REPORT

Annual Coal Combustion Residuals Groundwater Report - 2021

Great River Energy, Coal Creek Station

Submitted to:

Great River Energy

Coal Creek Station, 2875 Third Street SW
Underwood, North Dakota 58576

Submitted by:

Golder Associates Inc.

7245 W Alaska Drive, Suite 200, Lakewood, Colorado, USA 80226

+1 303 980-0540

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Executive Summary

This report presents the results from groundwater monitoring events that occurred at Great River Energy's Coal Creek Station in 2021 to meet the requirements of the United States Environmental Protection Agency's Coal Combustion Residuals Rule (40 Code of Federal Regulations 257.90 through 257.98). The facilities entered 2021 under a detection monitoring program and remain in a detection monitoring program at the conclusion of 2021. The following items of statistical significance were identified in 2021 for the comparative statistical analysis of the fourth quarter (Q4) 2020 and second quarter (Q2) 2021 detection monitoring events:

- Verified Statistically Significant Increases (SSIs):
  - MW-DP4 (downgradient, Drains Pond System), Fluoride
    - Initially verified in Q2 2020, ongoing in Q4 2020 and Q2 2021.
    - Successful alternative source demonstration (ASD) completed October 27, 2020 (Golder Associates USA Inc. [Golder] 2021a); reconfirmation of the validity of the ASD completed May 21, 2021 (Appendix A) and January 6, 2022 (Appendix B).
  - MW-DP4 (downgradient, Drains Pond System), Field-Measured pH
    - Verified in Q4 2020, Q2 2021 analytical and cumulative sum (CUSUM) values within statistical limits (SLs).
    - Successful ASD completed May 21, 2021 (Appendix A); as noted in the reconfirmation of the validity of the alternative source demonstration completed January 6, 2022 (Appendix B), the Q2 2021 field pH value and CUSUM values were within the SLs, but field pH was included in the ASD as consecutive data points within the SLs have not been observed.
  - MW-DP4 (downgradient, Drains Pond System), Chloride
    - Verified in Q2 2021.
    - Successful ASD completed January 6, 2022 (Appendix B)
  - MW-49 (downgradient, Upstream Raise 91), Chloride
    - Initially Verified in Q4 2019, ongoing in Q2 2020, Q4 2020, and Q2 2021.
    - Successful ASD completed May 13, 2020 (Golder 2021a); reconfirmation of the validity of the ASD completed October 27, 2020 (Golder 2021a), May 21, 2021 (Appendix A), and January 6, 2022 (Appendix B).
  - MW-16-6 (upgradient, Upstream Raise 92), Total Dissolved Solids
    - Initially verified in Q4 2019, ongoing in Q2 2020, Q4 2020, and Q2 2021.
    - As an upgradient location, the facility was determined not be the source of the verified SSI based on a review of site observations and measured groundwater levels as well as the geographic location of the well. Per the Statistical Methods Certification (Golder 2021b), no ASD has been conducted for MW-16-6 as an upgradient location.

- MW-10 (downgradient, Upstream Raise 92), Boron
  - Initially verified in Q2 2020, ongoing in Q4 2020 and Q2 2021.
  - Successful ASD completed October 27, 2020 (Golder 2021a); reconfirmation of the validity of the ASD completed May 21, 2021 (Appendix A) and January 6, 2022 (Appendix B).
- MW-10 (downgradient, Upstream Raise 92), Fluoride
  - Initially verified in Q2 2020, ongoing in Q4 2020 and Q2 2021.
  - Successful ASD completed October 27, 2020 (Golder 2021a); reconfirmation of the validity of the ASD completed May 21, 2021 (Appendix A) and January 6, 2022 (Appendix B).
- MW-10 (downgradient, Upstream Raise 92), Field-Measured pH
  - Initially verified in Q2 2020, ongoing in Q4 2020 and Q2 2021.
  - Successful ASD completed October 27, 2020 (Golder 2021a); reconfirmation of the validity of the ASD completed May 21, 2021 (Appendix A) and January 6, 2022 (Appendix B).
- MW-16-1 (downgradient, Upstream Raise 92), Boron
  - Verified in Q4 2020, ongoing in Q2 2021.
  - Successful alternative source demonstration completed May 21, 2021 (Appendix A); reconfirmation of the validity of the alternative source demonstration completed January 6, 2022 (Appendix B).
- MW-16-1 (downgradient, Upstream Raise 92), Field-Measured pH
  - Initially verified in Q2 2020, ongoing in Q4 2020 and Q2 2021.
  - Successful ASD completed October 27, 2020 (Golder 2021a); reconfirmation of the validity of the ASD completed May 21, 2021 (Appendix A) and January 6, 2022 (Appendix B).
- MW-72 (upgradient, Southeast 16), Chloride
  - Initially verified in Q4 2019, ongoing in Q2 2020, Q4 2020, and Q2 2021.
  - As an upgradient location, the facility was determined not be the source of the verified SSI based on a review of site observations and measured groundwater levels as well as the geographic location of the well. Per the Statistical Methods Certification (Golder 2021b), no ASD has been conducted for MW-72 as an upgradient location.

- Potential Exceedances and False-Positives:
  - The potential exceedance identified in Q2 2020 for sulfate at MW-10 (downgradient, Upstream Raise 92) was found to be a false-positive through confirmatory re-sampling during the Q4 2020 sampling event.
  - The potential exceedance identified in Q4 2020 for boron at MW-DP4 (downgradient, Drains Pond System) was found to be a false-positive through confirmatory re-sampling during the Q2 2021 sampling event.

- The potential exceedance identified in Q4 2020 for chloride at MW-16-7 (upgradient, Upstream Raise 92) was found to be a false-positive through confirmatory re-sampling during the Q2 2021 sampling event.
- The potential exceedance identified in Q4 2020 for boron at MW-16-0 (downgradient, Upstream Raise 92) was found to be a false-positive through confirmatory re-sampling during the Q2 2021 sampling event.
- A potential exceedance was identified in Q2 2021 for fluoride at MW-DP3 (upgradient, Drains Pond System). Confirmatory re-sampling was conducted in Q4 2021, with associated statistical analysis to occur in the first quarter (Q1) 2022.
- A potential exceedance was identified in Q2 2021 for field-measured pH at MW-DP2B (downgradient, Drains Pond System). Confirmatory re-sampling was conducted in Q4 2021, with associated statistical analysis to occur in Q1 2022.

Following successful ASDs for the verified SSIs identified in Q4 2020 and Q2 2021, the Coal Creek Station facilities remain in detection monitoring. Confirmatory re-sampling for the potential exceedances identified in Q2 2021 occurred during the Q4 2021 sampling event. Comparative statistical analysis for the Q4 2021 detection monitoring event will be completed within 90 days of data finalization, in Q1 2022. As described in the Coal Combustion Residuals Groundwater Monitoring System Certification (Golder 2019) and the Coal Combustion Residuals Groundwater Monitoring Statistical Methods Certification (Golder 2021b), the groundwater monitoring and analytical procedures meet the general requirements of the CCR rule, and modifications to the monitoring networks and sampling program are not recommended at this time.

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1.0 INTRODUCTION

Golder Associates USA Inc. (Golder), a member of WSP, prepared this report for the 2021 groundwater sampling and comparative statistical analysis for Great River Energy's (GRE) Coal Creek Station (CCS) to meet the requirements of the United States Environmental Protection Agency's (USEPA) Coal Combustion Residuals (CCR) rule's sections on groundwater monitoring and corrective action, 40 Code of Federal Regulations (CFR) Sections 257.90 through 257.98.

1.1 Purpose

The federal CCR rule established specific requirements for reporting of actions related to groundwater monitoring and corrective actions in 40 CFR 257.90 and as amended. In accordance with part (e) of 40 CFR 257.90, owners and operators of CCR units must prepare an annual groundwater monitoring and corrective action report.

1.2 Site Background

GRE's CCS is a coal-fired electric generation facility located in McLean County, North Dakota, approximately 10 miles northwest of Washburn, North Dakota. CCRs are managed in composite-lined surface water impoundment cells and dry waste facilities regulated and permitted by the North Dakota Department of Environmental Quality (NDDEQ) in accordance with North Dakota Administrative Code Article 33.1-20, Solid Waste Management and Land Protection.

CCS has four CCR facilities that are within the purview of the USEPA CCR rule:

- Drains Pond System CCR Surface Impoundment (Drains Pond System)
- Upstream Raise 91 CCR Surface Impoundment (Upstream Raise 91)
- Upstream Raise 92 CCR Surface Impoundment (Upstream Raise 92)
- Southeast Section 16 CCR Landfill (Southeast 16)

Each CCR facility is monitored by a separate monitoring network, in accordance with the Coal Combustion Residuals Groundwater Monitoring System Certification (Golder 2019). Locations of the facilities, groundwater monitoring network units, and groundwater monitoring wells are shown in Figure 1 and Figure 2.

In April 2021, disposal of CCR and non-CCR waste ceased, and closure was initiated at Upstream Raise 92. Upstream Raise 92 is no longer used as a dewatering facility for hydraulically conveyed flue gas desulfurization (FGD) material and will be closed with CCR in-place.

2.0 GROUNDWATER MONITORING NETWORK PROGRAM STATUS

The CCR groundwater monitoring system at CCS consists of 23 monitoring locations (8 upgradient and 15 downgradient wells). The monitoring locations are shown in Figure 1 and Figure 2 and listed in Table 1. Additional information on the groundwater monitoring system can be found in the Coal Combustion Residuals Groundwater Monitoring System Certification, Revision 1 (Golder 2019). Each CCR facility is part of monitoring network consisting of at least one upgradient and three downgradient monitoring wells.

- The Drains Pond System has two upgradient and four downgradient monitoring wells.
- Upstream Raise 91 has two upgradient and three downgradient monitoring wells.

- Upstream Raise 92 has two upgradient and three downgradient monitoring wells.
- Southeast 16 has two upgradient and five downgradient monitoring wells.

2.1 Completed Key Actions in 2021

The following key actions were completed in 2021:

- The 2020 annual CCR groundwater monitoring and corrective action report was completed and placed in the operating record and on the publicly accessible CCR website (Golder 2021a).
- Revision 2 of the Coal Combustion Residuals Groundwater Monitoring Statistical Methods Certification (Golder 2021b) was placed within the operating record and on the publicly accessible CCR website.
- Detection monitoring samples were collected in June (second quarter [Q2]) and October (fourth quarter [Q4]) 2021 from the program wells and analyzed for the Appendix III constituent list associated with the CCR rule. Additionally, the Q2 2021 samples were analyzed for the Appendix IV constituent list associated with the CCR rule for ongoing collection of baseline data.
- Comparative statistical analysis was completed within 90 days of receipt of the final analytical results for the Q4 2020 and Q2 2021 detection monitoring samples, collected in October 2020 and June 2021, respectively.
- Successful alternative source demonstrations (ASD) were completed for the verified statistically significant increases (SSIs) identified following the Q4 2020 comparative statistical analysis. These ASDs are included in Appendix A. Further information is included in Section 4.1.1.
- Monitoring well hydraulic testing was performed at MW-16-6, MW-40, MW-75, MW-DP3, MW-91-1, and MW-91-2 in September 2021. Results of the monitoring well hydraulic testing have been used in Section 3.1.1 along with slug testing results from 2007 collected from other system wells.
- Successful ASDs were completed for the verified SSIs identified following the Q2 2021 comparative statistical analysis. These ASDs are included as Appendix B. Further information is included in Section 4.1.3.

2.2 Installation and Decommissioning of Wells

No wells were added or removed from the CCR monitoring well networks in 2021.

2.3 Problems and Resolutions

As in prior years (2018 through 2020), no samples were able to be collected from MW-DP2 in 2021. Well MW-DP2 will continue to be monitored as part of the CCR monitoring program and samples will be collected when enough water is present within the well. Well MW-DP2B (installed November 2018) has been incorporated into the Drains Pond System monitoring program as an additional point of compliance to continue to adequately monitor the Drains Pond System.

2.3.1 Q2 2021 Monitoring Event

During the Q2 2021 monitoring event, samples from MW-49, MW-91-1, MW-16-6 (U), MW-91-2 (U), and MW-75 (U) were received outside of the required temperature range due to shipping delays that occurred between shipment from the site and receipt by the laboratory. This issue was noted by the laboratory within the narrative description of the analytical results but did not require the use of any qualifiers for the analytical results per the analytical laboratory. Results of the out-of-temperature samples are consistent with past events.

Additionally, the chloride concentration for the Q2 2021 sample from MW-DP2B was initially reported as a non-detect with a 20x dilution, elevating the detection limit. Re-analysis was requested on the undiluted sample, resulting in a detected value reported out of hold-time. The result is marked with an H qualifier on the associated tables.

Calcium was detected in the method blank associated with the following samples collected during the Q2 2021 monitoring event at a level exceeding the reporting limit. Samples were flagged with the ‘B’ qualifier and were not re-extracted or re-analyzed as the sample results were greater than 10 times the value found in the method blank.

- MW-16-1 (Downgradient, Upstream Raise 91)
- MW-42 (Upgradient, Upstream Raise 92)
- MW-72 (Upgradient, Upstream Raise 92)
- MW-16-2 (Downgradient, Upstream Raise 92)
- MW-16-3 (Downgradient, Upstream Raise 92)
- MW-16-4 (Downgradient, Upstream Raise 92)
- MW-15 (Downgradient, Upstream Raise 92)
- MW-16-5 (Downgradient, Upstream Raise 92)

No further issues were noted related to the collection of samples or the chemical analysis for the Q2 2021 monitoring event.

2.3.2 Q4 2021 Monitoring Event

During the Q4 2021 monitoring event, boron failed the high recovery criteria for the matrix spike duplicate of the sample collected from MW-DP2B. Either sample matrix interference and/or non-homogeneity of the original sample were suspected, as the associated laboratory control sample recovery was within acceptable limits. The result for boron at MW-DP2B was marked with a ‘F1’ qualifier indicating this issue. The F1 qualifier is included on the associated table.

Similarly, fluoride failed the low recovery criteria for the matrix spike and matrix spike duplicate of the sample collected from MW-72. Either sample matrix interference and/or non-homogeneity of the original sample were suspected, as the associated laboratory control sample recovery was within acceptable limits. The result for fluoride at MW-72 was marked with a ‘F1’ qualifier indicating this issue and is included on the associated table.

During initial review of the fluoride result for the Q4 2021 monitoring event at MW-42, a discrepancy was noted between the reported value and past results at the well. A request was made to Eurofins TestAmerica to re-review the value, where the discrepancy was determined to be the result of a data entry error. For further confirmation, the sample was re-analyzed outside of hold time, confirming that the discrepancy was solely a data entry error. The error was corrected, and only the revised result is presented in this report.

No further issues were noted related to the collection of samples or the chemical analysis for the Q4 2021 monitoring event.

2.4 Key Activities for 2022

The following key activities are anticipated to be completed in 2022:

- The 2021 annual CCR groundwater monitoring and corrective action report will be completed and placed in the operating record and on the publicly accessible CCR website.
- Comparative statistics will be completed for the Q4 2021 detection monitoring samples within 90 days of receipt of the final analytical results.
- Detection monitoring sampling events will occur in Q2 2022 and Q4 2022, and will consist of sampling, data review, and comparative statistics. Comparative statistics for both the Q2 2022 and Q4 2022 detection monitoring samples will be completed within 90 days of receipt of the final analytical results.

3.0 GROUNDWATER MONITORING ANALYTICAL PROGRAM STATUS

Analytical activities associated with the groundwater monitoring program are described below.

3.1 Collected Samples

Detection monitoring samples were collected from wells within the CCR rule well networks by GRE staff in June (Q2) 2021 and October (Q4) 2021. Precise dates vary between locations and can be found in Table 2 through Table 24. Further, the Q2 2021 samples were analyzed for the Appendix IV constituent list for additional baseline information. Results for the various samples collected throughout 2021 are summarized in Table 2 through Table 24.

Samples were collected using low-flow methodology with dedicated bladder pumps installed at each monitoring well. The sampling procedures and analytical testing methods were conducted in accordance with USEPA accepted procedures.

3.1.1 Groundwater Elevation and Flow Rate

Depths to groundwater were measured in each well during each sampling event prior to purging. Groundwater elevations can be found in Table 2 through Table 24. Groundwater elevations and interpolated groundwater contours from the Q2 2021 detection monitoring event are shown in Figure 1. Groundwater elevations and interpolated groundwater contours from the Q4 2021 detection monitoring event are shown in Figure 2. Based on both the Q2 (June) 2021 and Q4 (October) 2021 groundwater elevations and interpolated contours, the shallow groundwater at the CCR facilities generally follows surface topography, flowing to the east and north. The dates for groundwater information shown in the figures generally display site seasonal variability in groundwater levels between the spring/summer and fall/winter.

The groundwater flow rate across each facility 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 in ft/day, estimated from slug testing results from system wells conducted in 2007 and 2021
- i is the hydraulic gradient in feet per feet (ft/ft), calculated based on groundwater elevations for each monitoring event

- n_e is the effective porosity, a unitless parameter, which is estimated to be 0.3 for unfractured glacial till, reflective of site soils (Ohio EPA 2015)

The range of groundwater flow rates calculated for each unit during the Q2 2021 and Q4 2021 detection monitoring sampling events are shown below. Groundwater flow rates are presented based on a range of measured hydraulic conductivity values for each unit, also shown below.

- Drains Pond System (range of k values: 0.01 ft/day to 2.83 ft/day)
  - Q2 2021: 0.001 – 0.25 ft/day
  - Q4 2021: 0.001 – 0.25 ft/day
- Upstream Raise 91 (range of k values: 0.01 ft/day to 56.69 ft/day)
  - Q2 2021: 0.0004 – 1.93 ft/day
  - Q4 2021: 0.0004 – 1.92 ft/day
- Upstream Raise 92 (range of k values: 0.09 ft/day to 56.69 ft/day)
  - Q2 2021: 0.003 – 2.25 ft/day
  - Q4 2021: 0.003 – 2.25 ft/day
- Southeast 16 (range of k values: 1.51 ft/day to 56.69 ft/day)
  - Q2 2021: 0.01 – 0.50 ft/day
  - Q4 2021: 0.01 – 0.55 ft/day

3.2 Monitoring Data (Analytical Results)

Analytical results for samples collected in 2021 for monitoring wells within the networks are shown in Table 2 through Table 24.

3.3 Comparative Statistical Analysis

The comparative statistical analysis for the Q4 2020 and Q2 2021 detection monitoring events is summarized below, with the results presented in Table 25 through Table 47. Comparative statistical analysis for the Q4 2021 detection monitoring event will occur within 90 days of data review following receipt of the analytical data. Based on the timing of receipt of the analytical results for the Q4 2021 detection monitoring samples, comparative statistical analysis for the Q4 2021 event will be completed during the first quarter (Q1) 2022. A full description of the steps taken for comparative statistical analyses can be found in the Coal Combustion Residuals Groundwater Statistical Method Certification, Revision 2 (Golder 2021b), available on the publicly accessible CCR website.

Comparative statistical analysis is conducted following each detection monitoring sampling event, consisting of the Appendix III parameters (USEPA 2015). The comparative statistical analysis consists of a comparison of detection monitoring results collected during the period of interest (the compliance period) to the statistical limit (SL) calculated from the baseline period. For constituent-well pairs with increasing trends identified during the baseline period, an alternative trend test, as described by the Electric Power Research Institute (EPRI 2015), has been used to determine statistical significance. For constituent-well pairs with decreasing trends identified during the baseline period, a Sen's Slope trend test was used to assess the results. A detailed discussion of the methodology used for comparative statistical analysis can be found in the Coal Combustion Residuals Groundwater Statistical Methods Certification, Revision 2 (Golder 2021b).

3.3.1 Definitions

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

- Elevated Cumulative Sum (CUSUM) – occurs when the calculated CUSUM value is greater than the Shewhart-CUSUM limit established by the baseline statistical analysis, but the analytical result does not exceed the Shewhart-CUSUM limit. An elevated CUSUM is an indication that concentrations are gradually increasing and that analytical results may exceed the Shewhart-CUSUM limit in the future. For elevated CUSUMs in the case of two-tailed analysis for field-measured pH, the CUSUM value may also be below the lower Shewhart-CUSUM limit established by the baseline statistical analysis
- Potential Exceedance – an initial elevated CUSUM or an initial analytical result that exceeds the parametric prediction limit (PL), the Shewhart-CUSUM limit, or the non-parametric SL established by the baseline statistical analysis. Confirmatory resampling will determine if the potential exceedance is a false-positive or a verified SSI. Non-detect results that exceed either the parametric PL, the Shewhart-CUSUM limit, or the non-parametric SL are not considered potential exceedances.
- False-positive – an analytical result that exceeds the SL that can clearly be attributed to laboratory error, changes in analytical precision, or is invalidated through confirmatory re-sampling. False-positives are not used in calculation of any subsequent CUSUMs.
- Confirmatory re-sampling – designated as the next scheduled sampling event.
- Verified SSI – interpreted as two consecutive exceedances (the original sample and the confirmatory re-sample for analytical results, two consecutive elevated CUSUMs, or a combination of an analytical result above the PL/SL and an elevated CUSUM in either event order) for the same constituent at the same well.

3.3.2 Potential Exceedances

The following potential exceedances were identified for the Q4 2020 detection monitoring event:

- MW-DP4 (downgradient, Drains Pond System), Boron Elevated CUSUM
- MW-DP4 (downgradient, Drains Pond System), Chloride
- MW-16-7 (upgradient, Upstream Raise 92), Chloride
- MW-16-0 (downgradient, Upstream Raise 92), Boron

Confirmatory re-sampling for these constituent-well pairs occurred during the Q2 2021 detection monitoring sampling event, with results discussed in the following sections.

The following potential exceedances were identified for the Q2 2021 detection monitoring event:

- MW-DP3 (Upgradient, Drains Pond System), Fluoride
- MW-DP2B (Downgradient, Drains Pond System), Field-Measured pH

Confirmatory re-sampling for these constituents occurred during the Q4 2021 detection monitoring sampling event. Comparative statistics of the Q4 2021 detection monitoring event will be completed within 90 days of data review for the final analytical results, in Q1 2022.

3.3.3 False-Positives

Following the Q4 2020 confirmatory re-sampling event, the potential exceedance for sulfate at MW-10 (downgradient, Upstream Raise 92) identified during the Q2 2020 detection monitoring sampling event was determined to be a false-positive.

Following the Q2 2021 confirmatory re-sampling event, the following false-positives were identified for the Q4 2020 detection monitoring event:

- MW-DP4 (Downgradient, Drains Pond System), Boron
- MW-16-7 (Upgradient, Upstream Raise 92), Chloride
- MW-16-0 (Downgradient, Upstream Raise 92), Boron

3.3.4 Verified SSIs

Following the Q4 2020 confirmatory re-sampling event, the following verified SSIs were confirmed during the Q4 2020 detection monitoring event:

- MW-DP4 (downgradient, Drains Pond System), Fluoride – Initially Verified in Q2 2020
- MW-DP4 (downgradient, Drains Pond System), Field-Measured pH
- MW-49 (downgradient, Upstream Raise 91), Chloride – Initially Verified in Q4 2019
- MW-16-6 (upgradient, Upstream Raise 92), Total Dissolved Solids (TDS) – Initially Verified in Q4 2019
- MW-10 (downgradient, Upstream Raise 92), Boron – Initially Verified in Q2 2020
- MW-10 (downgradient, Upstream Raise 92), Fluoride – Initially Verified in Q2 2020
- MW-10 (downgradient, Upstream Raise 92), Field-Measured pH – Initially Verified in Q2 2020
- MW-16-1 (downgradient, Upstream Raise 92), Boron
- MW-16-1 (downgradient, Upstream Raise 92), Field-Measured pH – Initially Verified in Q2 2020
- MW-72 (upgradient, Southeast 16), Chloride – Initially Verified in Q4 2019

Associated steps following identification of the verified SSIs in Q4 2020 are described in Sections 4.1.1 and 4.1.2.

Following the Q2 2021 confirmatory re-sampling event, the following verified SSIs were confirmed during the Q2 2021 detection monitoring event:

- MW-DP4 (Downgradient, Drains Pond System), Chloride
- MW-DP4 (Downgradient, Drains Pond System), Fluoride – initially verified in Q2 2020
- MW-49 (Downgradient, Upstream Raise 91), Chloride – initially verified in Q4 2019

- MW-16-6 (Upgradient, Upstream Raise 92), TDS – initially verified in Q4 2019
- MW-10 (Downgradient, Upstream Raise 92), Boron – initially verified in Q2 2020
- MW-10 (Downgradient, Upstream Raise 92), Fluoride – initially verified in Q2 2020
- MW-10 (Downgradient, Upstream Raise 92), Field-Measured pH – initially verified in Q2 2020
- MW-16-1 (Downgradient, Upstream Raise 92), Boron – initially verified in Q4 2020
- MW-16-1 (Downgradient, Upstream Raise 92), Field-Measured pH – initially verified in Q2 2020
- MW-72 (Upgradient, Southeast Section 16), Chloride – initially verified in Q4 2019

For field-measured pH at MW-DP4, the Q2 2021 analytical value and calculated CUSUM value were within the bounds of the upper and lower statistical limits based on the two-tailed analysis for field-measured pH. The Q2 2021 value is listed as a previously verified SSI without consecutive data points within statistical limits.

The Q4 2020 and Q2 2021 elevated CUSUM values for chloride at MW-75 (upgradient, Upstream Raise 91) are not considered verified SSIs. The calculated CUSUM values above the statistical limit reflect a change in the reporting limit due to a change in analytical methodologies stemming from the switch in analytical laboratories. As the values are associated with non-detect analytical results at the reporting limit without dilutions for an upgradient monitoring location, the results are considered in compliance. Statistical methodology will be updated to better account for the change in analytical methodology during the next baseline update.

Associated steps following identification of the verified SSIs in Q2 2021 are described in Sections 4.1.2 and 4.1.3.

3.3.5 Trending Data

During establishment and updating of statistical baseline periods, a few wells at the site were found to have trending data, preventing establishment of a statistical limit using data solely from the baseline sampling period. A description of the methods used for determining statistical significance at these wells follows.

Increasing Trends:

- MW-DP2 (downgradient, Drains Pond System), Total Dissolved Solids: As noted in Section 2.3, MW-DP2 had insufficient volume to sample during the Q4 2020 and Q2 2021 detection monitoring sampling events. Following collection of further data, the total dissolved solids data will be reassessed to determine if a baseline period can be established based on non-trending data.

Decreasing Trends:

- MW-DP2 (downgradient, Drains Pond System), Fluoride: As noted in Section 2.3, MW-DP2 had insufficient volume to sample during the Q4 2020 and Q2 2021 detection monitoring sampling events. Following collection of further data, the fluoride data will be reassessed to determine if a baseline period can be established on non-trending data.
- MW-DP2B (downgradient, Drains Pond System), Chloride: A statistically significant decreasing trend was identified through the samples used for establishing the initial baseline period for MW-DP2B. With inclusion of the Q4 2020 and Q2 2021 results, the completed data set for chloride at MW-DP2B continues to have a significantly decreasing trend, based on Sen's Slope analysis for the complete data set. Following collection

of further data, the chloride data for MW-DP2B will be reassessed to determine if a baseline period can be established based on non-trending data.

- MW-91-2 (Upgradient, Upstream Raise 91), Calcium: With inclusion of the Q4 2020 and Q2 2021 detection monitoring sampling results, the complete data set for calcium at MW-91-2 continues to have a statistically significant decreasing trend, based on Sen's Slope analysis for the complete data set. Following collection of further data, the calcium data for MW-91-2 will be reassessed to determine if a baseline period can be established based on non-trending data.

4.0 PROGRAM TRANSITIONS

Beginning in Q4 2017, the groundwater monitoring programs at CCS transitioned from the baseline period to detection monitoring for the majority of program wells. During the baseline period, at least eight independent samples from the wells within the program were collected and analyzed for the constituents listed in Appendix III and Appendix IV of the federal CCR rule prior to October 17, 2017, as specified in 40 CFR 257.94(b). The first detection monitoring samples were collected in Q4 2017.

4.1 Detection Monitoring

The four monitoring networks within the purview of the CCR rule are each currently in detection monitoring. Samples for the detection monitoring program are collected on a semi-annual basis, beginning with the samples collected in Q4 2017. GRE plans to collect semi-annual samples for the detection monitoring program in Q2 and Q4 2022.

40 CFR 257.94(e) states the conditions under which a CCR unit must transition to assessment monitoring or complete an ASD:

> "If the owner or operator of the CCR unit determines, pursuant to 40 CFR 257.93(h) that there is an SSI over background levels for one or more of the constituents listed in Appendix III to this part at any monitoring well at the waste boundary specified under 40 CFR 257.91(a)(2), the owner or operator must: (1) Except as provided for in paragraph (e)(2) of this section, within 90 days of detecting a SSI over background levels for any constituent, establish an assessment monitoring program meeting the requirements of 40 CFR 257.95. (2) The owner or operator may demonstrate that a source other than the CCR unit caused the statistically significant levels for a constituent or that the SSI resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality."

