Detection Monitoring Round 4 [D4]) were collected on January 16-18 and 23, 2019 and analytical data were received on April 15, 2019. In accordance with 40 C.F.R. § 257.93(h)(2), statistical analysis of the data to identify SSIs of 40 C.F.R. Part 257 Appendix III parameters over background concentrations was completed by July 15, 2019, within 90 days of receipt of the analytical data. The statistical determination identified the following SSIs at downgradient monitoring wells:

- Chloride at well G120
- Fluoride at well T127

In accordance with the Statistical Analysis Plan,¹ to confirm the SSIs, wells G120 and T127 were resampled (D4R) on May 3, 2019 and analyzed only for the SSI parameters at each well. Following evaluation of analytical data from D4R, the following SSI was confirmed:

- Fluoride at well T127

Pursuant to 40 C.F.R. § 257.94(e)(2), the following demonstrates that sources other than the Coffeen Landfill were the cause of the SSI listed above. This ASD was completed by October 14, 2019, within 90 days of determination of the SSIs, as required by 40 C.F.R. § 257.94(e)(2).

ALTERNATE SOURCE DEMONSTRATION: LINES OF EVIDENCE

Lines of evidence supporting this ASD include the following:

1. Landfill Design.
2. The ionic composition of landfill leachate is different from the ionic composition of groundwater.
3. Concentrations of boron and sulfate, common indicators for CCR impacts to groundwater, are near or below background concentrations and are stable in the downgradient wells.

These lines of evidence are described and supported in greater detail below. Monitoring well locations, leachate sample locations, and groundwater flow direction are shown on Figure 1.

¹ Natural Resource Technology, an OBG Company, Statistical Analysis Plan, Coffeen Power Station, Newton Power Station, Illinois Power Generating Company, October 17, 2017.

The groundwater elevation contours shown on Figure 1 were measured on January 15, 2019, the first day of a combined sampling event at Coffeen Power Station for the five CCR units located there and for multiple monitoring programs required by both federal and state regulations. As noted above, groundwater sampling for D4 occurred on January 16-18 and 23, 2019.

LINE OF EVIDENCE #1: LANDFILL DESIGN

The Coffeen Landfill was constructed in 2010. The constructed landfill liner includes the following design components:

- A 60-mil high-density polyethylene (HDPE) geomembrane
- Three-foot-thick layer of recompacted, low-permeability soil having a maximum hydraulic conductivity of 1×10^{-7} centimeters per second (cm/s)

The Illinois Environmental Protection Agency (IEPA)-approved Coffeen Landfill liner system exceeds the design criteria for a composite liner for new CCR landfills established by 40 C.F.R. § 257.70.

LINE OF EVIDENCE #2: THE IONIC COMPOSITION OF LANDFILL LEACHATE IS DIFFERENT FROM THE IONIC COMPOSITION OF GROUNDWATER

Piper diagrams graphically represent ionic composition of aqueous solutions. A Piper diagram displays the position of water samples relative to their major cation and anion content, providing the information needed to identify compositional categories or groupings. Figure 2, below, is a Piper diagram that displays the ionic composition of samples from the background and downgradient monitoring wells associated with the Landfill, as well as leachate samples collected during Quarter 2 2015, Quarter 4 2016, and Quarter 3 2017. The ionic compositional groupings identified are shown in the green and black ellipses on the diamond portion of the Piper diagram. These are summarized in Table 1 and discussed in more detail below.

The ionic compositions plotted on the Piper diagrams can be categorized into two distinct groups. Samples of background and downgradient groundwater from the Landfill wells (enclosed within a black ellipse) are tightly clustered, have no dominant cation, and have high percentages of carbonate-bicarbonate anions. The Landfill leachate samples (enclosed within a green ellipse) are compositionally distinct from the groundwater and have moderate to high percentages of sodium-potassium cations and moderate to high percentages of sulfate anions. The differences in ionic composition between the groundwater and leachate indicate that the leachate is not the source of CCR constituents detected in groundwater.

