



REPORT

Annual Groundwater Monitoring Report – 2019

*Active Coal Combustion Residuals Landfill
Escalante Generating Station,
Prewitt, New Mexico*

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Executive Summary

This report summarizes the groundwater monitoring activities and results for the 2019 detection monitoring program for the active coal combustion residuals (CCR) landfill at Escalante Generating Station, along with the comparative statistical analysis. The CCR landfill, which is owned and operated by Tri-State Generation and Transmission Association, Inc., is currently in detection monitoring, and no program transitions occurred in 2019.

Four verified statistically significant increases (SSIs) were identified in 2019. These include field pH at TRcpc-17, chloride at TRcpc-16, sulfate at TRcpc-18, and fluoride at TRcpc-16. Demonstrations of natural variability were prepared for each of these SSIs, and it was recommended that the landfill remain in detection monitoring. Four potential exceedances were identified for the November 2019 sampling event. These include field pH at TRcpc-1, TRcpc-15, and TRcpc-16 and total recoverable boron at TRcpc-1. A confirmatory resampling event for these potential exceedances is scheduled to occur within 90 days of the SSI determination, during the first quarter of 2020. As described in the Groundwater Monitoring System Certification (Golder 2017a) and the Groundwater Monitoring Statistical Methods Certification (Golder 2017b), the groundwater monitoring and analytical procedures meet the requirements of 40 CFR 257 (the Coal Combustion Residuals Rule), and modifications to the monitoring network and sampling program are not recommended at this time.

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1.0 INTRODUCTION

Golder Associates Inc. (Golder) has prepared this report to describe the 2019 groundwater monitoring activities and comparative statistical analysis for the active coal combustion residuals (CCR) landfill (the Facility) at Escalante Generating Station (the site), which is owned and operated by Tri-State Generation and Transmission Association, Inc. (Tri-State). This report was written to meet the requirements of 40 CFR 257.90(e).

1.1 Facility Information

Escalante Generating Station is a 270-megawatt coal-fired electric generation facility located near Prewitt, New Mexico. The active CCR landfill at the site contains fly ash, bottom ash, and flue gas desulfurization solids (scrubber solids).

1.2 Purpose

The CCR Rule established specific requirements for reporting of groundwater monitoring and corrective action in 40 CFR 257.90. Per part (e) of 40 CFR 257.90, no later than January 31, 2018, and annually thereafter, owners or operators of CCR units must prepare an annual groundwater monitoring and corrective action report.

2.0 GROUNDWATER MONITORING NETWORK PROGRAM STATUS

The groundwater monitoring system for the active CCR landfill at Escalante Generating Station consists of six monitoring wells, as shown on Figure 1. The two upgradient monitoring wells are TRcpc-1 and TRcpc-2. The four downgradient monitoring wells are TRcpc-15, TRcpc-16, TRcpc-17, and TRcpc-18 (Golder 2017a).

2.1 Completed Key Actions in 2019

The following key actions were completed in 2019:

- The 2018 Annual Groundwater Monitoring Report was finalized and placed within the operating record and on Tri-State's publicly accessible CCR website.
- The fourth and fifth detection monitoring sampling events were performed on April 9, 2019, and November 4 and 5, 2019, respectively.
- Demonstrations of natural variability were prepared as a result of verified statistically significant increases (SSIs) for field pH at TRcpc-17, chloride at TRcpc-16, sulfate at TRcpc-18, and fluoride at TRcpc-16 (refer to Appendix A through Appendix C). Each of these recommended that the Facility remain in detection monitoring.

2.2 Installation and Decommissioning of Monitoring Wells

No monitoring wells were installed or decommissioned for the active CCR landfill at Escalante Generating Station in 2019.

2.3 Problems and Resolutions

The following problems were experienced during the 2019 sampling events:

- Samples were not collected at TRcpc-17 during the April 2019 sampling event due to a pump malfunction. Samples for the first half of 2019 were instead collected from TRcpc-17 on June 25, 2019.

- Difficulty in field meter calibration for pH was noted in the November 2019 sampling event. The manufacturer of the field meter will be contacted in the first quarter of 2020 to provide guidance on potential impacts to pH measurements obtained during the November 2019 sampling event.

2.4 Proposed Key Activities for 2020

The following key actions are expected to be completed in 2020:

- Confirmatory resampling for potential exceedances¹ described in Section 3.4.2 is planned to be conducted in the first quarter of 2020.
- Detection monitoring sampling events are planned to occur in the second and fourth quarters of 2020.

3.0 GROUNDWATER MONITORING PROGRAM STATUS

Activities associated with the groundwater monitoring program are described below.

3.1 Groundwater Flow

The groundwater elevation was measured in each well prior to purging during each sampling event. Elevations are presented in Table 1 through Table 6. Groundwater elevations from the April 2019 and November 2019 sampling events are shown on Figure 1 and Figure 2, respectively.

Based on the April 2019 and November 2019 groundwater elevations, the groundwater in the Correo Sandstone generally flows east with a localized northerly flow component under the active CCR landfill.

The groundwater flow rate was estimated with the equation $V_s = k \times i/n_e$, where:

- V_s is the groundwater flow rate, in feet per day (ft/day);
- k is the hydraulic conductivity estimated from site pumping test data, in ft/day;
- i is the hydraulic gradient calculated based on groundwater elevations between TRcpc-1 and TRcpc-16, in feet per foot (ft/ft);
- n_e is the effective porosity, estimated to be 0.33 based on historical testing results for samples of Correo Sandstone obtained on site.

Groundwater flow velocity estimates range from 0.00004 ft/day to 0.19 ft/day for the April 2019 and November 2019 sampling events.

3.2 Monitoring Data (Analytical Results)

Analytical results for detection monitoring in 2019 are shown in Table 1 through Table 6.

3.3 Samples Collected

The fourth and fifth detection monitoring sampling events were conducted in April and November of 2019 for TRcpc-1, TRcpc-2, TRcpc-15, TRcpc-16, and TRcpc-18 and in June and November 2019 for TRcpc-17. Additionally, samples were collected from wells TRcpc-1, TRcpc-2, TRcpc-16, TRcpc-17, and TRcpc-18 on

¹ The term "unverified statistically significant increase" was used in previous annual groundwater monitoring reports for the Facility.

February 28, 2019; from well TRcpc-16 on June 25, 2019; and from well TRcpc-15 on July 1, 2019 for confirmatory resampling associated with the detection monitoring program.

3.4 Comparative Statistical Analysis

The comparative statistical analysis is summarized below, and the results are presented in Table 7 through Table 12. A full description of the steps taken for the comparative statistical analysis can be found in the Groundwater Monitoring Statistical Methods Certification (Golder 2017b).

3.4.1 Definitions

The following definitions are used in discussion of the comparative statistical analysis:

- SSI – is a statistically significant increase (SSI) and is defined as an analytical result that exceeds the parametric or non-parametric statistical limit established by the baseline statistical analysis.
- Potential Exceedance – is defined as an initial analytical result that exceeds the parametric or non-parametric statistical limit established by the baseline statistical analysis. Confirmatory resampling will determine if the potential exceedance is a false-positive or a verified statistically significant increase (SSI).
- False-positive SSI – is defined as an analytical result that exceeds the statistical limit but can clearly be attributed to laboratory error or changes in analytical precision or is invalidated through confirmatory resampling.
- Confirmatory resampling – is designated as the resampling event that occurs within 90 days of identifying an SSI over the statistical limit for determination of a verified SSI².
- Verified SSI – is interpreted as two consecutive SSIs (the original sample and the confirmatory resample for analytical results) for the same constituent at the same well.

3.4.2 Potential Exceedances

Four potential exceedances were identified for the November 2019 sampling event. These include field pH at TRcpc-1, TRcpc-15, and TRcpc-16 and total recoverable boron at TRcpc-1.

Per the Groundwater Monitoring Statistical Methods Certification (Golder 2017b), a confirmatory resampling event for these potential exceedances is scheduled to occur within 90 days of the SSI determination, during the first quarter of 2020.

3.4.3 False-positive Statistically Significant Increases

Confirmatory resampling for potential exceedances associated with the October 2018 sampling event occurred in February 2019. The resampling event identified three false positives associated with the October 2018 sampling event. These include field pH at TRcpc-1 and TRcpc-2 and total dissolved solids at TRcpc-1. No further action is needed.

² Resampling may not occur within 90 days of the sampling event that resulted in the potential exceedance because of the additional time required for activities that must occur before a potential exceedance can be identified. These include sample delivery, analytical testing, review of results, and comparative statistical analysis.

Confirmatory resampling for potential exceedances associated with the April 2019 sampling event occurred in July 2019. The resampling event identified one false positive associated with the April 2019 sampling event for field pH at TRcpc-15. No further action is needed.

3.4.4 Verified Statistically Significant Increases

Total recoverable calcium results for samples collected from TRcpc-18 during both 2019 detection monitoring events indicate verified SSIs. The initial exceedance for TRcpc-18 total recoverable calcium occurred during the August 2017 sampling event and was verified with confirmatory resampling conducted in January 2018. In April 2018³, a demonstration of natural variability was prepared for total recoverable calcium in TRcpc-18, and it was recommended that the Facility remain in detection monitoring (Golder 2019). The April 2018 ASD indicating that the calcium results reflect natural variability is applicable to the April 2019 and November 2019 results, and it is recommended that the Facility remain in detection monitoring.

Field pH measurements for samples collected from TRcpc-17 during both 2019 detection monitoring events indicate verified SSIs. TRcpc-17 field pH was initially identified as being below the lower statistical limit during the October 2018 sampling event and was verified with confirmatory resampling conducted in February 2019. In May 2019, a demonstration of natural variability was prepared for field pH in TRcpc-17, and it was recommended that the Facility remain in detection monitoring (Appendix A). The May 2019 ASD indicating that the field pH results reflect natural variability is applicable to the April 2019 and November 2019 results, and it is recommended that the Facility remain in detection monitoring.

The chloride result for the sample collected from TRcpc-16 during the October 2018 detection monitoring event indicates a verified SSI. The initial exceedance for TRcpc-16 chloride occurred during the October 2018 sampling event and was verified with confirmatory resampling conducted in February 2019. In June 2019, a demonstration of natural variability was prepared for chloride in TRcpc-16, and it was recommended that the Facility remain in detection monitoring (Appendix B). During the April 2019 and November 2019 detection monitoring sampling events, the chloride results did not exceed the statistical limit.

Sulfate results for samples collected from TRcpc-18 during the October 2018 and April 2019 detection monitoring events indicate verified SSIs. The initial exceedance for TRcpc-18 sulfate occurred during the October 2018 sampling event and was verified with confirmatory resampling conducted in February 2019. In June 2019, a demonstration of natural variability was prepared for sulfate in TRcpc-18, and it was recommended that the Facility remain in detection monitoring (Appendix B). The June 2019 ASD indicating that the sulfate results reflect natural variability is applicable to the April 2019 result, and it is recommended that the Facility remain in detection monitoring. During the November 2019 detection monitoring sampling event, the sulfate result did not exceed the statistical limit.

The fluoride result for the sample collected from TRcpc-16 during the April 2019 detection monitoring event indicates a verified SSI. The initial exceedance for TRcpc-16 fluoride occurred during the April 2019 sampling event and was verified with confirmatory resampling conducted in June 2019. In October 2019, a demonstration of natural variability was prepared for fluoride in TRcpc-16, and it was recommended that the Facility remain in

³ Under 40 CFR 257.94(e)(2) these demonstrations should occur within 90 days of identifying the verified SSI. The demonstrations may not occur within 90 days of the confirmatory resample event that resulted in the verified SSI because of the additional time required for activities that must occur before a verified SSI can be identified. These include sample delivery, analytical testing, review of results, and comparative statistical analysis.

detection monitoring (Appendix C). During the November 2019 detection monitoring sampling event, fluoride did not exceed the statistical limit.

4.0 PROGRAM TRANSITIONS

In the third quarter of 2017, the groundwater monitoring program for the active CCR landfill at Escalante Generating Station transitioned from the baseline period to detection monitoring. The Facility is currently in detection monitoring, and no program transitions occurred in 2019.

4.1 Detection Monitoring

Samples for the detection monitoring program are collected on a semi-annual basis, beginning with the sample collected in August 2017. Tri-State plans to collect semi-annual samples for the detection monitoring program in the second and fourth quarters of 2020. In 2019, demonstrations of natural variability were prepared for field pH in TRcpc-17 (Appendix A), chloride in TRcpc-16 (Appendix B), sulfate in TRcpc-18 (Appendix B), and fluoride in TRcpc-16 (Appendix C).

4.2 Assessment Monitoring

The groundwater monitoring program for the active CCR landfill at Escalante Generating Station is not in assessment monitoring. Assessment monitoring has not been triggered as described in 40 CFR 257.95. As such, no alternative source demonstrations have been made under an assessment monitoring program and no actions are required.

4.3 Corrective Measures and Assessment

The groundwater monitoring program for the active CCR landfill at Escalante Generating Station does not indicate the need for corrective measures. An assessment of corrective measures, as described in 40 CFR 257.96, is not required.

5.0 RECOMMENDATIONS AND CLOSING

This report presents the groundwater monitoring activities and results for the 2019 detection monitoring program for the active CCR landfill at Escalante Generating Station, along with the comparative statistical analysis. The significant findings from the 2019 monitoring activities and comparative statistical analysis are as follows:

- Four potential exceedances were identified based on the results of the November 2019 detection monitoring sampling event, and confirmatory resampling is scheduled for the first quarter of 2020.
- Confirmatory resampling in February 2019 identified three false-positive SSIs associated with the October 2018 sampling event.
- Confirmatory resampling in July 2019 identified one false-positive SSI associated with the April 2019 sampling event.
- A demonstration of natural variability was prepared for chloride in TRcpc-16 in June 2019. No verified SSIs were identified for chloride in TRcpc-16 in 2019.
- Six verified SSIs were identified during the 2019 detection monitoring program. A demonstration of natural variability was prepared or found to be applicable for each, and it is recommended that the Facility remain in detection monitoring. No further actions are required. The verified SSIs are as follows:

- Total recoverable calcium in TRcpc-18: April and November 2019
- Field pH in TRcpc-17: June and November 2019
- Sulfate in TRcpc-18: April 2019
- Fluoride in TRcpc-16: April 2019

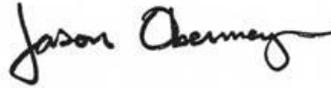
As described in the Groundwater Monitoring System Certification (Golder 2017a) and the Groundwater Monitoring Statistical Methods Certification (Golder 2017b), the groundwater monitoring and analytical procedures meet the requirements of the CCR Rule, and modifications to the monitoring network and sampling program are not recommended at this time.

Signature Page

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6.0 REFERENCES

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Golder Associates Inc. (Golder). 2017b. Active Coal Combustion Residuals Landfill Groundwater Statistical Method Certification, Escalante Generating Station. Report prepared for Tri-State Generation and Transmission Association, Inc. October 13.

Golder Associates Inc. (Golder). 2019. Active Coal Combustions Residuals Landfill Annual Groundwater Monitoring Report – 2018, Escalante Generating Stations, Prewitt, New Mexico. Report prepared for Tri-State Generation and Transmission Association, Inc. January 29.