4.1.1 Alternative Source Demonstrations – Q4 2020

GRE pursued ASDs after identifying the verified SSIs for chloride at MW-49, fluoride and field pH at MW-DP4, boron, fluoride, and field pH at MW-10, and boron and field pH at MW-16-1 during the Q4 2020 detection monitoring event. Successful ASDs were completed within 90 days of identification of the verified SSIs from the Q4 2020 detection monitoring event, and are included as Appendix A. As a result of the successful ASD outcomes, GRE remained in detection monitoring for the Q2 2021 sampling event.

4.1.2 Upgradient Verified SSIs – Q4 2020 and Q2 2021

Per the Groundwater Monitoring Statistical Methods Certification (Golder 2021b), an ASD will only be completed for verified SSIs identified in downgradient wells. ASDs were not completed for the verified SSIs identified during Q4 2020 and Q2 2021 for upgradient wells MW-16-6 and MW-72, as the facilities were determined not to be the cause of the verified SSIs, based on groundwater flow and direction.

4.1.3 Alternative Source Demonstrations – Q2 2021

GRE pursued ASDs after identifying the verified SSIs for chloride at MW-49, chloride and fluoride at MW-DP4, boron, fluoride, and field pH at MW-10, and boron and field pH at MW-16-1 during the Q2 2021 detection monitoring event. While the analytical and CUSUM values for field pH at MW-DP4 were within the associated statistical limits in Q2 2021, discussion of field pH was included within the ASD for the Q2 2021 events as a previously verified SSI without consecutive data points within statistical limits. Successful ASDs were completed within 90 days of identification of the verified SSIs from the Q2 2021 detection monitoring event, and are included as Appendix B. As a result of the successful ASD outcomes, GRE remains in detection monitoring for the Q4 2021 sampling event.

4.2 Assessment Monitoring

With the completion of the successful ASDs, the results of the comparative statistical analysis through Q2 2021 for the groundwater monitoring programs at CCS do not trigger the need to implement assessment monitoring as described in 40 CFR 257.95.

4.3 Corrective Measures and Assessment

Results to date from the CCR groundwater monitoring programs at CCS do not trigger the need to assess or implement corrective measures. Since the CCR groundwater monitoring programs do not require corrective measures, an assessment of corrective measures, as described in 40 CFR 257.96, has not been initiated and no actions are required.

5.0 CLOSING

This report presents the analytical results from the Q2 2021 and Q4 2021 detection monitoring events of the CCR groundwater monitoring programs at CCS. Comparative statistical analyses for the Q4 2020 and Q2 2021 detection monitoring events are also included. Comparative statistical analysis for the Q4 2021 detection monitoring event conducted in October 2021 will occur within 90 days of finalizing data review (during Q1 2022). The groundwater monitoring and analytical procedures implemented meet the requirements of the CCR rule and are consistent with the approach described in Revision 1 to the Groundwater Monitoring System Certification (Golder 2019) and Revision 2 to the Groundwater Monitoring Statistical Methods Certification (Golder 2021b). Comparative statistics and the ASDs presented within this report support remaining in detection monitoring, and do not trigger assessment monitoring nor an assessment of corrective measures.

Signature Page

Golder Associates Inc.

Erin L. Hunter, PhD
Senior Project Engineer

Todd J. Stong, PE
Associate and Senior Consultant

ELH/TJS/df

https://golderassociates.sharepoint.com/sites/140044/project files/6 deliverables/21451024c/reports/15-r-2021_ccr_gw_report/15-r-0-/21451024c-fnl-2021_ccr_gw_rpt.docx

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TABLES

Table 1: Monitoring Network Well Summary

Facility	Location	Well ID	Date Constructed	TOC Elevation (ft AMSL)	Ground Surface Elevation (ft AMSL)	Completion Depth (ft)	Drilled Depth (ft)	Screen Interval (ft bgs)	Top of Screen Elevation (ft AMSL)	Bottom of Screen Elevation (ft AMSL)	Sand Pack Interval (ft bgs)	Geologic Unit(s) Completed In
Drains Pond System	Upgradient	MW-DP3	4/3/2015	1,932.7	1,929.6	19.0	21.0	9.0-19.0	1,920.6	1,910.6	6.0-19.0	fill, coal, clay
		MW-DP5 [1]	11/18/2015	1,939.2	1,935.0	--	--	18.0-43.0	1,919.0	1,892.0	16.0-43.0	sandy lean clay, clayey sand
	Downgradient	MW-DP1 [2]	6/10/2014	1,913.6	1,911.1	45.0	46.0	25.0-45.0	1,886.1	1,866.1	21.0-45.0	silt with sand, silty sand
		MW-DP2	4/3/2015	1,898.1	1,894.9	17.0	18.0	7.0-17.0	1,887.9	1,877.9	5.0-17.0	sandy lean clay, clay sand
		MW-DP2B [3]	11/20/2018	1,898.6	1,895.6			12.0-22.0	1,883.6	1,873.6	10.0-22.0	sandy lean clay, sand with silt/gravel, silty sand
		MW-DP4	4/3/2015	1,917.4	1,914.2	29.0	31.0	19.0-29.0	1,895.2	1,885.2	17.0-29.0	sandy clay, sand with silt/gravel, clay, clayey sand
Upstream Raise 91	Upgradient	MW-75	7/19/1989	1,941.4	1,938.9	40.0	40.5	30.0-40.0	1,908.9	1,898.9	27.7-40	clayey silt, silty sand
		MW-91-2	11/6/2017	1,938.5	1,938.7	31.0	31.0	21.0-31.0	1,917.7	1,907.7	19.0-31.0	fat clay, coal
	Downgradient	MW-49	5/20/1988	1,905.9	1,903.6	19.9	25.0	9.85-19.85	1,893.8	1,883.8	4.85-19.85	sandy gravelly clay, sandy silt, shale (rock)
		MW-51	5/20/1988	1,896.9	1,895.5	18.8	20.0	8.8-18.8	1,886.7	1,876.7	3.8-18.8	sand with silt and gravel
		MW-91-1	11/6/2017	1,905.1	1,902.0	26.0	26.0	16.0-26.0	1,886.0	1,876.0	14.0-26.0	sand with silt and gravel, fat clay
Upstream Raise 92	Upgradient	MW-16-6	7/14/2015	1,917.2	1,913.9	13.0	16.0	4.0-14.0	1,909.9	1,899.9	3.0-14.0	sandy lean clay, coal, lean clay
		MW-16-7	7/14/2015	1,889.1	1,886.6	32.0	33.0	22.0-32.0	1,864.6	1,854.6	20.0-32.0	fat clay, clayey sand, sandy clay
	Downgradient	MW-10 [4]	11/2/1979	1,910.6	1,907.6	38.0	42.0	28-38	1,877.2	1,867.2	26-38	sand
		MW-16-0	12/8/2017	1,883.4	1,880.4	9.5	9.5	4.5-9.5	1,875.9	1,870.9	2.5-9.5	lean clay with sand
		MW-16-1	10/31/2007	1,879.5	1,876.1	11.5	16.0	6.5-11.5	1,869.6	1,864.6	4.5-11.5	silty sand
Southeast Section 16 Facility	Upgradient	MW-42	5/28/1986	1,881.6	1,878.8	14.4	21.5	9.4-14.4	1,869.4	1,864.4	9-14.4	silty sand, lean clay
		MW-72	7/18/1989	1,884.6	1,882.4	23.0	24.0	7.5-17.5	1,874.9	1,864.9	6.5-23.0	silty clay, silty sand
	Downgradient	MW-15	11/7/1979	1,877.3	1,874.3	20.0	38.0	10-20	1,864.3	1,854.3	9-20	sand, clay till
		MW-16-2	10/31/2007	1,880.6	1,877.8	12.0	16.0	7-12	1,870.8	1,865.8	5-12	sandy lean clay
		MW-16-3	10/31/2007	1,878.5	1,875.6	12.0	16.0	7-12	1,868.6	1,863.6	5-12	sandy lean clay
		MW-16-4	10/31/2007	1,877.5	1,874.6	17.0	16.0	7-17	1,867.6	1,857.6	5-17	sandy lean clay
		MW-16-5	10/31/2007	1,880.2	1,877.1	11.5	16.0	6.5-11.5	1,870.6	1,865.6	4.5-11.5	sand with silt and gravel

Notes:
ft: feet
ft AMSL: feet above mean sea level
ft bgs: feet below ground surface
TOC: top of casing
1. For MW-DP5, the ground surface elevation is taken from the original borehole log, but is inconsistent with the available survey for the top of casing.
2. For MW-DP1 only the top of casing elevation was provided. The PVC riser is assumed to be 2.5 ft above ground surface.
3. For MW-DP2B only the top of casing elevation was provided. The PVC riser is assumed to be 3.0 ft above ground surface.
4. The casing for MW-10 was extended in 2020. Only the updated top of casing elevation was provided. The PVC riser is assumed to be 3.0 ft above ground surface.
Well construction measurements are from the original borehole log, well data sheet, or well construction form.
For some wells, elevations have been updated with more recent survey information than the original driller's logs.

Table 2: Sample Results Summary Table - MW-DP3

		MW-DP3		
		Additional Baseline Data	Detection Monitoring	
	Units	2-Jun-21	2-Jun-21	20-Oct-21
Water Elevation	ft AMSL	1920.0	1920.0	1920.0
Appendix III Parameters				
Boron	mg/L	---	0.60	0.63
Calcium	mg/L	---	230	230
Chloride	mg/L	---	9.4	10
Fluoride	mg/L	---	0.99	< 0.10 U
pH, Field	s.u.	---	6.31	6.37
Sulfate	mg/L	---	1100	1100
Total Dissolved Solids	mg/L	---	2200	2200
Appendix IV Parameters				
Antimony	mg/L	< 0.0020 U	---	---
Arsenic	mg/L	< 0.0050 U	---	---
Barium	mg/L	0.041	---	---
Beryllium	mg/L	< 0.0010 U	---	---
Cadmium	mg/L	< 0.0010 U	---	---
Chromium	mg/L	< 0.0020 U	---	---
Cobalt	mg/L	< 0.0010 U	---	---
Fluoride	mg/L	0.99	---	---
Lead	mg/L	< 0.0010 U	---	---
Lithium	mg/L	0.16	---	---
Mercury	mg/L	< 0.0002 U	---	---
Molybdenum	mg/L	< 0.0020	---	---
Radium 226	pCi/L	0.667 ± 0.189	---	---
Radium 228	pCi/L	0.218 U ± 0.240	---	---
Radium 226 and 228 combined	pCi/L	0.884 ± 0.305	---	---
Selenium	mg/L	< 0.0050	---	---
Thallium	mg/L	< 0.0010	---	---

Legend:
--, not analyzed
ft AMSL, feet above mean sea level
mg/L, milligrams per liter
s.u., standard units for pH
pCi/L, picocuries per liter

Laboratory Provided Qualifiers:
U (general chemistry) = Not detected above the shown practical quantitation limit
U (radiochemistry) = Result is less than the sample detection limit (varies by sample)

Notes:
Samples collected from June 2018 to present were analyzed by Eurofins TestAmerica Laboratories.
Non-detects have been listed at the reported practical quantitation limit.
Metal results represent the total concentration (i.e. samples have not been filtered).
Radium-226 and -228 combined has been reported as the calculated sum of Radium-226 and Radium-228 results, or the reporting limit for non-detect results.

Table 3: Sample Results Summary Table - MW-DP5

		MW-DP5		
		Additional Baseline Data	Detection Monitoring	
	Units	2-Jun-21	2-Jun-21	20-Oct-21
Water Elevation	ft AMSL	1911.9	1911.8	1910.9
Appendix III Parameters				
Boron	mg/L	---	0.11	0.11
Calcium	mg/L	---	310	310
Chloride	mg/L	---	65	76
Fluoride	mg/L	---	0.24	0.16
pH, Field	s.u.	---	7.05	7.16
Sulfate	mg/L	---	3200	3200
Total Dissolved Solids	mg/L	---	5400	5400
Appendix IV Parameters				
Antimony	mg/L	0.0025	---	---
Arsenic	mg/L	< 0.0050 U	---	---
Barium	mg/L	0.0096	---	---
Beryllium	mg/L	< 0.0010 U	---	---
Cadmium	mg/L	< 0.0010 U	---	---
Chromium	mg/L	< 0.0020 U	---	---
Cobalt	mg/L	< 0.0010 U	---	---
Fluoride	mg/L	0.24	---	---
Lead	mg/L	< 0.0010 U	---	---
Lithium	mg/L	0.5	---	---
Mercury	mg/L	< 0.0002 U	---	---
Molybdenum	mg/L	0.0024	---	---
Radium 226	pCi/L	0.267 ± 0.158	---	---
Radium 228	pCi/L	-0.0561 U ± 0.232	---	---
Radium 226 and 228 combined	pCi/L	0.211 U ± 0.281	---	---
Selenium	mg/L	0.23	---	---
Thallium	mg/L	< 0.0010 U	---	---

Legend:
--, not analyzed
ft AMSL, feet above mean sea level
mg/L, milligrams per liter
s.u., standard units for pH
pCi/L, picocuries per liter

Laboratory Provided Qualifiers:
U (general chemistry) = Not detected above the shown practical quantitation limit
U (radiochemistry) = Result is less than the sample detection limit (varies by sample)

Notes:
Samples collected from June 2018 to present were analyzed by Eurofins TestAmerica Laboratories.

Non-detects have been listed at the reported practical quantitation limit.

Metal results represent the total concentration (i.e. samples have not been filtered).
Radium-226 and -228 combined has been reported as the calculated sum of Radium-226 and Radium-228 results, or the reporting limit for non-detect results.

Table 4: Sample Results Summary Table - MW-DP1

		MW-DP1		
		Additional Baseline Data	Detection Monitoring	
	Units	2-Jun-21	2-Jun-21	20-Oct-21
Water Elevation	ft AMSL	1882.5	1882.5	1882.2
Appendix III Parameters				
Boron	mg/L	---	0.75	0.78
Calcium	mg/L	---	52	52
Chloride	mg/L	---	< 3.0 U	< 3.0 U
Fluoride	mg/L	---	0.31	0.24
pH, Field	s.u.	---	7.29	7.46
Sulfate	mg/L	---	440	470
Total Dissolved Solids	mg/L	---	1300	1300
Appendix IV Parameters				
Antimony	mg/L	< 0.0020 U	---	---
Arsenic	mg/L	< 0.0050 U	---	---
Barium	mg/L	0.011	---	---
Beryllium	mg/L	< 0.0010 U	---	---
Cadmium	mg/L	< 0.0010 U	---	---
Chromium	mg/L	< 0.0020 U	---	---
Cobalt	mg/L	< 0.0010 U	---	---
Fluoride	mg/L	0.31	---	---
Lead	mg/L	< 0.0010 U	---	---
Lithium	mg/L	140	---	---
Mercury	mg/L	< 0.20 U	---	---
Molybdenum	mg/L	< 0.0020 U	---	---
Radium 226	pCi/L	0.272 ± 0.107	---	---
Radium 228	pCi/L	0.258 U ± 0.204	---	---
Radium 226 and 228 combined	pCi/L	0.531 ± 0.230	---	---
Selenium	mg/L	< 0.0050 U	---	---
Thallium	mg/L	< 0.0010 U	---	---

Legend:
--, not analyzed
ft AMSL, feet above mean sea level
mg/L, milligrams per liter
s.u., standard units for pH
pCi/L, picocuries per liter

Laboratory Provided Qualifiers:
U (general chemistry) = Not detected above the shown practical quantitation limit
U (radiochemistry) = Result is less than the sample detection limit (varies by sample)

Notes:
Samples collected from June 2018 to present were analyzed by Eurofins TestAmerica Laboratories.
Non-detects have been listed at the reported practical quantitation limit.
Metal results represent the total concentration (i.e. samples have not been filtered).
Radium-226 and -228 combined has been reported as the calculated sum of Radium-226 and Radium-228 results, or the reporting limit for non-detect results.

Table 5: Sample Results Summary Table - MW-DP2

		MW-DP2 Detection Monitoring	
	Units	2-Jun-21	20-Oct-21
Water Elevation	ft AMSL	***	***
Appendix III Parameters			
Boron	mg/L	---	---
Calcium	mg/L	---	---
Chloride	mg/L	---	---
Fluoride	mg/L	---	---
pH, Field	s.u.	---	---
Sulfate	mg/L	---	---
Total Dissolved Solids	mg/L	---	---
Appendix IV Parameters			
Antimony	mg/L	---	---
Arsenic	mg/L	---	---
Barium	mg/L	---	---
Beryllium	mg/L	---	---
Cadmium	mg/L	---	---
Chromium	mg/L	---	---
Cobalt	mg/L	---	---
Fluoride	mg/L	---	---
Lead	mg/L	---	---
Lithium	mg/L	---	---
Mercury	mg/L	---	---
Molybdenum	mg/L	---	---
Radium 226	pCi/L	---	---
Radium 228	pCi/L	---	---
Radium 226 and 228 combined	pCi/L	---	---
Selenium	mg/L	---	---
Thallium	mg/L	---	---

Legend:
--, not analyzed
ft AMSL, feet above mean sea level
mg/L, milligrams per liter
s.u., standard units for pH
pCi/L, picocuries per liter

Notes:
*** - Samples have not been collected at MW-DP2 since June 2018 as the well has been dry.

Table 6: Sample Results Summary Table - MW-DP2B

		MW-DP2B		
		Additional Baseline Data	Detection Monitoring	
	Units	2-Jun-21	2-Jun-21	10-Oct-21
Water Elevation	**ft AMSL**	**1879.0**	**1878.8**	**1877.9**
Appendix III Parameters				
Boron	mg/L	---	2.8	3.0 F1
Calcium	mg/L	---	250	250
Chloride	mg/L	---	51	62
Fluoride	mg/L	---	0.80	0.78
pH, Field	s.u.	---	6.68	6.91
Sulfate	mg/L	---	1900	1800
Total Dissolved Solids	mg/L	---	3500	3700
Appendix IV Parameters				
Antimony	mg/L	< 0.0020 U	---	---
Arsenic	mg/L	< 0.0050 U	---	---
Barium	mg/L	0.024	---	---
Beryllium	mg/L	< 0.0010 U	---	---
Cadmium	mg/L	< 0.0010 U	---	---
Chromium	mg/L	< 0.0020 U	---	---
Cobalt	mg/L	0.0025	---	---
Fluoride	mg/L	0.80	---	---
Lead	mg/L	< 0.0010 U	---	---
Lithium	mg/L	0.27	---	---
Mercury	mg/L	< 0.0002 U	---	---
Molybdenum	mg/L	< 0.0020 U	---	---
Radium 226	pCi/L	0.0681 U ± 0.0669	---	---
Radium 228	pCi/L	0.167 U ± 0.303	---	---
Radium 226 and 228 combined	pCi/L	0.235 U ± 0.310	---	---
Selenium	mg/L	< 0.0050 U	---	---
Thallium	mg/L	< 0.0010 U	---	---

Legend:
--, not analyzed
ft AMSL, feet above mean sea level
mg/L, milligrams per liter
s.u., standard units for pH
pCi/L, picocuries per liter

Laboratory Provided Qualifiers:
U (general chemistry) = Not detected above the shown practical quantitation limit
U (radiochemistry) = Result is less than the sample detection limit (varies by sample)
F1 = MS and/or MSD recovery exceeds control limits.

Notes:
Samples collected from June 2018 to present were analyzed by Eurofins TestAmerica Laboratories.
Non-detects have been listed at the reported practical quantitation limit.
Metal results represent the total concentration (i.e. samples have not been filtered).
Radium-226 and -228 combined has been reported as the calculated sum of Radium-226 and Radium-228 results, or the reporting limit for non-detect results.

Table 7: Sample Results Summary Table - MW-DP4

		MW-DP4		
		Additional Baseline Data	Detection Monitoring	
	Units	2-Jun-21	2-Jun-21	20-Oct-21
Water Elevation	ft AMSL	1893.0	1893.0	1892.4
Appendix III Parameters				
Boron	mg/L	---	0.45	0.53
Calcium	mg/L	---	260	270
Chloride	mg/L	---	71	74
Fluoride	mg/L	---	0.15	0.12
pH, Field	s.u.	---	6.87	7.06
Sulfate	mg/L	---	2700	2600
Total Dissolved Solids	mg/L	---	4500	4500
Appendix IV Parameters				
Antimony	mg/L	< 0.0020 U	---	---
Arsenic	mg/L	< 0.0050 U	---	---
Barium	mg/L	0.027	---	---
Beryllium	mg/L	< 0.0010 U	---	---
Cadmium	mg/L	< 0.0010 U	---	---
Chromium	mg/L	< 0.0020 U	---	---
Cobalt	mg/L	< 0.0010 U	---	---
Fluoride	mg/L	0.15	---	---
Lead	mg/L	< 0.0010 U	---	---
Lithium	mg/L	0.35	---	---
Mercury	mg/L	< 0.20 U	---	---
Molybdenum	mg/L	< 0.0020 U	---	---
Radium 226	pCi/L	0.0558 U ± 0.0664	---	---
Radium 228	pCi/L	0.0498 U ± 0.249	---	---
Radium 226 and 228 combined	pCi/L	0.106 U ± 0.258	---	---
Selenium	mg/L	0.20	---	---
Thallium	mg/L	< 0.0010 U	---	---

Legend:
--, not analyzed
ft AMSL, feet above mean sea level
mg/L, milligrams per liter
s.u., standard units for pH
pCi/L, picocuries per liter

Laboratory Provided Qualifiers:
U (general chemistry) = Not detected above the shown practical quantitation limit
U (radiochemistry) = Result is less than the sample detection limit (varies by sample)

Notes:
Samples collected from June 2018 to present were analyzed by Eurofins TestAmerica Laboratorie
Non-detects have been listed at the reported practical quantitation limit.
Metal results represent the total concentration (i.e. samples have not been filtered).
Radium-226 and -228 combined has been reported as the calculated sum of Radium-226 and Radium-228 results, or the reporting limit for non-detect results.

Table 8: Sample Results Summary Table - MW-91-2

		MW-91-2		
		Additional Baseline Data	Detection Monitoring	
	Units	3-Jun-21	3-Jun-21	25-Oct-21
Water Elevation	**ft AMSL**	**1920.7**	**1921.5**	**1920.6**
Appendix III Parameters				
Boron	mg/L	---	0.37	0.41
Calcium	mg/L	---	200	210
Chloride	mg/L	---	12	12
Fluoride	mg/L	---	0.11	< 0.10 U
pH, Field	s.u.	---	6.10	6.18
Sulfate	mg/L	---	790	830
Total Dissolved Solids	mg/L	---	1500	1600
Appendix IV Parameters				
Antimony	mg/L	< 0.0020 U	---	---
Arsenic	mg/L	< 0.0050 U	---	---
Barium	mg/L	0.13	---	---
Beryllium	mg/L	< 0.0010 U	---	---
Cadmium	mg/L	< 0.0010 U	---	---
Chromium	mg/L	< 0.0020 U	---	---
Cobalt	mg/L	< 0.0010 U	---	---
Fluoride	mg/L	0.11	---	---
Lead	mg/L	< 0.0010 U	---	---
Lithium	mg/L	0.085	---	---
Mercury	mg/L	< 0.0002 U	---	---
Molybdenum	mg/L	< 0.0020 U	---	---
Radium 226	pCi/L	0.782 ± 0.190	---	---
Radium 228	pCi/L	0.569 U ± 0.376	---	---
Radium 226 and 228 combined	pCi/L	1.35 ± 0.421	---	---
Selenium	mg/L	< 0.0050 U	---	---
Thallium	mg/L	< 0.0010 U	---	---

Legend:
--, not analyzed
ft AMSL, feet above mean sea level
mg/L, milligrams per liter
s.u., standard units for pH
pCi/L, picocuries per liter

Laboratory Provided Qualifiers:
U (general chemistry) = Not detected above the shown practical quantitation limit
U (radiochemistry) = Result is less than the sample detection limit (varies by sample)

Notes:
Samples collected from June 2018 to present were analyzed by Eurofins TestAmerica Laboratories.
Non-detects have been listed at the reported practical quantitation limit.
Metal results represent the total concentration (i.e. samples have not been filtered).
Radium-226 and -228 combined has been reported as the calculated sum of Radium-226 and Radium-228 results, or the reporting limit for non-detect results.

Table 9: Sample Results Summary Table - MW-75

		MW-75		
		Additional Baseline Data	Detection Monitoring	
	Units	3-Jun-21	3-Jun-21	25-Oct-21
Water Elevation	ft AMSL	1912.7	1913.6	1913.0
Appendix III Parameters				
Boron	mg/L	---	0.20	0.22
Calcium	mg/L	---	4.8	4.9
Chloride	mg/L	---	< 3.0 U	< 3.0 U
Fluoride	mg/L	---	0.47	0.45
pH, Field	s.u.	---	8.02	8.19
Sulfate	mg/L	---	75	69
Total Dissolved Solids	mg/L	---	840	850
Appendix IV Parameters				
Antimony	mg/L	< 0.0020 U	---	---
Arsenic	mg/L	< 0.0050 U	---	---
Barium	mg/L	0.03	---	---
Beryllium	mg/L	< 0.0010 U	---	---
Cadmium	mg/L	< 0.0010 U	---	---
Chromium	mg/L	< 0.0020 U	---	---
Cobalt	mg/L	< 0.0010 U	---	---
Fluoride	mg/L	0.47	---	---
Lead	mg/L	< 0.0010 U	---	---
Lithium	mg/L	0.072	---	---
Mercury	mg/L	< 0.0002 U	---	---
Molybdenum	mg/L	< 0.002 U	---	---
Radium 226	pCi/L	0.0538 U ± 0.0613	---	---
Radium 228	pCi/L	0.0115 U ± 0.247	---	---
Radium 226 and 228 combined	pCi/L	0.0653 U ± 0.254	---	---
Selenium	mg/L	< 0.0050 U	---	---
Thallium	mg/L	< 0.0010 U	---	---

Legend:
--, not analyzed
ft AMSL, feet above mean sea level
mg/L, milligrams per liter
s.u., standard units for pH
pCi/L, picocuries per liter

Laboratory Provided Qualifiers:
U (general chemistry) = Not detected above the shown practical quantitation limit
U (radiochemistry) = Result is less than the sample detection limit (varies by sample)

Notes:

Samples collected from June 2018 to present were analyzed by Eurofins TestAmerica Laboratories.
Non-detects have been listed at the reported practical quantitation limit.
Metal results represent the total concentration (i.e. samples have not been filtered).
Radium-226 and -228 combined has been reported as the calculated sum of Radium-226 and Radium-228 results, or the reporting limit for non-detect results.

Table 10: Sample Results Summary Table - MW-49

		MW-49		
		Additional Baseline Data	Detection Monitoring	
	Units	3-Jun-21	3-Jun-21	25-Oct-21
Water Elevation	**ft AMSL**	**1887.6**	**1887.6**	**1887.6**
Appendix III Parameters				
Boron	mg/L	---	4.5	4.6
Calcium	mg/L	---	200	200
Chloride	mg/L	---	65	65
Fluoride	mg/L	---	0.16	0.15
pH, Field	s.u.	---	6.91	7.02
Sulfate	mg/L	---	1500	1300
Total Dissolved Solids	mg/L	---	2800	2800
Appendix IV Parameters				
Antimony	mg/L	< 0.0020 U	---	---
Arsenic	mg/L	< 0.0050 U	---	---
Barium	mg/L	0.027	---	---
Beryllium	mg/L	< 0.0010 U	---	---
Cadmium	mg/L	< 0.0010 U	---	---
Chromium	mg/L	< 0.0020 U	---	---
Cobalt	mg/L	< 0.0010 U	---	---
Fluoride	mg/L	0.16	---	---
Lead	mg/L	< 0.0010 U	---	---
Lithium	mg/L	0.23	---	---
Mercury	mg/L	< 0.0002 U	---	---
Molybdenum	mg/L	0.0026	---	---
Radium 226	pCi/L	0.0893 U ± 0.0725	---	---
Radium 228	pCi/L	0.201 U ± 0.243	---	---
Radium 226 and 228 combined	pCi/L	0.290 U ± 0.254	---	---
Selenium	mg/L	< 0.0050 U	---	---
Thallium	mg/L	< 0.0010 U	---	---

Legend:
--, not analyzed
ft AMSL, feet above mean sea level
mg/L, milligrams per liter
s.u., standard units for pH
pCi/L, picocuries per liter

Laboratory Provided Qualifiers:
U (general chemistry) = Not detected above the shown practical quantitation limit
U (radiochemistry) = Result is less than the sample detection limit (varies by sample)

Notes:
Samples collected from June 2018 to present were analyzed by Eurofins TestAmerica Laboratories.
Non-detects have been listed at the reported practical quantitation limit.
Metal results represent the total concentration (i.e. samples have not been filtered).
Radium-226 and -228 combined has been reported as the calculated sum of Radium-226 and Radium-228 results, or the reporting limit for non-detect results.