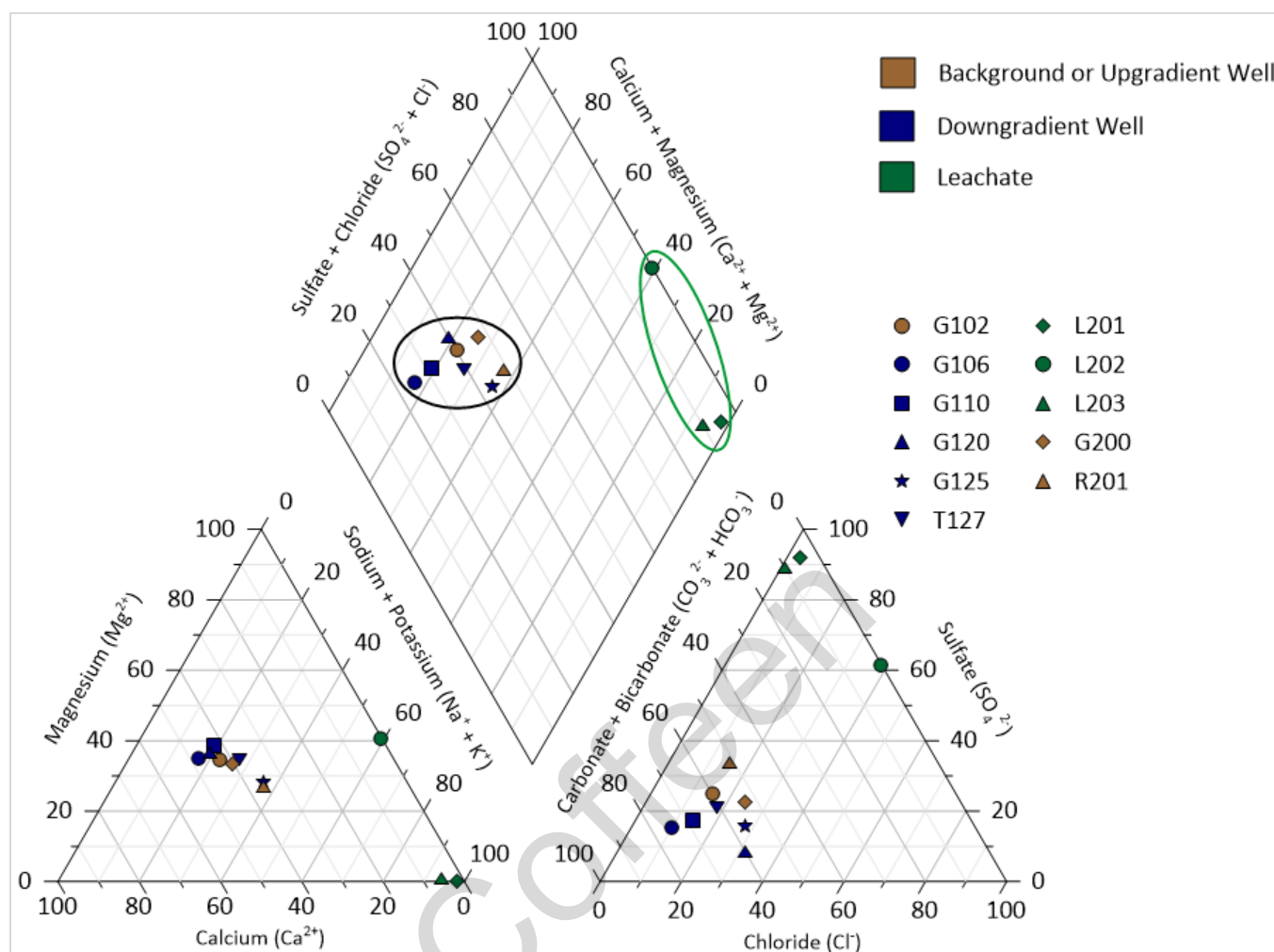


Figure 2. Piper Diagram Showing Ionic Composition of Samples of Background and Downgradient Groundwater and Landfill Leachate.

The ionic characteristics of these samples are provided in Table 1 below:

Grouping	Black	Green
Locations	Landfill Wells Groundwater	Landfill Leachate
Dominant Cation	No dominant cation	Moderate to High Sodium-Potassium
Dominant Anion	High Carbonate-Bicarbonate	Moderate to High Sulfate

Table 1. Summary of Ionic Classification.

LINE OF EVIDENCE #3: CONCENTRATIONS OF BORON AND SULFATE, COMMON INDICATORS FOR CCR IMPACTS TO GROUNDWATER, ARE NEAR OR BELOW BACKGROUND CONCENTRATIONS AND ARE STABLE IN THE DOWNGRADIANT WELLS

Boron and sulfate are common indicators of CCR impacts to groundwater due to their leachability from CCR and mobility in groundwater; however, downgradient concentrations of both are near or below concentrations in background wells as described below.