Tables

Table 1. Sample Results Summary Table – TRcpc-1

Analytes	Units	Confirmatory Resample (2/28/2019)	Compliance Point (4/9/2019)	Compliance Point (11/4/2019)
Static Water Elevation	ft amsl	6862.6	6861.8	6861.6
Appendix III				
Boron, Total Recoverable	mg/L	--	1.6	1.7
Calcium, Total Recoverable	mg/L	--	12	13
Chloride	mg/L	--	660	600
Fluoride	mg/L	--	1.7	< 5.0
pH, Field-Measured	pH units	8.8	8.3	10.1
Sulfate	mg/L	--	840	800
Total Dissolved Solids	mg/L	2600 B	2600 H	2600

NOTES:

ft amsl: feet above mean sea level

mg/L: milligrams per liter

Non-detects are reported as less than the reporting limit

B: Analyte detected in the laboratory quality control blank and the sample

H: Analyte analyzed outside of hold time

Table 2. Sample Results Summary Table – TRcpc-2

Analytes	Units	Confirmatory Resample (2/28/2019)	Compliance Point (4/9/2019)	Compliance Point (11/5/2019)
Static Water Elevation	ft amsl	6852.5	6852.6	6852.7
Appendix III				
Boron, Total Recoverable	mg/L	--	1.6	1.6
Calcium, Total Recoverable	mg/L	--	15	15
Chloride	mg/L	--	1200	1100
Fluoride	mg/L	--	1.9	1.8 J
pH, Field-Measured	pH units	8.4	8.2	8.2
Sulfate	mg/L	--	570	490
Total Dissolved Solids	mg/L	--	2800 H	2800

NOTES:

ft amsl: feet above mean sea level

mg/L: milligrams per liter

J: Analyte detected at a concentration between the method detection limit and the reporting limit, and the concentration is an approximate value

H: Analyte analyzed outside of hold time

Table 3. Sample Results Summary Table – TRcpc-15

Analytes	Units	Compliance Point (4/9/2019)	Confirmatory Resample (7/1/2019)	Compliance Point (11/4/2019)
Static Water Elevation	ft amsl	6829.8	--	6829.7
Appendix III				
Boron, Total Recoverable	mg/L	1.4	--	1.4
Calcium, Total Recoverable	mg/L	7.0	--	6.7
Chloride	mg/L	580	--	540
Fluoride	mg/L	2.9	--	2.7 J
pH, Field-Measured	pH units	8.2	8.5	9.9
Sulfate	mg/L	250	--	230
Total Dissolved Solids	mg/L	1600 H	--	1600

NOTES:

ft amsl: feet above mean sea level

mg/L: milligrams per liter

J: Analyte detected at a concentration between the method detection limit and the reporting limit, and the concentration is an approximate value

H: Analyte analyzed outside of hold time

Table 4. Sample Results Summary Table – TRcpc-16

Analytes	Units	Confirmatory Resample (2/28/2019)	Compliance Point (4/9/2019)	Confirmatory Resample (6/25/2019)	Compliance Point (11/5/2019)
Static Water Elevation	ft amsl	6829.0	6829.0	---	6828.9
Appendix III					
Boron, Total Recoverable	mg/L	--	1.5	--	1.5
Calcium, Total Recoverable	mg/L	--	5.1	--	5.2
Chloride	mg/L	540	480	--	450 E
Fluoride	mg/L	--	3.7	3.8	2.9
pH, Field-Measured	pH units	--	8.3	--	8.2
Sulfate	mg/L	--	240	--	230 E
Total Dissolved Solids	mg/L	--	1500 H	--	1400

NOTES:

ft amsl: feet above mean sea level

H: Analyte analyzed outside of hold time

E: Results exceed calibration range, and a retest conducted outside of hold time confirmed the result

Table 5. Sample Results Summary Table – TRcpc-17

Analytes	Units	Confirmatory Resample (2/28/2019)	Compliance Point (6/25/2019)	Compliance Point (11/5/2019)
Static Water Elevation	ft amsl	6831.8	6831.1	6831.8
Appendix III				
Boron, Total Recoverable	mg/L	--	1.4	1.4
Calcium, Total Recoverable	mg/L	--	19	18
Chloride	mg/L	--	1500 H	1500
Fluoride	mg/L	--	1.9 H	1.9
pH, Field-Measured	pH units	8.4	8.5	8.2
Sulfate	mg/L	--	290 H	310
Total Dissolved Solids	mg/L	--	3200	3200

NOTES:

ft amsl: feet above mean sea level

mg/L: milligrams per liter

H: Analyte analyzed outside of hold time

Table 6. Sample Results Summary Table – TRcpc-18

Analytes	Units	Confirmatory Resample (2/28/2019)	Compliance Point (4/9/2019)	Compliance Point (11/5/2019)
Static Water Elevation	ft amsl	6842.4	6843.0	6842.3
Appendix III				
Boron, Total Recoverable	mg/L	--	0.88	0.86
Calcium, Total Recoverable	mg/L	--	4.6	4.4
Chloride	mg/L	--	360	340
Fluoride	mg/L	--	1.8	1.3 J
pH, Field-Measured	pH units	--	10.3	10.3
Sulfate	mg/L	240	240	210
Total Dissolved Solids	mg/L	--	1200 H	1200

NOTES:

ft amsl: feet above mean sea level

mg/L: milligrams per liter

J: Analyte detected at a concentration between the method detection limit and the reporting limit, and the concentration is an approximate value

H: Analyte analyzed outside of hold time

Table 7. Statistics Summary Table – TRcpc-1

Analytes	Units	Selected Statistical Method	Statistical Limit	October 2018			April 2019		November 2019	
				Compliance Point (10/29/2018)	Confirmatory Resample (2/28/2019)	SSI Determination	Compliance Point (4/9/2019)	SSI Determination	Compliance Point (11/4/2019)	SSI Determination
Appendix III										
Boron, Total Recoverable	mg/L	NP-PL	1.6	1.4	--	No	1.6	No	1.7	Potential Exceedance ¹
Calcium, Total Recoverable	mg/L	NP-PL	13	12	--	No	12	No	13	No
Chloride	mg/L	NP-PL	660	650	--	No	660	No	600	No
Fluoride	mg/L	NP-PL	1.8	1.6	--	No	1.7	No	< 5.0	No ²
pH, Field-Measured	pH units	NP-PL	8.3, 9.1	7.7	8.8	False Positive	8.3	No	10.1	Potential Exceedance ¹
Sulfate	mg/L	NP-PL	910	860 B	--	No	840	No	800	No
Total Dissolved Solids	mg/L	NP-PL	2600	3200	2600 B	False Positive	2600 H	No	2600	No

NOTES:

NP-PL: Non-parametric Prediction Limit

mg/L: milligrams per liter

Non-detects are reported as less than the reporting limit

B: Analyte detected in the laboratory quality control blank and the sample

H: Analyte analyzed outside of hold time

1. Confirmatory resampling is scheduled for the first quarter of 2020.

2. Result is not considered an SSI because it is a non-detect with a method detection limit of 1.7 mg/L, which is below the statistical limit.

Table 8. Statistics Summary Table – TRcpc-2

Analytes	Units	Selected Statistical Method	Statistical Limit	October 2018			April 2019		November 2019	
				Compliance Point (10/30/2018)	Confirmatory Resample (2/28/2019)	SSI Determination	Compliance Point (4/9/2019)	SSI Determination	Compliance Point (11/5/2019)	SSI Determination
Appendix III										
Boron, Total Recoverable	mg/L	P-PL	1.7	1.4	--	No	1.6	No	1.6	No
Calcium, Total Recoverable	mg/L	NP-PL	15	14	--	No	15	No	15	No
Chloride	mg/L	NP-PL	1200	1200	--	No	1200	No	1100	No
Fluoride	mg/L	NP-PL	2.2	1.8	--	No	1.9	No	1.8 J	No
pH, Field-Measured	pH units	P-PL	8.1, 8.7	7.8	8.4	False Positive	8.2	No	8.2	No
Sulfate	mg/L	NP-PL	590	570 B	--	No	570	No	490	No
Total Dissolved Solids	mg/L	P-PL	3025	2900	--	No	2800 H	No	2800	No

NOTES:

P-PL: Parametric Prediction Limit

NP-PL: Non-parametric Prediction Limit

mg/L: milligrams per liter

B: Analyte detected in the laboratory quality control blank and the sample

H: Analyte analyzed outside of hold time

J: Analyte detected at a concentration between the method detection limit and the reporting limit, and the concentration is an approximate value

Table 9. Statistics Summary Table – TRcpc-15

Analytes	Units	Selected Statistical Method	Statistical Limit	April 2019			November 2019	
				Compliance Point (4/9/2019)	Confirmatory Resample (7/1/2019)	SSI Determination	Compliance Point (11/4/2019)	SSI Determination
Appendix III								
Boron, Total Recoverable	mg/L	P-PL	1.63	1.4	--	No	1.4	No
Calcium, Total Recoverable	mg/L	P-PL	8.5	7.0	--	No	6.7	No
Chloride	mg/L	P-PL	618	580	--	No	540	No
Fluoride	mg/L	NP-PL	3.0	2.9	--	No	2.7 J	No
pH, Field-Measured	pH units	P-PL	8.4, 8.8	8.2	8.5	False Positive	9.9	Potential Exceedance ¹
Sulfate	mg/L	NP-PL	270	250	--	No	230	No
Total Dissolved Solids	mg/L	NP-PL	2200	1600 H	--	No	1600	No

NOTES:

P-PL: Parametric Prediction Limit

NP-PL: Non-parametric Prediction Limit

mg/L: milligrams per liter

H: Analyte analyzed outside of hold time

J: Analyte detected at a concentration between the method detection limit and the reporting limit, and the concentration is an approximate value

1. Confirmatory resampling is scheduled for the first quarter of 2020.

Table 10. Statistics Summary Table – TRcpc-16

Analytes	Units	Selected Statistical Method	Statistical Limit	October 2018			April 2019			November 2019	
				Compliance Point (10/23/2018)	Confirmatory Resample (2/28/2019)	SSI Determination	Compliance Point (4/9/2019)	Confirmatory Resample (6/25/2019)	SSI Determination	Compliance Point (11/5/2019)	SSI Determination
Appendix III											
Boron, Total Recoverable	mg/L	P-PL	1.77	1.3	--	No	1.5	--	No	1.5	No
Calcium, Total Recoverable	mg/L	P-PL	7.3	4.8	--	No	5.1	--	No	5.2	No
Chloride	mg/L	NP-PL	480	490	540	Verified SSI ¹	480	--	No	450 E	No
Fluoride	mg/L	NP-PL	3.6	3.6	--	No	3.7	3.8	Verified SSI ²	2.9	No
pH, Field-Measured	pH units	P-PL	8.3, 8.9	8.4	--	No	8.3	--	No	8.2	Potential Exceedance ³
Sulfate	mg/L	NP-PL	290	260 B	--	No	240	--	No	230 E	No
Total Dissolved Solids	mg/L	NP-PL	2200	1500 H	--	No	1500 H	--	No	1400	No

NOTES:

P-PL: Parametric Prediction Limit

NP-PL: Non-parametric Prediction Limit

mg/L: milligrams per liter

B: Analyte detected in the laboratory quality control blank and the sample

H: Analyte analyzed outside of hold time

E: Results exceed calibration range, and a retest conducted outside of hold time confirmed the result

1. Successful demonstration of natural variability conducted in June 2019 is applicable, and the Facility remains in detection monitoring.

2. Successful demonstration of natural variability conducted in October 2019 is applicable, and the Facility remains in detection monitoring.

3. Confirmatory resampling is scheduled for the first quarter of 2020.

Table 11. Statistics Summary Table – TRcpc-17

Analytes	Units	Selected Statistical Method	Statistical Limit	October 2018			June 2019		November 2019	
				Compliance Point (10/25/2018)	Confirmatory Resample (2/28/2019)	SSI Determination	Compliance Point (6/25/2019)	SSI Determination	Compliance Point (11/5/2019)	SSI Determination
Appendix III										
Boron, Total Recoverable	mg/L	NP-PL	1.4	1.2	--	No	1.4	No	1.4	No
Calcium, Total Recoverable	mg/L	Trend ¹	-	18	--	No	19	No	18	No
Chloride	mg/L	NP-PL	1700	1600	--	No	1500 H	No	1500	No
Fluoride	mg/L	NP-PL	2.7	2.6	--	No	1.9 H	No	1.9	No
pH, Field-Measured ²	pH units	P-PL	8.1, 8.2	8.7 (8.0)	8.4 (7.6)	Verified SSI ³	8.5 (7.5)	Verified SSI ³	8.2 (7.1)	Verified SSI ³
Sulfate	mg/L	P-PL	395	330 B	--	No	290 H	No	310	No
Total Dissolved Solids	mg/L	P-PL	3855	3200 H	--	No	3200	No	3200	No

NOTES:

P-PL: Parametric Prediction Limit

NP-PL: Non-parametric Prediction Limit

mg/L: milligrams per liter

Once a verified SSI is identified, confirmatory resampling is not necessary for subsequent SSIs

B: Analyte detected in the laboratory quality control blank and the sample

H: Analyte analyzed outside of hold time

1. Baseline data exhibited statistically significant decreasing trend. Therefore, a trend analysis is used for the determination of SSIs.

2. A statistical limit (two-tailed) was established using detrended data. Compliance data is detrended for comparison to statistical limit. Detrended value is shown in parentheses.

3. Successful demonstration of natural variability conducted in May 2019 is applicable, and the Facility remains in detection monitoring.

Table 12. Statistics Summary Table – TRcpc-18

Analytes	Units	Selected Statistical Method	Statistical Limit	October 2018			April 2019		November 2019	
				Compliance Point (10/30/2018)	Confirmatory Resample (2/28/2019)	SSI Determination	Compliance Point (4/9/2019)	SSI Determination	Compliance Point (11/5/2019)	SSI Determination
Appendix III										
Boron, Total Recoverable	mg/L	P-PL	0.97	0.81	--	No	0.88	No	0.86	No
Calcium, Total Recoverable	mg/L	NP-PL	4.2	4.6	--	Verified SSI ¹	4.6	Verified SSI ¹	4.4	Verified SSI ¹
Chloride	mg/L	NP-PL	380	360	--	No	360	No	340	No
Fluoride	mg/L	P-PL	2.5	1.7	--	No	1.8	No	1.3 J	No
pH, Field-Measured	pH units	P-PL	9.4, 11.8	10.0	--	No	10.3	No	10.3	No
Sulfate	mg/L	NP-PL	210	250 B	240	Verified SSI ²	240	Verified SSI ²	210	No
Total Dissolved Solids	mg/L	NP-PL	1400	1200	--	No	1200 H	No	1200	No

NOTES:

P-PL: Parametric Prediction Limit

NP-PL: Non-parametric Prediction Limit

mg/L: milligrams per liter

Once a verified SSI is identified, confirmatory resampling is not necessary for subsequent SSIs

B: Analyte detected in the laboratory quality control blank and the sample

J: Analyte detected at a concentration between the method detection limit and the reporting limit, and the concentration is an approximate value

H: Analyte analyzed outside of hold time

1. Successful demonstration of natural variability conducted in April 2018 is applicable, and the Facility remains in detection monitoring.

2. Successful demonstration of natural variability conducted in June 2019 is applicable, and the Facility remains in detection monitoring.

Figures



LEGEND

	TRcpc-1	UPGRADIENT MONITORING WELL
	TRcpc-18	DOWNGRADIENT MONITORING WELL
	6843.0	GROUNDWATER ELEVATION (APRIL 2019)

- NOTES**
- GROUNDWATER ELEVATION AT TRcpc-17 WAS RECORDED IN JUNE 2019



CLIENT



CONSULTANT



YYYY-MM-DD	2020-01-10
DESIGNED	BJP
PREPARED	BJP
REVIEWED	SAH
APPROVED	JEO

PROJECT
 ESCALANTE GENERATING STATION
 ACTIVE COAL COMBUSTION RESIDUALS LANDFILL
 ANNUAL GROUNDWATER MONITORING REPORT

TITLE
 MONITORING WELL LOCATIONS AND GROUNDWATER
 ELEVATIONS (APRIL 2019)

PROJECT NO.
 19118706

REV.
 0

FIGURE
 1



LEGEND

	TRcpc-1	UPGRADIENT MONITORING WELL
	TRcpc-18	DOWNGRADIENT MONITORING WELL
6842.3		GROUNDWATER ELEVATION (NOVEMBER 2019)



CLIENT



CONSULTANT



YYYY-MM-DD 2020-01-10

DESIGNED BJP

PREPARED BJP

REVIEWED SAH

APPROVED JEO

PROJECT

ESCALANTE GENERATING STATION
ACTIVE COAL COMBUSTION RESIDUALS LANDFILL
ANNUAL GROUNDWATER MONITORING REPORT

TITLE

MONITORING WELL LOCATIONS AND GROUNDWATER
ELEVATIONS (NOVEMBER 2019)

PROJECT NO.
19118706

REV.
0

FIGURE
2

APPENDIX A

**Demonstration of Natural Variability
for pH at TRcpc-17,
Escalante Generating Station**

CERTIFICATION

Professional Engineer Certification Statement [40 CFR 257.94(e)(2)]

I hereby certify that, having reviewed the attached documentation and being familiar with the provisions of Title 40 of the Code of Federal Regulations Section 257.94 (40 CFR 257.94), this written demonstration is accurate to the best of my knowledge and has been prepared in accordance with recognized and generally accepted good engineering practices, including the consideration of applicable industry standards, and the requirements of 40 CFR 257.94(e)(2).

Golder Associates Inc.

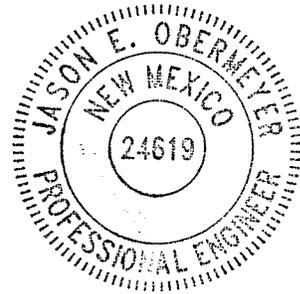


Signature

May 29, 2019
Date of Certification

Jason Obermeyer, PE
Name

24619
New Mexico Professional Engineer Number



TECHNICAL MEMORANDUM

DATE May 29, 2019

Reference No. 19118706-004-1-TM-0

TO Chantell Johnson
Tri-State Generation and Transmission Association, Inc.

CC Jason Obermeyer

FROM Sara Harkins and Tricia Hall

EMAIL SHarkins@Golder.com

DEMONSTRATION OF NATURAL VARIABILITY FOR pH AT TRCPC-17, ESCALANTE GENERATING STATION

Golder Associates Inc. (Golder) is providing this technical memorandum to support a demonstration of natural variability resulting in a statistically significant increase¹ (SSI) for field-measured pH at groundwater monitoring well TRcpc-17. TRcpc-17 is located at the active coal combustion residuals (CCR) landfill at Escalante Generating Station (the site), which is owned and operated by Tri-State Generation and Transmission Association, Inc. (Tri-State). Groundwater is being monitored at Escalante Generating Station to meet the requirements of the US Environmental Protection Agency's (USEPA) CCR Rule (40 CFR Part 257).