Table 11: Sample Results Summary Table - MW-91-1

		MW-91-1		
		Additional Baseline Data	Detection Monitoring	
	Units	3-Jun-21	3-Jun-21	25-Oct-21
Water Elevation	ft AMSL	1878.9	1878.4	1877.8
Appendix III Parameters				
Boron	mg/L	---	2.7	2.7
Calcium	mg/L	---	200	240
Chloride	mg/L	---	65	79
Fluoride	mg/L	---	0.22	0.22
pH, Field	s.u.	---	6.81	7.02
Sulfate	mg/L	---	1000	1300
Total Dissolved Solids	mg/L	---	2200	2700
Appendix IV Parameters				
Antimony	mg/L	0.0022	---	---
Arsenic	mg/L	< 0.0050 U	---	---
Barium	mg/L	0.046	---	---
Beryllium	mg/L	< 0.0010 U	---	---
Cadmium	mg/L	< 0.0010 U	---	---
Chromium	mg/L	< 0.0020 U	---	---
Cobalt	mg/L	0.0011	---	---
Fluoride	mg/L	0.22	---	---
Lead	mg/L	< 0.0010 U	---	---
Lithium	mg/L	0.14	---	---
Mercury	mg/L	< 0.0002 U	---	---
Molybdenum	mg/L	0.0052	---	---
Radium 226	pCi/L	0.0863 U ± 0.0701	---	---
Radium 228	pCi/L	0.324 U ± 0.247	---	---
Radium 226 and 228 combined	pCi/L	0.410 U ± 0.257	---	---
Selenium	mg/L	< 0.0050 U	---	---
Thallium	mg/L	< 0.0010 U	---	---

Legend:
--, not analyzed
ft AMSL, feet above mean sea level
mg/L, milligrams per liter
s.u., standard units for pH
pCi/L, picocuries per liter

Laboratory Provided Qualifiers:
U (general chemistry) = Not detected above the shown practical quantitation limit
U (radiochemistry) = Result is less than the sample detection limit (varies by sample)

Notes:
Samples collected from June 2018 to present were analyzed by Eurofins TestAmerica Laboratories.
Non-detects have been listed at the reported practical quantitation limit.
Metal results represent the total concentration (i.e. samples have not been filtered).
Radium-226 and -228 combined has been reported as the calculated sum of Radium-226 and Radium-228 results, or the reporting limit for non-detect results.

Table 12: Sample Results Summary Table - MW-51

		MW-51		
		Additional Baseline Data	Detection Monitoring	
	Units	10-Jun-21	10-Jun-21	26-Oct-21
Water Elevation	ft AMSL	1878.9	1878.7	1878.4
Appendix III Parameters				
Boron	mg/L	---	3.8	4.0
Calcium	mg/L	---	260	250
Chloride	mg/L	---	63	70
Fluoride	mg/L	---	0.29	0.32
pH, Field	s.u.	---	7.04	7.14
Sulfate	mg/L	---	3200	2900
Total Dissolved Solids	mg/L	---	5400	5200
Appendix IV Parameters				
Antimony	mg/L	< 0.0020 U	---	---
Arsenic	mg/L	< 0.0050 U	---	---
Barium	mg/L	0.019	---	---
Beryllium	mg/L	< 0.0010 U	---	---
Cadmium	mg/L	< 0.0010 U	---	---
Chromium	mg/L	< 0.0020 U	---	---
Cobalt	mg/L	< 0.0010 U	---	---
Fluoride	mg/L	0.29	---	---
Lead	mg/L	< 0.0010 U	---	---
Lithium	mg/L	0.52	---	---
Mercury	mg/L	< 0.0002 U	---	---
Molybdenum	mg/L	0.0058	---	---
Radium 226	pCi/L	0.0110 U ± 0.0719	---	---
Radium 228	pCi/L	0.309 U ± 0.299	---	---
Radium 226 and 228 combined	pCi/L	0.320 U ± 0.308	---	---
Selenium	mg/L	0.013	---	---
Thallium	mg/L	< 0.0010 U	---	---

Legend:
--, not analyzed
ft AMSL, feet above mean sea level
mg/L, milligrams per liter
s.u., standard units for pH
pCi/L, picocuries per liter

Laboratory Provided Qualifiers:
U (general chemistry) = Not detected above the shown practical quantitation limit
U (radiochemistry) = Result is less than the sample detection limit (varies by sample)

Notes:
Samples collected from June 2018 to present were analyzed by Eurofins TestAmerica Laboratories.
Non-detects have been listed at the reported practical quantitation limit.
Metal results represent the total concentration (i.e. samples have not been filtered).
Radium-226 and -228 combined has been reported as the calculated sum of Radium-226 and Radium-228 results, or the reporting limit for non-detect results.

Table 13: Sample Results Summary Table - MW-16-6

		MW-16-6		
		Additional Baseline Data	Detection Monitoring	
	Units	3-Jun-21	3-Jun-21	25-Oct-21
Water Elevation	ft AMSL	1910.0	1909.9	1909.3
Appendix III Parameters				
Boron	mg/L	---	4.5	5.2
Calcium	mg/L	---	530	550
Chloride	mg/L	---	34	32
Fluoride	mg/L	---	< 0.10 U	< 0.10 U
pH, Field	s.u.	---	5.63	5.76
Sulfate	mg/L	---	3800	3800
Total Dissolved Solids	mg/L	---	5900	6000
Appendix IV Parameters				
Antimony	mg/L	< 0.0020 U	---	---
Arsenic	mg/L	< 0.0050 U	---	---
Barium	mg/L	0.031	---	---
Beryllium	mg/L	< 0.0010 U	---	---
Cadmium	mg/L	< 0.0010 U	---	---
Chromium	mg/L	< 0.0020 U	---	---
Cobalt	mg/L	0.0026	---	---
Fluoride	mg/L	< 0.10 U	---	---
Lead	mg/L	< 0.0010 U	---	---
Lithium	mg/L	0.60	---	---
Mercury	mg/L	< 0.0002 U	---	---
Molybdenum	mg/L	0.0023	---	---
Radium 226	pCi/L	0.0512 U ± 0.0733	---	---
Radium 228	pCi/L	0.208 U ± 0.291	---	---
Radium 226 and 228 combined	pCi/L	0.259 U ± 0.300	---	---
Selenium	mg/L	< 0.0050 U	---	---
Thallium	mg/L	< 0.0010 U	---	---

Legend:
--, not analyzed
ft AMSL, feet above mean sea level
mg/L, milligrams per liter
s.u., standard units for pH
pCi/L, picocuries per liter

Laboratory Provided Qualifiers:
U (general chemistry) = Not detected above the shown practical quantitation limit
U (radiochemistry) = Result is less than the sample detection limit (varies by sample)

Notes:
Samples collected from June 2018 to present were analyzed by Eurofins TestAmerica Laboratories
Non-detects have been listed at the reported practical quantitation limit.
Metal results represent the total concentration (i.e. samples have not been filtered).
Radium-226 and -228 combined has been reported as the calculated sum of Radium-226 and Radium-228 results, or the reporting limit for non-detect results.

Table 14: Sample Results Summary Table - MW-16-7

		MW-16-7		
		Additional Baseline Data	Detection Monitoring	
	Units	9-Jun-21	9-Jun-21	21-Oct-21
Water Elevation	**ft AMSL**	**1875.8**	**1875.9**	**1874.9**
Appendix III Parameters				
Boron	mg/L	---	< 0.10 U	< 0.10 U
Calcium	mg/L	---	350	370
Chloride	mg/L	---	86	110
Fluoride	mg/L	---	< 0.10 U	< 0.10 U
pH, Field	s.u.	---	6.84	7.01
Sulfate	mg/L	---	2400	2700
Total Dissolved Solids	mg/L	---	4100	4400
Appendix IV Parameters				
Antimony	mg/L	< 0.0020 U	---	---
Arsenic	mg/L	< 0.0050 U	---	---
Barium	mg/L	0.012	---	---
Beryllium	mg/L	< 0.0010 U	---	---
Cadmium	mg/L	< 0.0010 U	---	---
Chromium	mg/L	< 0.0020 U	---	---
Cobalt	mg/L	< 0.0010 U	---	---
Fluoride	mg/L	< 0.10 U	---	---
Lead	mg/L	< 0.0010 U	---	---
Lithium	mg/L	0.45	---	---
Mercury	mg/L	< 0.0002 U	---	---
Molybdenum	mg/L	< 0.0020 U	---	---
Radium 226	pCi/L	0.0616 U ± 0.0845	---	---
Radium 228	pCi/L	0.201 U ± 0.242	---	---
Radium 226 and 228 combined	pCi/L	0.262 U ± 0.256	---	---
Selenium	mg/L	0.18	---	---
Thallium	mg/L	< 0.0010 U	---	---

Legend:
--, not analyzed
ft AMSL, feet above mean sea level
mg/L, milligrams per liter
s.u., standard units for pH
pCi/L, picocuries per liter

Laboratory Provided Qualifiers:
U (general chemistry) = Not detected above the shown practical quantitation limit
U (radiochemistry) = Result is less than the sample detection limit (varies by sample)

Notes:
Samples collected from June 2018 to present were analyzed by Eurofins TestAmerica Laboratories.
Non-detects have been listed at the reported practical quantitation limit.

Metal results represent the total concentration (i.e. samples have not been filtered).
Radium-226 and -228 combined has been reported as the calculated sum of Radium-226 and Radium-228 results, or the reporting limit for non-detect results.

Table 15: Sample Results Summary Table - MW-10

		MW-10		
		Additional Baseline Data	Detection Monitoring	
	Units	10-Jun-21	10-Jun-21	25-Oct-21
Water Elevation	ft AMSL	1878.1	1877.8	1877.7
Appendix III Parameters				
Boron	mg/L	---	2.6	2.4
Calcium	mg/L	---	290	280
Chloride	mg/L	---	22	25
Fluoride	mg/L	---	0.18	0.19
pH, Field	s.u.	---	6.74	6.77
Sulfate	mg/L	---	1200	1200
Total Dissolved Solids	mg/L	---	2700	2600
Appendix IV Parameters				
Antimony	mg/L	< 0.0020 U	---	---
Arsenic	mg/L	< 0.0050 U	---	---
Barium	mg/L	0.034	---	---
Beryllium	mg/L	< 0.0010 U	---	---
Cadmium	mg/L	< 0.0010 U	---	---
Chromium	mg/L	< 0.0020 U	---	---
Cobalt	mg/L	< 0.0010 U	---	---
Fluoride	mg/L	0.18	---	---
Lead	mg/L	< 0.0010 U	---	---
Lithium	mg/L	0.22	---	---
Mercury	mg/L	< 0.0002 U	---	---
Molybdenum	mg/L	< 0.0020 U	---	---
Radium 226	pCi/L	-0.00721 U ± 0.0734	---	---
Radium 228	pCi/L	0.143 U ± 0.344	---	---
Radium 226 and 228 combined	pCi/L	0.136 U ± 0.352	---	---
Selenium	mg/L	< 0.0050 U	---	---
Thallium	mg/L	< 0.0010 U	---	---

Legend:
--, not analyzed
ft AMSL, feet above mean sea level
mg/L, milligrams per liter
s.u., standard units for pH
pCi/L, picocuries per liter

Laboratory Provided Qualifiers:
U (general chemistry) = Not detected above the shown practical quantitation limit
U (radiochemistry) = Result is less than the sample detection limit (varies by sample)

Notes:
Samples collected from June 2018 to present were analyzed by Eurofins TestAmerica Laboratories.
Non-detects have been listed at the reported practical quantitation limit.
Metal results represent the total concentration (i.e. samples have not been filtered).
Radium-226 and -228 combined has been reported as the calculated sum of Radium-226 and Radium-228 results, or the reporting limit for non-detect results.

Table 16: Sample Results Summary Table - MW-16-0

		MW-16-0		
		Additional Baseline Data	Detection Monitoring	
	Units	10-Jun-21	10-Jun-21	25-Oct-21
Water Elevation	ft AMSL	1874.1	1874.1	1873.6
Appendix III Parameters				
Boron	mg/L	---	8.7	9.5
Calcium	mg/L	---	410	370
Chloride	mg/L	---	26	32
Fluoride	mg/L	---	0.20	0.20
pH, Field	s.u.	---	7.20	7.20
Sulfate	mg/L	---	2500	2500
Total Dissolved Solids	mg/L	---	4200	4100
Appendix IV Parameters				
Antimony	mg/L	< 0.0020 U	---	---
Arsenic	mg/L	< 0.0050 U	---	---
Barium	mg/L	0.019	---	---
Beryllium	mg/L	< 0.0010 U	---	---
Cadmium	mg/L	< 0.0010 U	---	---
Chromium	mg/L	< 0.0020 U	---	---
Cobalt	mg/L	< 0.0010 U	---	---
Fluoride	mg/L	0.20	---	---
Lead	mg/L	< 0.0010 U	---	---
Lithium	mg/L	0.11	---	---
Mercury	mg/L	< 0.0002 U	---	---
Molybdenum	mg/L	0.014	---	---
Radium 226	pCi/L	0.0617 U ± 0.0809	---	---
Radium 228	pCi/L	0.563 ± 0.312	---	---
Radium 226 and 228 combined	pCi/L	0.625 ± 0.322	---	---
Selenium	mg/L	0.024	---	---
Thallium	mg/L	< 0.0010 U	---	---

Legend:
--, not analyzed
ft AMSL, feet above mean sea level
mg/L, milligrams per liter
s.u., standard units for pH
pCi/L, picocuries per liter

Laboratory Provided Qualifiers:
U (general chemistry) = Not detected above the shown practical quantitation limit
U (radiochemistry) = Result is less than the sample detection limit (varies by sample)

Notes:
Samples collected from June 2018 to present were analyzed by Eurofins TestAmerica Laboratories.
Non-detects have been listed at the reported practical quantitation limit.
Metal results represent the total concentration (i.e. samples have not been filtered).
Radium-226 and -228 combined has been reported as the calculated sum of Radium-226 and Radium-228 results, or the reporting limit for non-detect results.

Table 17: Sample Results Summary Table - MW-16-1

		MW-16-1		
		Additional Baseline Data	Detection Monitoring	
	Units	14-Jun-21	14-Jun-21	26-Oct-21
Water Elevation	ft AMSL	1871.2	1871.2	1869.1
Appendix III Parameters				
Boron	mg/L	---	13	12
Calcium	mg/L	---	540	520
Chloride	mg/L	---	260	280
Fluoride	mg/L	---	0.21	0.22
pH, Field	s.u.	---	7.13	7.23
Sulfate	mg/L	---	2800	2600
Total Dissolved Solids	mg/L	---	4800	4500
Appendix IV Parameters				
Antimony	mg/L	< 0.0020 U	---	---
Arsenic	mg/L	< 0.0050 U	---	---
Barium	mg/L	0.014	---	---
Beryllium	mg/L	< 0.0010 U	---	---
Cadmium	mg/L	< 0.0010 U	---	---
Chromium	mg/L	< 0.0020 U	---	---
Cobalt	mg/L	< 0.0010 U	---	---
Fluoride	mg/L	0.21	---	---
Lead	mg/L	< 0.0010 U	---	---
Lithium	mg/L	0.092	---	---
Mercury	mg/L	< 0.0002 U	---	---
Molybdenum	mg/L	0.024	---	---
Radium 226	pCi/L	0.0118 U ± 0.0774	---	---
Radium 228	pCi/L	0.0808 U ± 0.315	---	---
Radium 226 and 228 combined	pCi/L	0.0926 U ± 0.324	---	---
Selenium	mg/L	0.023	---	---
Thallium	mg/L	< 0.0010 U	---	---

Legend:
--, not analyzed
ft AMSL, feet above mean sea level
mg/L, milligrams per liter
s.u., standard units for pH
pCi/L, picocuries per liter

Laboratory Provided Qualifiers:
U (general chemistry) = Not detected above the shown practical quantitation limit
U (radiochemistry) = Result is less than the sample detection limit (varies by sample)

Notes:
Samples collected from June 2018 to present were analyzed by Eurofins TestAmerica Laboratories.
Non-detects have been listed at the reported practical quantitation limit.
Metal results represent the total concentration (i.e. samples have not been filtered).
Radium-226 and -228 combined has been reported as the calculated sum of Radium-226 and Radium-228 results, or the reporting limit for non-detect

Table 18: Sample Results Summary Table - MW-72

		MW-72		
		Additional Baseline Data	Detection Monitoring	
	Units	14-Jun-21	14-Jun-21	21-Oct-21
Water Elevation	ft AMSL	1878.6	1878.6	1877.0
Appendix III Parameters				
Boron	mg/L	---	0.16	0.17
Calcium	mg/L	---	720	750
Chloride	mg/L	---	35	30
Fluoride	mg/L	---	0.16	0.17 F1
pH, Field	s.u.	---	6.66	6.78
Sulfate	mg/L	---	3000	3100
Total Dissolved Solids	mg/L	---	5000	5200
Appendix IV Parameters				
Antimony	mg/L	< 0.0020 U ^+	---	---
Arsenic	mg/L	< 0.0050 U	---	---
Barium	mg/L	0.019	---	---
Beryllium	mg/L	< 0.0010 U	---	---
Cadmium	mg/L	< 0.0010 U	---	---
Chromium	mg/L	< 0.0020 U	---	---
Cobalt	mg/L	< 0.0010 U	---	---
Fluoride	mg/L	0.16	---	---
Lead	mg/L	< 0.0010 U	---	---
Lithium	mg/L	0.22	---	---
Mercury	mg/L	< 0.0002 U	---	---
Molybdenum	mg/L	0.0027	---	---
Radium 226	pCi/L	0.0568 U ± 0.0981	---	---
Radium 228	pCi/L	0.349 U ± 0.352	---	---
Radium 226 and 228 combined	pCi/L	0.406 U ± 0.365	---	---
Selenium	mg/L	< 0.0050 U	---	---
Thallium	mg/L	< 0.0010 U	---	---

Legend:
--, not analyzed
ft AMSL, feet above mean sea level
mg/L, milligrams per liter
s.u., standard units for pH
pCi/L, picocuries per liter

Laboratory Provided Qualifiers:
U (general chemistry) = Not detected above the shown practical quantitation limit
U (radiochemistry) = Result is less than the sample detection limit (varies by sample)
^+ = Continuing Calibration Verification (CCV) is outside acceptance limits, biased high
F1 = MS and/or MSD recovery exceeds control limits.

Notes:
Samples collected from June 2018 to present were analyzed by Eurofins TestAmerica Laboratories.
Non-detects have been listed at the reported practical quantitation limit.
Metal results represent the total concentration (i.e. samples have not been filtered).
Radium-226 and -228 combined has been reported as the calculated sum of Radium-226 and Radium-228 results, or the reporting limit for non-detect results.

Table 19: Sample Results Summary Table - MW-42

		MW-42		
		Additional Baseline Data	Detection Monitoring	
	Units	14-Jun-21	14-Jun-21	21-Oct-21
Water Elevation	ft AMSL	1875.6	1875.6	1872.7
Appendix III Parameters				
Boron	mg/L	---	0.90	1.00
Calcium	mg/L	---	280	290
Chloride	mg/L	---	24	19
Fluoride	mg/L	---	0.20	0.18
pH, Field	s.u.	---	7.21	7.30
Sulfate	mg/L	---	1400	1500
Total Dissolved Solids	mg/L	---	2600	2600
Appendix IV Parameters				
Antimony	mg/L	< 0.0020 U	---	---
Arsenic	mg/L	< 0.0050 U	---	---
Barium	mg/L	0.065	---	---
Beryllium	mg/L	< 0.0010 U	---	---
Cadmium	mg/L	< 0.0010 U	---	---
Chromium	mg/L	< 0.0020 U	---	---
Cobalt	mg/L	< 0.0010 U	---	---
Fluoride	mg/L	0.2	---	---
Lead	mg/L	< 0.0010 U	---	---
Lithium	mg/L	0.16	---	---
Mercury	mg/L	< 0.0002 U	---	---
Molybdenum	mg/L	0.0045	---	---
Radium 226	pCi/L	0.147 U ± 0.119	---	---
Radium 228	pCi/L	-0.322 U ± 0.343	---	---
Radium 226 and 228 combined	pCi/L	-0.176 U ± 0.363	---	---
Selenium	mg/L	< 0.0050 U	---	---
Thallium	mg/L	< 0.0010 U	---	---

Legend:
--, not analyzed
ft AMSL, feet above mean sea level
mg/L, milligrams per liter
s.u., standard units for pH
pCi/L, picocuries per liter

Laboratory Provided Qualifiers:
U (general chemistry) = Not detected above the shown practical quantitation limit
U (radiochemistry) = Result is less than the sample detection limit (varies by sample)

Notes:
Samples collected from June 2018 to present were analyzed by Eurofins TestAmerica Laboratories.
Non-detects have been listed at the reported practical quantitation limit.
Metal results represent the total concentration (i.e. samples have not been filtered).
Radium-226 and -228 combined has been reported as the calculated sum of Radium-226 and Radium-228 results, or the reporting limit for non-detect

Table 20: Sample Results Summary Table - MW-16-2

		MW-16-2		
		Additional Baseline Data	Detection Monitoring	
	Units	14-Jun-21	14-Jun-21	26-Oct-21
Water Elevation	ft AMSL	1871.6	1871.6	1869.1
Appendix III Parameters				
Boron	mg/L	---	8.7	9.0
Calcium	mg/L	---	390	430
Chloride	mg/L	---	180	200
Fluoride	mg/L	---	0.44	0.34
pH, Field	s.u.	---	7.01	7.13
Sulfate	mg/L	---	2100	2200
Total Dissolved Solids	mg/L	---	3700	3800
Appendix IV Parameters				
Antimony	mg/L	< 0.0020 U^+	---	---
Arsenic	mg/L	< 0.0050 U	---	---
Barium	mg/L	0.014	---	---
Beryllium	mg/L	< 0.0010 U	---	---
Cadmium	mg/L	< 0.0010 U	---	---
Chromium	mg/L	< 0.0020 U	---	---
Cobalt	mg/L	< 0.0010 U	---	---
Fluoride	mg/L	0.44	---	---
Lead	mg/L	< 0.0010 U	---	---
Lithium	mg/L	0.12	---	---
Mercury	mg/L	< 0.0002 U	---	---
Molybdenum	mg/L	< 0.0020 U	---	---
Radium 226	pCi/L	0.000710 U ± 0.0614	---	---
Radium 228	pCi/L	-0.454 U ± 0.237	---	---
Radium 226 and 228 combined	pCi/L	-0.454 U ± 0.245	---	---
Selenium	mg/L	< 0.0050 U	---	---
Thallium	mg/L	< 0.0010 U	---	---

Legend:
--, not analyzed
ft AMSL, feet above mean sea level
mg/L, milligrams per liter
s.u., standard units for pH
pCi/L, picocuries per liter

Laboratory Provided Qualifiers:
U (general chemistry) = Not detected above the shown practical quantitation limit
U (radiochemistry) = Result is less than the sample detection limit (varies by sample)
^+ = Continuing Calibration Verification (CCV) is outside acceptance limits, biased high

Notes:
Samples collected from June 2018 to present were analyzed by Eurofins TestAmerica Laboratories.
Non-detects have been listed at the reported practical quantitation limit.
Metal results represent the total concentration (i.e. samples have not been filtered).
Radium-226 and -228 combined has been reported as the calculated sum of Radium-226 and Radium-228 results, or the reporting limit for non-detect results.

Table 21: Sample Results Summary Table - MW-16-3

		MW-16-3		
		Additional Baseline Data	Detection Monitoring	
	Units	14-Jun-21	14-Jun-21	26-Oct-21
Water Elevation	**ft AMSL**	**1871.6**	**1871.6**	**1869.0**
Appendix III Parameters				
Boron	mg/L	---	20	21
Calcium	mg/L	---	410	410
Chloride	mg/L	---	640	600
Fluoride	mg/L	---	1.4	1.4
pH, Field	s.u.	---	6.90	7.11
Sulfate	mg/L	---	5300	4900
Total Dissolved Solids	mg/L	---	9400	9100
Appendix IV Parameters				
Antimony	mg/L	< 0.0020 U	---	---
Arsenic	mg/L	< 0.0050 U	---	---
Barium	mg/L	0.02	---	---
Beryllium	mg/L	< 0.0010 U	---	---
Cadmium	mg/L	< 0.0010 U	---	---
Chromium	mg/L	< 0.0020 U	---	---
Cobalt	mg/L	< 0.0010 U	---	---
Fluoride	mg/L	1.4	---	---
Lead	mg/L	< 0.0010 U	---	---
Lithium	mg/L	0.4	---	---
Mercury	mg/L	< 0.0002 U	---	---
Molybdenum	mg/L	0.0021	---	---
Radium 226	pCi/L	0.0740 U ± 0.0736	---	---
Radium 228	pCi/L	0.00768 U ± 0.227	---	---
Radium 226 and 228 combined	pCi/L	0.0817 U ± 0.239	---	---
Selenium	mg/L	< 0.0050 U	---	---
Thallium	mg/L	< 0.0010 U	---	---

Legend:
--, not analyzed
ft AMSL, feet above mean sea level
mg/L, milligrams per liter
s.u., standard units for pH
pCi/L, picocuries per liter

Laboratory Provided Qualifiers:
U (general chemistry) = Not detected above the shown practical quantitation limit
U (radiochemistry) = Result is less than the sample detection limit (varies by sample)

Notes:
Samples collected from June 2018 to present were analyzed by Eurofins TestAmerica Laboratories.
Non-detects have been listed at the reported practical quantitation limit.
Metal results represent the total concentration (i.e. samples have not been filtered).
Radium-226 and -228 combined has been reported as the calculated sum of Radium-226 and Radium-228 results, or the reporting limit for non-detect results.

Table 22: Sample Results Summary Table - MW-16-4

		MW-16-4		
		Additional Baseline Data	Detection Monitoring	
	Units	15-Jun-21	15-Jun-21	26-Oct-21
Water Elevation	ft AMSL	1870.9	1870.8	1868.2
Appendix III Parameters				
Boron	mg/L	---	0.5	0.61
Calcium	mg/L	---	440	420
Chloride	mg/L	---	32	29
Fluoride	mg/L	---	0.25	0.27
pH, Field	s.u.	---	6.75	6.82
Sulfate	mg/L	---	3200	3200
Total Dissolved Solids	mg/L	---	5200	5000
Appendix IV Parameters				
Antimony	mg/L	< 0.0020 U	---	---
Arsenic	mg/L	< 0.0050 U	---	---
Barium	mg/L	0.0064	---	---
Beryllium	mg/L	< 0.0010 U	---	---
Cadmium	mg/L	< 0.0010 U	---	---
Chromium	mg/L	< 0.0020 U	---	---
Cobalt	mg/L	< 0.0010 U	---	---
Fluoride	mg/L	0.25	---	---
Lead	mg/L	< 0.0010 U	---	---
Lithium	mg/L	0.6	---	---
Mercury	mg/L	< 0.0002 U	---	---
Molybdenum	mg/L	0.002	---	---
Radium 226	pCi/L	0.0740 U ± 0.0714	---	---
Radium 228	pCi/L	0.0932 U ± 0.272	---	---
Radium 226 and 228 combined	pCi/L	0.167 U ± 0.281	---	---
Selenium	mg/L	< 0.0050 U	---	---
Thallium	mg/L	< 0.0010 U	---	---

Legend:
--, not analyzed
ft AMSL, feet above mean sea level
mg/L, milligrams per liter
s.u., standard units for pH
pCi/L, picocuries per liter

Laboratory Provided Qualifiers:
U (general chemistry) = Not detected above the shown practical quantitation limit
U (radiochemistry) = Result is less than the sample detection limit (varies by sample)

Notes:
Samples collected from June 2018 to present were analyzed by Eurofins TestAmerica Laboratories.
Non-detects have been listed at the reported practical quantitation limit.
Metal results represent the total concentration (i.e. samples have not been filtered).
Radium-226 and -228 combined has been reported as the calculated sum of Radium-226 and Radium-228 results, or the reporting limit for non-detect results.