Boron

Boron concentrations are near or below analytical method reporting limits. As listed in the statistical summary provided in Attachment A (rightmost column), boron was not detected in 75 to 92 percent (%) of the samples at

each downgradient well. Only 12 of 60 downgradient water samples had a detected boron concentration. Boron was not detected in 33 to 67% of the samples at each background well. The background wells have lower percentages of non-detects than the downgradient wells indicating higher boron concentrations at the background wells than at the downgradient wells.

Sulfate

Sulfate concentrations in downgradient wells and background wells are shown on Figure 3. All sulfate concentrations in downgradient wells are below the Upper Prediction Limit (UPL) of 329.4 milligrams per liter (mg/L), determined from concentrations in background monitoring wells G200 and R201. Maximum sulfate concentrations measured in groundwater at each downgradient well between 2015 and 2019 ranged from 47 mg/L to 110 mg/L.

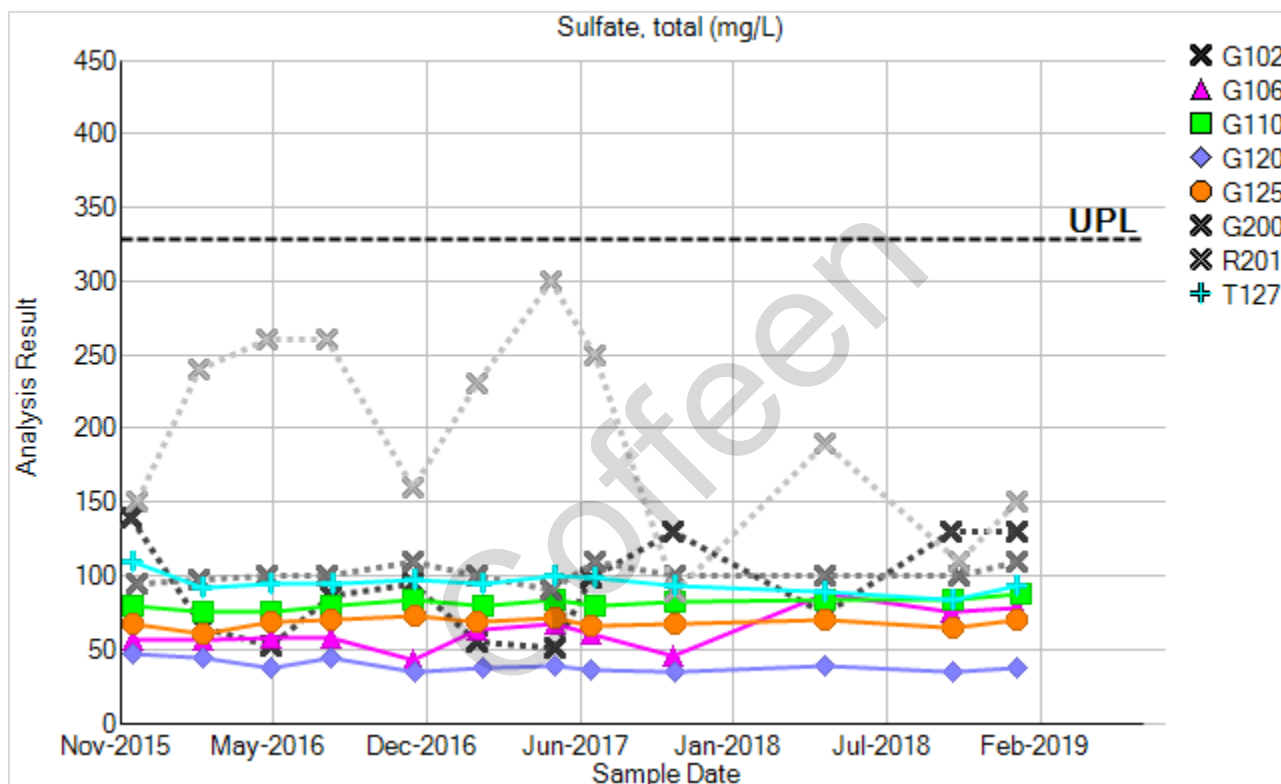


Figure 3. Sulfate Time Series.