1.0 ESCALANTE STATION CCR GROUNDWATER MONITORING PROGRAM

The monitoring network for the site's CCR Groundwater Program consists of groundwater monitoring wells TRcpc-1, TRcpc-2, TRcpc-15, TRcpc-16, TRcpc-17, and TRcpc-18 to monitor groundwater conditions around the active CCR landfill, which contains fly ash, bottom ash, and flue gas desulfurization solids (scrubber solids). The locations of the monitoring wells and the active CCR landfill are shown on Figure 1. Each of the six monitoring wells is screened in the Correo Sandstone, which represents the uppermost continuous water-bearing unit (i.e., aquifer) below the active CCR landfill. TRcpc-1 and TRcpc-2 are upgradient of the active CCR landfill, and TRcpc-15 through TRcpc-18 are downgradient.

Eight groundwater samples were collected on a monthly frequency from September 2016 through May 2017 at each monitoring well (with an additional sample for TRcpc-1 in August 2017). The resulting data were used to establish intrawell baseline statistical limits for each Appendix III constituent at each monitoring well. Intrawell baseline statistical limits represent groundwater conditions in each individual monitoring well (USEPA 2009). Samples collected after baseline statistical limits were established are part of the detection monitoring program. Data from the detection monitoring sampling are compared to the statistical limits to assess possible changes in groundwater chemistry at each well. When the concentration of a given constituent exceeds the statistical limit in two consecutive sampling events, it is considered a verified SSI over the baseline concentration. In the case of pH, which is a two-tailed limit, values below the lower statistical limit also indicate an SSI.

¹ The term SSI is used to be consistent with generally accepted language; however, as detailed in Section 1.0, the SSI is for values less than the two-tailed pH limit.

The parametric statistical limit established for pH at TRcpc-17 is based on detrended data, as the baseline data exhibit a statistically significant upward trend, with baseline values ranging from 8.0 to 8.3 standard units (SU). Sample results that are part of the detection monitoring program are detrended prior to comparison to the statistical limit. The pH values at TRcpc-17 were less than the lower statistical limit of 8.1 SU during the second semi-annual compliance event in October 2018 (8.7 SU, 8.0 SU detrended) and during the confirmatory sampling event in February 2019 (8.4 SU, 7.6 SU detrended), indicating an SSI.

The following sections describe the site geology, provide comparisons to other CCR groundwater monitoring wells at the site, and explain the statistical methodology relevant to the observed pH concentrations at TRcpc-17. This demonstration is performed in accordance with the statistical method certification for the site (Golder 2017) to meet the requirements of 40 CFR 257.94(e)(2), which states that the site may remain in detection monitoring if a demonstration can be made that a source other than the regulated CCR unit caused the SSI or that the SSI was a result of an error in sampling, analysis, or statistical evaluation or natural variability in groundwater quality that was not fully captured during baseline data collection. More specifically, this technical memorandum supports the demonstration that the SSI for pH at TRcpc-17 (October 2018 and February 2019 samples) was a result of natural variability in groundwater quality that was not fully captured during baseline data collection.

2.0 GEOLOGY AND HYDROGEOLOGY

The active CCR landfill is immediately underlain by Quaternary alluvium of variable thickness. The alluvial material is primarily composed of unconsolidated silty sand and clayey sand. The Triassic-aged Chinle Claystone underlies the alluvium and thickens towards the northeast within the boundary of the site, with thicknesses ranging from approximately 45 feet at TRcpc-18 to 205 feet at TRcpc-15. The Chinle Claystone behaves as a confining unit based on the thickness of the low-permeability claystone.

The Triassic-aged Correo Sandstone underlies the Chinle Claystone confining unit. As mentioned above, the six groundwater monitoring wells are each screened in the Correo Sandstone. The groundwater levels in the CCR wells, which are much higher than the screened interval (i.e., closer to the ground surface), indicate that the groundwater is under confining pressure from the overlying Chinle Claystone confining unit. The groundwater flow direction in the Correo Sandstone bed in the vicinity of the active CCR landfill is generally from west to east, with possible minor northerly or southerly components, as indicated by static groundwater levels in the monitoring wells installed at the site (Figure 1).

The Correo Sandstone is relatively uniform in thickness across the site and dips towards the northeast. According to Moench and Schlee (1967), the Correo Sandstone in the nearby Laguna mining district southeast of the site is composed primarily of quartz and feldspar and firmly cemented with quartz and calcite (CaCO_3). Calcite cement is more prominent in conglomeritic lenses of the Correo Sandstone. The regional interpretations of the Correo Sandstone by Moench and Schlee (1967) generally agree with the borehole logs from Golder (2016), which describe the Correo Sandstone as weakly cemented and having calcareous fragments.

Monitoring well TRcpc-17 is located on the east side of the active CCR landfill and was installed in January 2016. The Chinle Claystone is approximately 120 feet thick at this location, encountered at approximately 22 to 142 feet below ground surface (ft bgs) (Golder 2016). The Correo Sandstone was observed from 142 to 200 ft bgs, and the monitoring well is screened from 147 to 187 ft bgs. Due to the presence of calcareous fragments and calcite cement in the Correo Sandstone, natural variation of pH concentrations in groundwater samples is expected, and

the extent of the natural variation was likely not observed during baseline sampling, as discussed further in Section 3.0.

3.0 pH BASELINE AND HISTORICAL DATA COMPARISONS

Figure 1 shows the range of pH values measured at each of the network monitoring wells, while Figure 2 presents a time series graph for pH. These figures demonstrate the limited variability of the pH data collected for each well during the baseline period. They also demonstrate that the recent TRcpc-17 pH values are within the range of the variability observed across the well network.

Due to the time constraints associated with the implementation of the CCR Rule (40 CFR Part 257), the baseline data for the CCR program were collected on a compressed schedule, which consisted of monthly sampling between September 2016 and May 2017. We consider it likely that this compressed schedule (of less than one year) did not allow for natural variations in groundwater concentrations, such as those attributable to seasonal fluctuations or other sources of natural variability (Section 2.0), to be fully observed during the baseline data collection period.

The expected variation in pH concentration in the Correo Sandstone beneath the site can be approximated by the pH data collected from 2011 to 2018 at upgradient TRcpc-1 and TRcpc-2 (Figure 2). Upgradient pH values range from 7.7 to 9.4 SU. The greater variation observed with historical data can be mainly attributed to the longer monitoring period and longer time interval between events, which more suitably encompass expected natural variation. Thus, the relatively small variation observed with TRcpc-17 pH baseline data is in part a function of the limited sample size and monitoring period. The two compliance monitoring concentrations are likely part of the expected natural variation, especially considering the longer period of available pH data from upgradient locations.

The limited variability and likely autocorrelation of the baseline data are demonstrated by a significant result with the rank von Neumann ratio test. The rank von Neumann ratio is a non-parametric test for first-order autocorrelation of data series from a single population. Figure 3 presents the result of the rank von Neumann ratio test for the baseline TRcpc-17 field pH values and indicates a significant result at the 95% confidence level.

Additionally, the recent TRcpc-17 pH data were examined for the presence of a statistically significant trend using the non-parametric Mann-Kendall test. A statistically significant trend in pH at TRcpc-17 is not observed for either the six or eight most recent samples. Therefore, the results of the trend analysis do not indicate that a significant change in pH values has recently occurred at TRcpc-17. Trend analysis graphs are included in Figures 4 and 5.

4.0 SUMMARY AND CONCLUSIONS

This demonstration details the reasons behind Golder's conclusion that the SSI for field pH at TRcpc-17 is not an indication of groundwater impacts from Escalante Generating Station's active CCR landfill, but rather a reflection of natural variability in pH. The lines of evidence can be summarized as follows:

- Downgradient well TRcpc-17 pH values have ranged from 8.0 to 8.8 SU, which is within the range of the other active CCR landfill monitoring wells, including the upgradient wells (Figure 1).
- Due to time constraints associated with the implementation of the CCR Rule (40 CFR Part 257), the baseline data for the CCR program were collected on a compressed schedule, which did not allow for natural variations in groundwater concentrations to be fully observed during the baseline data collection period.

- Analysis of the recent pH data by an alternate methodology, the Mann-Kendall test for trends, does not indicate a statistically significant trend in the most recent six or the most recent eight pH values.

Based on the findings of this demonstration, Golder recommends that Tri-State continue with the detection monitoring program for the active CCR landfill at Escalante Generating Station.

5.0 REFERENCES

Golder Associates Inc. (Golder). 2016. Drilling and Monitoring Well Installation Summary at the Escalante Generating Station in Prewitt, New Mexico. August 19.

Golder Associates Inc. (Golder). 2017. Active Coal Combustion Residuals Landfill Groundwater Statistical Method Certification, Escalante Generating Station. October 13.

Moench, R.H., and J.S. Schlee. 1967. Geology and Uranium Deposits of the Laguna District, New Mexico. U.S. States Geological Survey Professional Paper 519.

US Environmental Protection Agency (USEPA), Office of Solid Waste. 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance. March.

Attachments: Figure 1 – Groundwater Elevations and pH Results
Figure 2 – Field pH Time Series
Figure 3 – Rank von Neumann Ratio Test
Figure 4 – Mann-Kendall Trend Test - Most Recent 6 Samples
Figure 5 – Mann-Kendall Trend Test - Most Recent 8 Samples

SH/TH/rjg

Figures



LEGEND	
	TRcpc-1 UPGRADIENT MONITORING WELL
	TRcpc-18 DOWNGRADIENT MONITORING WELL
6860	GROUNDWATER ELEVATION (OCTOBER 2018)
7.7	OCTOBER 2018 FIELD pH RESULT
(7.7-8.9)	RANGE OF ENTIRE FIELD pH DATA SERIES

- REFERENCES**
1. SAMPLE COLLECTION DATE RANGE FOR TRcpc-1 AND TRcpc-2: 2011 to 2019.
 2. SAMPLE COLLECTION DATE RANGE FOR TRcpc-15, TRcpc-16, TRcpc-17, AND TRcpc-18: 2016 to 2019.



CLIENT



CONSULTANT



YYYY-MM-DD	2019-05-28
DESIGNED	KAC
PREPARED	KAC
REVIEWED	TH
APPROVED	JEO

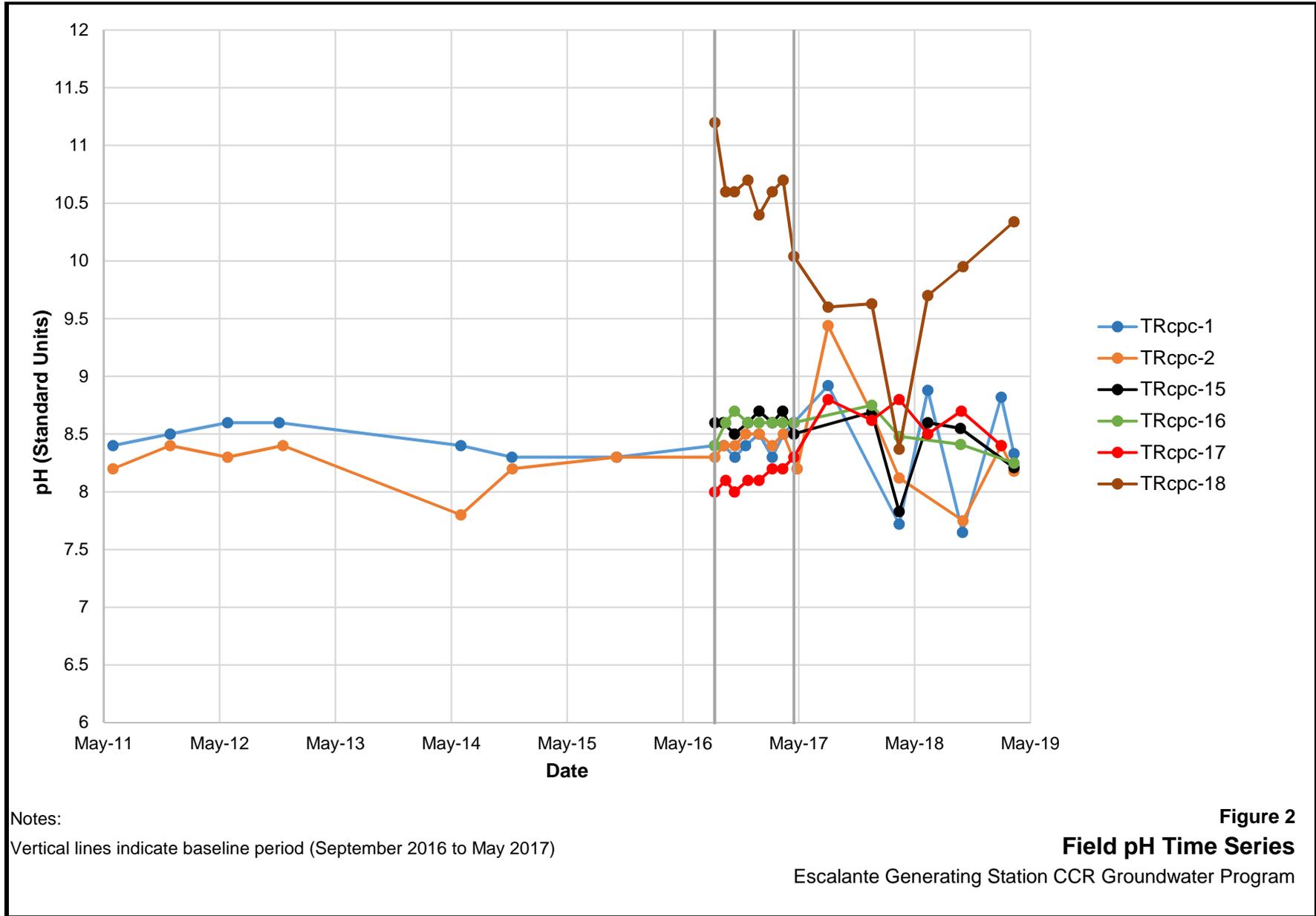
PROJECT
 ESCALANTE GENERATING STATION
 ACTIVE COAL COMBUSTION RESIDUALS LANDFILL

TITLE
 GROUNDWATER ELEVATIONS AND pH RESULTS

PROJECT NO.
 19118706

REV.
 A

FIGURE
 1



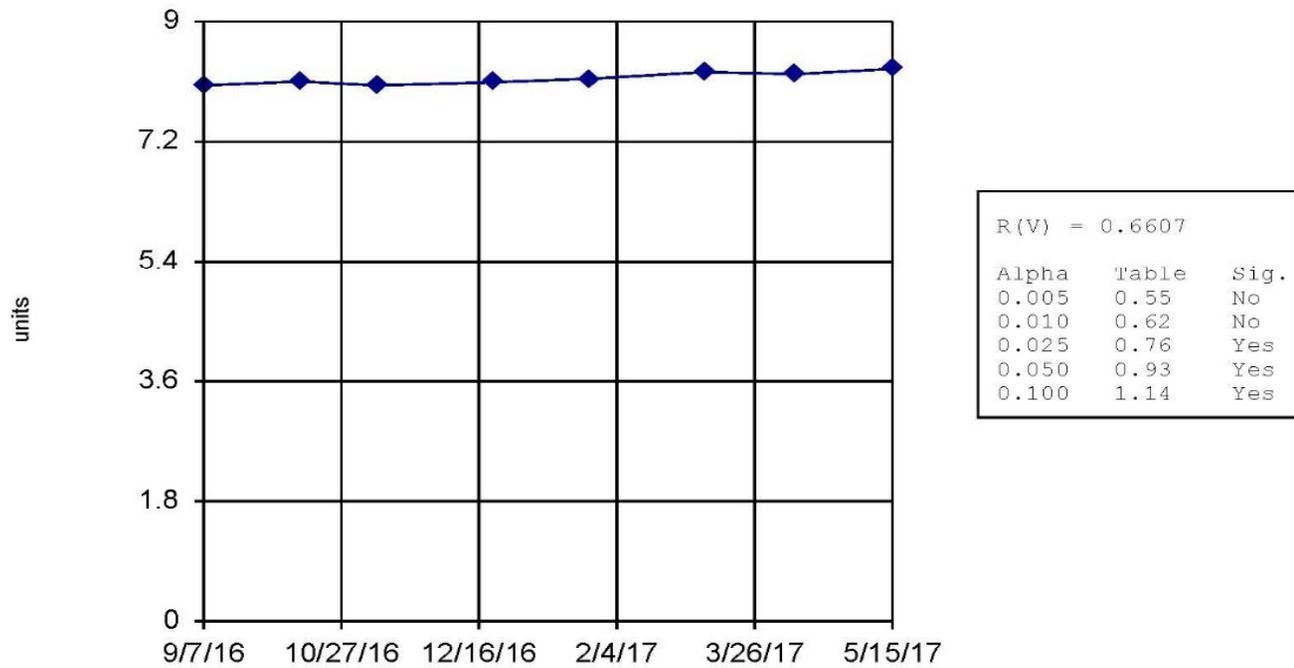
Notes:

Vertical lines indicate baseline period (September 2016 to May 2017)

Figure 2
Field pH Time Series

Escalante Generating Station CCR Groundwater Program

Rank Von Neumann TRcpc-17



Constituent: pH Analysis Run 5/24/2019 12:42 PM

Figure 3
Rank von Neumann Ratio Test
Escalante Generating Station CCR Groundwater Program