Table 23: Sample Results Summary Table - MW-15

		MW-15		
		Additional Baseline Data	Detection Monitoring	
	Units	15-Jun-21	15-Jun-21	26-Oct-21
Water Elevation	ft AMSL	1870.6	1870.6	1868.3
Appendix III Parameters				
Boron	mg/L	---	27	26
Calcium	mg/L	---	420	440
Chloride	mg/L	---	210	250
Fluoride	mg/L	---	0.43	0.43
pH, Field	s.u.	---	7.01	7.07
Sulfate	mg/L	---	3700	3600
Total Dissolved Solids	mg/L	---	6200	7300
Appendix IV Parameters				
Antimony	mg/L	< 0.0020 U	---	---
Arsenic	mg/L	< 0.0050 U	---	---
Barium	mg/L	0.018	---	---
Beryllium	mg/L	< 0.0010 U	---	---
Cadmium	mg/L	< 0.0010 U	---	---
Chromium	mg/L	< 0.0020 U	---	---
Cobalt	mg/L	< 0.0010 U	---	---
Fluoride	mg/L	0.43	---	---
Lead	mg/L	< 0.0010 U	---	---
Lithium	mg/L	0.32	---	---
Mercury	mg/L	< 0.0002 U	---	---
Molybdenum	mg/L	< 0.0020 U	---	---
Radium 226	pCi/L	0.0586 U ± 0.0651	---	---
Radium 228	pCi/L	0.222 U ± 0.230	---	---
Radium 226 and 228 combined	pCi/L	0.281 U ± 0.239	---	---
Selenium	mg/L	< 0.0050 U	---	---
Thallium	mg/L	< 0.0010 U	---	---

Legend:
--, not analyzed
ft AMSL, feet above mean sea level
mg/L, milligrams per liter
s.u., standard units for pH
pCi/L, picocuries per liter

Laboratory Provided Qualifiers:
U (general chemistry) = Not detected above the shown practical quantitation limit
U (radiochemistry) = Result is less than the sample detection limit (varies by sample)

Notes:
Samples collected from June 2018 to present were analyzed by Eurofins TestAmerica Laboratories.
Non-detects have been listed at the reported practical quantitation limit.
Metal results represent the total concentration (i.e. samples have not been filtered).
Radium-226 and -228 combined has been reported as the calculated sum of Radium-226 and Radium-228 results, or the reporting limit for non-detect results.

Table 24: Sample Results Summary Table - MW-16-5

		MW-16-5		
		Additional Baseline Data	Detection Monitoring	
	Units	15-Jun-21	15-Jun-21	26-Oct-21
Water Elevation	ft AMSL	1870.5	1870.6	1869.6
Appendix III Parameters				
Boron	mg/L	---	13	15
Calcium	mg/L	---	280	310
Chloride	mg/L	---	94	95
Fluoride	mg/L	---	0.68	0.77
pH, Field	s.u.	---	7.10	7.24
Sulfate	mg/L	---	2100	2100
Total Dissolved Solids	mg/L	---	3300	3700
Appendix IV Parameters				
Antimony	mg/L	< 0.0020 U	---	---
Arsenic	mg/L	< 0.0050 U	---	---
Barium	mg/L	0.014	---	---
Beryllium	mg/L	< 0.0010 U	---	---
Cadmium	mg/L	< 0.0010 U	---	---
Chromium	mg/L	< 0.0020 U	---	---
Cobalt	mg/L	< 0.0010 U	---	---
Fluoride	mg/L	0.68	---	---
Lead	mg/L	< 0.0010 U	---	---
Lithium	mg/L	0.19	---	---
Mercury	mg/L	< 0.0002 U	---	---
Molybdenum	mg/L	< 0.0020 U	---	---
Radium 226	pCi/L	0.112 U ± 0.0907	---	---
Radium 228	pCi/L	0.177 U ± 0.228	---	---
Radium 226 and 228 combined	pCi/L	0.289 U ± 0.245	---	---
Selenium	mg/L	< 0.0050 U	---	---
Thallium	mg/L	< 0.0010 U	---	---

Legend:
--, not analyzed
ft AMSL, feet above mean sea level
mg/L, milligrams per liter
s.u., standard units for pH
pCi/L, picocuries per liter

Laboratory Provided Qualifiers:
U (general chemistry) = Not detected above the shown practical quantitation
U (radiochemistry) = Result is less than the sample detection limit (varies by

Notes:
Samples collected from June 2018 to present were analyzed by Eurofins TestAmerica Laboratories.
Non-detects have been listed at the reported practical quantitation limit.
Metal results represent the total concentration (i.e. samples have not been filtered).
Radium-226 and -228 combined has been reported as the calculated sum of Radium-226 and Radium-228 results, or the reporting limit for non-detect results.

Table 25: MW-DP3 (U) Comparative Statistics

Appendix III Analytes	Units	Statistical Method	Statistical Limit	Q4 2020 Detection Monitoring Result 10/19/2020	CUSUM Value	Within Compliance?	Q2 2021 Detection Monitoring Result 6/2/2021	CUSUM Value	Within Compliance?
Boron, Total	mg/L	CUSUM	0.90	0.64	0.63	Yes	0.60	0.63	Yes
Calcium, Total	mg/L	CUSUM	330	230	251	Yes	230	251	Yes
Chloride	mg/L	CUSUM	25.1	9.9 H	12.1	Yes	9.4	12.1	Yes
Fluoride	mg/L	CUSUM	0.14	< 0.10 U	0.11	Yes	0.99	0.99	No - Potential Exceedance
pH, Field-Measured	s.u.	CUSUM	6.02, 6.62	6.31	6.32, 6.32	Yes	6.31	6.32, 6.32	Yes
Sulfate	mg/L	CUSUM	1577	1100	1205	Yes	1100	1205	Yes
Total Dissolved Solids	mg/L	CUSUM	2559	2300	2291	Yes	2200	2260	Yes

Notes:
mg/L, milligrams per liter
s.u., standard units for pH
CUSUM: Parametric Shewhart-CUSUM Control Chart
H: Analyzed outside of holding time
U: Not detected at the shown reporting limit

Table 26: MW-DP5 (U) Comparative Statistics

Appendix III Analytes	Units	Statistical Method	Statistical Limit	Q4 2020 Detection Monitoring Result 10/19/2020	CUSUM Value	Within Compliance?	Q2 2021 Detection Monitoring Result 6/2/2021	CUSUM Value	Within Compliance?
Boron, Total	mg/L	NP-PL	0.50	0.11	---	Yes	0.11	---	Yes
Calcium, Total	mg/L	CUSUM	387	320	296	Yes	310	293	Yes
Chloride	mg/L	CUSUM	95	62	80	Yes	65	80	Yes
Fluoride	mg/L	CUSUM	0.36	0.20	0.24	Yes	0.24	0.24	Yes
pH, Field-Measured	s.u.	CUSUM	6.92, 7.41	7.14	7.16, 7.16	Yes	7.05	7.11, 7.16	Yes
Sulfate	mg/L	CUSUM	5161	3100	3426	Yes	3200	3426	Yes
Total Dissolved Solids	mg/L	CUSUM	5829	5500	5430	Yes	5400	5390	Yes

Notes:
mg/L, milligrams per liter
s.u., standard units for pH
NP-PL: Non-Parametric Prediction Limit
CUSUM: Parametric Shewhart-CUSUM Control Chart

Table 27: MW-DP1 (D) Comparative Statistics

Appendix III Analytes	Units	Statistical Method	Statistical Limit	Q4 2020 Detection Monitoring Result 10/20/2020	CUSUM Value	Within Compliance?	Q2 2021 Detection Monitoring Result 6/2/2021	CUSUM Value	Within Compliance?
Boron, Total [1]	mg/L	CUSUM	1.18	0.77	0.83	Yes	0.75	0.83	Yes
Calcium, Total	mg/L	CUSUM	274	53	110	Yes	52	110	Yes
Chloride	mg/L	CUSUM	69	< 3.0 U	7.0	Yes	< 3.0 U	7.0	Yes
Fluoride [1]	mg/L	CUSUM	0.34	0.25	0.28	Yes	0.31	0.29	Yes
pH, Field-Measured	s.u.	CUSUM	7.05, 7.66	7.4	7.35, 7.35	Yes	7.29	7.35, 7.35	Yes
Sulfate	mg/L	CUSUM	2120	450	601	Yes	440	601	Yes
Total Dissolved Solids [1]	mg/L	CUSUM	2931	1400	1464	Yes	1300	1464	Yes

Notes:
mg/L, milligrams per liter
s.u., standard units for pH
CUSUM: Parametric Shewhart-CUSUM Control Chart
U: Not detected at the shown reporting limit
1. Statistical Limits for Boron, Fluoride, and Total Dissolved Solids are deseasonalized, and may vary from event to event based on the deseasonalized values.

Table 28: MW-DP2 (D) Comparative Statistics

		Statistical Method	Statistical Limit	Q4 2020 Detection Monitoring Result	CUSUM Value	Within Compliance?	Q2 2021 Detection Monitoring Result	CUSUM Value	Within Compliance?
Appendix III Analytes	Units			10/20/2020					
Boron, Total	mg/L	CUSUM	3.59	***	---	---	***	---	---
Calcium, Total	mg/L	CUSUM	357	***	---	---	***	---	---
Chloride	mg/L	CUSUM	87	***	---	---	***	---	---
Fluoride	mg/L	Decreasing Trend	NLS	***	---	---	***	---	---
pH, Field-Measured	s.u.	CUSUM	6.63, 7.12	***	---	---	***	---	---
Sulfate	mg/L	CUSUM	1949	***	---	---	***	---	---
Total Dissolved Solids	mg/L	Increasing Trend	NLS	***	---	---	***	---	---

Notes:
mg/L, milligrams per liter
s.u., standard units for pH
CUSUM: Parametric Shewhart-CUSUM Control Chart
Trend: Trends were identified in the background period. See text for discussion of significance.
NLS: No limit set due to trending data.
*** - See discussion in text regarding lack of samples.

Table 29: MW-DP2B (D) Comparative Statistics

Appendix III Analytes	Units	Statistical Method	Statistical Limit	Q4 2020 Detection Monitoring Result 10/20/2020	CUSUM Value	Within Compliance?	Q2 2021 Detection Monitoring Result 6/2/2021	CUSUM Value	Within Compliance?
Boron, Total	mg/L	CUSUM	3.4	2.8	2.6	Yes	2.8	2.7	Yes
Calcium, Total	mg/L	CUSUM	306	250	256	Yes	250	256	Yes
Chloride	mg/L	Decreasing Trend	NLS	60	---	---	63 H	---	---
Fluoride	mg/L	CUSUM	1.13	0.84	0.84	Yes	0.8	0.84	Yes
pH, Field-Measured	s.u.	CUSUM	6.71, 7.09	6.97	6.90, 6.93	Yes	6.68	6.72, 6.90	No - Potential Exceedance
Sulfate	mg/L	CUSUM	2453	1800	1944	Yes	1900	1944	Yes
Total Dissolved Solids	mg/L	CUSUM	4117	4000	3900	Yes	3500	3667	Yes

Notes:
mg/L, milligrams per liter
s.u., standard units for pH
CUSUM: Parametric Shewhart-CUSUM Control Chart
Trend: Trends were identified in the background period. See text for discussion of significance.
NLS: No limit set due to trending data.
H: Analyzed outside of holding time

Table 30: MW-DP4 (D) Comparative Statistics

Appendix III Analytes	Units	Statistical Method	Statistical Limit	Q4 2020 Detection Monitoring Result 10/20/2020	CUSUM Value	Within Compliance?	Q2 2021 Detection Monitoring Result 6/2/2021	CUSUM Value	Within Compliance?
Boron, Total	mg/L	CUSUM	0.69	0.56	0.70	No - Potential Exceedance	0.45	0.59	Yes - Prior Result was False-Positive
Calcium, Total	mg/L	CUSUM	384	260	274	Yes	260	274	Yes
Chloride	mg/L	CUSUM	70	80	74	No - Potential Exceedance	71	95	No - Verified Exceedance
Fluoride	mg/L	CUSUM	0.24	0.16	0.32	No - Previously Verified SSI	0.15	0.30	No - Previously Verified SSI
pH, Field-Measured	s.u.	CUSUM	6.70, 7.29	7.13	7.00, 7.47	No - Verified SSI	6.87	6.94, 7.28	Yes - Prior Result was a Verified Exceedance, Analytical Result and CUSUM Value Below Statistical Limits
Sulfate	mg/L	CUSUM	3531	2500	2532	Yes	2700	2532	Yes
Total Dissolved Solids	mg/L	CUSUM	5611	4800	4452	Yes	4500	4384	Yes

Notes:
mg/L, milligrams per liter
s.u., standard units for pH
CUSUM: Parametric Shewhart-CUSUM Control Chart

Table 31: MW-91-2 (U) Comparative Statistics

Appendix III Analytes	Units	Statistical Method	Statistical Limit	Q4 2020 Detection Monitoring Result 10/20/2020	CUSUM Value	Within Compliance?	Q2 2021 Detection Monitoring Result 6/3/2021	CUSUM Value	Within Compliance?
Boron, Total	mg/L	CUSUM	0.53	0.37	0.41	Yes	0.37	0.41	Yes
Calcium, Total	mg/L	Decreasing Trend	NLS	230	---	---	200	---	---
Chloride	mg/L	CUSUM	20	9.6 H	15	Yes	12	15	Yes
Fluoride	mg/L	NP-PL	0.50	< 0.10 U	---	Yes	0.11	---	Yes
pH, Field-Measured	s.u.	CUSUM	5.74, 6.66	6.21	6.20, 6.33	Yes	6.1	6.20, 6.20	Yes
Sulfate	mg/L	CUSUM	1469	760	1079	Yes	790	1079	Yes
Total Dissolved Solids	mg/L	CUSUM	2203	1500	1919	Yes	1500	1919	Yes

Notes:
mg/L, milligrams per liter
s.u., standard units for pH
NP-PL: Non-Parametric Prediction Limit
CUSUM: Parametric Shewhart-CUSUM Control Chart
Trend: Trends were identified in the background period. See text for discussion of significance.
NLS: No limit set due to trending data.
U: Not detected at the shown reporting limit
H: Analyzed outside of holding time

Table 32: MW-75 (U) Comparative Statistics

Appendix III Analytes	Units	Statistical Method	Statistical Limit	Q4 2020 Detection Monitoring Result 10/20/2020	CUSUM Value	Within Compliance?	Q2 2021 Detection Monitoring Result 6/3/2021	CUSUM Value	Within Compliance?
Boron, Total	mg/L	CUSUM	0.30	0.22	0.21	Yes	0.20	0.21	Yes
Calcium, Total	mg/L	CUSUM	7.6	5.1	5.5	Yes	4.8	5.5	Yes
Chloride	mg/L	CUSUM	3.2	< 3.0 U	3.9	Yes - See Text	< 3.0 U	5.5	Yes - See Text
Fluoride	mg/L	CUSUM	0.64	0.46	0.49	Yes	0.47	0.49	Yes
pH, Field-Measured	s.u.	CUSUM	7.76, 8.44	8.27	8.10, 8.19	Yes	8.02	8.10, 8.10	Yes
Sulfate	mg/L	CUSUM	92	72	73	Yes	75	73	Yes
Total Dissolved Solids	mg/L	CUSUM	948	870	850	Yes	840	839	Yes

Notes:
mg/L, milligrams per liter
s.u., standard units for pH
CUSUM: Parametric Shewhart-CUSUM Control Chart
U: Not detected at the shown reporting limit

Table 33: MW-49 (D) Comparative Statistics

Appendix III Analytes	Units	Statistical Method	Statistical Limit	Q4 2020 Detection Monitoring Result 10/20/2020	CUSUM Value	Within Compliance?	Q2 2021 Detection Monitoring Result 6/3/2021	CUSUM Value	Within Compliance?
Boron, Total	mg/L	CUSUM	6.3	4.8	4.8	Yes	4.5	4.8	Yes
Calcium, Total	mg/L	CUSUM	233	200	198	Yes	200	198	Yes
Chloride	mg/L	CUSUM	74	64	84	No - Previously Verified SSI	65	84	No - Previously Verified SSI
Fluoride	mg/L	CUSUM	0.26	0.15	0.18	Yes	0.16	0.18	Yes
pH, Field-Measured	s.u.	CUSUM	6.71, 7.32	7.08	7.01, 7.01	Yes	6.91	6.99, 7.01	Yes
Sulfate	mg/L	CUSUM	1752	1200	1271	Yes	1500	1380	Yes
Total Dissolved Solids	mg/L	CUSUM	2956	2800	2756	Yes	2800	2821	Yes

Notes:
mg/L, milligrams per liter
s.u., standard units for pH
CUSUM: Parametric Shewhart-CUSUM Control Chart

Table 34: MW-51 (D) Comparative Statistics

Appendix III Analytes	Units	Statistical Method	Statistical Limit	Q4 2020 Detection Monitoring Result 10/21/2020	CUSUM Value	Within Compliance?	Q2 2021 Detection Monitoring Result	CUSUM Value	Within Compliance?
Boron, Total	mg/L	NP-PL	5.7	4.3	---	Yes	3.8	---	Yes
Calcium, Total	mg/L	CUSUM	458	240	270	Yes	260	270	Yes
Chloride	mg/L	CUSUM	195	51	69	Yes	63	69	Yes
Fluoride	mg/L	CUSUM	0.60	0.25	0.36	Yes	0.29	0.36	Yes
pH, Field-Measured	s.u.	CUSUM	6.56, 7.55	6.99	7.06, 7.06	Yes	7.04	7.06, 7.06	Yes
Sulfate	mg/L	CUSUM	5249	2800	3103	Yes	3200	3103	Yes
Total Dissolved Solids	mg/L	CUSUM	7079	5400	5174	Yes	5400	5174	Yes

Notes:
mg/L, milligrams per liter
s.u., standard units for pH
NP-PL: Non-Parametric Prediction Limit
CUSUM: Parametric Shewhart-CUSUM Control Chart

Table 35: MW-91-1 (D) Comparative Statistics

Appendix III Analytes	Units	Statistical Method	Statistical Limit	Q4 2020 Detection Monitoring Result 10/21/2020	CUSUM Value	Within Compliance?	Q2 2021 Detection Monitoring Result 6/3/2021	CUSUM Value	Within Compliance?
Boron, Total	mg/L	CUSUM	3.8	2.7	3.00	Yes	2.7	3.0	Yes
Calcium, Total	mg/L	CUSUM	319	200	216	Yes	200	216	Yes
Chloride	mg/L	CUSUM	88	54	74	Yes	65	74	Yes
Fluoride	mg/L	CUSUM	0.39	0.19	0.23	Yes	0.22	0.23	Yes
pH, Field-Measured	s.u.	CUSUM	6.66, 7.25	7.06	6.96, 6.99	Yes	6.81	6.88, 6.96	Yes
Sulfate	mg/L	NP-PL	1300	970	---	Yes	1000	---	Yes
Total Dissolved Solids	mg/L	NP-PL	2400	2100	---	Yes	2200	---	Yes

Notes:
mg/L, milligrams per liter
s.u., standard units for pH
NP-PL: Non-Parametric Prediction Limit
CUSUM: Parametric Shewhart-CUSUM Control Chart

Table 36: MW-16-6 (U) Comparative Statistics

Appendix III Analytes	Units	Statistical Method	Statistical Limit	Q4 2020 Detection Monitoring Result 10/21/2020	CUSUM Value	Within Compliance?	Q2 2021 Detection Monitoring Result 6/3/2021	CUSUM Value	Within Compliance?
Boron, Total	mg/L	CUSUM	6.9	5.4	4.8	Yes	4.5	4.6	Yes
Calcium, Total	mg/L	CUSUM	634	540	518	Yes	530	518	Yes
Chloride	mg/L	CUSUM	54	29	40	Yes	34	40	Yes
Fluoride	mg/L	NP-PL	0.10	< 0.10 U	---	Yes	< 0.10 U	---	Yes
pH, Field-Measured	s.u.	CUSUM	5.55, 5.92	5.80	5.73, 5.92	Yes	5.63	5.68, 5.77	Yes
Sulfate	mg/L	CUSUM	4913	3400	3590	Yes	3800	3590	Yes
Total Dissolved Solids	mg/L	CUSUM	6277	6100	7528	No - Previously Verified SSI	5900	7672	No - Previously Verified SSI

Notes:
mg/L, milligrams per liter
s.u., standard units for pH
NP-PL: Non-Parametric Prediction Limit
CUSUM: Parametric Shewhart-CUSUM Control Chart
U: Not detected at the shown reporting limit

Table 37: MW-16-7 (U) Comparative Statistics

Appendix III Analytes	Units	Statistical Method	Statistical Limit	Q4 2020 Detection Monitoring Result 10/21/2020	CUSUM Value	Within Compliance?	Q2 2021 Detection Monitoring Result 6/9/2021	CUSUM Value	Within Compliance?
Boron, Total	mg/L	NP-PL	0.11	< 0.10 U	---	Yes	< 0.10 U	---	Yes
Calcium, Total	mg/L	CUSUM	472	350	350	Yes	350	350	Yes
Chloride	mg/L	CUSUM	99	100	95	No - Potential Exceedance	86	97	Yes - Prior Result Was a False-Positive
Fluoride	mg/L	NP-PL	0.12	< 0.10 U	---	Yes	< 0.10 U	---	Yes
pH, Field-Measured	s.u.	CUSUM	6.61, 7.18	6.99	6.90, 6.92	Yes	6.84	6.90, 6.90	Yes
Sulfate	mg/L	CUSUM	3167	2300	2429	Yes	2400	2429	Yes
Total Dissolved Solids	mg/L	CUSUM	4717	4400	4239	Yes	4100	4157	Yes

Notes:
mg/L, milligrams per liter
s.u., standard units for pH
NP-PL: Non-Parametric Prediction Limit
CUSUM: Parametric Shewhart-CUSUM Control Chart
U: Not detected at the shown reporting limit

Table 38: MW-10 (D) Comparative Statistics

Appendix III Analytes	Units	Statistical Method	Statistical Limit	Q4 2020 Detection Monitoring Result 10/27/2020	CUSUM Value	Within Compliance?	Q2 2021 Detection Monitoring Result 6/10/2021	CUSUM Value	Within Compliance?
Boron, Total	mg/L	CUSUM	3.7	2.6	7.98	No - Previously Verified SSI	2.6	8.0	No - Previously Verified SSI
Calcium, Total	mg/L	CUSUM	387	280	256	Yes	290	257	Yes
Chloride	mg/L	CUSUM	26	23	21	Yes	22	23	Yes
Fluoride	mg/L	CUSUM	0.29	0.17	0.53	No - Previously Verified SSI	0.18	0.48	No - Previously Verified SSI
pH, Field-Measured	s.u.	CUSUM	6.57, 7.10	6.81	6.84, 7.97	No - Previously Verified SSI	6.74	6.81, 7.81	No - Previously Verified SSI
Sulfate	mg/L	NP-PL	1470	1100	---	Yes - Prior Result Was a False-Positive	1200	---	Yes
Total Dissolved Solids	mg/L	CUSUM	3495	2600	2542	Yes	2700	2701	Yes

Notes:
mg/L, milligrams per liter
s.u., standard units for pH
NP-PL: Non-Parametric Prediction Limit
CUSUM: Parametric Shewhart-CUSUM Control Chart

Table 39: MW-16-0 (D) Comparative Statistics

Appendix III Analytes	Units	Statistical Method	Statistical Limit	Q4 2020 Detection Monitoring Result 10/27/2020	CUSUM Value	Within Compliance?	Q2 2021 Detection Monitoring Result 6/10/2021	CUSUM Value	Within Compliance?
Boron, Total	mg/L	CUSUM	10.1	9.1	10.4	No - Potential Exceedance	8.7	10.0	Yes - Prior Result Was a False-Positive
Calcium, Total	mg/L	CUSUM	581	460	422	Yes	410	412	Yes
Chloride	mg/L	CUSUM	47	25	36	Yes	26	36	Yes
Fluoride	mg/L	CUSUM	0.31	0.17	0.21	Yes	0.20	0.21	Yes
pH, Field-Measured	s.u.	CUSUM	6.89, 7.62	7.2	7.25, 7.25	Yes	7.20	7.25, 7.25	Yes
Sulfate	mg/L	CUSUM	3290	2700	2528	Yes	2500	2516	Yes
Total Dissolved Solids	mg/L	CUSUM	4616	4400	4303	Yes	4200	4230	Yes

Notes:
mg/L, milligrams per liter
s.u., standard units for pH
CUSUM: Parametric Shewhart-CUSUM Control Chart

Table 40: MW-16-1 (D) Comparative Statistics

Appendix III Analytes	Units	Statistical Method	Statistical Limit	Q4 2020 Detection Monitoring Result 10/27/2020	CUSUM Value	Within Compliance?	Q2 2021 Detection Monitoring Result 6/14/2021	CUSUM Value	Within Compliance?
Boron, Total	mg/L	CUSUM	21	15	24	No - Verified SSI	13	25	No - Previously Verified SSI
Calcium, Total	mg/L	CUSUM	757	490	561	Yes	540 B	561	Yes
Chloride	mg/L	CUSUM	342	220	254	Yes	260	254	Yes
Fluoride	mg/L	CUSUM	0.59	0.28	0.42	Yes	0.21	0.28	Yes
pH, Field-Measured	s.u.	CUSUM	6.92, 7.34	7.24	7.13, 7.86	No - Previously Verified SSI	7.13	7.13, 7.81	No - Previously Verified SSI
Sulfate	mg/L	CUSUM	3996	2900	3464	Yes	2800	3317	Yes
Total Dissolved Solids	mg/L	CUSUM	6615	4800	6011	Yes	4800	6037	Yes

Notes:
mg/L, milligrams per liter
s.u., standard units for pH
CUSUM: Parametric Shewhart-CUSUM Control Chart
B: Compound was found in the blank and the sample.

Table 41: MW-42 (U) Comparative Statistics

		Statistical Method	Statistical Limit	Q4 2020 Detection Monitoring Result	CUSUM Value	Within Compliance?	Q2 2021 Detection Monitoring Result	CUSUM Value	Within Compliance?
Appendix III Analytes	Units			10/21/2020			6/14/2021		
Boron, Total	mg/L	CUSUM	2.2	1.1	1.0	Yes	0.9	1.0	Yes
Calcium, Total	mg/L	CUSUM	346	280	285	Yes	280 B	295	Yes
Chloride	mg/L	CUSUM	28	17	21	Yes	24	24	Yes
Fluoride	mg/L	CUSUM	0.42	0.21	0.30	Yes	0.20	0.30	Yes
pH, Field-Measured	s.u.	CUSUM	6.95, 7.65	7.31	7.30, 7.30	Yes	7.21	7.30, 7.30	Yes
Sulfate	mg/L	CUSUM	2177	1300	1414	Yes	1400	1414	Yes
Total Dissolved Solids	mg/L	CUSUM	3179	2600	2412	Yes	2600	2412	Yes

Notes:
mg/L, milligrams per liter
s.u., standard units for pH
CUSUM: Parametric Shewhart-CUSUM Control Chart
B: Compound was found in the blank and the sample.

Table 42: MW-72 (U) Comparative Statistics

Appendix III Analytes	Units	Statistical Method	Statistical Limit	Q4 2020 Detection Monitoring Result 10/21/2020	CUSUM Value	Within Compliance?	Q2 2021 Detection Monitoring Result 6/14/2021	CUSUM Value	Within Compliance?
Boron, Total	mg/L	CUSUM	0.21	0.16	0.16	Yes	0.16	0.18	Yes
Calcium, Total	mg/L	CUSUM	1048	760	799	Yes	720 B	799	Yes
Chloride	mg/L	CUSUM	35	30	40	No - Previously Verified SSI	35	46	No - Previously Verified SSI
Fluoride	mg/L	CUSUM	0.34	0.16	0.22	Yes	0.16	0.22	Yes
pH, Field-Measured	s.u.	CUSUM	6.48, 6.99	6.74	6.74, 6.74	Yes	6.66	6.72, 6.74	Yes
Sulfate	mg/L	CUSUM	3914	3200	3088	Yes	3000	3088	Yes
Total Dissolved Solids	mg/L	CUSUM	5824	5800	5632	Yes	5000	5397	Yes

Notes:
mg/L, milligrams per liter
s.u., standard units for pH
CUSUM: Parametric Shewhart-CUSUM Control Chart
B: Compound was found in the blank and the sample.

Table 43: MW-16-2 (D) Comparative Statistics

Appendix III Analytes	Units	Statistical Method	Statistical Limit	Q4 2020 Detection Monitoring Result 10/27/2020	CUSUM Value	Within Compliance?	Q2 2021 Detection Monitoring Result 6/14/2021	CUSUM Value	Within Compliance?
Boron, Total	mg/L	CUSUM	14.4	10	10	Yes	8.7	10.0	Yes
Calcium, Total	mg/L	CUSUM	608	360	415	Yes	390 B	415	Yes
Chloride	mg/L	CUSUM	223	150	174	Yes	180	174	Yes
Fluoride	mg/L	CUSUM	1.26	0.57	0.60	Yes	0.44	0.60	Yes
pH, Field-Measured	s.u.	CUSUM	6.83, 7.43	7.18	7.13, 7.13	Yes	7.01	7.09, 7.13	Yes
Sulfate	mg/L	CUSUM	3255	2100	2315	Yes	2100	2315	Yes
Total Dissolved Solids	mg/L	CUSUM	4616	3700	3856	Yes	3700	3825	Yes

Notes:
mg/L, milligrams per liter
s.u., standard units for pH
CUSUM: Parametric Shewhart-CUSUM Control Chart
B: Compound was found in the blank and the sample.