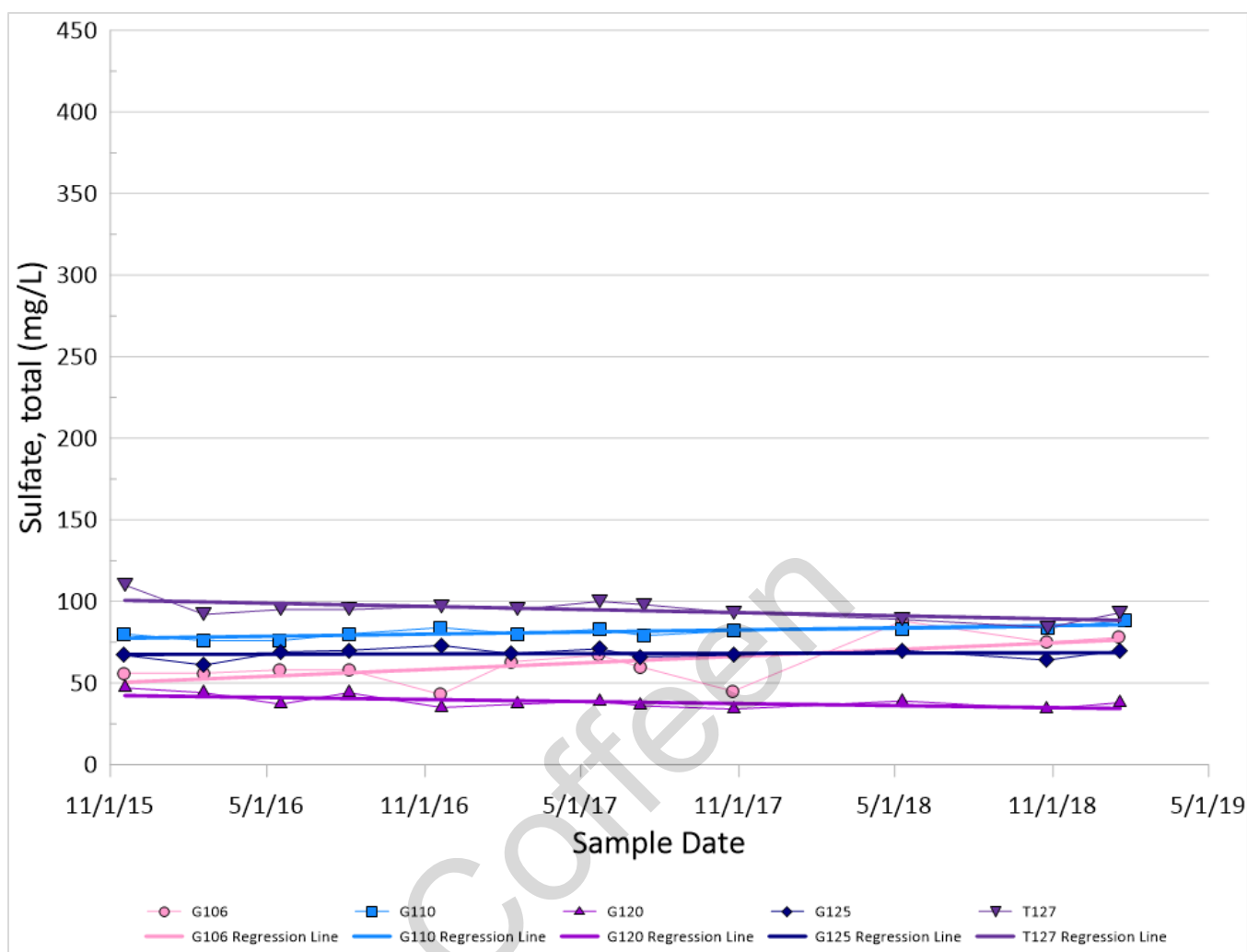


Figure 4. Downgradient Wells Sulfate Trends with Linear Regression Lines.

Sulfate is stable in downgradient wells. Linear regression lines calculated for the data at each monitoring well (straight lines as shown on Figure 4) show that concentrations from 2015 to 2019 have slight upward or downward slopes, meaning that concentrations over time may be slightly increasing or decreasing. Mann-Kendall trend analysis tests were performed (Attachment B) to determine if sulfate concentrations at each well are increasing, decreasing, or stable (i.e., no statistically significant upward or downward trend). If the Mann-Kendall test did not identify a trend, the coefficient of variation (CV) was calculated (Attachment C) to determine if the concentrations are too variable to identify a trend (i.e., CV greater than or equal to 1). If a trend was identified, the CV was calculated to indicate whether data used to establish the trend are suggestive of a low- or high-magnitude trend. Data with a CV less than or equal to 1 suggest a low-magnitude trend.