Golder Associates

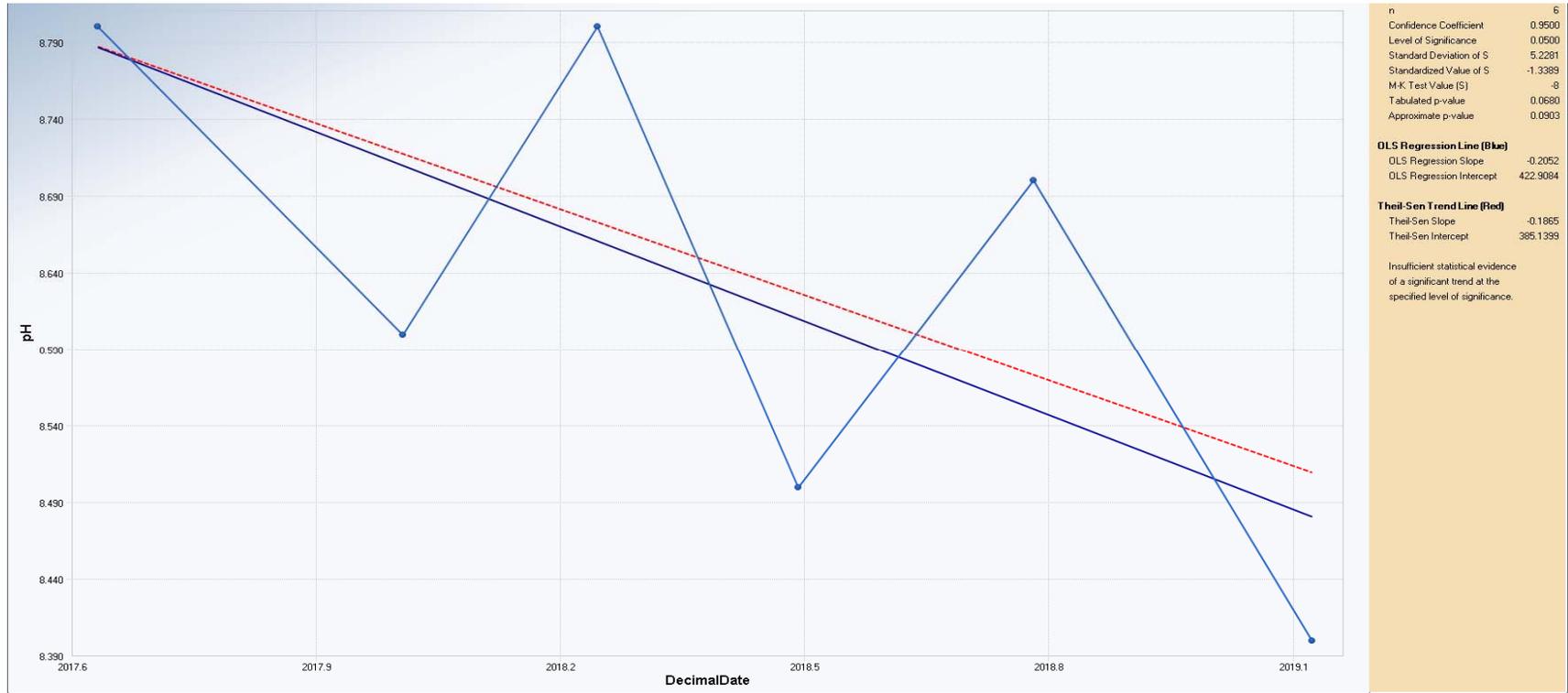


Figure 4
Mann-Kendall Trend Test - Most Recent 6 Samples
 Escalante Generating Station CCR Groundwater Program

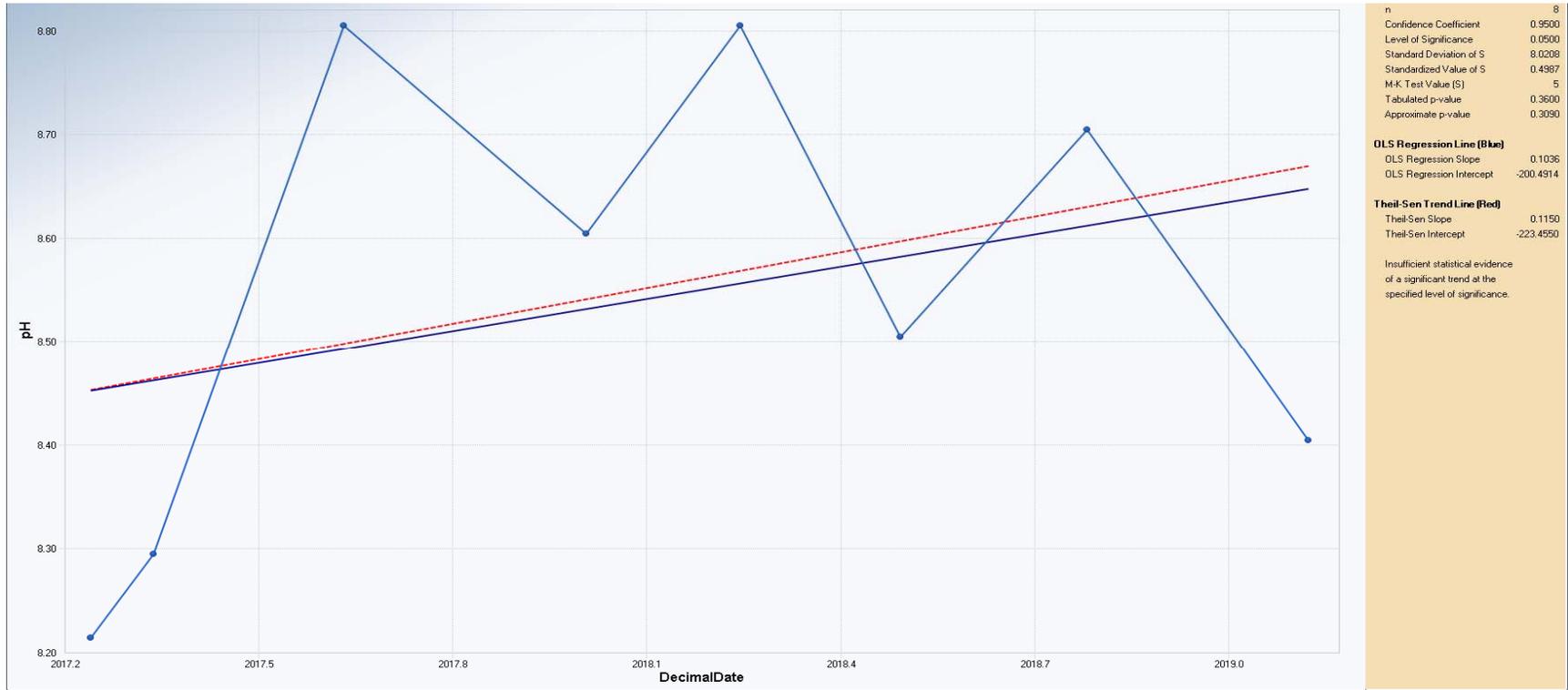


Figure 5
Mann-Kendall Trend Test - Most Recent 8 Samples
 Escalante Generating Station CCR Groundwater Program

APPENDIX B

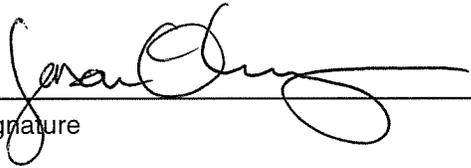
**Demonstration of Natural Variability
for Chloride at TRcpc-16
and Sulfate at TRcpc-18,
Escalante Generating Station**

CERTIFICATION

Professional Engineer Certification Statement [40 CFR 257.94(e)(2)]

I hereby certify that, having reviewed the attached documentation and being familiar with the provisions of Title 40 of the Code of Federal Regulations Section 257.94 (40 CFR 257.94), this written demonstration is accurate to the best of my knowledge and has been prepared in accordance with recognized and generally accepted good engineering practices, including the consideration of applicable industry standards, and the requirements of 40 CFR 257.94(e)(2).

Golder Associates Inc.



Signature

June 7, 2019

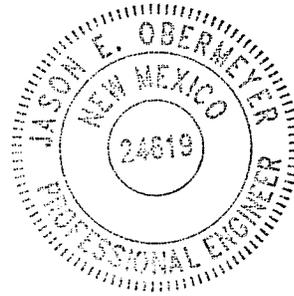
Date of Certification

Jason Obermeyer, PE

Name

24619

New Mexico Professional Engineer Number



TECHNICAL MEMORANDUM

DATE June 7, 2019

Reference No. 19118706-004-2-TM-0

TO Chantell Johnson
Tri-State Generation and Transmission Association, Inc.

CC Jason Obermeyer

FROM Sara Harkins and Tricia Hall

EMAIL SHarkins@Golder.com

DEMONSTRATION OF NATURAL VARIABILITY FOR CHLORIDE AT TRCPC-16 AND SULFATE AT TRCPC-18, ESCALANTE GENERATING STATION

Golder Associates Inc. (Golder) is providing this technical memorandum to support a demonstration of natural variability resulting in a statistically significant increase (SSI) for chloride at well TRcpc-16 and sulfate at well TRcpc-18. Both wells are located at the active coal combustion residuals (CCR) landfill at Escalante Generating Station (the site), which is owned and operated by Tri-State Generation and Transmission Association, Inc. (Tri-State). Groundwater is being monitored at Escalante Generating Station to meet the requirements of the US Environmental Protection Agency's (USEPA) CCR Rule (40 CFR Part 257).

1.0 ESCALANTE STATION CCR GROUNDWATER MONITORING PROGRAM

The monitoring network for the site's CCR Groundwater Monitoring Program consists of groundwater monitoring wells TRcpc-1, TRcpc-2, TRcpc-15, TRcpc-16, TRcpc-17, and TRcpc-18 to monitor groundwater conditions around the active CCR landfill, which contains fly ash, bottom ash, and flue gas desulfurization solids (scrubber solids). The locations of the monitoring wells and the active CCR landfill are shown on Figure 1. Each of the six monitoring wells is screened in the Correo Sandstone, which represents the uppermost continuous water-bearing unit (i.e., aquifer) below the active CCR landfill. TRcpc-1 and TRcpc-2 are upgradient of the active CCR landfill, and TRcpc-15 through TRcpc-18 are downgradient.

Eight groundwater samples were collected on a monthly frequency from September 2016 through May 2017 at each monitoring well (with an additional sample for TRcpc-1 in August 2017). The resulting data were used to establish intrawell baseline statistical limits for each Appendix III constituent at each monitoring well. Intrawell baseline statistical limits represent groundwater conditions in each individual monitoring well (USEPA 2009). Samples collected after baseline statistical limits were established are part of the detection monitoring program. Data from the detection monitoring sampling are compared to the statistical limits to assess possible changes in groundwater chemistry at each well. When the concentration of a given constituent exceeds the statistical limit in two consecutive sampling events, it is considered a verified SSI over the baseline concentration.

Chloride concentrations at TRcpc-16 exceeded the non-parametric statistical limit of 480 milligrams per liter (mg/L) during the semi-annual compliance sampling event in October 2018 (490 mg/L) and during the confirmatory sampling event in February 2019 (540 mg/L), indicating an SSI over baseline. Sulfate concentrations at TRcpc-18 exceeded the non-parametric statistical limit of 210 milligrams per liter (mg/L) during the semi-annual compliance sampling event in October 2018 (250 mg/L) and during the confirmatory sampling event in February

2019 (240 mg/L), indicating an SSI over baseline. The non-parametric limit is the highest concentration observed during the baseline period for the well. A non-parametric methodology was selected for chloride at TRcpc-16 and sulfate at TRcpc-18 because the baseline data were not normally or lognormally distributed, which is a requirement to implement a parametric methodology.

The following sections describe the site geology, provide comparisons to other CCR groundwater monitoring wells at the site, and explain the statistical methodology relevant to the observed chloride and sulfate concentrations at TRcpc-16 and TRcpc-18, respectively. This demonstration is performed in accordance with the statistical method certification for the site (Golder 2017) to meet the requirements of 40 CFR 257.94(e)(2), which states that the site may remain in detection monitoring if a demonstration can be made that a source other than the regulated CCR unit caused the SSI or that the SSI was a result of an error in sampling, analysis, or statistical evaluation or natural variability in groundwater quality that was not fully captured during baseline data collection. More specifically, this technical memorandum supports the demonstration that the SSIs for chloride at TRcpc-16 and sulfate at TRcpc-18 were a result of natural variability in groundwater quality that was not fully captured during baseline data collection.

2.0 GEOLOGY AND HYDROGEOLOGY

The active CCR landfill is immediately underlain by Quaternary alluvium of variable thickness. The alluvial material is primarily composed of unconsolidated silty sand and clayey sand. The Triassic-aged Chinle Claystone underlies the alluvium and thickens towards the northeast within the boundary of the site, with thicknesses ranging from approximately 45 feet at TRcpc-18 to 205 feet at TRcpc-15. The Chinle Claystone behaves as a confining unit based on the thickness of the low-permeability claystone.

The Triassic-aged Correo Sandstone underlies the Chinle Claystone confining unit. As mentioned above, the six groundwater monitoring wells are each screened in the Correo Sandstone. The groundwater levels in the CCR wells, which are much higher than the screened interval (i.e., closer to the ground surface), indicate that the groundwater is under confining pressure from the overlying Chinle Claystone confining unit. The groundwater flow direction in the Correo Sandstone bed near the active CCR landfill is generally from west to east, with possible minor northerly or southerly components, as indicated by static groundwater levels in the monitoring wells installed at the site.

3.0 CHLORIDE AT TRCPC-16

Chloride concentrations in October 2018 and ranges for the entire CCR Groundwater Monitoring Program dataset are shown on Figure 1. Time series of chloride concentrations for the monitoring wells are plotted on Figure 2. Summary statistics for the chloride data collected during the baseline period for the CCR monitoring wells, as well as an expanded data series collected as part of an older monitoring program for TRcpc-1 and TRcpc-2, are presented in Table 1. Summary statistics and time series graphs, presented in Table 1 and Figure 2, respectively, are useful for evaluating the variability of chloride concentrations for TRcpc-16 and the other CCR monitoring wells. The baseline data indicate that chloride concentration varies at each monitoring well, as indicated by the standard deviation and coefficient of variation. When compared to other monitoring wells, TRcpc-16 shows the second smallest range, second lowest standard deviation, and second lowest coefficient of variation. Additionally, Figure 1 and Figure 2 demonstrate that the chloride concentrations at TRcpc-16 are within the range of concentrations reported for other wells in the CCR Groundwater Monitoring Program.

Due to the time constraints associated with the implementation of the CCR Rule (40 CFR Part 257), the baseline data for the CCR Groundwater Monitoring Program were collected on a compressed schedule, which consisted of monthly sampling between September 2016 and May 2017. We consider it likely that this compressed schedule (of less than one year) did not allow for natural variations in groundwater concentrations, such as those attributable to seasonal fluctuations or other sources of natural variability, to be fully observed during the baseline data collection period.

The expected variation in chloride concentration in the Correo Sandstone beneath the site can be approximated by the chloride collected from 1983 to 2017 at upgradient TRcpc-1 and TRcpc-2 (Table 1). The historical chloride data (108 data points) at TRcpc-1 and TRcpc-2 have calculated coefficients of variation of 0.08 and 0.04, respectively, while the coefficients of variation calculated for the eight CCR Groundwater Monitoring Program baseline data points for chloride for these wells are 0.03 and 0.04, respectively. The greater variation observed with historical data at TRcpc-1 can be mainly attributed to the larger sample size and longer monitoring period, which more suitably encompass expected natural variation. Thus, the relatively small variation observed with TRcpc-16 chloride baseline data, with a coefficient of variation of 0.02, is in part a function of the limited sample size and monitoring period. The two compliance monitoring concentrations are likely part of the expected natural variation, with a coefficient of variation for the entire chloride dataset for TRcpc-16 (11 data points, including detection monitoring samples) of 0.05.

Due to the false positive potential associated with the selected non-parametric prediction limit methodology (Section 5.0), an alternate method was also used to interpret the data. The chloride data were examined for the presence of a statistically significant increasing trend using the non-parametric Mann-Kendall test. A statistically significant trend is not observed in the most recent 8 samples, the most recent 6 samples, or the entire data set (baseline and compliance) for chloride at TRcpc-16. This lack of an observed statistically significant trend indicates there have not been any significant changes in chloride concentration at TRcpc-16. Chloride trend analysis graphs are included in Figures 3 through Figure 5.

4.0 SULFATE AT TRCPC-18

Sulfate concentrations in October 2018 and ranges for the entire CCR Groundwater Monitoring Program dataset are shown on Figure 6. Time series of sulfate concentrations for the monitoring wells are plotted on Figure 7. Summary statistics for the sulfate data collected during the baseline period for the CCR monitoring wells, as well as an expanded data series collected as part of an older monitoring program for TRcpc-1 and TRcpc-2, are presented in Table 2. Summary statistics and time series graphs, presented in Table 2 and Figure 7, respectively, are useful for evaluating the variability of sulfate concentrations for TRcpc-18 and the other CCR monitoring wells. The baseline data indicate that sulfate concentration varies at each monitoring well, as indicated by the standard deviation and coefficient of variation. When compared to other monitoring wells, TRcpc-18 shows the smallest range, lowest standard deviation, and lowest coefficient of variation. Additionally, Figure 6 and Figure 7 demonstrate that the sulfate concentrations at TRcpc-18 are lower than the range of concentrations reported for other wells in the CCR Groundwater Monitoring Program.