Table 44: MW-16-3 (D) Comparative Statistics

		Statistical Method	Statistical Limit	Q4 2020 Detection Monitoring Result	CUSUM Value	Within Compliance?	Q2 2021 Detection Monitoring Result	CUSUM Value	Within Compliance?
Appendix III Analytes	**Units**			**10/27/2020**			**6/14/2021**		
Boron, Total	mg/L	CUSUM	27	20	18	Yes	20	18	Yes
Calcium, Total	mg/L	CUSUM	616	390	431	Yes	410 B	431	Yes
Chloride	mg/L	CUSUM	944	550	606	Yes	640	606	Yes
Fluoride	mg/L	CUSUM	2.2	1.4	1.5	Yes	1.4	1.5	Yes
pH, Field-Measured	s.u.	CUSUM	6.90, 7.24	7.11	7.07, 7.10	Yes	6.90	6.98, 7.07	Yes
Sulfate	mg/L	CUSUM	7782	5000	5137	Yes	5300	5137	Yes
Total Dissolved Solids	mg/L	CUSUM	12488	9100	9118	Yes	9400	9118	Yes

Notes:
mg/L, milligrams per liter
s.u., standard units for pH
CUSUM: Parametric Shewhart-CUSUM Control Chart
B: Compound was found in the blank and the sample.

Table 45: MW-16-4 (D) Comparative Statistics

Appendix III Analytes	Units	Statistical Method	Statistical Limit	Q4 2020 Detection Monitoring Result 10/22/2020	CUSUM Value	Within Compliance?	Q2 2021 Detection Monitoring Result 6/15/2021	CUSUM Value	Within Compliance?
Boron, Total	mg/L	CUSUM	1.1	0.61	0.60	Yes	0.50	0.57	Yes
Calcium, Total	mg/L	CUSUM	667	450	417	Yes	440 B	417	Yes
Chloride [1]	mg/L	CUSUM	54	19	35	Yes	32	35	Yes
Fluoride	mg/L	CUSUM	0.43	0.25	0.32	Yes	0.25	0.32	Yes
pH, Field-Measured	s.u.	CUSUM	6.34, 7.38	6.8	6.86, 6.86	Yes	6.75	6.86, 6.86	Yes
Sulfate	mg/L	CUSUM	4104	3200	3310	Yes	3200	3310	Yes
Total Dissolved Solids[1]	mg/L	CUSUM	6337	6400	5678	No	5200	5952	Yes

Notes:
mg/L, milligrams per liter
s.u., standard units for pH
CUSUM: Parametric Shewhart-CUSUM Control Chart
B: Compound was found in the blank and the sample.
1. Statistical Limits for Chloride and TDS are deseasonalized, and may vary from event to event based on the deseasonalized value:

Table 46: MW-15 (D) Comparative Statistics

Appendix III Analytes	Units	Statistical Method	Statistical Limit	Q4 2020 Detection Monitoring Result 10/22/2020	CUSUM Value	Within Compliance?	Q2 2021 Detection Monitoring Result 6/15/2021	CUSUM Value	Within Compliance?
Boron, Total	mg/L	CUSUM	35	26	27	Yes	27	27	Yes
Calcium, Total	mg/L	CUSUM	557	460	444	Yes	420 B	444	Yes
Chloride [1]	mg/L	CUSUM	413	190	281	Yes	210	281	Yes
Fluoride	mg/L	CUSUM	0.78	0.38	0.58	Yes	0.43	0.58	Yes
pH, Field-Measured	s.u.	CUSUM	6.74, 7.39	7.02	7.06, 7.06	Yes	7.01	7.06, 7.06	Yes
Sulfate	mg/L	CUSUM	4872	3300	3888	Yes	3700	3888	Yes
Total Dissolved Solids	mg/L	CUSUM	8191	4800	6164	Yes	6200	6164	Yes

Notes:
mg/L, milligrams per liter
s.u., standard units for pH
CUSUM: Parametric Shewhart-CUSUM Control Chart
B: Compound was found in the blank and the sample.
1. Statistical Limit for Chloride is deseasonalized, and may vary slightly from event to event based on the deseasonalized values.

Table 47: MW-16-5 (D) Comparative Statistics

		Statistical Method	Statistical Limit	Q4 2020 Detection Monitoring Result	CUSUM Value	Within Compliance?	Q2 2021 Detection Monitoring Result	CUSUM Value	Within Compliance?
Appendix III Analytes	**Units**			**10/22/2020**			**6/15/2021**		
Boron, Total	mg/L	CUSUM	24	15	14	Yes	13	14	Yes
Calcium, Total	mg/L	CUSUM	551	390	344	Yes	280 B	344	Yes
Chloride	mg/L	CUSUM	195	120	130	Yes	94	130	Yes
Fluoride	mg/L	CUSUM	1.22	0.71	0.84	Yes	0.68	0.84	Yes
pH, Field-Measured	s.u.	CUSUM	6.80, 7.53	7.14	7.16, 7.16	Yes	7.1	7.16, 7.16	Yes
Sulfate	mg/L	CUSUM	3809	2500	2241	Yes	2100	2241	Yes
Total Dissolved Solids	mg/L	CUSUM	4365	4000	3814	Yes	3300	3622	Yes

Notes:
mg/L, milligrams per liter
s.u., standard units for pH
CUSUM: Parametric Shewhart-CUSUM Control Chart
B: Compound was found in the blank and the sample.

FIGURES

LEGEND

- UPGRADIENT MONITORING WELL
- DOWNGRADIENT MONITORING WELL - DRAINS POND SYSTEM
- DOWNGRADIENT MONITORING WELL - UPSTREAM RAISE 91
- DOWNGRADIENT MONITORING WELL - UPSTREAM RAISE 92
- DOWNGRADIENT MONITORING WELL - SOUTHEAST 16
- GENERAL DIRECTION OF GROUNDWATER FLOW
- 1890 POTENTIOMETRIC SURFACE CONTOURS (SEE NOTE 2)

NOTE(S)

1. GROUNDWATER ELEVATIONS SHOWN WERE MEASURED MAY/JUNE 2021.
2. POTENTIOMETRIC SURFACE CONTOURS WERE CREATED USING WATER LEVEL INFORMATION FROM THE MAY/JUNE 2021 GROUNDWATER ELEVATIONS SHOWN, AS WELL AS SURVEYED SURFACE WATER EXPRESSIONS, ADDITIONAL SITE WELLS, AND PIEZOMETERS NOT SHOWN. CONTOUR INTERVAL IS 5 FEET.
3. AT MW-DP2, SUFFICIENT VOLUME WAS NOT AVAILABLE TO MEASURE A WATER LEVEL OR TO SAMPLE.
4. AERIAL IMAGERY OBTAINED FROM UNITED STATES DEPARTMENT OF AGRICULTURE, NATIONAL AGRICULTURE IMAGERY PROGRAM, 2020.

DRAFT

N

0 300 600
1" = 300' FEET

GOLDER
MEMBER OF WSP

MONITORING WELL LOCATIONS AND MAY/JUNE 2021 GROUNDWATER CONDITIONS
GREAT RIVER ENERGY - COAL CREEK STATION

FIGURE 1

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LEGEND

- UPGRADIENT MONITORING WELL
- DOWNGRADIENT MONITORING WELL - DRAINS POND SYSTEM
- DOWNGRADIENT MONITORING WELL - UPSTREAM RAISE 91
- DOWNGRADIENT MONITORING WELL - UPSTREAM RAISE 92
- DOWNGRADIENT MONITORING WELL - SOUTHEAST 16
- GENERAL DIRECTION OF GROUNDWATER FLOW
- 1890 POTENTIOMETRIC SURFACE CONTOURS (SEE NOTE 2)

NOTE(S)

1. GROUNDWATER ELEVATIONS SHOWN WERE MEASURED OCTOBER/NOVEMBER 2021.
2. POTENTIOMETRIC SURFACE CONTOURS WERE CREATED USING WATER LEVEL INFORMATION FROM THE OCTOBER/NOVEMBER 2021 GROUNDWATER ELEVATIONS SHOWN, AS WELL AS SURVEYED SURFACE WATER EXPRESSIONS, ADDITIONAL SITE WELLS, AND PIEZOMETERS NOT SHOWN. CONTOUR INTERVAL IS 5 FEET.
3. AT MW-DP2, SUFFICIENT VOLUME WAS NOT AVAILABLE TO MEASURE A WATER LEVEL OR TO SAMPLE.
4. AERIAL IMAGERY OBTAINED FROM UNITED STATES DEPARTMENT OF AGRICULTURE, NATIONAL AGRICULTURE IMAGERY PROGRAM, 2020.

DRAFT

N

0 300 600
1" = 300' FEET

GOLDER
MEMBER OF WSP

MONITORING WELL LOCATIONS AND OCTOBER/NOVEMBER 2021 GROUNDWATER CONDITIONS
GREAT RIVER ENERGY - COAL CREEK STATION

FIGURE 2

APPENDIX A

ALTERNATIVE SOURCE DEMONSTRATIONS – Q4 2020

REPORT

Alternate Source Demonstration for Monitoring Wells MW-10 and MW-16-1

Great River Energy - Coal Creek Station

Submitted to:

Great River Energy

Coal Creek Station
2875 Third Street SW
Underwood, North Dakota 58576

Submitted by:

Golder Associates Inc.

7245 W Alaska Drive, Suite 200, Lakewood, Colorado, USA 80226

+1 303 980-0540

21451024C-6-R-0

May 21, 2021

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1.0 INTRODUCTION

On behalf of Great River Energy (GRE), Golder Associates Inc. (Golder) performed a statistical evaluation of groundwater monitoring results from the fourth quarter (Q4) 2020 groundwater detection monitoring event at Coal Creek Station's Upstream Raise 92 coal combustion residual (CCR) surface impoundment. The statistical evaluation was performed as described in the Coal Combustion Residuals Groundwater Statistical Method Certification for Coal Creek Station, Revision 1 (Golder 2019b), in accordance with applicable provisions of 40 Code of Federal Regulations (CFR) Part 257, Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities; Final Rule (CCR rule), as amended.

Statistical analyses of the Appendix III detection monitoring data indicated potential exceedances of the statistical limits based on the parametric Shewhart-CUSUM (Cumulative Summation) control chart analysis for the following parameters and monitoring wells in the fourth quarter (Q4) 2019 sampling results:

- fluoride in samples collected from monitoring well MW-10
- boron in samples collected from monitoring well MW-10
- field pH in samples collected from monitoring well MW-10
- field pH in samples collected from monitoring well MW-16-1

These potential exceedances were subsequently verified as statistically significant increases (SSIs) following the second quarter (Q2) 2020 detection monitoring sampling event. The Q4 2020 detection monitoring results for the above were also verified SSIs. Additionally, boron in samples collected from monitoring well MW-16-1 was identified as a potential exceedance following the Q2 2020 detection monitoring sampling event and a verified SSI following the Q4 2020 monitoring event.

Although determination of a verified SSI generally indicates that the groundwater monitoring program should transition from detection monitoring to assessment monitoring, 40 CFR Part 257.94(e)(2) allows the owner or operator (i.e., GRE) 90 days from the date of determining a verified SSI to demonstrate a source other than the regulated CCR facility 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 the baseline data collection period.

Golder's review of the hydrological and geologic conditions at the site indicates the SSIs are likely an indication of a temporary impact due to a stormwater runoff event. As described below, the response to this runoff event was conducted as outlined in 40 CFR 257.83(b)(5). A desktop study of previously collected CCR-impacted water from the facility, nearby surface water, and groundwater samples was conducted to assess potential fluoride, boron, and field pH sources. As a part of this work, potential error in the statistical analysis and the natural variability of concentrations in groundwater were evaluated. CCR-impacted water from the facility is broken into three categories for this demonstration. Contact water is defined as stormwater that comes into contact with CCR materials, porewater is defined as water collected from piezometers screened within the CCR deposition zone of the facility, and sump water is defined as water collected from the sumps overlying the composite liner system of the facility. Sump water and porewater samples have extended contact times with CCR materials while contact water has limited contact time with CCR materials. Based upon this review and in accordance with provisions of the CCR Rule, Golder has prepared this Alternative Source Demonstration (ASD) for monitoring wells MW-10 and

MW-16-1 at Upstream Raise 92. An ASD was initially developed following the Q2 2020 verified SSI (Golder 2020d, Golder 2021) and was reviewed for ongoing applicability and updated where necessary.

This ASD conforms to the requirements of 40 CFR Part 257.94(e)(2) and provides the basis for concluding that the verified SSIs at MW-10 and MW-16-1 are not an indication of seepage release from Upstream Raise 92. The following sections provide a summary of the CCR facilities, a storm event in September 2019, analytical and geochemical assessment results, and lines of evidence demonstrating stormwater that contacted CCR materials (contact water) is likely responsible for the SSIs at MW-10 and MW-16-1.

2.0 BACKGROUND

2.1 Site Background

GRE's Coal Creek Station (CCS) is a coal-fired electric generation facility located in McLean County, approximately 10 miles northwest of Washburn, North Dakota. CCRs are managed in composite-lined surface water impoundment cells and dry landfills regulated and permitted by the North Dakota Department of Environmental Quality (NDDEQ) in accordance with North Dakota Administrative Code (NDAC) Title 33.1, Article 33.1-20, Solid Waste Management and Land Protection.

CCS has four CCR facilities that are within the purview of the United States Environmental Protection Agency CCR rule. This ASD applies to the Upstream Raise 92 CCR surface impoundment. Upstream Raise 92 is located in the south-central portion of the plant site, east of the CCS plant buildings (Figure 1).

2.2 Site Geology

CCS and McLean County are situated at the eastern-most extent of the Williston Basin, a structural and sedimentary basin (USGS 1999). The region is characterized by the presence of glacial drift, reaching thicknesses of several hundred feet, and overlying the Sentinel Butte Member, the source of commercially mined coal in the direct vicinity of CCS (Falkirk 1979). The Sentinel Butte Member is the highest strata of the Paleocene Fort Union Formation, overlying the Tongue River, Ludlow, and Cannonball Members (USGS 1999). The Sentinel Butte Member is marked by drab-gray units, demarcating the separation from the lower Tongue River Member.

The site geology of CCS includes unconsolidated surficial deposits of the Coleharbor formation, consisting of stratified and unstratified glacial drift. The near-surface materials are silty clay and sandy clay till with interbedded lenses (CPA/UPA 1989).

2.3 Site Hydrogeology

Regional groundwater flow of the uppermost water-bearing unit in the vicinity of CCS is a subtle expression of the surface topography, which is influenced by the configuration of the eroded bedrock. Based on available groundwater elevation data, the shallow groundwater at the CCR facilities at CCS generally follows surface topography, flowing east and north towards Lower Samuelson Slough and Sayler Slough. Available groundwater elevation data indicate that groundwater in the area of Upstream Raise 92 generally flows from the southwest to the northeast, diagonally across the footprint of the facility.

Hydraulic conductivities in the area of the Upstream Raise 92 range from 0.35 feet per day (ft/day) to 12.96 ft/day, with calculated groundwater flow rates during the Q4 2020 detection monitoring event ranging from 0.01 to 0.53 ft/day.

2.4 Groundwater Monitoring Network

The groundwater monitoring network for Upstream Raise 92 was developed with consideration for the size, disposal and operational history, anticipated flow direction, and location of adjoining facilities. Based on these factors, the Upstream Raise 92 monitoring well network consists of two upgradient and three downgradient monitoring wells used for monitoring the unit under the CCR rule.

The two upgradient monitoring wells (MW-16-6, MW-16-7) included in the groundwater monitoring network for Upstream Raise 92 are used to represent upgradient water flowing towards the unit from the west and south. The three downgradient wells (MW-10, MW-16-0, MW-16-1) are spaced along the north side of the facility. Upstream Raise 92 directly abuts Southeast Section 16 on its eastern edge, preventing installation of monitoring wells along the eastern side of Upstream Raise 92 without jeopardizing the integrity of the liner system. The Upstream Raise 92 monitoring network wells are presented in Figure 1. Other monitoring locations used to support this ASD are also presented in Figure 1.

2.5 Groundwater Conditions

Between September 2015 and June 2017, GRE collected nine independent baseline groundwater samples from MW-16-6, MW-16-7, MW-10, MW-16-0, and MW-16-1, as required by 40 CFR Part 257.94, for use within the CCR rule monitoring program. The results of the CCR baseline monitoring were used to develop statistical limits for each constituent at each monitoring well, based on site conditions and parameter specific characteristics such as the data distribution and detection frequency (Golder 2019b).

Following completion of the baseline monitoring events at each well, GRE began collecting groundwater samples on a semi-annual basis to support the detection monitoring program. Groundwater samples for detection monitoring are collected at each upgradient and downgradient monitoring well and analyzed for 40 CFR Part 257 Appendix III constituents. During the detection monitoring program, results from groundwater analysis are compared to the statistical limits to determine whether groundwater quality remains consistent, or if changes in groundwater quality are observed.

In accordance with the site Statistical Method Certification (Golder 2019b) and recommendations within the United States Environmental Protection Agency's (USEPA) Unified Guidance (USEPA 2009), a baseline update was conducted for most well-constituent pairs within the Upstream Raise 92 monitoring network prior to conducting comparative statistical analysis for the Q4 2019 detection monitoring event. As a result of the baseline update, results collected during the detection monitoring program were evaluated to determine if they were from the same statistical population as those collected during the initial baseline monitoring program.

Figure 2 displays a time-series plot of historical water levels in each monitoring well. Water levels in both upgradient and downgradient wells increased between the Q2 2019 and Q4 2019 sampling events. Most of the groundwater levels remained elevated above pre-2019 levels during the Q2 2020 sampling event. During the Q4 2020 sampling event water levels generally returned to pre-2019 levels.

As discussed below and presented in Figure 3, the boron, fluoride, and field pH values in samples collected from MW-10 and MW-16-1 increased between the Q2 2019 and Q4 2019 sampling events. However, the values in the Q4 2020 groundwater samples generally decreased back towards the range of baseline measurements.

2.5.1 Boron at MW-10

Boron concentrations in groundwater at MW-10 during the initial baseline monitoring period ranged between 1.8 and 3.0 milligrams per liter (mg/L) in the nine baseline samples collected as part of the CCR rule monitoring program. The boron concentrations of detection monitoring samples collected between October 2017 and June 2019 that were incorporated into the updated baseline period ranged between 2.0 and 2.8 mg/L. The Shewhart-CUSUM statistical limit for the well-constituent pair was set at 3.7 mg/L following the baseline update.

The Q4 2019 detection monitoring event reported a boron concentration of 6.4 mg/L at MW-10, with a calculated CUSUM value of 6.0 mg/L, exceeding the statistical limit. Verification resampling was conducted during the Q2 2020 detection monitoring event, confirming the SSI for boron at MW-10 with a boron concentration of 4.6 mg/L and a calculated CUSUM value of 8.0 mg/L. During the Q4 2020 detection monitoring event boron was also identified as a verified SSI with a concentration of 2.6 mg/L and a calculated CUSUM of 8.0 mg/L.

2.5.2 Fluoride at MW-10

Fluoride concentrations in groundwater at MW-10 during the initial baseline monitoring period ranged between 0.19 and 0.23 mg/L in the nine baseline samples collected as part of the CCR rule monitoring program. The fluoride concentration of detection monitoring samples collected between October 2017 and June 2019 that were incorporated into the updated baseline period ranged between 0.17 and non-detect with a detection limit of 0.50 mg/L. The Shewhart-CUSUM statistical limit for the well-constituent pair was set at 0.29 mg/L following the baseline update.

The Q4 2019 detection monitoring event reported a fluoride concentration of 0.47 mg/L at MW-10, with a calculated CUSUM value of 0.45 mg/L, exceeding the statistical limit. Verification resampling was conducted during the Q2 2020 detection monitoring event, confirming the SSI for fluoride at MW-10 with a fluoride concentration of 0.37 mg/L and a calculated CUSUM value of 0.59 mg/L. During the Q4 2020 detection monitoring event fluoride was also identified as a verified SSI with a concentration of 0.17 mg/L and a calculated CUSUM of 0.53 mg/L.

2.5.3 Field pH at MW-10

Field pH in groundwater at MW-10 during the initial baseline monitoring period ranged between 6.72 and 6.95 standard units (SU) in the nine baseline samples collected as part of the CCR rule monitoring program. Detection monitoring samples collected between October 2017 and June 2019 that were incorporated into the updated baseline period had field pH values between 6.81 and 6.92 SU. The Shewhart-CUSUM upper statistical limit for the well-constituent pair was set at 7.10 SU following the baseline update.

The Q4 2019 detection monitoring event reported a pH value of 7.49 SU at MW-10, with a calculated upper CUSUM value of 7.42 SU, exceeding the statistical limit. Verification resampling was conducted during the Q2 2020 detection monitoring event, confirming the SSI for field pH at MW-10 with field pH of 7.54 SU and calculated upper CUSUM value of 8.06 SU. During the Q4 2020 detection monitoring event pH was also identified as a verified SSI with a value of 6.81 SU and a calculated upper CUSUM of 7.97 SU.

2.5.4 Field pH at MW-16-1

Field pH in groundwater at MW-16-1 during the initial baseline monitoring period ranged between 7.06 and 7.21 SU in the nine baseline samples collected as part of the CCR rule monitoring program. Detection monitoring samples collected between October 2017 and June 2019 that were incorporated into the updated baseline period had field pH values between 7.13 and 7.16 SU. The Shewhart-CUSUM upper statistical limit for the well-constituent pair was set at 7.34 SU following the baseline update.

The Q4 2019 detection monitoring event reported a pH value of 7.60 SU at MW-16-1, with a calculated upper CUSUM value of 7.55 SU, exceeding the statistical limit. Verification resampling was conducted during the Q2 2020 detection monitoring event, confirming the SSI for field pH at MW-16-1 with a field pH of 7.43 SU and calculated upper CUSUM value of 7.80 SU. During the Q4 2020 detection monitoring event pH was also identified as a verified SSI with a value of 7.24 SU and a calculated upper CUSUM of 7.86 SU.

2.5.5 Boron at MW-16-1

Boron in groundwater at MW-16-1 during the initial baseline monitoring period ranged between 5.26 and 13.6 mg/L in the nine baseline samples collected as part of the CCR rule monitoring program. The Shewhart-CUSUM upper statistical limit for the well-constituent pair was set at 20.7 mg/L. Detection monitoring samples collected between October 2017 and October 2019 had boron values between 13 and 16.8 mg/L.

The Q2 2020 detection monitoring event reported a boron value of 16 mg/L at MW-16-1, with a calculated CUSUM value of 22 mg/L, exceeding the statistical limit. Verification resampling was conducted during the Q4 2020 detection monitoring events, confirming the SSI for boron at MW-16-1 with boron concentration of 15 mg/L and a calculated CUSUM value of 24 mg/L.

3.0 POTENTIAL SITE FLUORIDE, BORON, AND FIELD pH SOURCES

To assess the potential sources for a change in fluoride and boron, concentrations and pH values at MW-10 and pH values at MW-16-1, Golder reviewed previously collected data and performed supplemental assessment activities. The following sections summarize the supplemental assessment activities.

3.1 Overview of September 20-21, 2019 Storm Event

Between Friday, September 20 and Saturday, September 21, 2019, a large thunderstorm system affected central North Dakota. The National Weather Service described the storm event in the following excerpt (NWS 2019):

> *"A large mid to upper level low pressure system moved across North Dakota on September 20th through September 21st, 2019. This low pressure system led to excessive rain across much of central North Dakota, as the atmosphere featured anomalously high moisture with a low level jet impinging on a stationary frontal boundary. These ingredients created a perfect scenario for thunderstorm training, which generally occurred in a line extending from Morton through Burleigh, Kidder, Stutsman, Sheridan, Wells, and Foster counties. The hardest hit areas were in portions of Sheridan and Wells counties, where some areas received over 7 inches of rain in less than 15 hours."*

Figure 4 shows a times series of monthly precipitation records from CCS between 2016 and 2020 and Turtle Lake, ND (approximately 20 miles northeast of the Site) between 1993 and 2020. The contribution from the storm on September 20 - 21, 2019 made September 2019 the wettest month over the period of record (7.4 inches of rain at CCS and 8.7 inches of rain at Turtle Lake). The average rainfall for September at Turtle Lake between 1993 and 2018 is 1.3 inches.

Three days after the storm event (September 24, 2019), a registered professional engineer (PE) from Golder was on Site performing the annual PE inspection of Upstream Raise 91 and Upstream Raise 92 per USEPA

Regulation 40 CFR 257.83(b) requirements. In the annual PE inspection reports (Golder 2020a and Golder 2020b), the Golder representatives noted the following:

- Standing water in the drainage ditches around Upstream Raise 91 and Upstream Raise 92
- Erosion of the fly ash cover along the inside of the ramp on the north side of Upstream Raise 92

Given the observed erosion, precipitation falling on the north side of Upstream Raise 92 (including a haul road ramp) likely contributed to significant runoff from exposed CCR slopes. Contact water was designed to flow from the inside of this ramp into a perimeter ditch at the toe of the CCR slope that is within the composite-lined footprint of the CCR surface impoundment. However, due to significant haul traffic over the course of several years and rounding off of the haul ramp and road near the toe of the facility, contact water appears to have had an opportunity to flow off of the lined footprint, especially in the case of a significant rain event (Figure 5). Although not directly observed, contact water is suspected to have flowed down the upper ramp and onto the lower ramp and lower perimeter berm slopes. Standing water was observed in the ditch near the lower ramp of Upstream Raise 92 that is meant to collect and route non-contact water from grass-covered slopes of the perimeter berm of the CCR surface impoundment.

Based on these observations, GRE personnel reviewed the contact water runoff controls for this area of Upstream Raise 92 and developed a plan to repair and improve contact water controls. Beginning in May 2020, once weather conditions allowed, these contact water controls were implemented to prevent contact water runoff during future storm events. The repairs are outlined in the Corrective Measures Report (Golder 2020c). The response to this event outlined in the Corrective Measures Report was consistent with the requirements of 40 CFR 257.83(b)(5) which states, "If a deficiency or release is identified during an inspection, the owner or operator must remedy the deficiency or release as soon as feasible and prepare documentation detailing the corrective measures taken."

Monitoring wells MW-10 and MW-16-1 are in low areas in close proximity to the north lower ramp of Upstream Raise 92 and the contact water flowing off of the facility is likely to have accumulated in the area around these wells.

3.2 Data Sources Used in Alternative Source Review

To evaluate potential site sources of fluoride, boron, and field pH near Upstream Raise 91 and Upstream Raise 92, Golder reviewed the following groundwater, surface water, and CCR-impacted water results (see Figure 1 and Figure 5 for locations).

3.2.1 Groundwater Monitoring Data

Data collected between September 2015 and October 2020 for the CCR rule monitoring program were considered in the evaluation. As part of the monitoring program, field personnel collected groundwater samples from the following monitoring wells:

- Upgradient to Upstream Raise 92: MW-16-6 and MW-16-7
- Downgradient to Upstream Raise 92: MW-10, MW-16-0, and MW-16-1
- Downgradient to Upstream Raise 91: MW-51 (the eastern-most downgradient monitoring well of Upstream Raise 91 that is within the surface water drainage ditch at the toe of the perimeter berm slope at the border between Upstream Raise 91 and Upstream Raise 92)

3.2.2 CCR-Impacted Waters

Sump water and porewater collected from Upstream Raise 92 was used to characterize waters in extended contact with CCR materials and includes the following:

- Upstream Raise 92 north sump (Sump-N-AP92)
- Porewater from Upstream Raise 92 piezometers (PZ-1, PZ-11, and PZ-13) screened within the deposited CCR

While MW-10 and MW-16-1 are downgradient wells for Upstream Raise 92, sump water from other CCR storage facilities was also included to increase the sample size and capture potential variability in sump water and porewater samples, especially given the drainage and process water systems between Upstream Raise 91 and the Drains Pond System are connected to Upstream Raise 92 via piping:

- Upstream Raise 91 sump (Sump-UR91)
- Southwest 16 sump (Sump-NW-SW16)

3.2.3 Short Term Leach Testing of CCR Materials

Short-term leach testing of the CCR materials by the synthetic precipitation leaching procedure (SPLP) was performed by USEPA Method 1312 (USEPA 1994). The SPLP simulates the interaction between a solid and meteoric water, which provides a screening-level estimate of ash effluent water quality.

CCR materials were collected by site personnel between 2012 and 2017. Details about the collection procedure are listed by material type below:

- Three bottom ash samples from Section 26 (a historic containment area for CCRs in a previously mined area) were collected in-situ at the facility in May 2017
- One bottom ash sample was collected from the Drains Pond System west cell in May 2017
- Two fly ash samples were collected from the fly ash silos (One sample was collected in November 2017 and one was collected in May 2017)
- Three coal rejects samples were collected from Ash Pond 91(also referred to as Upstream Raise 91) in June 2013
- One coal rejects sample was collected from Upstream Raise 91 in May 2017
- One Flue Gas Desulfurization (FGD) material sample was collected from the FGD material blowdown line at the scrubbers in May 2017

3.2.4 Ditch on the North Side of Upstream Raise 92

As part of the investigation of Upstream Raise 92 (Golder 2020c), standing water was observed in the ditch near the lower ramp of Upstream Raise 92. A water sample was collected from this drainage ditch located on the north side of Upstream Raise 92 (Ditch_N_UR92, see Figure 5), herein referred to as ditch water. This water likely represents contact water runoff from Upstream Raise 92.