Sulfate concentrations were stable in background wells G102, G200, and R201, and downgradient wells G125, G200, and T127. A statistically significant downward trend was identified in downgradient well G120. Statistically significant upward trends were identified in downgradient monitoring wells G106 and G110. Although the sulfate trends at G106, G110, and G120 were determined to be significant based on the Mann-Kendall tests, the concentrations demonstrated low variability (CV less than or equal to 1), suggesting low-magnitude trends. Table 2 provides summary statistics, including CV and trend per well.

Monitoring Well	Sulfate (mg/L)					Trend	CV
	Minimum	Maximum	Median	Standard Deviation			
G102	51	140	90.5	33.6		stable	0.36
G106	43	88	59	13.1		upward	0.21
G110	76	88	81	3.5		upward	0.04
G120	34	47	37.5	4.2		downward	0.11
G125	61	73	68.5	3.3		stable	0.05
G200	90	110	100	6.3		stable	0.06
R201	89	300	210	67.0		stable	0.34
T127	84	110	95	6.3		stable	0.07

Table 2. Minimum, Maximum, Median, Standard Deviation, Trend, and Coefficient of Variation of Sulfate in Groundwater.

Concentrations of boron and sulfate near or below background levels, and the relative stability of these concentrations, support the conclusion that the Landfill is not the source of CCR constituents detected in the downgradient groundwater monitoring wells.

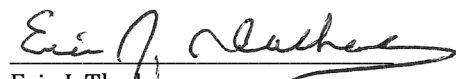
Based on these three lines of evidence, it has been demonstrated that the Coffeen Landfill is not the source of the fluoride SSI in T127.

This information serves as the written ASD prepared in accordance with 40 C.F.R. § 257.94(e)(2) that the SSI observed during D4 was not due to the Landfill. Therefore, an assessment monitoring program is not required and the Coffeen Landfill will remain in detection monitoring.

Attachments

- Figure 1 Monitoring Well and Leachate Location Map
- Attachment A Boron Statistical Summary for Landfill Monitoring Wells
- Attachment B Mann-Kendall Trend Analyses
- Attachment C Coefficient of Variation Evaluation

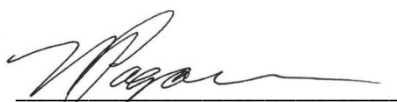
I, Eric J. Tlachac, a qualified professional engineer in good standing in the State of Illinois, certify that the information in this report is accurate as of the date of my signature below. The content of this report is not to be used for other than its intended purpose and meaning, or for extrapolations beyond the interpretations contained herein.



Eric J. Tlachac
Qualified Professional Engineer
062-063091
Illinois
O'Brien & Gere Engineers, Inc., a Ramboll Company
Date: October 14, 2019



I, Nicole M. Pagano, a professional geologist in good standing in the State of Illinois, certify that the information in this report is accurate as of the date of my signature below. The content of this report is not to be used for other than its intended purpose and meaning, or for extrapolations beyond the interpretations contained herein.