Due to the time constraints associated with the implementation of the CCR Rule (40 CFR Part 257), the baseline data for the CCR Groundwater Monitoring Program were collected on a compressed schedule, which consisted of monthly sampling between September 2016 and May 2017. We consider it likely that this compressed schedule (of less than one year) did not allow for natural variations in groundwater concentrations, such as those

attributable to seasonal fluctuations or other sources of natural variability, to be fully observed during the baseline data collection period.

The expected variation in sulfate concentration in the Correo Sandstone beneath the site can be approximated by the sulfate collected from 1983 to 2017 at upgradient TRcpc-1 and TRcpc-2 (Table 2). The historical sulfate data (108 data points) at TRcpc-1 and TRcpc-2 have calculated coefficients of variation of 0.09 and 0.11, respectively, which are more than twice the coefficients of variation calculated for the eight CCR Groundwater Monitoring Program baseline data points for sulfate for these wells (0.04 and 0.03, respectively). The greater variation observed with historical data can be mainly attributed to the larger sample size and longer monitoring period, which more suitably encompass expected natural variation. Thus, the relatively small variation observed with TRcpc-18 sulfate baseline data, with a coefficient of variation of 0.02, is in part a function of the limited sample size and monitoring period. The two compliance monitoring concentrations are likely part of the expected natural variation, with a coefficient of variation for the entire sulfate dataset for TRcpc-18 (11 data points, including detection monitoring samples) of 0.08.

Due to the false positive potential associated with the selected non-parametric prediction limit methodology (Section 5.0), an alternate method was also used to interpret the data. The sulfate data were examined for the presence of a statistically significant increasing trend using the non-parametric Mann-Kendall test. A statistically significant trend is not observed in the most recent 8 samples, the most recent 6 samples, or the entire data set (baseline and compliance) for sulfate at TRcpc-18. This lack of an observed statistically significant trend indicates there have not been any significant changes in sulfate concentration at TRcpc-18. Sulfate trend analysis graphs are included in Figures 8 through Figure 10.

5.0 NON-PARAMETRIC PREDICTION LIMITS AND FALSE POSITIVE RATE

The primary goal in a groundwater detection monitoring program is to identify real changes to groundwater quality if they occur, with a specific focus on increasing concentrations in detection monitoring data when compared to baseline data. Statistical tests are used to identify the possible presence of elevated concentrations, and they must have adequate statistical power to do so. Statistical power is the likelihood of detecting a change in concentrations when a change is present in reality. A second critical goal is to avoid false positive errors (Type I errors), which occur when groundwater concentrations are incorrectly identified as being significantly greater than baseline when contamination does not exist.

A site-wide false positive rate (SWFPR) is used to measure the susceptibility to false positive errors. The Unified Guidance (USEPA 2009) recommends an annual SWFPR of 10%. This SWFPR equates to a target per well-constituent false positive rate of 0.38% using equation 19.17 in the Unified Guidance:

$$\alpha_{w \times c} = 1 - (1 - \alpha)^{\frac{1}{(w \times c)}}$$

where α is the SWFPR, w equals the actual number of downgradient compliance wells (four in this case), and c is the number of monitoring constituents (seven in this case). However, based on Table 19-19 in Appendix D of the Unified Guidance the achievable false positive rate for a non-parametric prediction limit with a background dataset of eight measurements where two statistical evaluations are performed per year is 4.2% (much greater than the target of 0.38% noted above). The only way to reduce this false positive rate would be to increase the number of background samples, which was not feasible under the time constraints of the CCR Rule. Thus, there is a relatively high probability of falsely identifying groundwater contamination for parameters that are being tested with a non-parametric methodology at the site, which may have occurred during the comparative statistical

analysis for chloride at TRcpc-16 and sulfate at TRcpc-18. Unfortunately, due to the nature of the non-parametric prediction limits, the false positive rate will remain elevated for the site until more sampling events are conducted. The data from future sampling events can be incorporated into an updated baseline period in accordance with the statistical methodology for the site (Golder 2017), which will result in either one of the following: 1) the underlying data distribution can be defined and a parametric methodology can be implemented, or 2) a non-parametric prediction limit can be constructed on a greater number of samples.

6.0 SUMMARY AND CONCLUSIONS

This demonstration details the reasons behind Golder's conclusion that the statistically significant increases in chloride concentration at TRcpc-16 and sulfate concentration at TRcpc-18 are not indications of groundwater impacts from Escalante Station's active CCR landfill, but rather a reflection of natural variability in concentrations. The lines of evidence can be summarized as follows:

- Downgradient well TRcpc-16 has lower chloride concentrations than most of the other active CCR landfill monitoring wells, including the upgradient wells (Figure 1).
- Downgradient well TRcpc-18 has lower sulfate concentrations than the other active CCR landfill monitoring wells, including the upgradient wells (Figure 6).
- Due to time constraints associated with the implementation of the CCR Rule (40 CFR Part 257), the baseline data for the CCR Groundwater Monitoring Program were collected on a compressed schedule, which did not allow for natural variations in groundwater concentrations to be fully observed during the baseline data collection period.
- Because of the low variability and limited number of baseline samples currently available, the selected statistical methodology to assess chloride at TRcpc-16 and sulfate at TRcpc-18, a non-parametric prediction limit, has a high false positive rate.
- Analysis of chloride at TRcpc-16 and sulfate at TRcpc-18 by an alternate methodology, the Mann-Kendall test for trends, does not indicate a statistically significant increasing trend.

Based on the findings of this demonstration, Golder recommends that Tri-State continue with the detection monitoring program for the active CCR landfill at Escalante Generating Station.

7.0 REFERENCES

Golder Associates Inc. (Golder). 2017. Active Coal Combustion Residuals Landfill Groundwater Statistical Method Certification. October 13.

US Environmental Protection Agency (USEPA), Office of Solid Waste. 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance. March.

Attachments: Table 1 – Chloride Summary Statistics
Table 2 – Sulfate Summary Statistics
Figure 1 – Groundwater Elevations and Chloride Concentrations
Figure 2 – Chloride Time Series
Figure 3 – Mann-Kendall Trend Test – Most Recent 6 Chloride Samples at TRcpc-16
Figure 4 – Mann-Kendall Trend Test – Most Recent 8 Chloride Samples at TRcpc-16
Figure 5 – Mann-Kendall Trend Test – Whole Dataset for Chloride Samples at TRcpc-16
Figure 6 – Groundwater Elevations and Sulfate Concentrations
Figure 7 – Sulfate Time Series
Figure 8 – Mann-Kendall Trend Test – Most Recent 6 Sulfate Samples at TRcpc-18
Figure 9 – Mann-Kendall Trend Test – Most Recent 8 Sulfate Samples at TRcpc-18
Figure 10 – Mann-Kendall Trend Test – Whole Dataset for Sulfate Samples at TRcpc-18

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Tables

Table 1: Chloride Summary Statistics

Monitoring Well	Constituent	Date Range	Chloride Concentration - Baseline				
			Minimum	Mean	Maximum	Coefficient of Variation	Standard Deviation
TRcpc-1	Chloride, CCR Program	2016-2017	600	623	660	0.03	17
TRcpc-1	Chloride, Historical Program	1983-2017	572	675	800	0.08	53
TRcpc-2	Chloride, CCR Program	2016-2017	1100	1125	1200	0.04	43
TRcpc-2	Chloride, Historical Program	1983-2017	970	1091	1300	0.04	42
TRcpc-15	Chloride, CCR Program	2016-2017	520	548	590	0.03	19
TRcpc-16	Chloride, CCR Program	2016-2017	460	468	480	0.02	8
TRcpc-17	Chloride, CCR Program	2016-2017	1500	1600	1700	0.03	50
TRcpc-18	Chloride, CCR Program	2016-2017	370	379	380	0.01	3

Notes:

2016-2017 date range indicates baseline sampling period for CCR Groundwater Monitoring Program.

Visual outliers removed from TRcpc-1 and TRcpc-2 historical data.

Table 2: Sulfate Summary Statistics

Monitoring Well	Constituent	Date Range	Sulfate Concentration - Baseline				
			Minimum	Mean	Maximum	Coefficient of Variation	Standard Deviation
TRcpc-1	Sulfate, CCR Program	2016-2017	800	830	910	0.04	34
TRcpc-1	Sulfate, Historical Program	1983-2017	420	866	1000	0.09	81
TRcpc-2	Sulfate, CCR Program	2016-2017	530	543	590	0.03	19
TRcpc-2	Sulfate, Historical Program	1983-2017	255	526	650	0.11	57
TRcpc-15	Sulfate, CCR Program	2016-2017	240	250	270	0.03	9
TRcpc-16	Sulfate, CCR Program	2016-2017	270	279	290	0.02	6
TRcpc-17	Sulfate, CCR Program	2016-2017	330	351	370	0.03	12
TRcpc-18	Sulfate, CCR Program	2016-2017	200	208	210	0.02	4

Notes:

2016-2017 date range indicates baseline sampling period for CCR Groundwater Monitoring Program.

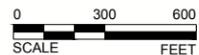
Visual outliers removed from TRcpc-1 and TRcpc-2 historical data.

Figures



LEGEND	
TRcpc-1	UPGRADIENT MONITORING WELL
TRcpc-18	DOWNGRADIENT MONITORING WELL
6860	GROUNDWATER ELEVATION (OCTOBER 2018)
650 mg/L	CHLORIDE CONCENTRATION - OCTOBER 2018 SAMPLING EVENT
(530-660 mg/L)	CHLORIDE CONCENTRATION RANGE FOR ENTIRE CCR DATASET - 2016-2019

NOTE(S)
 1. APRIL 2019 CHLORIDE RESULT NOT INCLUDED IN DATA RANGE PENDING RESULT CONFIRMATION FROM LABORATORY



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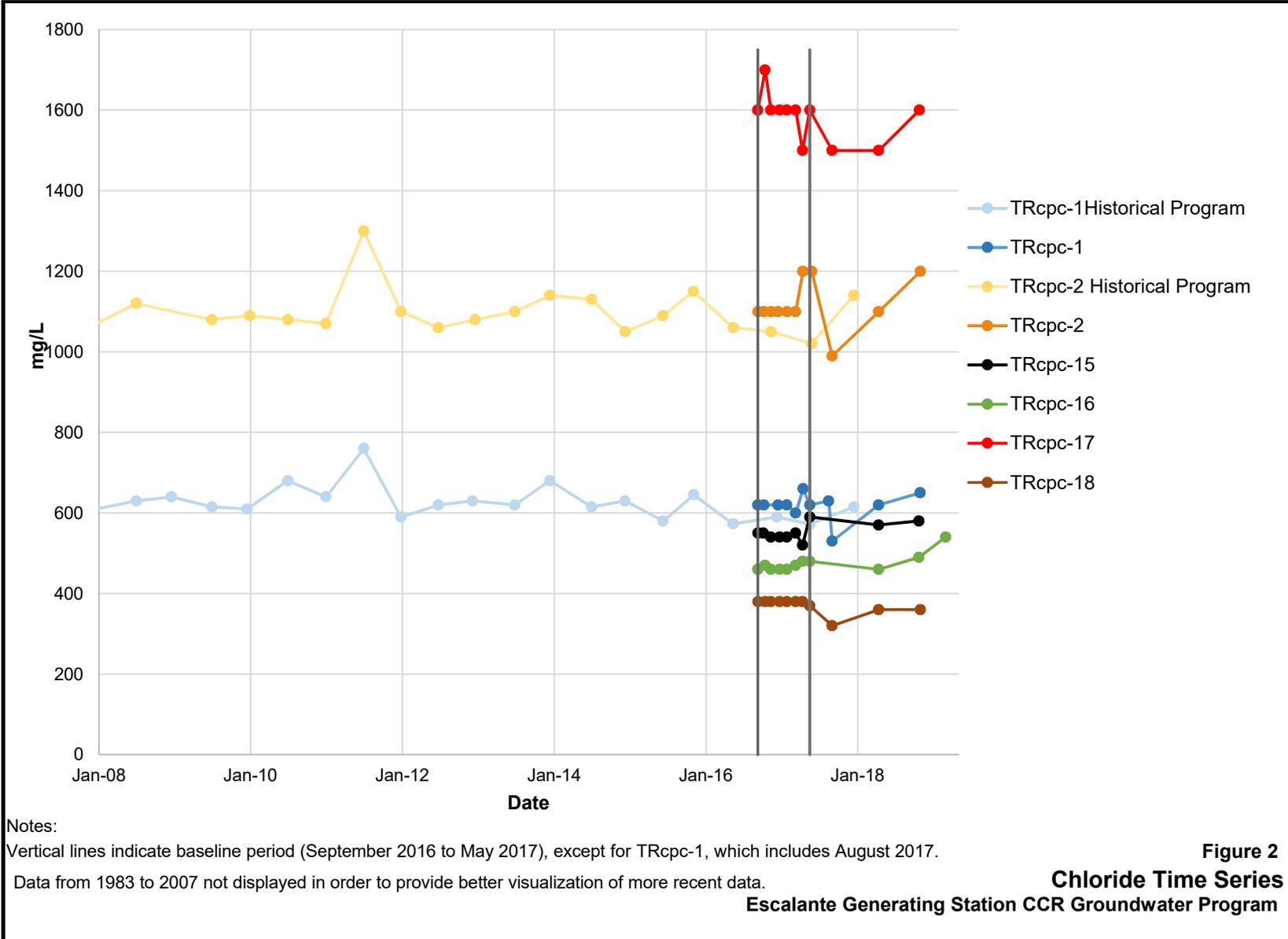
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GOLDER	DESIGNED	KAC
	PREPARED	KAC
	REVIEWED	TH
	APPROVED	JEO

PROJECT
 ESCALANTE GENERATING STATION
 ACTIVE COAL COMBUSTION RESIDUALS LANDFILL

TITLE
 GROUNDWATER ELEVATIONS AND CHLORIDE CONCENTRATIONS

PROJECT NO. 19118706
 REV. A

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Golder Associates



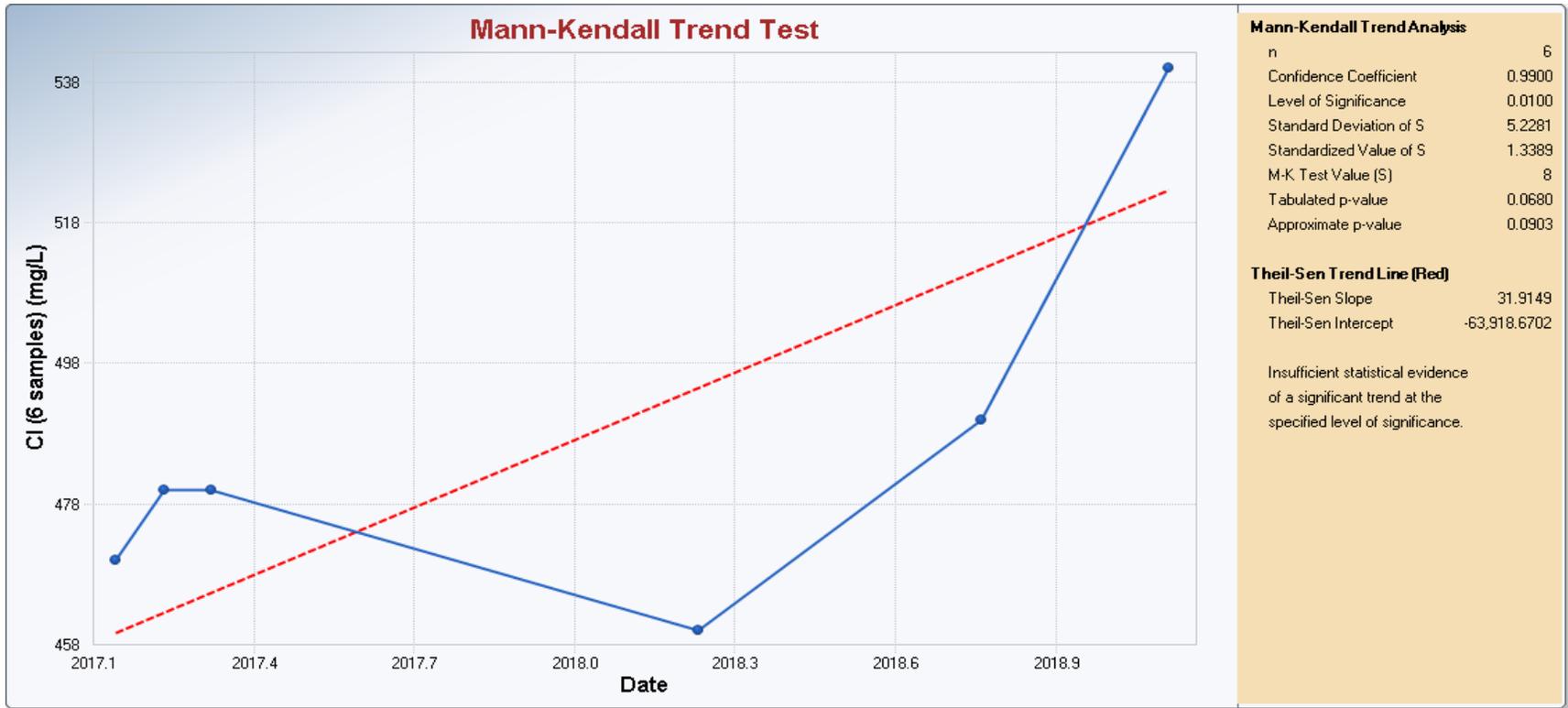


Figure 3
Mann-Kendall Trend Test - Most Recent 6 Chloride Samples at TRpc-16
Escalante Generating Station CCR Groundwater Program