3.3 Evaluation of Potential Sources of Boron, Fluoride, and Field pH

The relative proportion of major ion concentrations in groundwater samples and potential sources are depicted on a Piper diagram in Figure 6. This Piper diagram compares water quality results from groundwater, sump water, CCR material SPLP leachates, and Upstream Raise 92 ditch water to evaluate potential sources of boron, fluoride, and field pH. The results from the more recent groundwater sampling events are marked with blue symbols to distinguish between older and more recent samples. Figure 7 presents a scatter plot of the sulfate to chloride ratio versus the boron to chloride ratio as an additional method to compare site sources. The data suggests the SSIs identified for samples collected from MW-10 and MW-16-1 can be primarily attributed to a contact water runoff event associated with a significant rain event in September 2019.

3.3.1 Contact Water Runoff Event from Upstream Raise 92

Based on the magnitude of the September 2019 storm event and site observations of the CCR slopes and haul road ramp on the north side of Upstream Raise 92 after this event, contact water runoff from Upstream Raise 92 was evaluated as a potential source for the changing boron and fluoride concentrations and field pH values at the downgradient monitoring wells.

The conceptual model for contact water runoff impacting the shallow groundwater wells assumes that:

1) Due to failure of the contact water controls during a significant precipitation event, contact water flowing down existing CCR slopes and the upper haul road ramp on the north side of Upstream Raise 92 was able to bypass the controls, flow off the composite lined footprint along the north side of Upstream Raise 92, and pond near the downgradient monitoring wells.
2) This ponded contact water then partially infiltrated into the shallow groundwater monitored by the downgradient wells, resulting in a change in water quality monitored during the Q4 2019, Q2 2020, and Q4 2020 sampling events.
3) Because of the transient nature of this event, it is expected that water quality in the downgradient wells would shift towards contact water quality immediately after the event, and then would shift back towards historical water quality after the event.

Boron and fluoride concentrations and pH values in samples collected from ditch water (water that has been in short-term contact with CCR and expected to be similar to the water that was released during the storm event), MW-10, and MW-16-1 are presented in Table 1. Concentrations are generally higher in samples collected from ditch water than the monitoring wells, indicating that contact water runoff from Upstream Raise 92 could be responsible for elevated boron and fluoride concentrations and field pH values observed in recent samples collected from MW-10 and MW-16-1.

Table 1: Summary of Select Concentrations in Potential Contact Water Runoff and Downgradient Wells

Analyte	Units	Ditch water (Ditch_N_UR92) (10/24/2019)	MW-10 (Baseline and Detection Monitoring)	MW-16-1 (Baseline and Detection Monitoring)
pH	SU	8.1 (Lab)	6.74 – 7.54 (Field)	7.06 – 7.60 (Field)
Boron	mg/L	12.0	1.8 – 6.4	5.3 – 16.8
Fluoride	mg/L	0.26	0.17 – 0.47	0.16 – 0.77

Notes:
SU: standard units
Lab: pH measure in laboratory
Field: pH measure in the field
mg/L: milligrams per liter

SPLP testing was also used to assess the water quality expected from short-term interactions of water with CCR. As concentrations observed in SPLP leachates are partly a function of the liquid to solid ratio of the test conducted, results should not be directly compared to Site waters. Instead, Piper diagrams and ion ratios allow for comparisons of relative concentrations of Site waters to SPLP leachates.

The relative proportion of major ion concentrations in groundwater samples and potential boron, fluoride, and field pH sources are depicted on a Piper diagram in Figure 6. The Piper diagram indicates that the Q4 2019 groundwater samples from MW-10 shifted towards a more sulfate dominant signature, and closer to the CCR SPLP leachates and ditch water (Ditch_N_UR92) sample (surrogates for contact water) on the plot. The major ion signature of the Q2 and Q4 2020 groundwater samples shifted back towards the historical (May 2017 to June 2019) signature, suggesting the groundwater quality change was temporary and transient. Similar proportions of major ions between MW-16-1 samples and surrogates for contact water (CCR SPLP leachates and the ditch water sample) limit the ability to make similar observation related to MW-16-1. As discussed in Section 2.5, the boron, fluoride, and field pH concentrations in Q2 and Q4 2020 groundwater samples generally shifted back towards the range of baseline measurements.

The shifting of groundwater quality toward a potential source and then back toward the historical chemical signature is consistent with what would be expected if a stormwater runoff event temporarily influenced groundwater concentrations. If contact water flowed down existing CCR slopes and the haul road ramp on the north side of Upstream Raise 92 and ponded near the downgradient monitoring wells, the water is likely to have partially infiltrated into groundwater and influenced concentrations in nearby wells. After the storm and short-term contact water runoff infiltration event, the water quality signature of samples collected from a given downgradient well would return closer to the historical signature as the “plug” of infiltrated contact water migrates downgradient. A similar shift towards the CCR SPLP and ditch water sample signature in Q4 2019 samples and then back towards the historical signature in Q2 and Q4 2020, was also observed for Q2 and Q4 2020 samples collected from nearby wells MW-51 and MW-16-0, which are also located so as to have seen potential contact water runoff from the north haul road ramp at Upstream Raise 92. The widespread observation of water quality changes in the area likely affected by contact water runoff on the north side of Upstream Raise 92 suggests a temporary change in groundwater quality due to ponding and infiltration of contact water.

A return towards the historical chemical signature would not be expected if an ongoing source, such as seepage from the CCR facility, caused the initial change in the major ion signature. Furthermore, if seepage from a CCR facility was impacting groundwater at MW-10 or MW-16-1, the groundwater geochemistry would be expected to shift towards the major ion signature of sump samples on the Piper diagram, which is not observed.

Figure 7 presents an ion ratio plot to further highlight differences between estimated contact water chemistry (based on CCR material SPLPs and ditch water) and facility seepage chemistry (based on sump water and porewater samples). Sump water and porewater samples have extended contact times with CCR materials and have higher chloride to sulfate and chloride to boron ratios relative to groundwater samples, CCR material SPLP leachates and ditch water. The groundwater samples collected in Q4 2019 from MW-10 and MW-16-1 appear to be impacted by a water source with higher concentrations of sulfate and boron relative to chloride (shifting to the upper-right), indicating impacts likely due to contact water runoff. Similar to observations from the Piper diagram, the groundwater samples collected in Q2 and Q4 2020 from MW-10 and MW-16-1 shift back towards their historical chemical signatures, indicating that the “plug” of infiltrated contact water is migrating downgradient. These same temporal patterns are observed in MW-51 and to a lesser extent MW-16-0, which are nearby to MW-10 and MW-16-1 and likely experienced the same temporary impacts from contact water runoff.

3.3.2 Seepage from Upstream Raise 92

Seepage from Upstream Raise 92 has the potential to impact downgradient monitoring wells experiencing SSIs. The range of boron and fluoride concentrations, and pH values in samples collected from sumps and piezometers (porewater), and MW-10, and MW-16-1 are presented in Table 2. Sump water and piezometer water (porewater) concentrations and pH values are elevated above groundwater concentrations and pH values in samples collected from MW-10 and MW-16-1. Therefore, seepage, if occurring, could increase concentrations at MW-10 and MW-16-1. However, as discussed in Section 3.3.1, the ion ratios presented in Figure 7 show that the Q4 2019 groundwater samples at MW-10 and MW-16-1 shifted away from the sump water and porewater signatures, making leakage from Upstream Raise 92 an unlikely source for the observed changes in boron, fluoride, and field pH.

The presence of the composite liner systems at Upstream Raise 92 reduces the likelihood of seepage. The composite liner on the west side of Upstream Raise 92 includes a 2-foot thick compacted clay liner with a hydraulic conductivity of $1x10^{-7}$ cm/sec or less underlying a 40-mil high density polyethylene (HDPE) geomembrane. The composite liner on the east side of Upstream Raise 92 includes a 1-foot thick compacted clay liner with a hydraulic conductivity of $1x10^{-7}$ cm/sec or less underlying a 60-mil linear-low density polyethylene (LLDPE) geomembrane.

Table 2: Summary of Select Concentrations in Sumps and Piezometers and Downgradient Wells

Analyte	Units	Sumps and Piezometers Samples Upstream Raise 91, Upstream Raise 92, and Southwest 16 (2018 – 2019)	MW-10 (Baseline and Detection Monitoring)	MW-16-1 (Baseline and Detection Monitoring)
pH	SU	7.5 – 10.5 (Lab)	6.74 – 7.54 (Field)	7.06 – 7.60 (Field)
Boron	mg/L	3.7 - 50	1.8 – 6.4	5.3 – 16.8
Fluoride	mg/L	0.18 - 70	0.17 – 0.47	0.16 – 0.77

4.0 EVIDENCE OF AN ALTERATIVE SOURCE

Primary lines of evidence and conclusions drawn from the evidence used to support this ASD are provided in Table 3. In summary, the SSIs identified for samples collected from MW-10 and MW-16-1 were not an indication of seepage from the CCR unit and can be primarily attributed to a contact water runoff event associated with a significant rain event in September 2019.

Table 3: Primary and Supporting Lines of Evidence from ASD Analysis

Key Line of Evidence	Supporting Evidence	Description
Hydrogeology	Groundwater elevations at monitoring wells around Upstream Raise 92	Q4 2019 increases in water levels downgradient monitoring wells indicate a change in the hydrological regime downgradient of Upstream Raise 92, potentially reflecting the infiltration of contact water runoff from the upper CCR slopes and the north Upstream Raise 92 haul road ramp.
Engineering Controls	Upstream Raise 92 has a composite liner system	Upstream Raise 92 has composite liner systems consisting of compacted clay liner with a hydraulic conductivity of $1x10^{-7}$ cm/sec or less underlying a geomembrane, which decreases the likelihood of seepage from the facility.
Water Geochemistry	Relative ion abundances in groundwater differs from CCR facility porewater and sump water samples	The water quality signature of groundwater samples collected from downgradient wells MW-10 and MW-16-1 are not consistent with the signature of potential seepage from Upstream Raise 92, which is shown in two different ways on Figure 6 (Piper diagram) and Figure 7 (ion ratio plot). Groundwater chemistry results from MW-10 and MW-16-1 in Q4 2019 shift towards contact water (SPLP leachates and ditch water consistent with contact water runoff from the surface of the facility). In Q2 and Q4 2020 samples, the groundwater from MW-10 and MW-16-1 shifted back towards their historical chemical signature, indicating a short-term impact, from infiltration of contact water runoff.

5.0 CONCLUSIONS

In accordance with 40 CFR 257.95(g)(3), this ASD has been prepared in response to the identification of verified SSIs for boron, fluoride, and field pH at monitoring well MW-10 and field pH and boron at monitoring well MW-16-1 following the Q2 and Q4 2020 sampling events for Upstream Raise 92 at Coal Creek Station.

Based on review of site analytical results, recent changes to boron, fluoride, and field pH concentrations in groundwater downgradient of Upstream Raise 92 are likely not a result of leakage from a CCR facility but instead can be attributed to a contact water runoff event associated with a significant rain event in September 2019. As a result, GRE performed the actions outlined in the Corrective Measures Report (Golder 2020c) to prevent runoff from CCR slopes or the Upstream Raise 92 north haul road ramp from migrating off the composite-lined facility footprint during future storm events. Therefore, no further action (i.e., a transition to Assessment Monitoring) is warranted, and Upstream Raise 92 will remain in detection monitoring.

6.0 REFERENCES

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Signature Page

Golder Associates Inc.

Gregory Lehn
Staff Geochemist

Sara Harkins
Senior Project Geochemist

Todd Stong, PE
Associate and Senior Consultant

GL/SH/TS/mp

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Figures

LEGEND

- UPGRADIENT MONITORING WELL
- DOWNGRADIENT MONITORING WELL - DRAINS POND SYSTEM
- DOWNGRADIENT MONITORING WELL - UPSTREAM RAISE 91
- DOWNGRADIENT MONITORING WELL - UPSTREAM RAISE 92
- SAMPLED PIEZOMETER - UPSTREAM RAISE 92
- DOWNGRADIENT MONITORING WELL - SOUTHEAST 16
- GENERAL DIRECTION OF GROUNDWATER FLOW
- 1915 — POTENTIOMETRIC SURFACE CONTOURS (SEE NOTE 2)
- UPSTREAM RAISE 92 BOUNDARY

NOTE(S)

1. GROUNDWATER ELEVATIONS SHOWN WERE MEASURED OCTOBER-NOVEMBER 2020.
2. POTENTIOMETRIC SURFACE CONTOURS WERE CREATED USING WATER LEVEL INFORMATION FROM THE OCTOBER-NOVEMBER 2020 GROUNDWATER ELEVATIONS SHOWN, AS WELL AS SURVEYED SURFACE WATER EXPRESSIONS, ADDITIONAL SITE WELLS, AND PIEZOMETERS NOT SHOWN. CONTOUR INTERVAL IS 5 FEET.
3. AERIAL IMAGERY OBTAINED FROM UNITED STATES DEPARTMENT OF AGRICULTURE, NATIONAL AGRICULTURE IMAGERY PROGRAM, 2019.

0 200 400
1" = 200' FEET

CLIENT
GREAT RIVER ENERGY
COAL CREEK STATION

PROJECT
ALTERNATIVE SOURCE DEMONSTRATION

CONSULTANT

GOLDER
MEMBER OF WSP

YYYY-MM-DD	2021-05-07
DESIGNED	BJP
PREPARED	BJP
REVIEWED	CCS
APPROVED	TJS

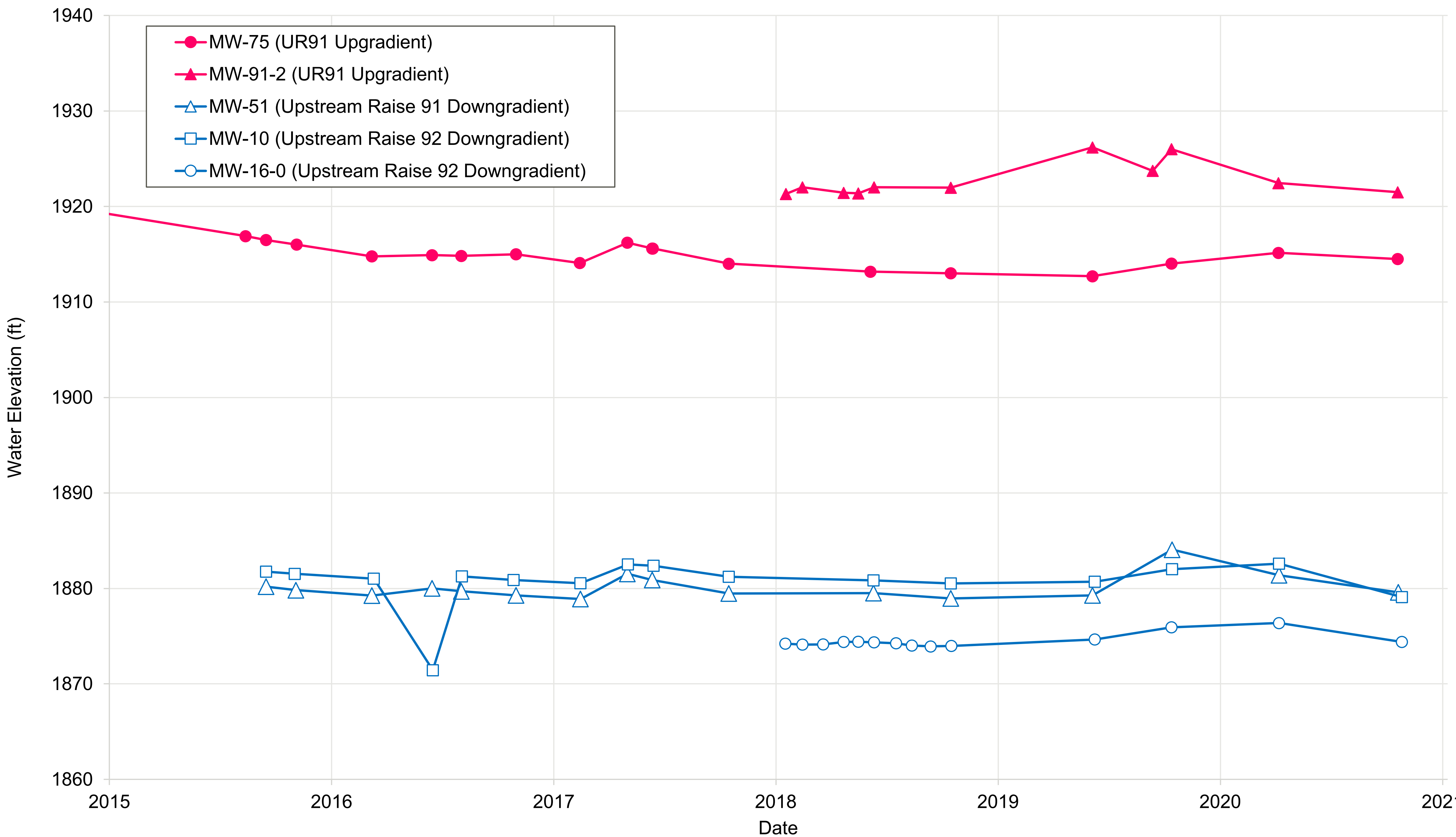
TITLE
OCTOBER-NOVEMBER 2020 GROUNDWATER CONTOURS AND SAMPLING LOCATIONS

PROJECT NO.	PHASE	REV.	FIGURE
21451024C	2	0	1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D

Path: \\Denver.golder.gds\acad\GREAT RIVER ENERGY\COAL CREEK\99_PROJECTS\21451024\21451024C\ASD (Q2 2020)\ | File Name: Figure 1_OctNov 2020 MW Network.dwg | Last Edited By: bpurcell Date: 2021-05-07 Time:12:35:37 PM | Printed By: BPurcell Date: 2021-05-07 Time:12:35:53 PM

PATH: https://golderassociates.sharepoint.com/sites/140044/Project Files/5 Technical Work/6 - Water Quality/Q4 2020 ASDs/Contact Water Release ASD | FILE NAME: CCS Q4 2020 ASD Working Data.xlsx



CLIENT
Great River Energy Coal Creek Station

PROJECT
Alternative Source Demonstration

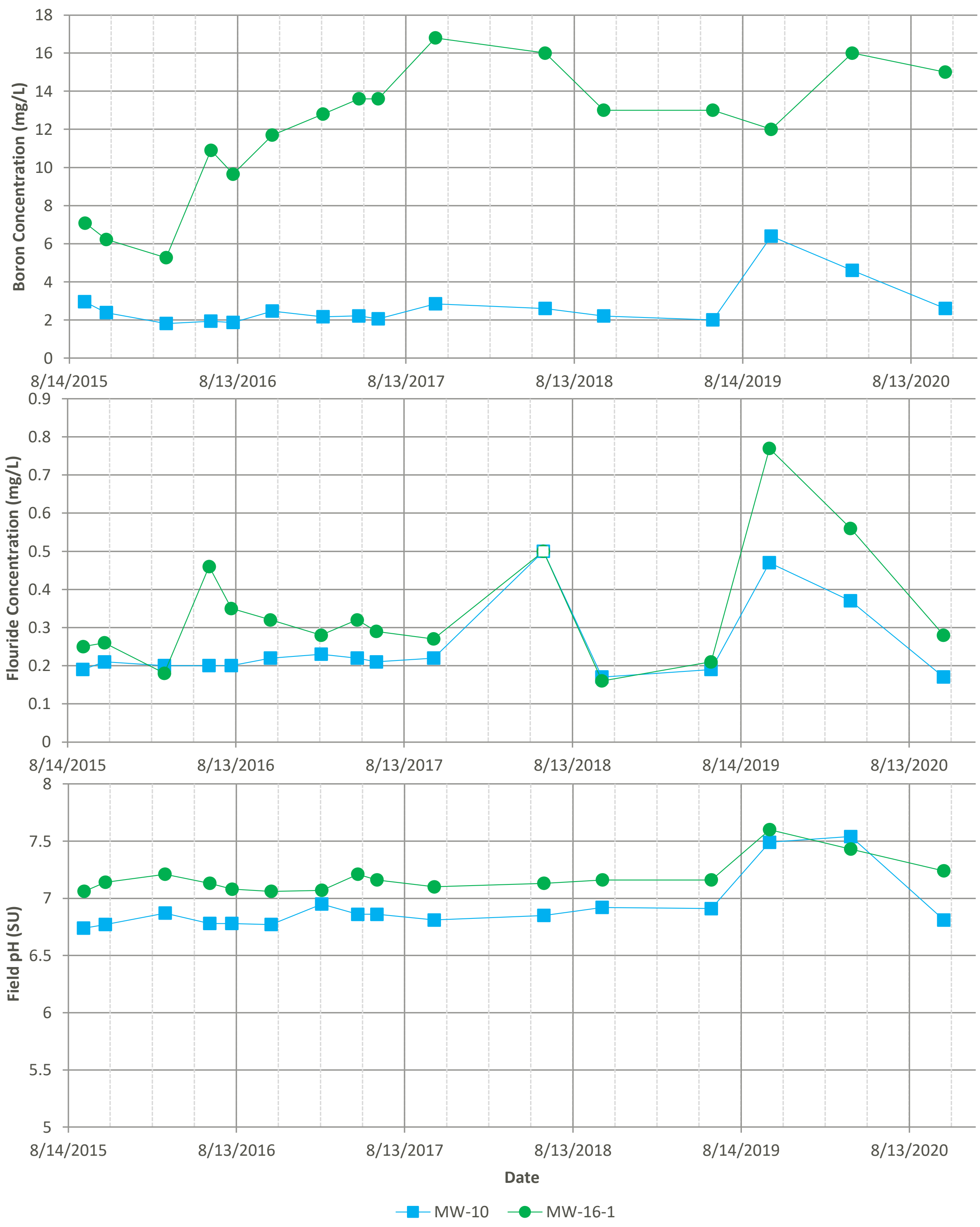
CONSULTANT
GOLDER
MEMBER OF WSP

TITLE
Time Series of Groundwater Elevations in Network Wells

PROJECT NO.	PHASE	REV.	FIGURE
21451024	--	0	2

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A

PATH: https://golderassociates.sharepoint.com/sites/140044/Project Files/5 Technical Work/6 - Water Quality/Q4 2020 ASDs/Contact Water Release ASD | FILE NAME: CCS Q4 2020 ASD Working Data.xlsx



CLIENT
Great River Energy Coal Creek Station

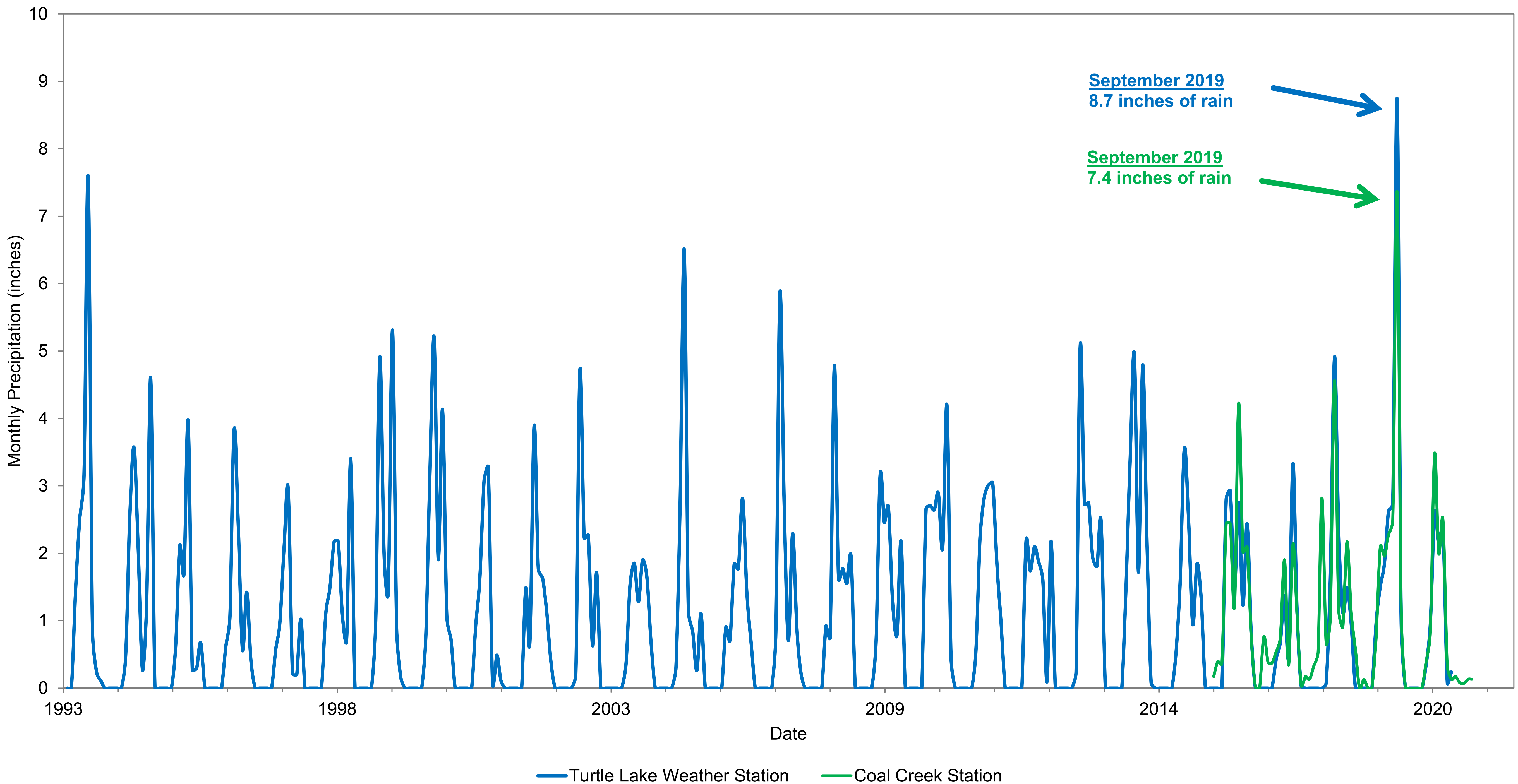
PROJECT
Alternative Source Demonstration

CONSULTANT
GOLDER
MEMBER OF WSP

TITLE
Time Series of Boron, Fluoride, and pH in MW-10 and MW-16-1

PROJECT NO.	PHASE	REV.	FIGURE
21451024	--	0	3

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A



Note: Turtle Lake Weather Station is located approximately 20 miles northwest of Coal Creek Station.