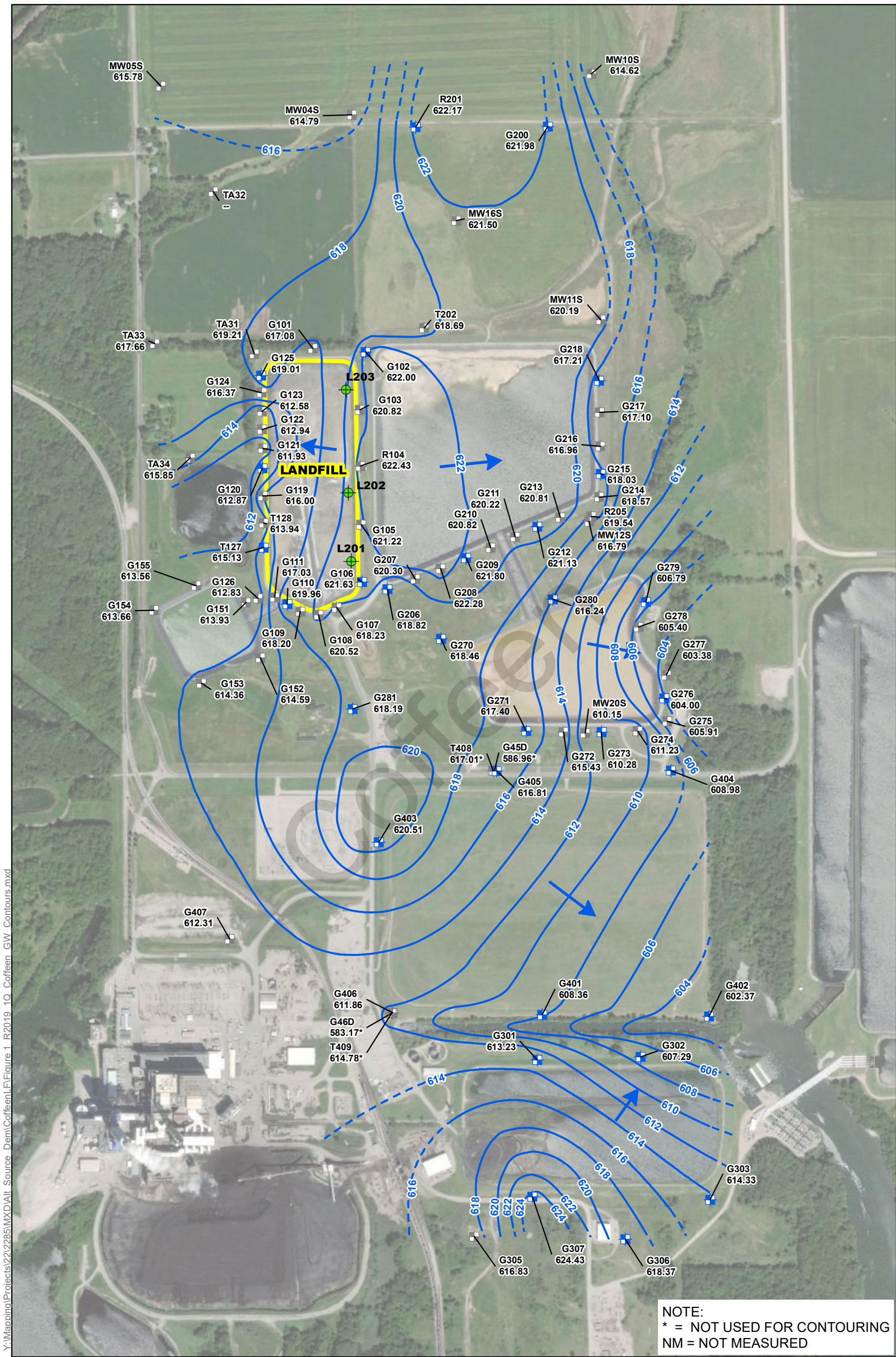


Nicole M. Pagano
Professional Geologist
196-000750
O'Brien & Gere Engineers, Inc., a Ramboll Company
Date: October 14, 2019



Figure

Coffeen

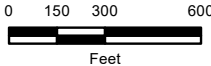


Y:\Mapping\Projects\22\2285\MXD\Alt Source Dem\Coffeen\Figure 1 R2019 1Q Coffeen GW Contours.mxd

- CCR RULE MONITORING WELL LOCATION
- NON-CCR RULE MONITORING WELL LOCATION
- LEACHATE WELL LOCATION
- GROUNDWATER ELEVATION CONTOUR (2-FT CONTOUR INTERVAL, NAVD88)
- INFERRED GROUNDWATER ELEVATION CONTOUR
- GROUNDWATER FLOW DIRECTION
- CCR MONITORED UNIT

ALTERNATE SOURCE DEMONSTRATION
COFFEEN POWER STATION
COFFEEN, ILLINOIS

MONITORING WELL AND
LEACHATE LOCATION MAP
COFFEEN LANDFILL



O'BRIEN & GERE ENGINEERS, INC.

Attachment A
Boron Statistical Summary
for Landfill Monitoring
Wells

Coffeen
Statistical Summary for Multiple Parameters (100)

User Supplied Information

Date Range: 11/16/2015 to 06/30/2019

Option for LT Pts:

x 1.00

Locations: G102,G106,G110,G120,G125,G200,R201,T127

Parameter Units
B, tot mg/L

Location	Class	Count	Mean	Median	Maximum	Minimum	Std Dev	Sen Slope Units/yr	Normal / Log Normal	% of Non-Detects
T127	Compliance	12	0.013	0.010	0.033	0.010	0.007	0.000	No / No	75.00
R201	Compliance	12	0.011	0.010	0.017	0.010	0.002	0.000	No / No	66.67
G200	Compliance	12	0.073	0.010	0.390	0.010	0.137	0.000	No / No	41.67
G125	Compliance	12	0.011	0.010	0.018	0.010	0.002	0.000	No / No	91.67
G120	Compliance	12	0.012	0.010	0.028	0.010	0.005	0.000	No / No	75.00
G110	Compliance	12	0.012	0.010	0.025	0.010	0.005	0.000	No / No	83.33
G106	Compliance	12	0.015	0.010	0.058	0.010	0.014	0.000	No / No	75.00
G102	Compliance	12	0.013	0.014	0.019	0.010	0.003	0.001	No / No	33.33