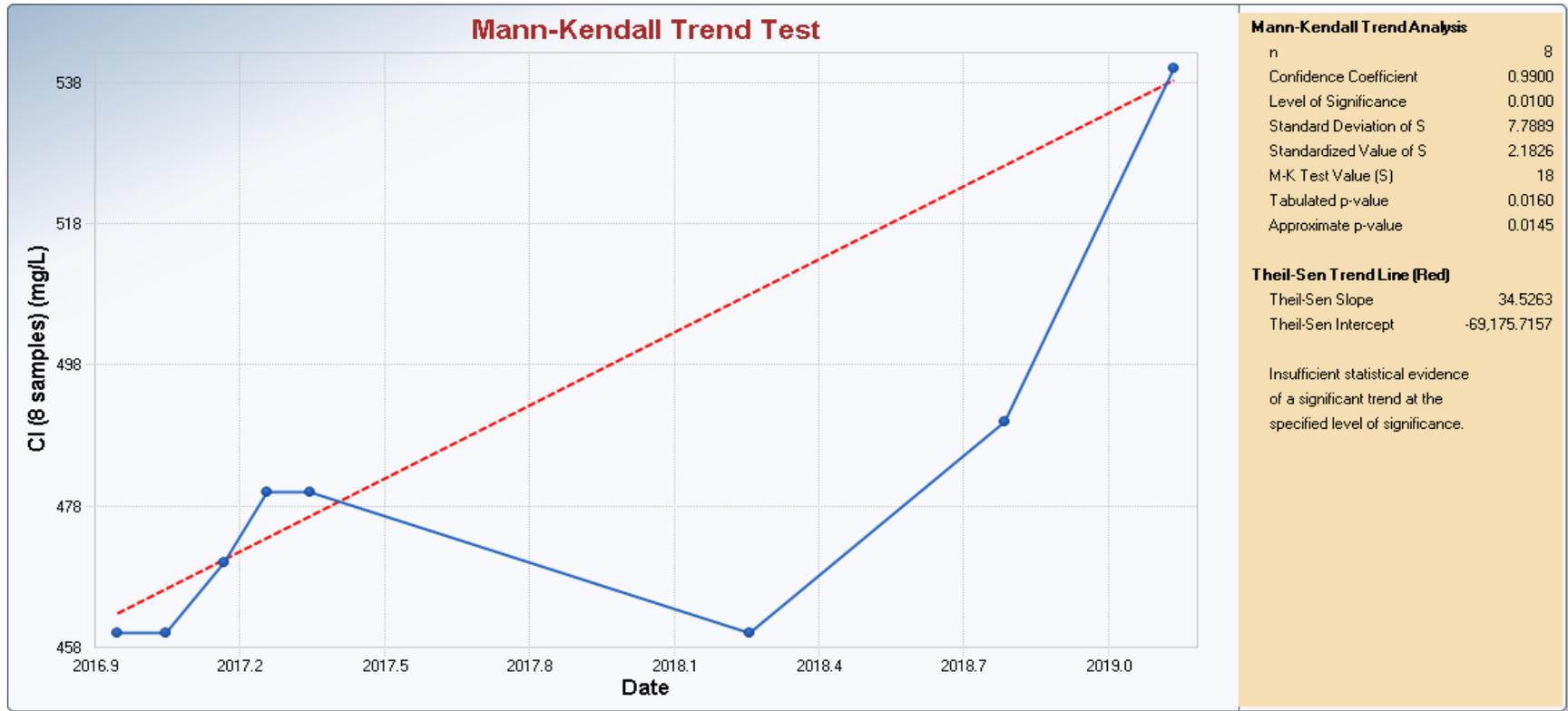


Figure 4
Mann-Kendall Trend Test - Most Recent 8 Chloride Samples at TRpc-16
 Escalante Generating Station CCR Groundwater Program

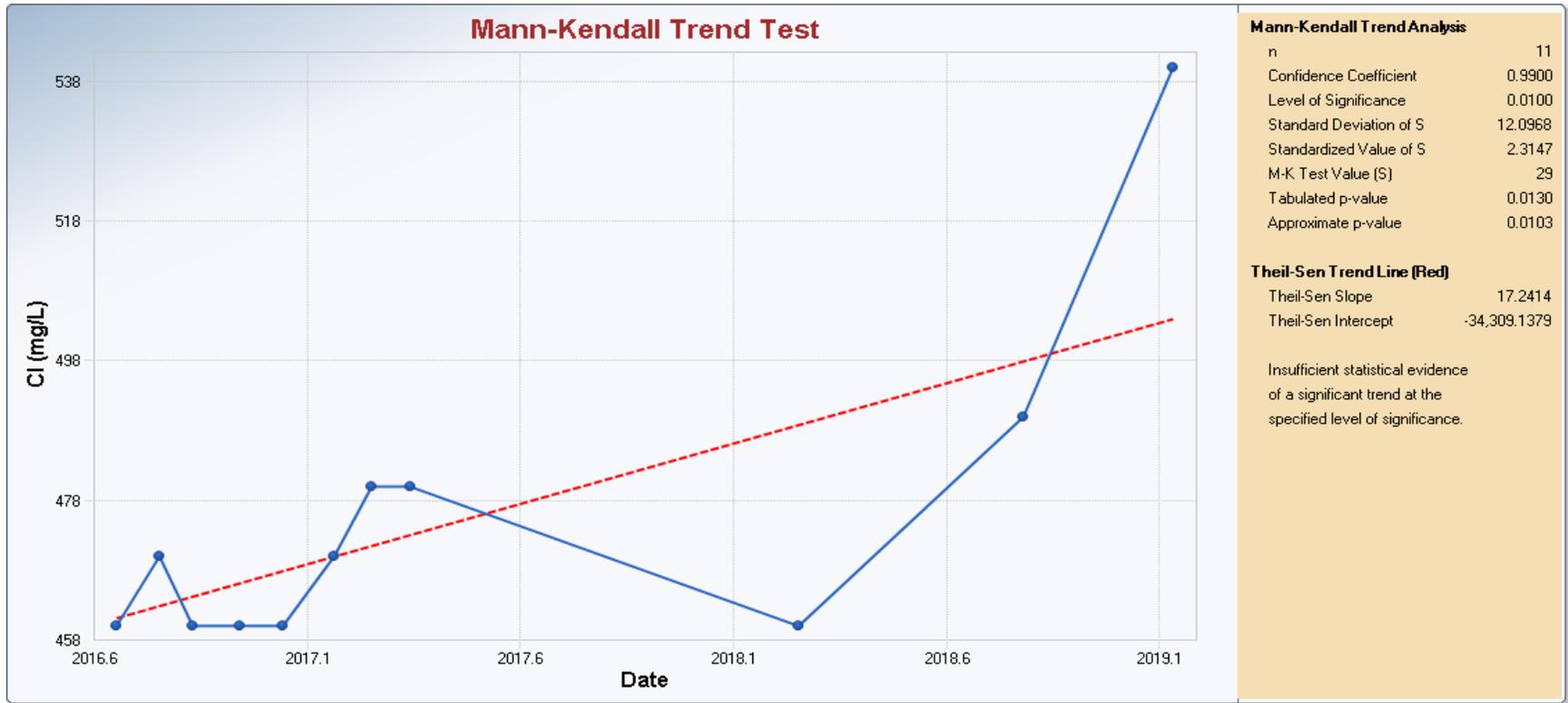
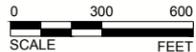


Figure 5
Mann-Kendall Trend Test – Whole Dataset Chloride Samples at TRpc-16
 Escalante Generating Station CCR Groundwater Program



LEGEND

	TRcpc-1	UPGRADIENT MONITORING WELL
	TRcpc-18	DOWNGRADIENT MONITORING WELL
6860		GROUNDWATER ELEVATION (OCTOBER 2018)
860 mg/L		SULFATE CONCENTRATION - OCTOBER 2018 SAMPLING EVENT
(760-910 mg/L)		SULFATE CONCENTRATION RANGE FOR ENTIRE CCR DATASET - 2016-2019



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 Generation and Transmission
 Association, Inc.
 A Touchstone Energy Cooperative

CONSULTANT

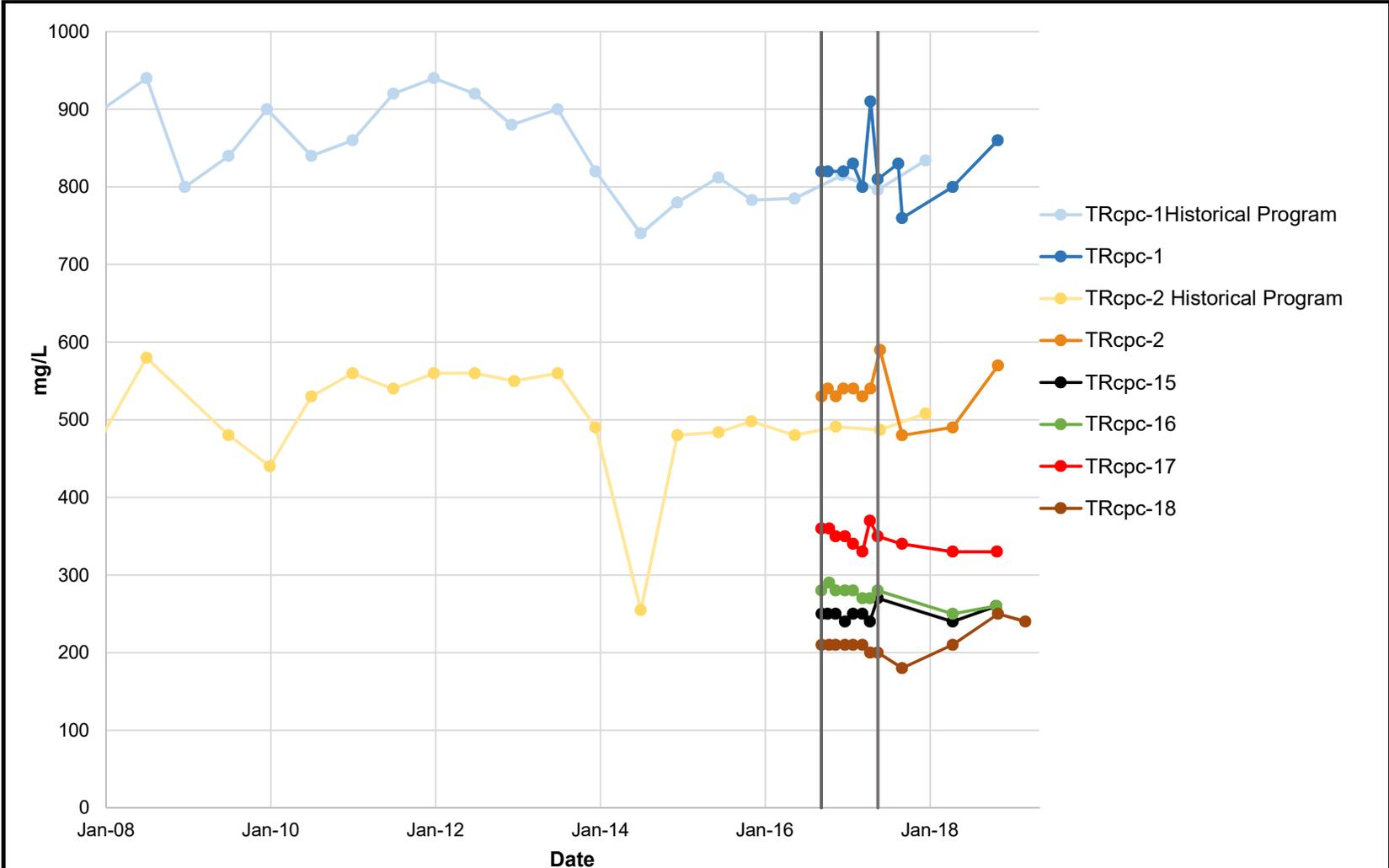
	GOLDER
YYYY-MM-DD	2019-06-04
DESIGNED	KAC
PREPARED	KAC
REVIEWED	TH
APPROVED	JEO

PROJECT
 ESCALANTE GENERATING STATION
 ACTIVE COAL COMBUSTION RESIDUALS LANDFILL

TITLE
 GROUNDWATER ELEVATIONS AND SULFATE
 CONCENTRATIONS

PROJECT NO. 19118706
 REV. A

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Notes:
Vertical lines indicate baseline period (September 2016 to May 2017), except for TRcpc-1, which includes August 2017.
Data from 1983 to 2007 not displayed in order to provide better visualization of more recent data.

Figure 7
Sulfate Time Series
Escalante Generating Station CCR Groundwater Program



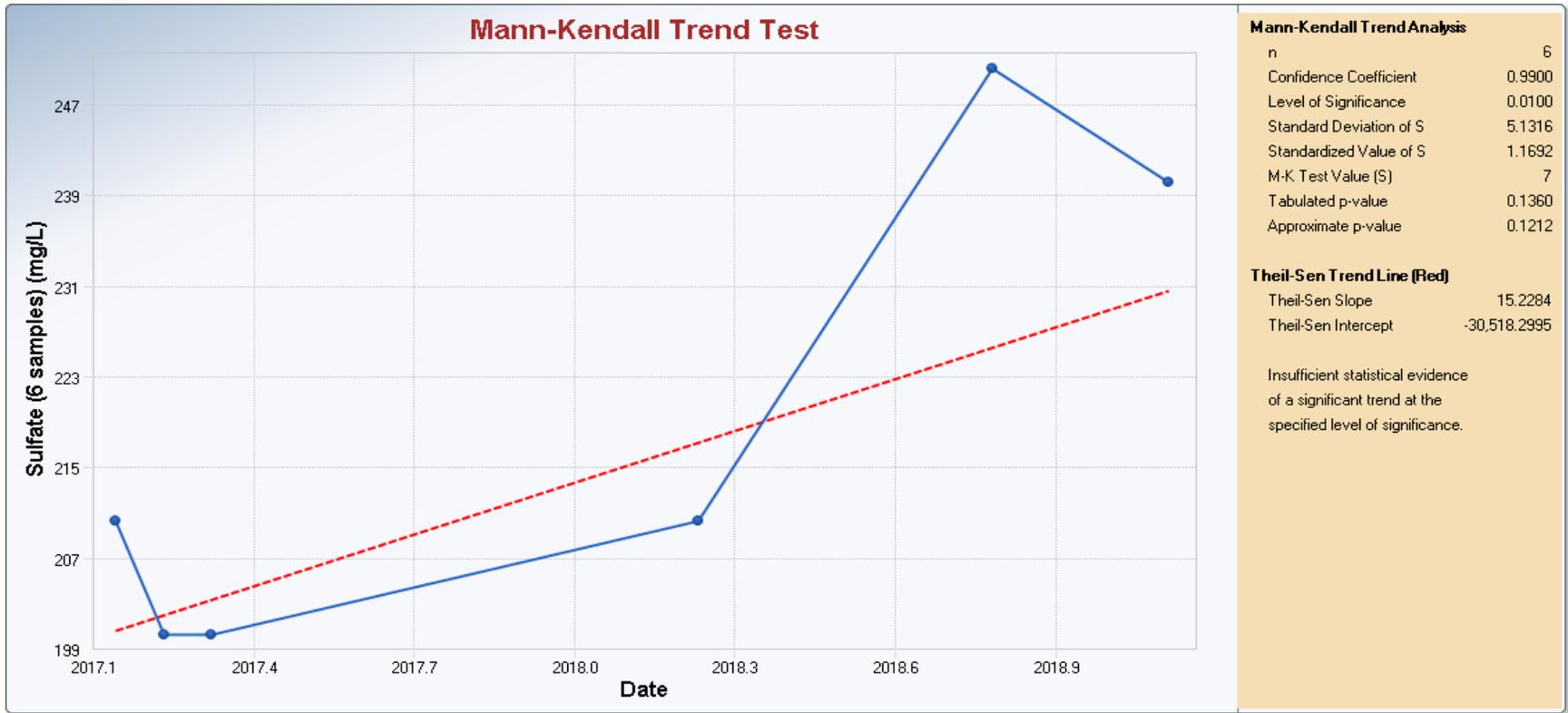


Figure 8
Mann-Kendall Trend Test - Most Recent 6 Sulfate Samples at TRpc-18
 Escalante Generating Station CCR Groundwater Program