CLIENT
Great River Energy Coal Creek Station

PROJECT
Alternative Source Demonstration

CONSULTANT
GOLDER
MEMBER OF WSP

TITLE
Time Series of Monthly Precipitation at CCS and Turtle Lake, ND Weather Stations

PROJECT NO.	PHASE	REV.	FIGURE
21451024	--	0	4

LEGEND

- DOWNGRADIENT MONITORING WELL - UPSTREAM RAISE 91
- DOWNGRADIENT MONITORING WELL - UPSTREAM RAISE 92
- OTHER SAMPLING LOCATION
- DESIGNED CONTACT WATER FLOW PATH
- SUSPECTED CONTACT WATER RUNOFF

NOTE(S)

1. AERIAL IMAGERY OBTAINED FROM UNITED STATES DEPARTMENT OF AGRICULTURE, NATIONAL AGRICULTURE IMAGERY PROGRAM, 2019.

CLIENT
GREAT RIVER ENERGY
COAL CREEK STATION

PROJECT
ALTERNATIVE SOURCE DEMONSTRATION

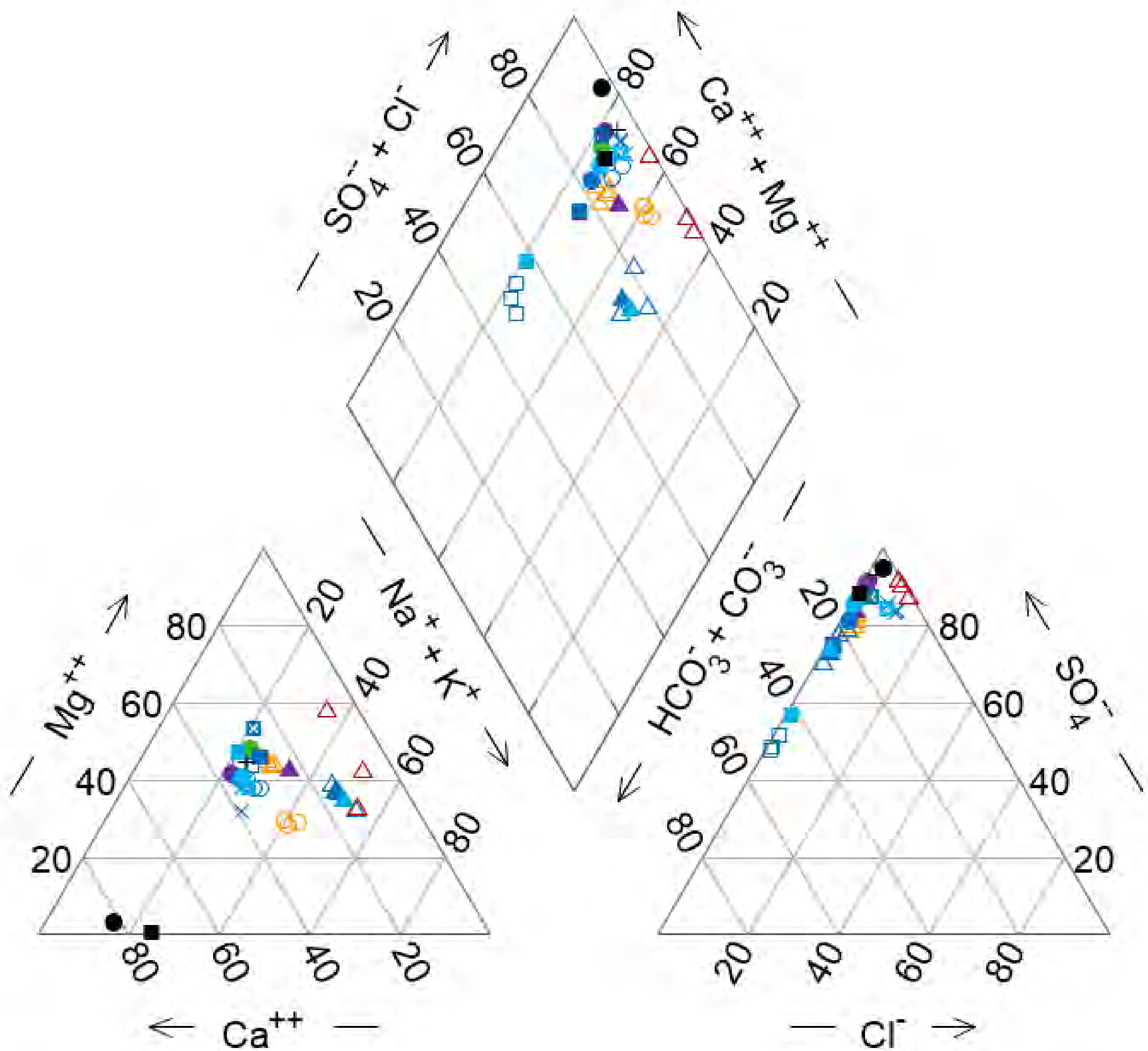
CONSULTANT

GOLDER
MEMBER OF WSP

YYYY-MM-DD	2021-05-07
DESIGNED	DVS
PREPARED	DVS
REVIEWED	CCS
APPROVED	TJS

TITLE
UPSTREAM RAISE 92 NORTH RAMP

PROJECT NO.	PHASE	REV.	FIGURE
21451024C	2	0	5



- MW-16-6 (May 2017 - April 2020)
- MW-16-7 (May 2017 - April 2020)
- MW-51 (May 2017 - June 2019)
- MW-51 (Oct 2019)
- MW-51 (Apr 2020)
- MW-51 (Oct 2020)
- MW-10 (May 2017 - June 2019)
- MW-10 (Oct 2019)
- MW-10 (Apr 2020)
- MW-10 (Oct 2020)
- MW-16-0 (June 2018 - June 2019)
- MW-16-0 (Oct 2019)
- MW-16-0 (Apr 2020)
- MW-16-0 (Oct 2020)
- MW-16-1 (May 2017 - June 2019)
- MW-16-1 (Apr 2020)
- MW-16-1 (Oct 2020)
- Ash SPLP (Bottom Ash)
- Ash SPLP (Fly Ash)
- Ash SPLP (Rejects)
- Sumps
- Ditch_N_UR92

Note:
* Samples from Oct 2019 did not have alkalinity measurements so alkalinity was estimated as the difference between major cations (Ca, Mg, Na, K) and major anions (SO_4, Cl, F). This technique is less precise and should be regarded as a high-level estimate.

CLIENT
Great River Energy Coal Creek Station

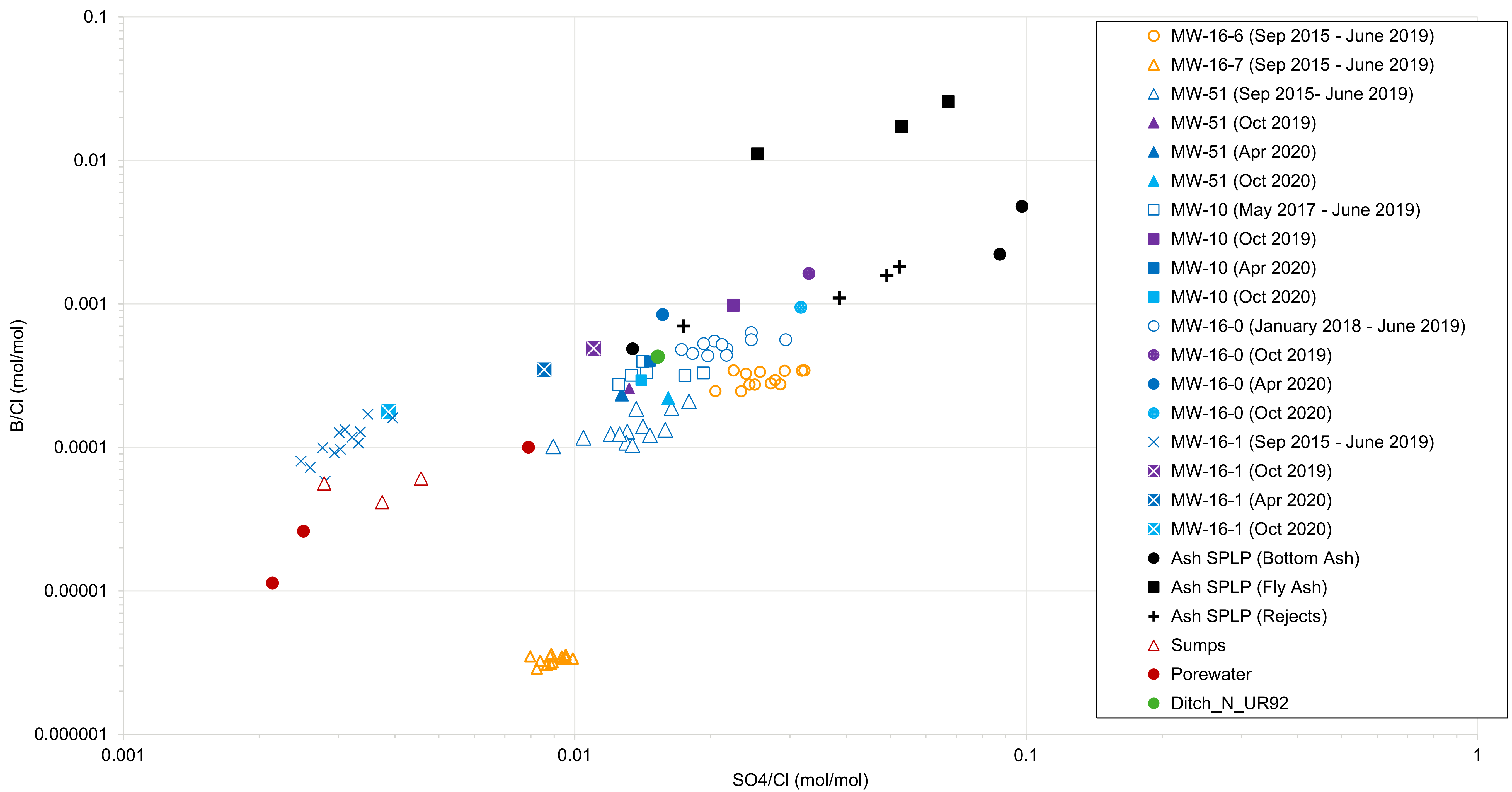
PROJECT
Alternative Source Demonstration

CONSULTANT
GOLDER MEMBER OF WSP

TITLE
Piper Diagram

PROJECT NO.	PHASE	REV.	FIGURE
21451024	--	0	6

PATH: https://golderassociates.sharepoint.com/sites/140044/Project Files/5 Technical Work/6 - Water Quality/Q4 2020 ASDs/Contact Water Release ASD | FILE NAME: CCS Q4 2020 ASD Working Data.xlsx



CLIENT
Great River Energy Coal Creek Station

PROJECT
Alternative Source Demonstration

CONSULTANT
GOLDER
MEMBER OF WSP

TITLE
Boron to Chloride versus Sulfate to Chloride Ratio Plot

PROJECT NO.	PHASE	REV.	FIGURE
21451024	--	0	7

GOLDER
MEMBER OF WSP

golder.com

REPORT

Alternative Source Demonstration for Chloride in Monitoring Well MW-49

Great River Energy – Coal Creek Station

Submitted to:

Great River Energy

Coal Creek Station
2875 Third Street SW
Underwood, North Dakota 58576

Submitted by:

Golder Associates Inc.

7245 W Alaska Drive, Suite 200, Lakewood, Colorado, USA 80226

+1 303 980-0540

21451024C-7-R-0

May 21, 2021

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1.0 INTRODUCTION

On behalf of Great River Energy (GRE), Golder Associates Inc. (Golder) performed a statistical evaluation of groundwater monitoring results from the fourth quarter (Q4) 2020 groundwater detection monitoring event at Coal Creek Station's Upstream Raise 91 coal combustion residual (CCR) surface impoundment. The statistical evaluation was performed as described in the Coal Combustion Residuals Groundwater Statistical Method Certification for Coal Creek Station, Revision 1 (Golder 2019b), in accordance with applicable provisions of United States Environmental Protection Agency (USEPA) 40 Code of Federal Regulations (CFR) Part 257, "Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities; Final Rule" (CCR rule), as amended.

Statistical analyses of the Appendix III detection monitoring data for chloride in groundwater at the downgradient monitoring well MW-49 indicated a potential exceedance of the statistical limit based on the parametric Shewhart–CUSUM (cumulative summation) control chart analysis of the Q2 2019 sampling results. This potential exceedance was subsequently verified as a statistically significant increase (SSI) following the Q4 2019 detection monitoring sampling event. The Q2 and Q4 2020 detection monitoring results for chloride at MW-49 were also verified SSIs. Although determination of a verified SSI generally indicates that the groundwater monitoring program should transition from detection monitoring to assessment monitoring, 40 CFR Part 257.94(e)(2) allows the owner or operator (i.e., GRE) 90 days from the date of determining a verified SSI (July 29, 2020) to demonstrate a source other than the regulated CCR facility 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 the baseline data collection.

Golder's review of the hydrological and geologic conditions at the site and the sampling and analytical procedures indicates the SSI is not an indication of impacts from the CCR unit. A desktop study of previously collected CCR-impacted water from the facility, nearby surface water, and groundwater samples was conducted to assess potential chloride sources. As a part of this work, potential error in the statistical analysis, laboratory methods, and the natural variability of chloride concentrations in groundwater were evaluated. Based on this review and in accordance with provisions of the CCR rule, Golder has prepared this Alternative Source Demonstration (ASD) for chloride at MW-49 and the Upstream Raise 91 CCR surface impoundment. An ASD was initially developed following the Q4 2019 verified SSI (Golder 2020a) and updated and reissued following the Q2 2020 SSI (Golder 2020b). In response to the Q4 2020 SSI, the ASD was reviewed for ongoing applicability and updated where necessary.

This ASD conforms to the requirements of 40 CFR Part 257.94(e)(2) and provides the basis for concluding that the verified SSI for chloride at MW-49 is not an indication of a release from Upstream Raise 91. The following sections provide a summary of Upstream Raise 91, sampling procedures and analytical methods, analytical and geochemical assessment results, and lines of evidence demonstrating an alternative source for the increased chloride concentrations at MW-49.

2.0 BACKGROUND

2.1 Site Background

GRE's Coal Creek Station (CCS) is a coal-fired electric generation facility located in McLean County, approximately 10 miles northwest of Washburn, North Dakota. CCRs are managed in composite-lined surface water impoundment cells and dry landfills regulated and permitted by the North Dakota Department of

Environmental Quality (NDDEQ) in accordance with North Dakota Administrative Code (NDAC) Article 33-20, Solid Waste Management and Land Protection.

CCS has four CCR facilities that are within the purview of the USEPA CCR rule. This ASD only applies to the Upstream Raise 91 CCR surface impoundment. Upstream Raise 91 is located in the south-central portion of the plant site, east of the CCS plant buildings (Figure 1).

2.2 Site Geology

CCS and McLean County are situated at the eastern-most extent of the Williston Basin, a structural and sedimentary basin (USGS 1999). The region is characterized by the presence of glacial drift, reaching thicknesses of several hundred feet and overlying the Sentinel Butte Member, the source of commercially mined coal in the direct vicinity of CCS (Falkirk 1979). The Sentinel Butte Member is the highest strata of the Paleocene Fort Union Formation, overlying the Tongue River, Ludlow, and Cannonball Members (USGS 1999). The Sentinel Butte Member is marked by drab-gray units, demarcating the separation from the lower Tongue River Member.

The site geology of CCS includes unconsolidated surficial deposits of the Coleharbor Formation, consisting of stratified and unstratified glacial drift. The near-surface materials are silty clay and sandy clay till with interbedded lenses (CPA/UPA 1989).

2.3 Site Hydrogeology

Regional groundwater flow of the uppermost water-bearing unit in the vicinity of CCS is a subtle expression of the surface topography, which is influenced by the configuration of the eroded bedrock. Based on available groundwater elevation data, the shallow groundwater at the CCR facilities at CCS generally follows surface topography, flowing east and north towards Lower Samuelson Slough and Sayler Slough. Available groundwater elevation data indicate that groundwater in the area of Upstream Raise 91 generally flows from the southwest to northeast, diagonally across the footprint of the facility, towards Lower Samuelson Slough.

Hydraulic conductivities in the area of Upstream Raise 91 range from 0.35 feet per day (ft/day) to 12.96 ft/day, with calculated groundwater flow rates during Q4 2020 ranging from 0.01 to 0.44 ft/day.

2.4 Groundwater Monitoring Network

The groundwater monitoring network for Upstream Raise 91 was developed with consideration for the size, disposal and operational history, anticipated flow direction, and location of adjoining facilities. Based on these factors, a monitoring well network consisting of two upgradient and three downgradient monitoring wells is used for monitoring the unit under the CCR rule.

The two upgradient monitoring wells (MW-75, MW-91-2) included in the groundwater monitoring network for Upstream Raise 91 are used to represent upgradient water quality flowing towards the unit from the west and south. The three downgradient wells (MW-49, MW-51, MW-91-1) are spaced along the northern edge of the facility. Upstream Raise 91 directly abuts Upstream Raise 92 on its eastern edge, preventing installation of monitoring wells along the eastern side of Upstream Raise 91 without jeopardizing the integrity of the liner system. The Upstream Raise 91 network wells are presented in Figure 1. Other monitoring locations used to support this ASD are also presented in Figure 1 and are discussed further in Section 5.0.

2.5 Groundwater Conditions

Between September 2015 and June 2017, GRE collected nine independent baseline groundwater samples from MW-75, MW-49, and MW-51, as required by 40 CFR Part 257.94, for use within the CCR rule monitoring program. Baseline samples were collected from MW-91-2 and MW-91-1 between January 2018 and October 2018 following installation of the wells in late 2017. Prior to installation of MW-91-2 and MW-91-1 and completion of the baseline monitoring at the wells, Upstream Raise 91 and Upstream Raise 92 were monitored jointly under a monitoring network consisting of the wells near both units (Golder 2019a). The results of the CCR baseline monitoring were used to develop appropriate statistical limits for each constituent at each monitoring well based on site and parameter specific conditions (Golder 2019b).

Following completion of the baseline monitoring events at each well, GRE began collecting groundwater samples on a semi-annual basis to support the detection monitoring program. Groundwater samples for detection monitoring are collected at each upgradient and downgradient monitoring well and analyzed for 40 CFR Part 257 Appendix III constituents. During the detection monitoring program, results from groundwater analysis are compared to the statistical limits calculated from the baseline monitoring results to determine whether groundwater quality remains consistent, or if changes in groundwater quality are observed.

Chloride concentrations in groundwater at MW-49 during the baseline monitoring period ranged between 59.2 and 67.1 milligrams per liter (mg/L) in the nine baseline samples collected as part of the CCR rule monitoring program. The Shewhart-CUSUM statistical limit for the well-constituent pair was set at 73.9 mg/L.

The Q2 2019 detection monitoring event reported a chloride concentration of 70.0 mg/L at MW-49, with a calculated CUSUM value of 77.4 mg/L, exceeding the statistical limit. Verification resampling was conducted during the Q4 2019 detection monitoring event, confirming the SSI for chloride at MW-49 with a chloride concentration of 71.0 mg/L and a calculated CUSUM value of 83.8 mg/L. The Q2 and Q4 2020 chloride results at MW-49 were verified SSIs (based on calculated CUSUM value) with chloride concentrations of 60.0 mg/L and 64.0 mg/L, respectively, which are in the range of baseline values. However, the calculated CUSUM values of 85.3 mg/L and 84.2 mg/L were greater than the statistical limit.

2.6 Sampling and Laboratory Testing Procedures

As part of the ASD, a review was conducted of the sampling and laboratory testing procedures used throughout baseline monitoring and detection monitoring to date, along with the collected results. A review of the statistical assessment methods and associated results found the procedures followed during baseline and detection monitoring to be consistent with the stated procedures listed in the published Groundwater Statistical Methods Certification (Golder 2019b). Calculated limits were found to be consistent with the chosen statistical procedures and recommended methodology found within the Unified Guidance (USEPA 2009).

In review of the analytical results, a shift in the MW-49 chloride concentrations was noted between data collected prior to June 2018 and data collected after June 2018. This shift was evaluated with a Wilcoxon rank-sum test, which showed statistical significance at the 95% confidence level (Figure 2). The Wilcoxon rank-sum test determines if measurements from one population are significantly different than measurements from another population. This test is non-parametric, meaning that the data are not assumed to fit a specific distribution, such as a normal distribution.

Beginning in June 2018 (Q2 2018, the second semi-annual detection monitoring event), GRE switched sampling staff. The potential impacts of this change are evaluated in Section 3.0. Also beginning in June 2018 (Q2 2018, the second semi-annual detection monitoring event), GRE switched analytical laboratories from Minnesota Valley Testing Laboratories, Inc. (MVTL) (Bismarck, North Dakota) to Eurofins TestAmerica (TestAmerica) (Denver laboratory in Arvada, Colorado). There are differences between the testing methodologies used for chloride by the two laboratories. An evaluation of the methods and their associated differences is discussed in Section 4.1.

3.0 POTENTIAL SAMPLING CAUSES

Between September 2015 and May 2018, sampling of the CCR rule wells and other wells and surface water sampling locations at Coal Creek Station was conducted by outside contractors from the Bismarck, North Dakota, location of MVTL. Beginning with the samples collected in June 2018, sampling has been conducted in-house by GRE employees. Low-flow pumps and sampling methods have been used to collect groundwater samples throughout the monitoring program for the CCR rule, following manufacturer recommendations (Geotech 2015) and USEPA guidance (USEPA Region I 2017). Although using the same sampling methods, there is a potential for minor differences in sampling technique between sampling personnel. The timing of the change in sampling personnel coincides with both the June 2018 shift in chloride concentrations described in Section 2.5 and the change in laboratories noted in Section 2.6.

4.0 POTENTIAL LABORATORY SOURCES

4.1 Changes in Testing Methodology

Prior to June 2018, GRE contracted MVTL as their analytical testing laboratory for the monitoring program for the CCR rule. For analysis of chloride, MVTL used a variation of the SM4500-Cl- method (published variations of the method are labeled SM4500-Cl- A through SM4500-Cl- I; Standard Methods Online 2018). In the most recent sampling prior to the analytical laboratory switch, MVTL used method SM4500-Cl- E, Chloride by Automated Ferricyanide Method. Instrumentation for the method is an automated spectrophotometer, as the method is a colorimetric means of measuring chloride in water. All variations of SM4500-Cl are only applicable for testing chloride and are not indicated for use for other analytes.

Under typical use of the method, the applicable concentration range is 1 to 200 mg/L of chloride, which can be extended to higher and lower concentrations by dilution, adjustment of sample size, and other typical testing adjustments (USGS 2002a). The typical chloride reporting limit provided by MVTL was 1.0 mg/L. Although not reported within MVTL's laboratory information management system at the time of testing, dilutions to the sample results are likely to have occurred, given the range in chloride concentrations reported using the method between 2015 and 2018 (1.1 to 697 mg/L across CCS samples collected as part of the monitoring program for the CCR rule).

Beginning with the June 2018 sampling events for the CCR rule groundwater monitoring program, GRE contracted TestAmerica as their analytical testing laboratory. For analysis of chloride, TestAmerica has used method SW9056A, the Determination of Inorganic Anions by Ion Chromatography (USEPA 2007). Ion chromatography identifies and separates different ions based on their affinity to an ion exchanging resin, which is packed in a flow-through column. The separated ions elute off the column at different times, characteristic to the ion size and charge, and are measured using an electrical conductivity meter, generating a series of peaks as the different ions leave the column (Figure 3). Relative to a baseline level of conductivity, the area of each peak is proportional to the ion's concentration in the sample. The peak area is compared to the peak areas generated by known concentrations in calibration standards to derive a sample concentration. In the case of method SW9056A, the specified analytical column (i.e., the ion exchanger), is required to be suitable for analyzing for chloride, fluoride, bromide, nitrate, nitrite, phosphate, and sulfate.

The typical chloride reporting limit provided by TestAmerica at the Denver laboratory was 3.0 mg/L. Dilutions have varied across samples, ranging from 1x dilution factors (i.e., no dilution and a reporting limit of 3.0 mg/L) to 50x dilution factors (with a corresponding reporting limit of 150 mg/L). Due to the capacity of the method for testing multiple anions, indiscriminate dilution intended to account for high concentrations of one anion, particularly in accounting for samples with higher sulfate concentrations as found at CCS, can negatively impact outcomes for the other anions measured by the method, resulting in non-detect results with excessive dilutions. This aspect is particularly salient due to the base application of the method, as loading of the ion exchange column within the ion chromatograph should not exceed concentrations of approximately 500 parts per million (ppm) (equivalent to 500 mg/L) of total anions within the sample when the sample to be tested is undiluted (USGS 2002b).

In comparing the methodologies used by the two laboratories, a few specific differences are apparent. First, the two methods analyze for chloride using fundamentally different mechanisms. Method SM4500-Cl- E uses spectrophotometry, which measures how much a chemical of interest absorbs light by passing a light source through a sample. Differentiation of chemical compounds is based on the principle that each compound will absorb light over a specific range of wavelengths (Standard Methods Online 2018; USGS 2002a). Method SW9056A uses ion chromatography, quantifying the species of interest based on their affinity for an ion exchanger (USEPA 2007; USGS 2002b). Due to the difference in mechanisms between the methods, samples that are analyzed by the two methods would be anticipated to show slightly different results, even if tested portions are drawn from the same sample.

Second, larger differences between quantified results could be anticipated in samples with complex matrices, particularly those with large concentrations of other anions measured through the SW9056A methodology. Although the ion exchangers used within ion chromatography are specific to each method, the column specified by SW9056A is intended to account for the affinity of the complete list of analytes specified by the method in sequential order (USEPA 2007). In samples at CCS, concentrations of sulfate alone, as the final sequential anion within the method, often exceed the total anion loading of the methodology prior to dilution of samples. As the concentrations of chloride are less than those of sulfate within samples from CCS based on previously collected information and geochemical water-typing, masking of the intended analyte by other anions intended for quantification could skew results. Appropriate calibration across multiple concentration ranges is intended to prevent this issue. However, based on past included laboratory qualifiers and explanations within laboratory narratives, pinpointing a group of ranges across samples can prove difficult.

One further difference between the results from the two laboratories are the number of significant digits reported within sample results. Results for chloride using method SM4500-Cl- E from MVTL were reported with three significant digits, while TestAmerica reports results for chloride using method SW9056A using only two significant digits. This difference in precision between the two laboratories may be subtle given the concentrations of chloride across samples, but could result in a difference in population medians, signifying a shift in concentrations with no cause from the facility. Similar differences are noted in the number of significant digits reported for boron, calcium, sulfate, and total dissolved solids between reporting from the two analytical laboratories.

4.2 Ion Chromatography

In addition to comparing differences between the chloride methods, Golder reviewed TestAmerica's SW9056A standard operating protocols and reviewed the ion chromatography output data to look for practices that have the potential to bias chloride concentrations high.

The quality of ion chromatography measurements is dependent on consistently processing data in the conversion of peak area to concentration. For example, the following aspects should be handled consistently:

- the time window used to calculate the area under a peak
- the method for determining baseline conductivity
- the approach for dealing with minor peaks that elute from the column at the same time as an analyte of interest

These data processing calculations are automatically performed by the instrument software and can result in minor differences between samples and standards. While TestAmerica checks ion chromatograph data to confirm that the instrument software is functioning consistently, there is a range of variability in the software data processing practices that is tolerated and the decision on whether to manually adjust the software-calculated concentrations by manually selecting peaks is the responsibility of TestAmerica personnel.

Golder's review of the TestAmerica ion chromatography data identified several data processing practices that have the potential to bias high chloride concentrations (Figure 4). These include:

- using a longer integration time for samples than calibration standards,
- selecting a lower baseline in samples relative to calibration standards, and
- including minor shoulder peaks in sample chloride peaks when they were excluded from calibration standard chloride peaks.

These practices were implemented in the processing of the ion chromatographs for the MW-49 samples collected between June 11, 2018, and October 15, 2019, and have the potential to bias high the chloride concentrations by up to 4.2%. Golder discussed the data processing practices with TestAmerica after an internal review, and TestAmerica deemed the practices as within the range of acceptable variability and a revision to the originally reported values was not warranted (D. Bieniulis, personal communication, May 8, 2020). While up to a 4.2% difference is relatively small, this difference could account for part of the June 2018 shift in MW-49 chloride concentrations described in Section 2.5 and result in identification of an SSI. Recently collected data in Q2 2020 and Q4 2020 suggest a subtle shift in laboratory practices. These laboratory practices will be monitored for changes in future analysis.

5.0 POTENTIAL SITE CHLORIDE SOURCES

To assess the potential sources for a change in chloride concentrations at MW-49, Golder reviewed recent site changes upgradient of Upstream Raise 91, as well as previously collected data from the CCR rule program and other site monitoring data that are collected under other programs. The following sections summarize the supplemental assessment activities.

5.1 Site Changes and Potential Impacts

The following sections discuss site changes and potential impacts associated with those changes over the last 40 years. Site changes may have affected constituent concentrations entering the groundwater system or the hydrologic and hydrogeologic conditions (water balance) of the site.

5.1.1 Construction History and Liner System

Upstream Raise 91 was constructed on the historic footprint of the South Ash Pond, which was built in the late 1970s on a foundation of re-compacted site soils (glacial tills) and put into service in 1979. In 1981, the South Ash Pond was taken out of service to reconstruct the clay liner and was put back into service from 1982 until 1987, at which point CCR materials were removed and the geometry of the South Ash Pond footprint was modified. Monitoring wells MW-49, MW-51, and MW-75 were installed near Upstream Raise 91 in 1988 and chloride has been analyzed since that time on an approximately semi-annual basis as part of the NDDEQ monitoring program.

Chloride concentrations in MW-49 increased significantly shortly after monitoring began in the late 1980s due to likely impacts from the South Ash Pond. In 1993, Upstream Raise 91 was deepened and a new composite liner consisting of a 2-foot-thick compacted clay liner underlying a 40-mil high-density polyethylene (HDPE) geomembrane was completed. Beginning in 1996, chloride concentrations started a downward trend, decreasing by approximately 50% over the next 10-year period (approximately from a high of 170 mg/L to 85 mg/L), likely a result of construction of the composite liner system. Overall, chloride concentrations decreased approximately 60% from 1996 to 2020 (from a high of approximately 170 mg/L to 70 mg/L).

5.1.2 Duck Pond and Drains Pond System Construction

Beginning in 2015, the drainages on the west and northwest sides of Upstream Raise 91 were modified to allow for construction of an expansion to the Drains Pond System. As a part of this construction, modifications to the existing drainage upgradient of Upstream Raise 91 were required and the composite-lined west and center cells of the Drains Pond System were constructed. In late 2019, the east cell of the Drains Pond System was closed by removal of CCR. In early 2020, the east cell was returned to operation as a non-CCR surface impoundment for the management of site process water and continues to be monitored by the Drains Pond System groundwater monitoring network.

Historically, the Duck Pond area was a low-lying area west of Upstream Raise 91. The depth of water contained in this area was generally 12 feet (water surface elevation approximately 1,911 feet) and the Duck Pond had a surface area of approximately three acres. As the water level increased, overflow passed through culvert piping to the north under what is now the center cell of the Drains Pond System. As part of the construction in 2015, the Duck Pond was dewatered, the area was graded, and culverts were installed to drain surface water south and east around the south side of Upstream Raise 91.