Attachment B
Mann-Kendall Trend
Analyses

Coffeen

Coffeen
Mann-Kendall Trend Analysis

User Supplied Information

Location ID:	G102	Parameter Code:	00945
Location Class:		Parameter:	SO4, tot
Location Type:		Units:	mg/L
Confidence Level:	95.00%	Period Length:	1 month(s)
Date Range:	11/16/2015 to 06/30/2019	Limit Name:	
		Averaged:	No

Trend Analysis

Trend of the least squares straight line

Slope (fitted to data):	0.030930	mg/L per day
R-Squared error of fit:	0.120877	

Sen's Non-parametric estimate of the slope (One-Sided Test)

Median Slope:	0.043059	mg/L per day
Lower Confidence Limit of Slope, M1:	-0.013577	mg/L per day
Upper Confidence Limit of Slope, M2+1:	0.085995	mg/L per day

Non-parametric Mann-Kendall Test for Trend

S Statistic:	0.968
Z test:	1.645
At the 95.0 % Confidence Level (One-Sided Test):	None

Coffeen
Mann-Kendall Trend Analysis

User Supplied Information

Location ID:	G106	Parameter Code:	00945
Location Class:		Parameter:	SO4, tot
Location Type:		Units:	mg/L
Confidence Level:	95.00%	Period Length:	1 month(s)
Date Range:	11/16/2015 to 06/30/2019	Limit Name:	
		Averaged:	No

Trend Analysis

Trend of the least squares straight line

Slope (fitted to data):	0.022411	mg/L per day
R-Squared error of fit:	0.416921	

Sen's Non-parametric estimate of the slope (One-Sided Test)

Median Slope:	0.019340	mg/L per day
Lower Confidence Limit of Slope, M1:	0.006729	mg/L per day
Upper Confidence Limit of Slope, M2+1:	0.030646	mg/L per day

Non-parametric Mann-Kendall Test for Trend

S Statistic:	2.274
Z test:	1.645
At the 95.0 % Confidence Level (One-Sided Test):	Upward

Coffeen
Mann-Kendall Trend Analysis

User Supplied Information

Location ID:	G110	Parameter Code:	00945
Location Class:		Parameter:	SO4, tot
Location Type:		Units:	mg/L
Confidence Level:	95.00%	Period Length:	1 month(s)
Date Range:	11/16/2015 to 06/30/2019	Limit Name:	
		Averaged:	No

Trend Analysis

Trend of the least squares straight line

Slope (fitted to data):	0.007120	mg/L per day
R-Squared error of fit:	0.603315	

Sen's Non-parametric estimate of the slope (One-Sided Test)

Median Slope:	0.006795	mg/L per day
Lower Confidence Limit of Slope, M1:	0.003395	mg/L per day
Upper Confidence Limit of Slope, M2+1:	0.010829	mg/L per day

Non-parametric Mann-Kendall Test for Trend

S Statistic:	2.439
Z test:	1.645
At the 95.0 % Confidence Level (One-Sided Test):	Upward

Coffeen
Mann-Kendall Trend Analysis

User Supplied Information

Location ID:	G120	Parameter Code:	00945
Location Class:		Parameter:	SO4, tot
Location Type:		Units:	mg/L
Confidence Level:	95.00%	Period Length:	1 month(s)
Date Range:	11/16/2015 to 06/30/2019	Limit Name:	
		Averaged:	No

Trend Analysis

Trend of the least squares straight line

Slope (fitted to data):	-0.006863	mg/L per day
R-Squared error of fit:	0.374294	

Sen's Non-parametric estimate of the slope (One-Sided Test)

Median Slope:	-0.006866	mg/L per day
Lower Confidence Limit of Slope, M1:	-0.014232	mg/L per day
Upper Confidence Limit of Slope, M2+1:	-0.000170	mg/L per day

Non-parametric Mann-Kendall Test for Trend

S Statistic:	-1.869
Z test:	1.645
At the 95.0 % Confidence Level (One-Sided Test):	Downward