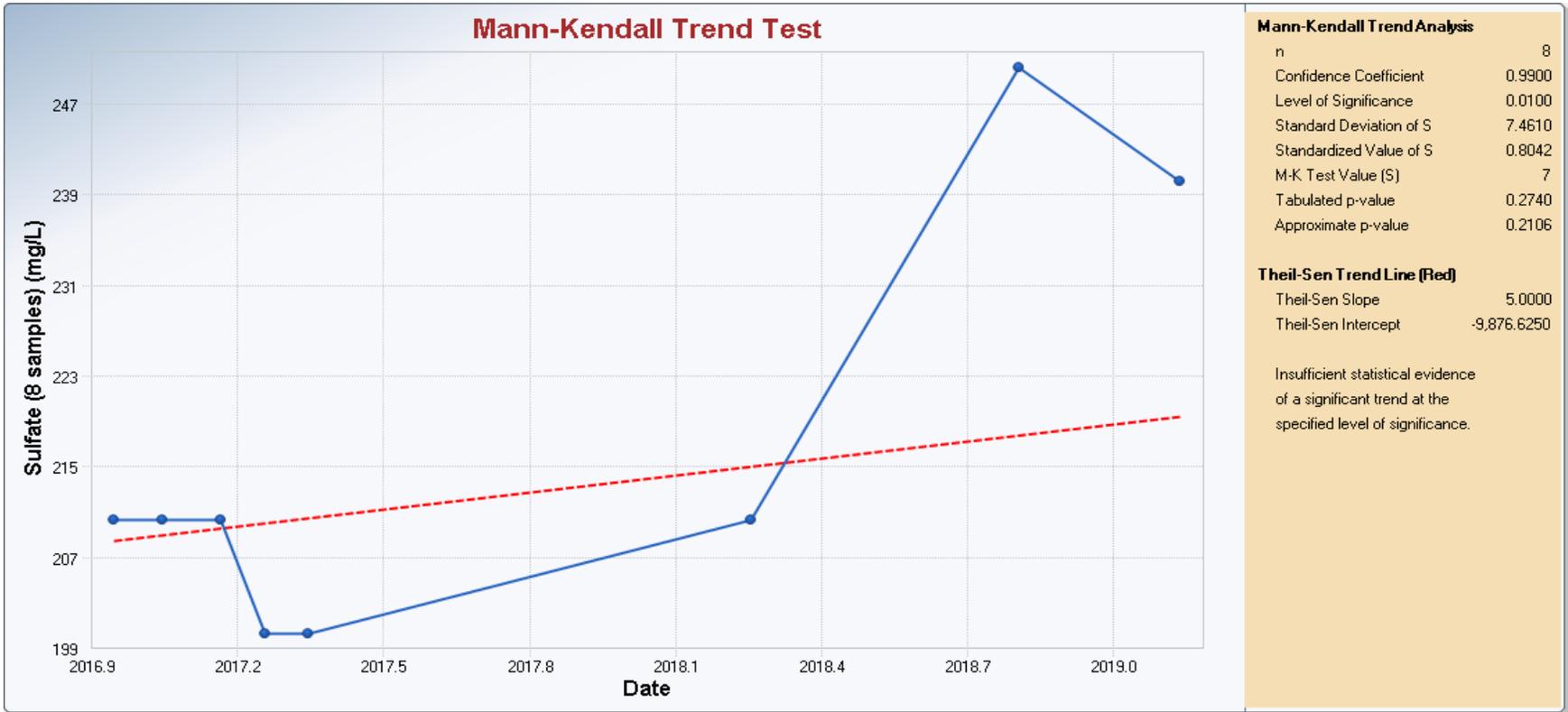


Figure 9
Mann-Kendall Trend Test - Most Recent 8 Sulfate Samples at TRpc-18
 Escalante Generating Station CCR Groundwater Program

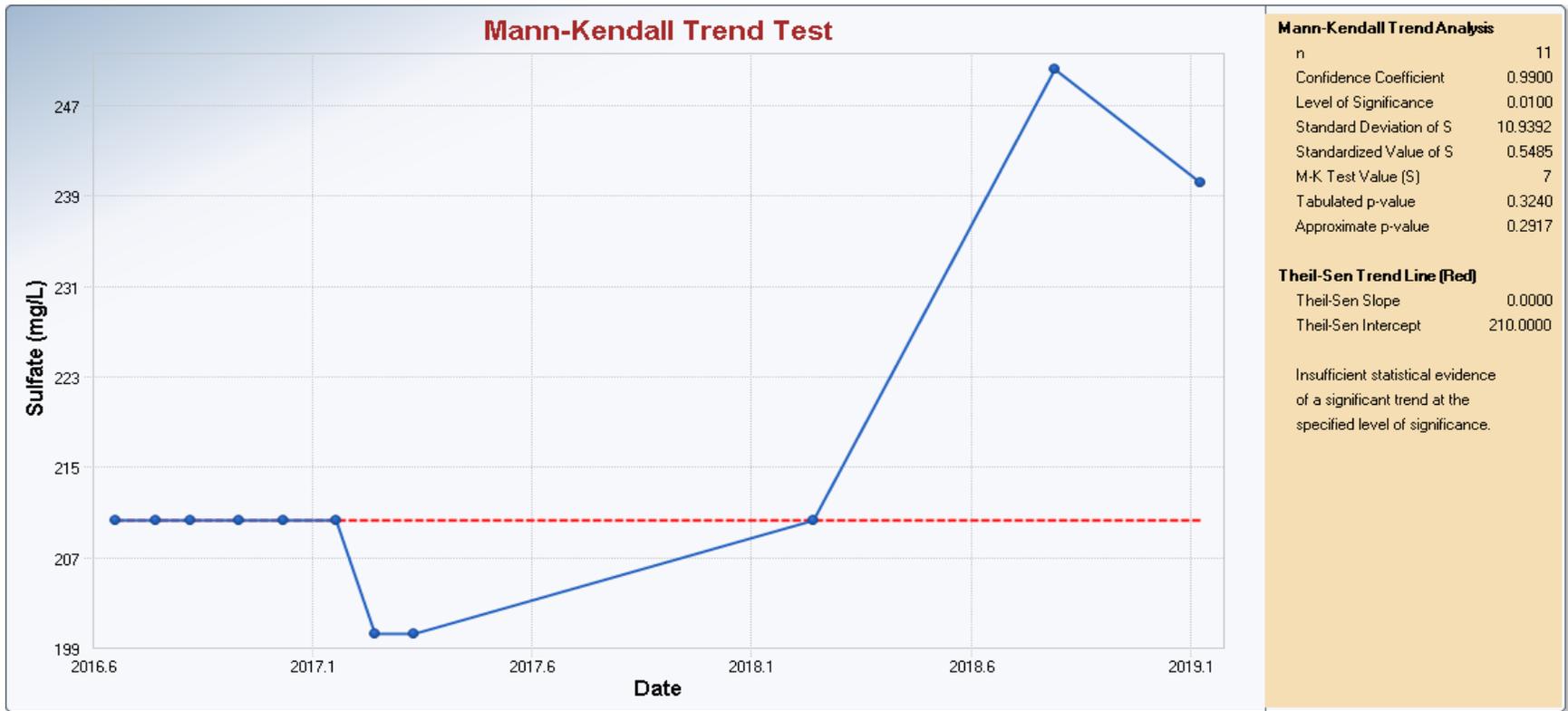


Figure 10
Mann-Kendall Trend Test - Whole Dataset Sulfate Samples at TRpc-18
 Escalante Generating Station CCR Groundwater Program

APPENDIX C

**Demonstration of Natural Variability
for Fluoride at TRcpc-16,
Escalante Generating Station**

CERTIFICATION

Professional Engineer Certification Statement [40 CFR 257.94(e)(2)]

I hereby certify that, having reviewed the attached documentation and being familiar with the provisions of Title 40 of the Code of Federal Regulations Section 257.94 (40 CFR 257.94), this written demonstration is accurate to the best of my knowledge and has been prepared in accordance with recognized and generally accepted good engineering practices, including the consideration of applicable industry standards, and the requirements of 40 CFR 257.94(e)(2).

Golder Associates Inc.



Signature



October 14, 2019

Date of Certification

Jason Obermeyer, PE

Name

24619

New Mexico Professional Engineer Number

TECHNICAL MEMORANDUM

DATE October 14, 2019

Project No. 19118706

TO Chantell Johnson
Tri-State Generation and Transmission Association, Inc.

FROM Sara Harkins

CC Jason Obermeyer

EMAIL: sharkins@golder.com

DEMONSTRATION OF NATURAL VARIABILITY FOR FLUORIDE AT TRCPC-16, ESCALANTE GENERATING STATION

Golder Associates Inc. (Golder) is providing this technical memorandum to support a demonstration of natural variability resulting in a statistically significant increase (SSI) for fluoride at groundwater monitoring well TRcpc-16. TRcpc-16 is located at the active coal combustion residuals (CCR) landfill at Escalante Generating Station (the site), which is owned and operated by Tri-State Generation and Transmission Association, Inc. (Tri-State). Groundwater is being monitored at Escalante Generating Station to meet the requirements of the U.S. Environmental Protection Agency's (USEPA) CCR Rule (40 CFR Part 257).

1.0 ESCALANTE STATION CCR GROUNDWATER MONITORING PROGRAM

The monitoring network for the site's CCR Groundwater Monitoring Program consists of groundwater monitoring wells TRcpc-1, TRcpc-2, TRcpc-15, TRcpc-16, TRcpc-17, and TRcpc-18 to monitor groundwater conditions around the active CCR landfill, which contains fly ash, bottom ash, and flue gas desulfurization solids (scrubber solids). The locations of the monitoring wells and the active CCR landfill are shown on Figure 1. Each of the six monitoring wells is screened in the Correo Sandstone, which represents the uppermost continuous water-bearing unit (i.e., aquifer) below the active CCR landfill. TRcpc-1 and TRcpc-2 are upgradient of the active CCR landfill, and TRcpc-15 through TRcpc-18 are downgradient.

Eight groundwater samples were collected on a monthly frequency from September 2016 through May 2017 at each monitoring well (with an additional sample for TRcpc-1 in August 2017). The resulting data were used to establish intrawell baseline statistical limits for each Appendix III constituent at each monitoring well. Intrawell baseline statistical limits represent groundwater conditions in each individual monitoring well (USEPA 2009). Samples collected after baseline statistical limits were established are part of the detection monitoring program. Data from the detection monitoring sampling are compared to the statistical limits to assess possible changes in groundwater chemistry at each well. When the concentration of a given constituent exceeds the statistical limit in two consecutive sampling events, it is considered a verified SSI over the baseline concentration.

The non-parametric statistical limit established for fluoride at TRcpc-16 is based on baseline values ranging from 2.9 to 3.6 milligrams per liter (mg/L). The non-parametric limit is the highest concentration observed during the baseline period for the well. A non-parametric methodology was selected for fluoride at TRcpc-16 because the baseline data were not normally or lognormally distributed, which is a requirement to implement a parametric methodology. The fluoride values at TRcpc-16 were higher than the non-parametric statistical limit of 3.6 mg/L during the first 2019 semi-annual compliance event in April 2019 (3.7 mg/L) and during the confirmatory sampling event in June 2019 (3.8 mg/L), indicating an SSI over baseline.

The following sections describe the site geology, provide comparisons to other CCR groundwater monitoring wells at the site, and explain the statistical methodology relevant to the observed fluoride concentrations at TRcpc-16. This demonstration is performed in accordance with the statistical method certification for the site (Golder 2017) to meet the requirements of 40 CFR 257.94(e)(2), which states that the site may remain in detection monitoring if a demonstration can be made that a source other than the regulated CCR unit caused the SSI or that the SSI was a result of an error in sampling, analysis, or statistical evaluation or natural variability in groundwater quality that was not fully captured during baseline data collection. More specifically, this technical memorandum supports the demonstration that the SSI for fluoride at TRcpc-16 (April 2019 and June 2019 samples) was a result of natural variability in groundwater quality that was not fully captured during baseline data collection.

2.0 GEOLOGY AND HYDROGEOLOGY

The active CCR landfill is immediately underlain by Quaternary alluvium of variable thickness. The alluvial material is primarily composed of unconsolidated silty sand and clayey sand. The Triassic-aged Chinle Claystone underlies the alluvium and thickens towards the northeast within the boundary of the site, with thicknesses ranging from approximately 45 feet at TRcpc-18 to 205 feet at TRcpc-15. The Chinle Claystone behaves as a confining unit based on the thickness of the low-permeability claystone.

The Triassic-aged Correo Sandstone underlies the Chinle Claystone confining unit. As mentioned above, the six groundwater monitoring wells are each screened in the Correo Sandstone. The groundwater levels in the CCR wells, which are much higher than the screened interval (i.e., closer to the ground surface), indicate that the groundwater is under confining pressure from the overlying Chinle Claystone confining unit. The groundwater flow direction in the Correo Sandstone bed in the vicinity of the active CCR landfill is generally from west to east, with possible minor northerly or southerly components, as indicated by static groundwater levels in the monitoring wells installed at the site (Figure 1).

3.0 FLUORIDE BASELINE AND HISTORICAL DATA COMPARISONS

Figure 1 shows the range of fluoride concentrations measured at each of the network monitoring wells, while Figure 2 presents a time series graph for fluoride. These figures demonstrate the limited variability of the fluoride data collected for each well during the baseline period.

Due to the time constraints associated with the implementation of the CCR Rule (40 CFR Part 257), the baseline data for the CCR Groundwater Monitoring Program were collected on a compressed schedule, which consisted of monthly sampling between September 2016 and May 2017. We consider it likely that this compressed schedule (less than one year) did not allow for natural variations in groundwater concentrations, such as those attributable to seasonal fluctuations or other sources of natural variability, to be fully observed during the baseline data collection period.

The expected variation in fluoride concentration in the Correo Sandstone beneath the site can be approximated by the fluoride data collected from 1983 to 2017 at upgradient TRcpc-1 and TRcpc-2 (Table 1). The historical fluoride data (108 data points) at TRcpc-1 and TRcpc-2 have calculated coefficients of variation of 0.17 and 0.16, respectively, while the coefficients of variation calculated for the eight CCR Groundwater Monitoring Program baseline data points for fluoride for these wells are 0.08 and 0.07, respectively. The greater variation observed with historical data at TRcpc-1 can be mainly attributed to the larger sample size and longer monitoring period, which more suitably encompass expected natural variation. Thus, the relatively small variation observed in the TRcpc-16 fluoride baseline data, with a coefficient of variation of 0.06, is in part a function of the limited sample size and monitoring period. The two compliance monitoring concentrations are likely part of the expected natural

variation, with a coefficient of variation for the entire fluoride dataset for TRcpc-16 (13 data points, including detection monitoring samples) of 0.06, the same as for the baseline period.

Due to the false positive potential associated with the selected non-parametric prediction limit methodology (Section 4.0), an alternate method was also used to interpret the data. The TRcpc-16 fluoride data were examined for the presence of a statistically significant trend using the non-parametric Mann-Kendall test. A statistically significant trend is not observed in the most recent eight samples, the most recent six samples, or the entire data set (baseline and compliance) for fluoride at TRcpc-16. This lack of an observed trend indicates that there have not been any statistically significant changes in fluoride concentration at TRcpc-16. Fluoride trend analysis graphs are included in Figures 3 through Figure 5.

4.0 NON-PARAMETRIC PREDICTION LIMITS AND FALSE POSITIVE RATE

The primary goal in a groundwater detection monitoring program is to identify real changes to groundwater quality if they occur, with a specific focus on increasing concentrations in detection monitoring data when compared to baseline data. Statistical tests are used to identify the possible presence of elevated concentrations, and they must have adequate statistical power to do so. Statistical power is the likelihood of detecting a change in concentrations when a change is present in reality. A second critical goal is to avoid false positive errors (Type I errors), which occur when groundwater concentrations are incorrectly identified as being significantly greater than baseline when contamination does not exist.

A site-wide false positive rate (SWFPR) is used to measure the susceptibility to false positive errors. The Unified Guidance (USEPA 2009) recommends an annual SWFPR of 10%. This SWFPR equates to a *target* per well-constituent false positive rate of 0.38% using equation 19.17 in the Unified Guidance:

$$\alpha_{w \cdot c} = 1 - (1 - \alpha)^{1/(w \cdot c)}$$

where α is the SWFPR, w equals the actual number of downgradient compliance wells (four in this case), and c is the number of monitoring constituents (seven in this case). However, based on Table 19-19 in Appendix D of the Unified Guidance the *achievable* false positive rate for a non-parametric prediction limit with a background dataset of eight measurements where two statistical evaluations are performed per year is 4.2% (much greater than the target of 0.38% noted above). The only way to reduce this false positive rate would be to increase the number of background samples, which was not feasible under the time constraints of the CCR Rule. Thus, there is a relatively high probability of falsely identifying groundwater contamination for parameters that are being tested with a non-parametric methodology at the site, which may have occurred during the comparative statistical analysis for fluoride at TRcpc-16. Unfortunately, due to the nature of the non-parametric prediction limits, the false positive rate will remain elevated for the site until more sampling events are conducted. The data from future sampling events can be incorporated into an updated baseline period in accordance with the statistical methodology for the site (Golder 2017), which will result in either one of the following: 1) the underlying data distribution can be defined and a parametric methodology can be implemented, or 2) a non-parametric prediction limit can be constructed on a greater number of samples.