Coffeen
Mann-Kendall Trend Analysis

User Supplied Information

Location ID:	G125	Parameter Code:	00945
Location Class:		Parameter:	SO4, tot
Location Type:		Units:	mg/L
Confidence Level:	95.00%	Period Length:	1 month(s)
Date Range:	11/16/2015 to 06/30/2019	Limit Name:	
		Averaged:	No

Trend Analysis

Trend of the least squares straight line

Slope (fitted to data):	0.000947	mg/L per day
R-Squared error of fit:	0.011893	

Sen's Non-parametric estimate of the slope (One-Sided Test)

Median Slope:	0.000512	mg/L per day
Lower Confidence Limit of Slope, M1:	-0.004177	mg/L per day
Upper Confidence Limit of Slope, M2+1:	0.007224	mg/L per day

Non-parametric Mann-Kendall Test for Trend

S Statistic:	0.208
Z test:	1.645
At the 95.0 % Confidence Level (One-Sided Test):	None

Coffeen
Mann-Kendall Trend Analysis

User Supplied Information

Location ID:	G200	Parameter Code:	00945
Location Class:		Parameter:	SO4, tot
Location Type:		Units:	mg/L
Confidence Level:	95.00%	Period Length:	1 month(s)
Date Range:	11/16/2015 to 06/30/2019	Limit Name:	
		Averaged:	No

Trend Analysis

Trend of the least squares straight line

Slope (fitted to data):	0.006122	mg/L per day
R-Squared error of fit:	0.136179	

Sen's Non-parametric estimate of the slope (One-Sided Test)

Median Slope:	0.004235	mg/L per day
Lower Confidence Limit of Slope, M1:	0.000000	mg/L per day
Upper Confidence Limit of Slope, M2+1:	0.017806	mg/L per day

Non-parametric Mann-Kendall Test for Trend

S Statistic:	1.562
Z test:	1.645
At the 95.0 % Confidence Level (One-Sided Test):	None

Coffeen
Mann-Kendall Trend Analysis

User Supplied Information

Location ID:	R201	Parameter Code:	00945
Location Class:		Parameter:	SO4, tot
Location Type:		Units:	mg/L
Confidence Level:	95.00%	Period Length:	1 month(s)
Date Range:	11/16/2015 to 06/30/2019	Limit Name:	
		Averaged:	No

Trend Analysis

Trend of the least squares straight line

Slope (fitted to data):	-0.078691	mg/L per day
R-Squared error of fit:	0.198410	

Sen's Non-parametric estimate of the slope (One-Sided Test)

Median Slope:	-0.077109	mg/L per day
Lower Confidence Limit of Slope, M1:	-0.165212	mg/L per day
Upper Confidence Limit of Slope, M2+1:	0.054952	mg/L per day

Non-parametric Mann-Kendall Test for Trend

S Statistic:	-1.033
Z test:	1.645
At the 95.0 % Confidence Level (One-Sided Test):	None

Coffeen
Mann-Kendall Trend Analysis

User Supplied Information

Location ID:	T127	Parameter Code:	00945
Location Class:		Parameter:	SO4, tot
Location Type:		Units:	mg/L
Confidence Level:	95.00%	Period Length:	1 month(s)
Date Range:	11/16/2015 to 06/30/2019	Limit Name:	
		Averaged:	No

Trend Analysis

Trend of the least squares straight line

Slope (fitted to data):	-0.010521	mg/L per day
R-Squared error of fit:	0.396236	

Sen's Non-parametric estimate of the slope (One-Sided Test)

Median Slope:	-0.008227	mg/L per day
Lower Confidence Limit of Slope, M1:	-0.018395	mg/L per day
Upper Confidence Limit of Slope, M2+1:	0.000000	mg/L per day

Non-parametric Mann-Kendall Test for Trend

S Statistic:	-1.456
Z test:	1.645
At the 95.0 % Confidence Level (One-Sided Test):	None

Attachment C
Coefficient of Variation
Evaluation

Coffeen

Coffeen

Coefficient of Variation
Date Range: 11/10/2015 to 6/30/2019

Sulfate, total (mg/L)

Location	Count	Mean	Std Dev	% Non-Detects	CV
G102	12	92.2	33.6	0.0	0.36
G106	12	62.3	13.1	0.0	0.21
G110	12	81.3	3.5	0.0	0.04
G120	12	38.7	4.2	0.0	0.11
G125	12	68.0	3.3	0.0	0.05
G200	12	101	6.3	0.0	0.06
R201	12	199	67.0	0.0	0.34
T127	12	95.1	6.3	0.0	0.07

CV=Std Dev/ Mean