5.0 SUMMARY AND CONCLUSIONS

This demonstration details the reasons behind Golder's conclusion that the SSI for fluoride at TRcpc-16 is not an indication of groundwater impacts from Escalante Generating Station's active CCR landfill, but rather a reflection of natural variability in fluoride. The lines of evidence can be summarized as follows:

- Due to time constraints associated with the implementation of the CCR Rule (40 CFR Part 257), the baseline data for the CCR Groundwater Monitoring Program were collected on a compressed schedule, which did not allow for natural variations in groundwater concentrations to be fully observed during the baseline data collection period.
- Because of the low variability and limited number of baseline samples currently available, the selected statistical methodology to assess fluoride at TRcpc-16, a non-parametric prediction limit, has a high false positive rate.
- Analysis of fluoride at TRcpc-16 by an alternate methodology, the Mann-Kendall test for trends, does not indicate a statistically significant increasing trend.

Based on the findings of this demonstration, Golder recommends that Tri-State continue with the detection monitoring program for the active CCR landfill at Escalante Generating Station.

6.0 REFERENCES

- Golder Associates Inc. (Golder), 2017. Active Coal Combustion Residuals Landfill Groundwater Statistical Method Certification, Escalante Generating Station. October 13.
- U.S. Environmental Protection Agency (USEPA), Office of Solid Waste, 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance. March.

ATTACHMENTS

- Table 1 – Fluoride Summary Statistics
- Figure 1 – Groundwater Elevations and Fluoride Results
- Figure 2 – Fluoride Time Series
- Figure 3 – Mann-Kendall Trend Test - Most Recent 6 Samples
- Figure 4 – Mann-Kendall Trend Test - Most Recent 8 Samples
- Figure 5 – Mann-Kendall Trend Test - Entire Data Set

Tables

Table 1: Fluoride Summary Statistics

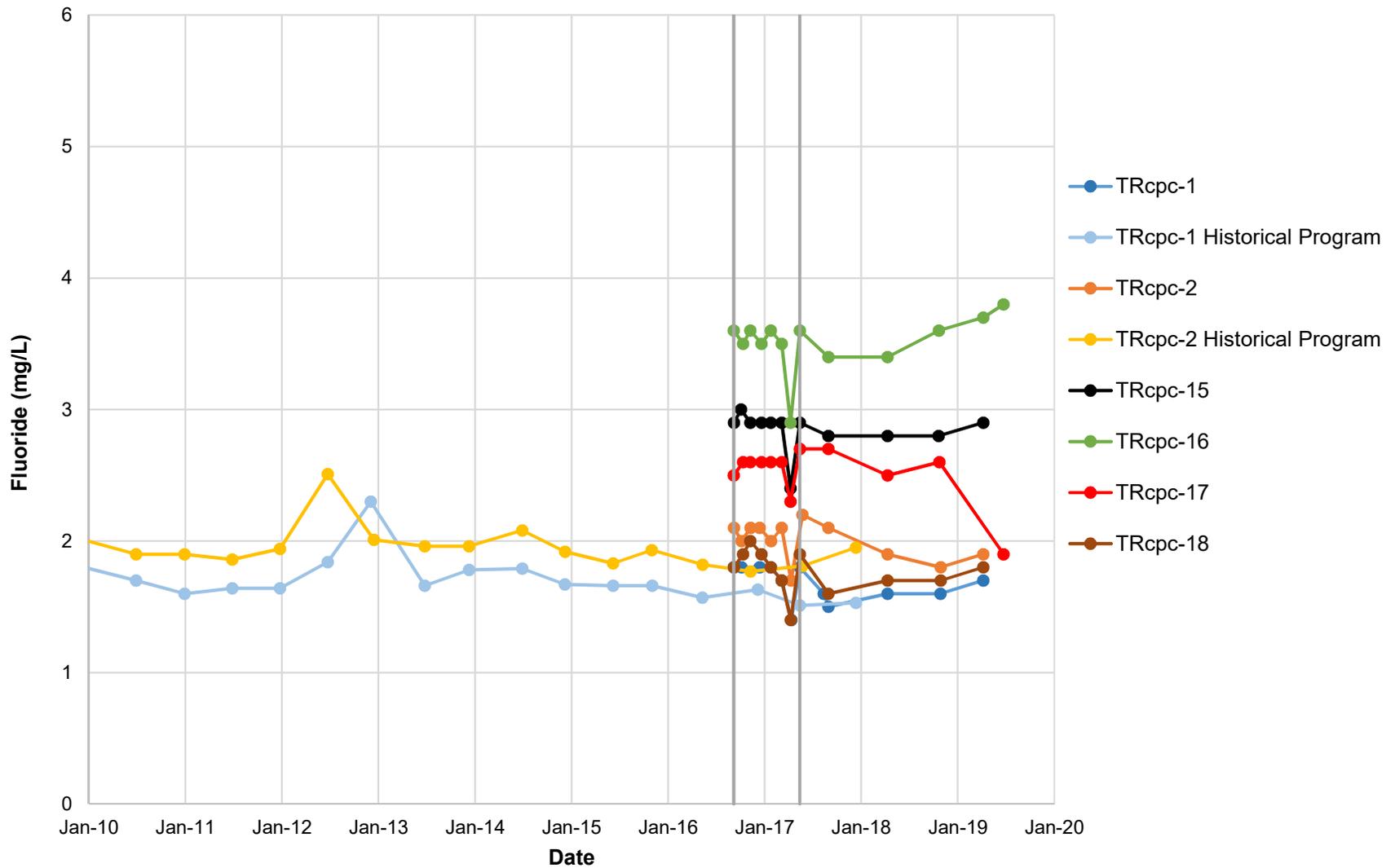
Monitoring Well	Constituent	Date Range	Fluoride Concentration - Baseline				
			Minimum	Mean	Maximum	Coefficient of Variation	Standard Deviation
TRcpc-1	Fluoride, CCR Program	2016-2017	1.4	1.71	1.8	0.08	0.14
TRcpc-1	Fluoride, Historical Program	1983-2017	0.7	1.67	3.2	0.17	0.29
TRcpc-2	Fluoride, CCR Program	2016-2017	1.7	2.04	2.2	0.07	0.14
TRcpc-2	Fluoride, Historical Program	1983-2017	0.4	2.04	3.6	0.16	0.32
TRcpc-15	Fluoride, CCR Program	2016-2017	2.4	2.85	3.0	0.06	0.17
TRcpc-16	Fluoride, CCR Program	2016-2017	2.9	3.48	3.6	0.06	0.22
TRcpc-17	Fluoride, CCR Program	2016-2017	2.3	2.56	2.7	0.04	0.11
TRcpc-18	Fluoride, CCR Program	2016-2017	1.4	1.80	2.0	0.10	0.17

Note:

The 2016-2017 date range indicates the baseline sampling period for the CCR Groundwater Monitoring Program.

Figures

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Notes:

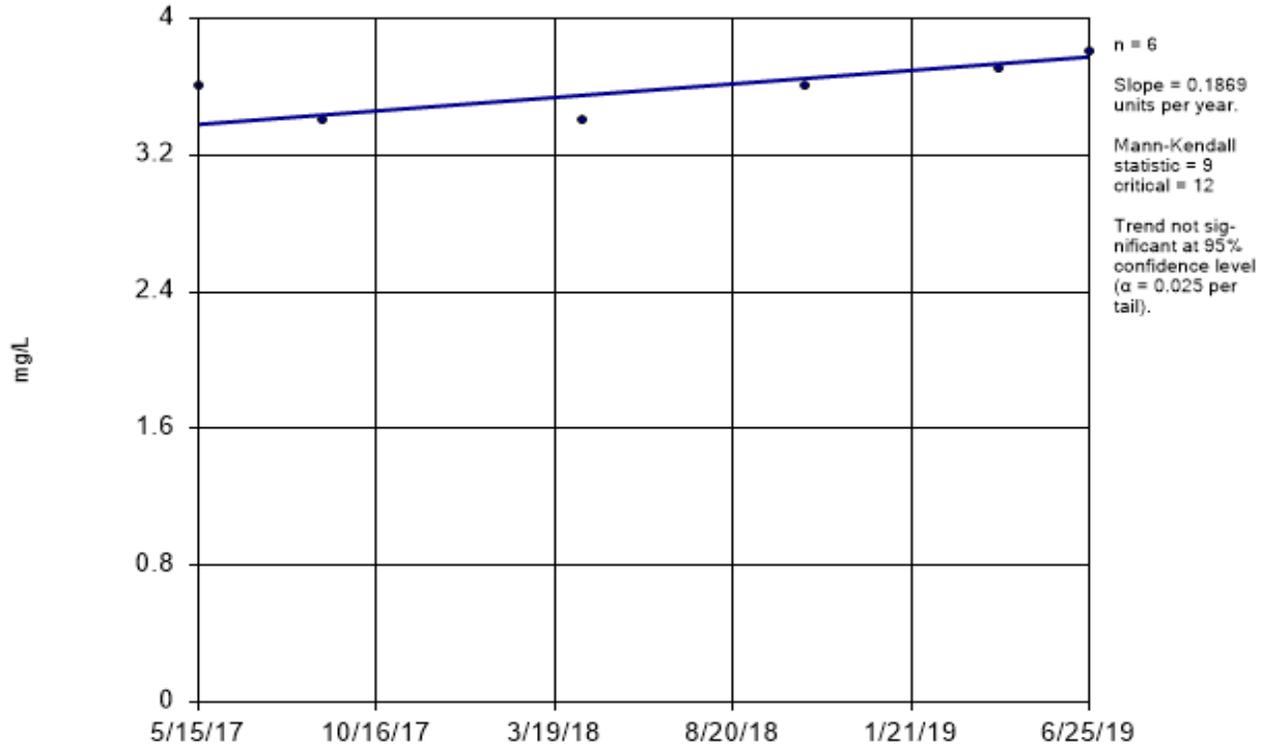
Vertical lines indicate the baseline period (September 2016 to May 2017), except for TRcpc-1 which included a sample in August 2017.

Data from 1983 to 2010 not displayed in order to provide better visualization of more recent data.

Figure 2
Fluoride Time Series

Escalante Generating Station CCR Groundwater Program

Sen's Slope Estimator TRCPC-16

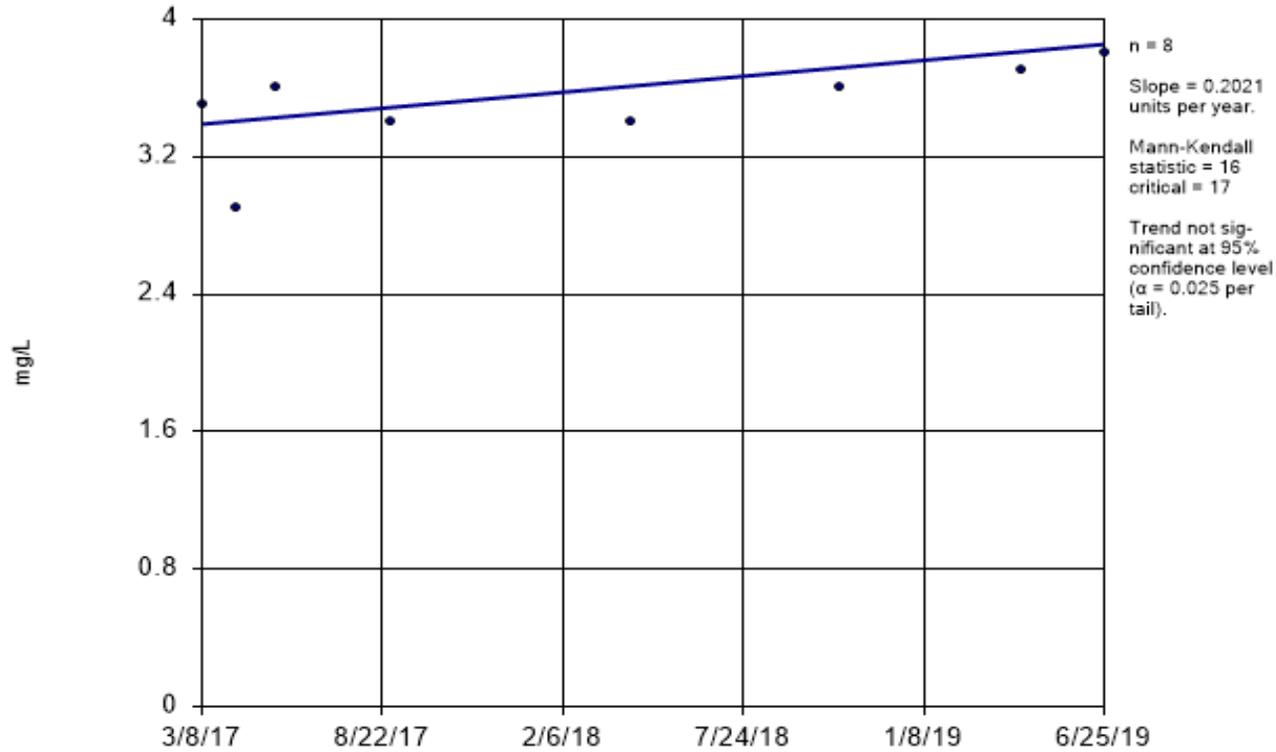


Constituent: Fluoride Analysis Run 9/30/2019 5:18 PM
Facility: Escalante Data File: Escalante-Well TRcpc-16

Figure 3
Mann-Kendall Trend Test - Most Recent 6 Samples
Escalante Generating Station CCR Groundwater Program

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Sen's Slope Estimator TRCPC-16

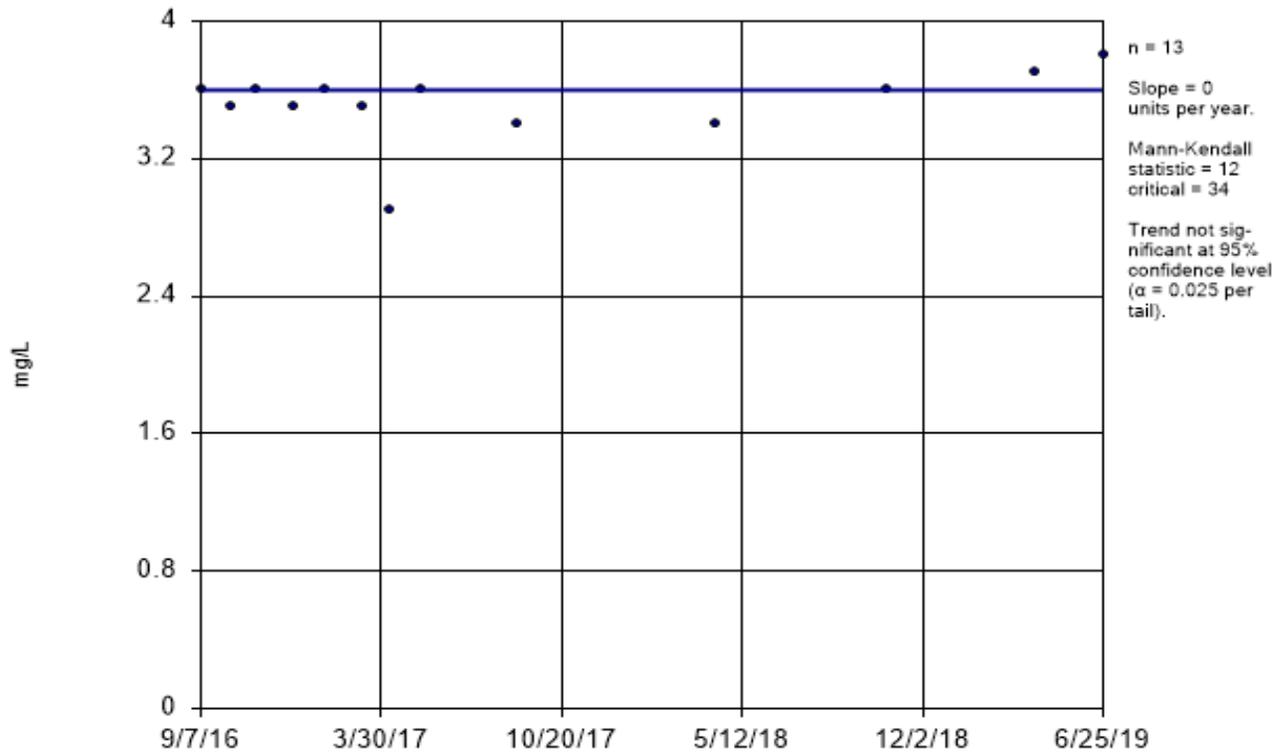


Constituent: Fluoride Analysis Run 9/30/2019 5:17 PM
Facility: Escalante Data File: Escalante-Well TRcpc-16

Figure 4
Mann-Kendall Trend Test - Most Recent 8 Samples
Escalante Generating Station CCR Groundwater Program

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Sen's Slope Estimator TRCPC-16



Constituent: Fluoride Analysis Run 9/30/2019 5:16 PM
Facility: Escalante Data File: Escalante-Well TRcpc-16

Figure 5
Mann-Kendall Trend Test - Entire Data Set
Escalante Generating Station CCR Groundwater Program

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