5.2 Data Sources

To determine if recent site changes upgradient of Upstream Raise 91 have impacted water quality in MW-49, the sampling locations and dates for groundwater, surface water, and contact water results were reviewed for each potential source provided below (see Figure 1 for locations).

5.2.1 Upstream Raise 91

Data collected between September 2015 and October 2020[1] for the CCR rule monitoring program were considered in the evaluation. As part of the monitoring program, field personnel collected groundwater samples from the following monitoring wells:

- upgradient to Upstream Raise 91: MW-75 and MW-91-2
- downgradient from Upstream Raise 91: MW-49, MW-51, and MW-91-1

Additionally, results for a November 2018 sample of ash contact water collected from the Upstream Raise 91 sump (Sump-UR91) were available for the evaluation.

5.2.2 Drains Pond System

Data collected between September 2015 and October 2020 for the CCR rule monitoring program were considered in the evaluation. As part of the monitoring program, field personnel collected groundwater samples from the following monitoring wells:

- upgradient to the Drains Pond System: MW-DP3 and MW-DP5
- downgradient from the Drains Pond System: MW-DP1, MW-DP2, MW-DP2B, and MW-DP4

Additionally, results for 18 samples collected between 2014 and 2019 of ash contact water collected from the surface of the east cell of the Drains Pond System (Drains Pond, SW-DP101) were used in the evaluation.

5.2.3 Upgradient Plant Cooling Water

Groundwater potentially influenced by upgradient plant cooling water is monitored at the following locations:

- Upgradient to the powerplant: MW-96
- Downgradient from the Extended Basin: MW-62, MW-63, and MW-65
- EEG wells: MW-17-1, MW-17-2, MW-17-3, MW-17-4, and MW-17-5 (these wells were installed to monitor a historical leak in the fuel line to the Emergency Engine Generator)

For the plant wells, results from samples collected between October 1988 and October 2020 were considered for this evaluation. The EEG wells were installed in the fourth quarter of 2017, and results included in this evaluation were for samples collected between January 2018 and October 2020.

Additionally, results for samples collected between October 1988 and April 2020 of surface water collected from the Extended Basin (SW-107) were used in the evaluation.

5.3 Evaluation of Potential Sources

Figure 5 displays a map of the locations and observed chloride concentrations (both the October 2020 concentration and the range of chloride values observed in baseline and detection monitoring) for the monitoring wells and surface water sources described in Section 5.2. As shown in Figure 1, groundwater generally flows from the southwest to the northeast. To assist with the identification of potential chloride sources to MW-49, Figure 6 compares the ranges of chloride concentrations for the monitoring wells and surface water sources on the site

[1] June 2019 samples from MW-91-1 and MW-91-2 not used because of a suspected quality control issue.

with a box and whisker plot. Figure 7 displays a scatter plot of the sulfate to chloride ratio versus the calcium to chloride ratio as a method of comparing water qualities across the site. Piper plots were not used due to the lack of consistently having the full suite of cations and anions for the different potential chloride sources at the site.

Several potential sources can influence chloride concentrations in groundwater at CCS, including infiltration of plant cooling water via the Extended Basin, seepage from the Drains Pond System, and seepage from Upstream Raise 91. These three potential sources of chloride are described in the following subsections. The data suggests that the increase in chloride concentration at MW-49 chloride is due to a change in the hydrological flow regime caused by the 2015 removal of the Duck Pond. This change likely increased the proportion of water with elevated chloride from the Extended Basin, affecting chloride concentrations at MW-49 that resulted in the SSIs.

5.3.1 Upstream Raise 91

The chloride concentration measured in the sample from the Upstream Raise 91 sump (790 mg/L) is higher than groundwater concentrations and indicates that seepage (if occurring) from Upstream Raise 91 could increase the chloride concentrations in MW-49. The presence of the liner system at Upstream Raise 91 (a 2-foot-thick compacted clay liner with a hydraulic conductivity of 1×10^{-7} centimeters/second [cm/s] or less underlying a 40-mil HDPE geomembrane) reduces the likelihood of seepage to groundwater. Figure 7 indicates that contact water in the Upstream Raise 91 sump has lower calcium to chloride ratios and lower sulfate to chloride ratios than water observed at MW-49. If seepage from Upstream Raise 91 was impacting groundwater at MW-49, a shift in both of these ratios in samples identified as SSIs from MW-49 (Q4 2018 through Q4 2020) towards those observed from the Upstream Raise 91 sump would be expected. A shift towards the Upstream Raise 91 sump signature was not observed in Figure 7 for the samples identified as SSIs.

5.3.2 Drains Pond System

Given the physical proximity of the east cell of the Drains Pond System to MW-49 and the elevated chloride concentrations observed in the surface water of the east cell of the Drains Pond System (125 to 827 mg/L), seepage (if occurring) from the east cell of the Drains Pond System could have the potential to elevate chloride concentrations at MW-49. The presence of the liner system of the east cell of the Drains Pond System (a 2-foot-thick compacted clay liner with a hydraulic conductivity of 1×10^{-7} cm/s or less underlying a 40-mil HDPE geomembrane) reduces the likelihood of seepage to groundwater. Contact water in the east cell of the Drains Pond System has lower calcium to chloride ratios than water observed in MW-49 (Figure 7). If seepage from the Drains Pond System was impacting groundwater at MW-49 a shift in the calcium to chloride ratios in the samples identified as SSIs from MW-49 (Q4 2018 through Q4 2020) towards those observed from the east cell of the Drains Pond System would be expected. A shift towards the Drains Pond System signature was not observed on Figure 7 for the samples identified as SSIs.

5.3.3 Upgradient Plant Cooling Water

To the west of CCS, water used for plant cooling is contained in the Extended Basin, which holds approximately 60 million gallons and is clay lined. The Extended Basin water originates from the Missouri River, but is cycled up to 15 times through the cooling towers. As the water is cycled, heat from the powerplant drives evaporation, which concentrates the constituents in the Extended Basin. Between 1988 and 2020, chloride concentrations in the Extended Basin ranged between 158 and 300 mg/L.

Nearby monitoring wells (MW-62, MW-63, and MW-65) located upgradient of the powerplant and immediately adjacent to the Extended Basin also have elevated chloride concentrations ranging from 8.0 to 290 mg/L indicating that water from the Extended Basin is impacting groundwater chloride concentrations. The elevated concentrations from the Extended Basin show considerable increase relative to MW-96, a background well for the plant that is side-gradient to the Extended Basin. Chloride concentrations at MW-96 range between 4.2 and 7.8 mg/L.

The water from the Extended Basin also appears to be impacting wells further downgradient. The concentrations observed along the flow path from the Extended Basin towards MW-49 include the following:

- The EEG wells located east of the Extended Basin have chloride concentrations ranging between 58 and 190 mg/L.
- Well MW-DP5 downgradient from the plant and upgradient of the Drains Pond System has chloride concentrations ranging between 62.0 and 84.8 mg/L. Well MW-DP3 also upgradient of the Drains Pond has chloride concentrations ranging between 8.6 and 19.8 mg/L.
- Wells MW-91-2 and MW-75 upgradient of Upstream Raise 91 and side gradient to the Extended Basin have chloride concentrations between 1.1 and 16.8 mg/L.

Variations in screened lithology and preferential flow paths in the glacial till may explain why some wells downgradient of the Extended Basin show elevated chloride concentrations while other wells (MW-DP3, MW 91-2, and MW-75) have chloride concentrations more similar to MW-96.

Figure 7 demonstrates that surface waters from the Extended Basin may be influencing ion ratios in groundwater samples from monitoring wells upgradient of Upstream Raise 91, including MW-62, MW-63, MW-65, MW-17-2, and MW-17-5, and monitoring wells downgradient of Upstream Raise 91, including MW-49 and MW-91-1.

The recent removal of the Duck Pond and regrading of the area directly upgradient of the Drains Pond System potentially altered the hydrological flow paths to MW-49 and increased the proportion of water with elevated chloride from the Extended Basin relative to other groundwater sources monitored at MW-49. In addition to the changing flow paths, the removal of the Duck Pond also eliminated infiltration of water from the Duck Pond to groundwater, which may have provided a dilution effect on groundwater concentrations upgradient of MW-49.

6.0 EVIDENCE OF AN ALTERNATIVE SOURCE

Primary lines of evidence and conclusions drawn from the evidence used to support this ASD are provided in Table 1. In summary, the chloride SSI in MW-49 is not likely and indication of a release from Upstream Raise 91. Instead, the change in chloride concentration is potentially a reflection of sampling and laboratory changes and/or changes in the groundwater flow regime related to the removal of the Duck Pond that have increased the proportion of water with elevated chloride from the Extended Basin relative to other groundwater sources monitored at MW-49.

Table 1: Primary and Supporting Lines of Evidence from ASD Analysis

Key Line of Evidence	Supporting Evidence	Description
Change in field personnel	Changed to site personnel from MVTL	Although using the same sampling methods, there is a potential for minor differences in sampling technique between sampling personnel. The timing of the change in sampling personnel coincides with the June 2018 shift in chloride concentrations.
Change in laboratory and methodology	Changed to TestAmerica from MVTL	The timing of the change in laboratory coincides with the June 2018 shift in chloride concentrations.
	Change from potentiometric method (SRM 4500-CL) to ion chromatography method (SRM 9056A)	Prior to June 2018, MVTL used method SM4500-Cl- E to measure chloride concentrations. Starting in June 2018, TestAmerica analyzed chloride concentrations by SW9056A. These methods have different mechanisms, detection limits, and matrix effects. The timing of the change in methodology coincides with the June 2018 shift in chloride concentrations.
Laboratory artifact biasing high sample concentrations	Ion chromatographs reflecting different data processing practices between some calibration standards and samples	Golder's review of the TestAmerica ion chromatography data identified several data processing practices (integration time length, baseline selection, and treatment of minor peaks) that have the potential to bias high chloride concentrations (Figure 4).
Groundwater geochemistry	Relative ion abundances in groundwater differs from Upstream Raise 91 sump water and surface water collected from the east cell of the Drains Pond system	The water quality signature of groundwater samples collected from downgradient well MW-49 are not consistent with the signature of potential seepage from Upstream Raise 91. As presented in Figure 7, differences in calcium–chloride and sulfate–chloride ratios are distinctly different between the ash-impacted waters and the downgradient groundwater samples, including from MW-49.
Local sources of chloride	Elevated chloride concentrations in the Extended Basin and other wells downgradient of the Extended Basin	Figure 6 suggests that chloride concentrations in the plant cooling water (Extended Basin) are impacting groundwater chloride concentrations in wells downgradient from the Extended Basin. Similarities in the ion ratios between water samples collected from MW-49, the Extended Basin, and wells immediately downgradient of the Extended Basin (Figure 7) suggest that the Extended Basin may be a potential source of elevated chloride at MW-49.
	Hydrogeology	The removal of the Duck Pond in 2015 and regrading of the area directly upgradient of the Drains Pond System potentially altered the hydrological flow paths, resulting in higher chloride concentrations at MW-49. This would be due to an increase in the proportion of groundwater potentially impacted by the Extended Basin and the removal of the more dilute water infiltrating from the Duck Pond.

7.0 CONCLUSION

In accordance with 40 CFR 257.95(g)(3), this ASD has been prepared in response to the identification of a verified SSI for chloride at monitoring well MW-49 following the Q4 2020 sampling event for Upstream Raise 91 at Coal Creek Station.

Based on review of historical analytical results and testing procedures, recent changes to chloride concentrations in groundwater at MW-49 are likely not a result of seepage from Upstream Raise 91. There are two potential alternative sources, laboratory and sampling artifacts and variability in the upgradient groundwater sources. Therefore, no further action (i.e., a transition to assessment monitoring) is warranted, and Upstream Raise 91 will remain in detection monitoring.

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Signature Page

Golder Associates Inc.

Gregory Lehn, PhD
Staff Geochemist

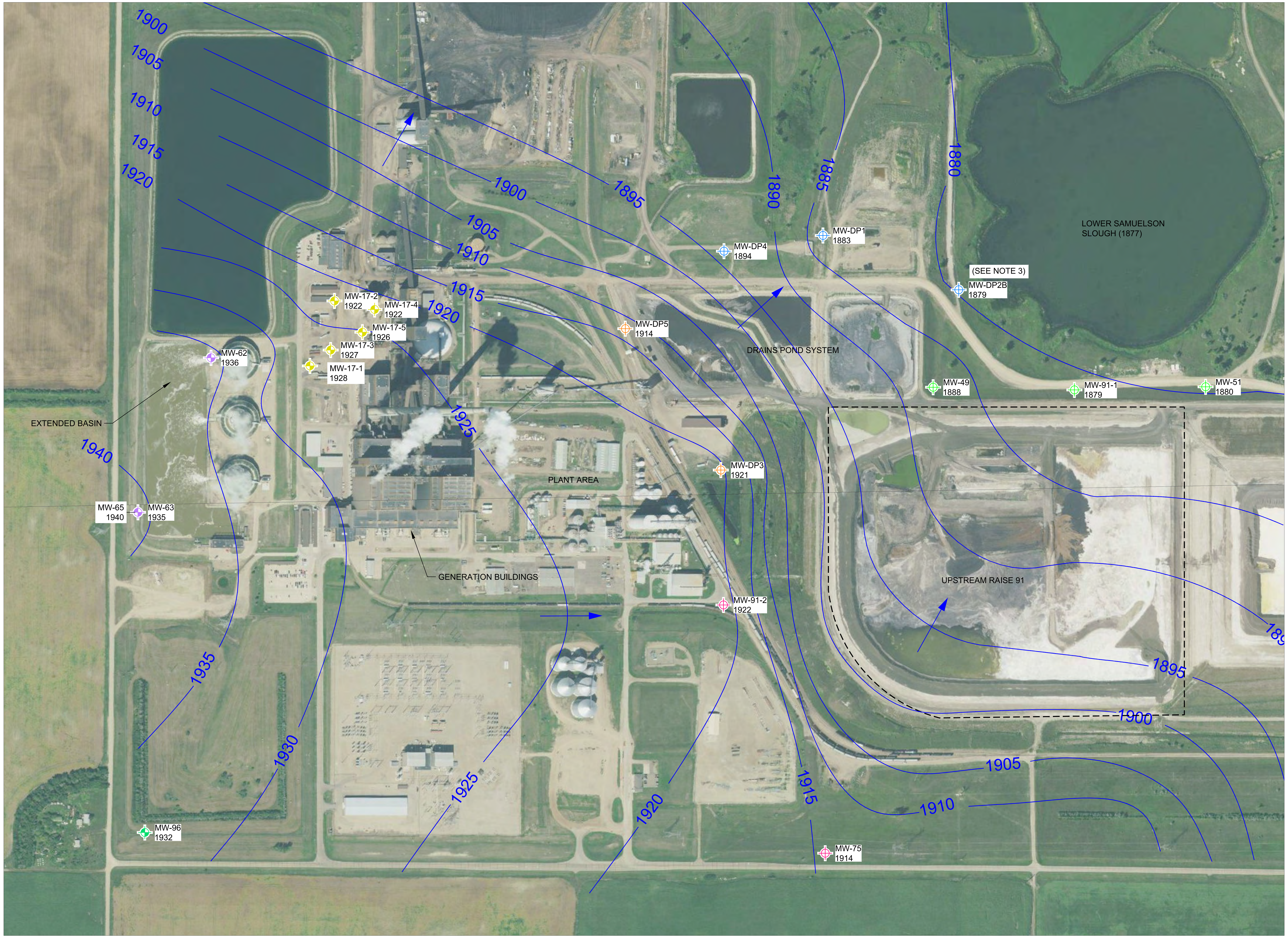
Todd Stong, PE
Associate and Senior Consultant

Sara Harkins, PG (WY)
Senior Project Geochemist

GL/TS/SH/af

https://golderassociates.sharepoint.com/sites/140044/project files/6 deliverables/reports/7-r-asd_for_chloride_in_mw-49/7-r-0/21451024c-7-r-0-asd_for_chloride_in_mw-49_21may21.docx

Figures



LEGEND

- NDDEQ PLANT AREA UPGRADIENT WELL
- NDDEQ PLANT AREA DOWNGRADIENT WELL
- EEG PROGRAM WELL
- DRAINS POND SYSTEM UPGRADIENT WELL
- DRAINS POND SYSTEM DOWNGRADIENT WELL
- UPSTREAM RAISE 91 UPGRADIENT WELL
- UPSTREAM RAISE 91 DOWNGRADIENT WELL
- GENERAL DIRECTION OF GROUNDWATER FLOW
- 1930 POTENTIOMETRIC SURFACE CONTOURS
- UPSTREAM RAISE 91 BOUNDARY

NOTE(S)

1. GROUNDWATER ELEVATIONS WERE MEASURED OCTOBER-NOVEMBER 2020, ELEVATION FEET ABOVE MEAN SEA LEVEL.
2. POTENTIOMETRIC SURFACE CONTOURS WERE CREATED FROM WATER LEVEL INFORMATION FROM THE OCTOBER-NOVEMBER 2020 GROUNDWATER ELEVATIONS SHOWN, AS WELL AS SURVEYED SURFACE WATER EXPRESSIONS, ADDITIONAL SITE WELLS, AND PIEZOMETERS NOT SHOWN. CONTOUR INTERVAL IS 5 FEET.
3. AERIAL IMAGERY OBTAINED FROM UNITED STATES DEPARTMENT OF AGRICULTURE, NATIONAL AGRICULTURE IMAGERY PROGRAM, 2019.

CLIENT
GREAT RIVER ENERGY
COAL CREEK STATION

PROJECT
ALTERNATIVE SOURCE DEMONSTRATION

CONSULTANT

GOLDER MEMBER OF WSP

YYYY-MM-DD	2021-05-11
DESIGNED	BJP
PREPARED	AGD
REVIEWED	CCS
APPROVED	TJS

TITLE
OCTOBER - NOVEMBER 2020 GROUNDWATER CONTOURS AND SAMPLING LOCATIONS

PROJECT NO.	REV.	FIGURE
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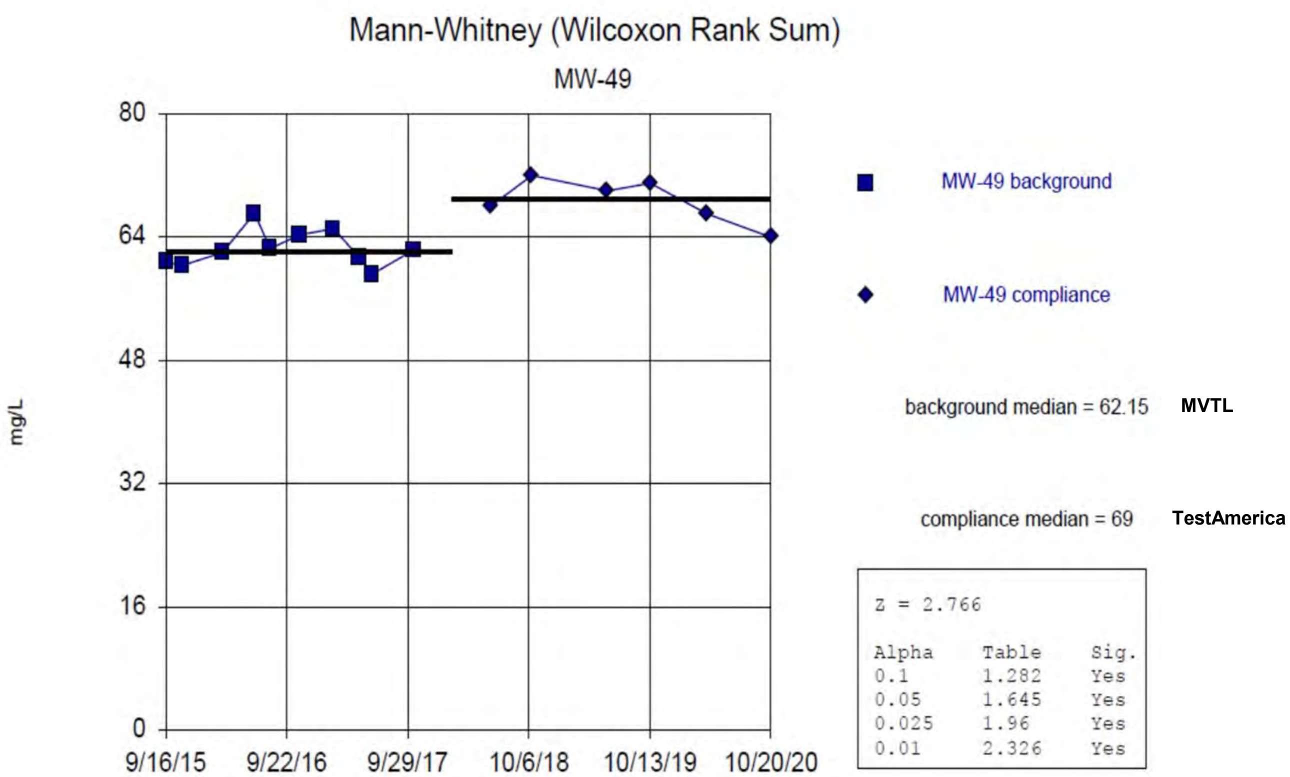

CLIENT
Great River Energy Coal Creek Station

PROJECT
Alternative Source Demonstration

CONSULTANT
GOLDER MEMBER OF WSP

TITLE
Wilcoxon Rank-Sum Test for MW-49 Chloride Concentrations

PROJECT NO.	PHASE	REV.	FIGURE
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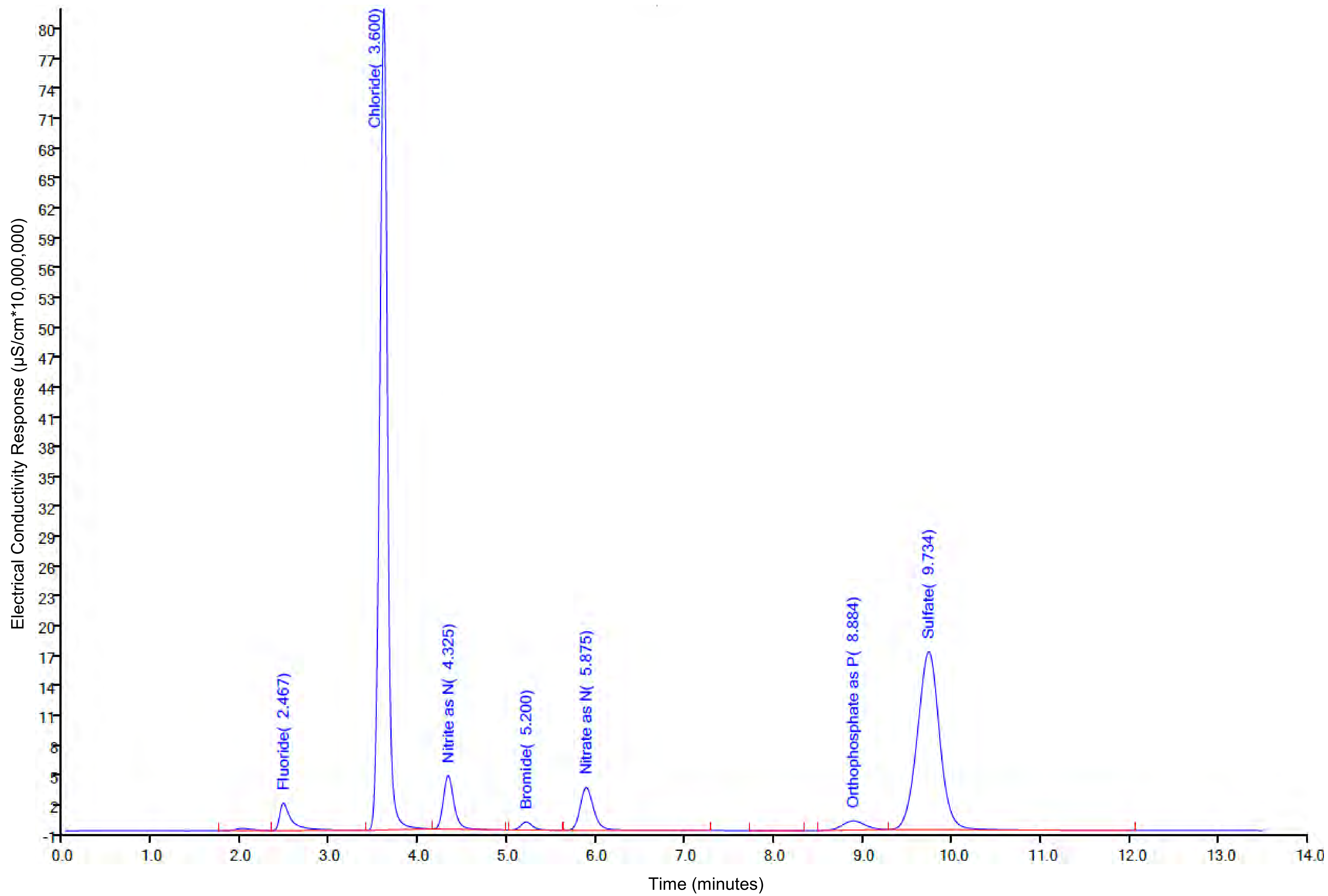


CLIENT
Great River Energy Coal Creek Station

PROJECT
Alternative Source Demonstration

CONSULTANT
GOLDER
MEMBER OF WSP

TITLE
Example of Ion Chromatograph Data

PROJECT NO.	PHASE	REV.	FIGURE
21450124	--	0	3

Software Data Processing | Manual Processing

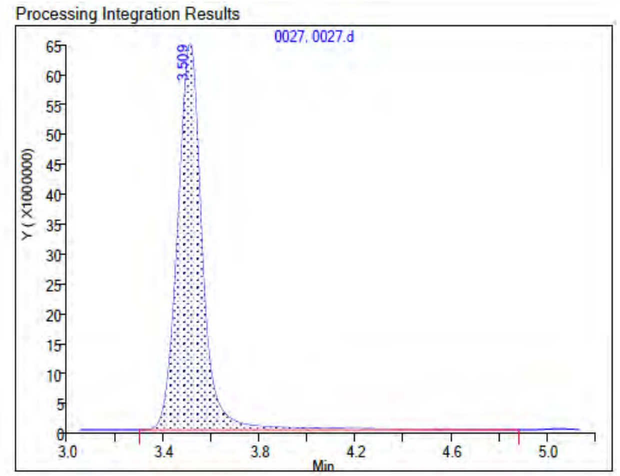
Example #1:

Shortened peak integration time to match calibration standards

Manual processing would decrease chloride concentration by 1.8%

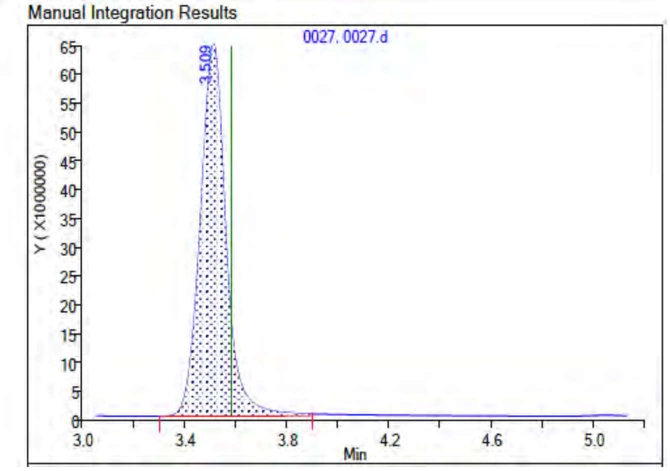
Software Data Processing:

RT: 3.51
Area: 457407359
Amount: 71.627674
Amount Units: ug/ml



Manual Processing:

RT: 3.51
Area: 449145333
Amount: 70.344660
Amount Units: ug/ml



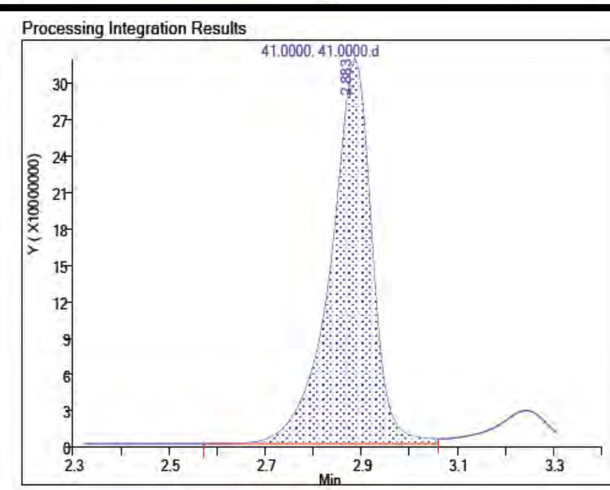
Example #2:

Right side of baseline brought up to minimum signal valley (not below valley), consistent with calibration standards

Manual Processing would decrease chloride concentration by 2.8%

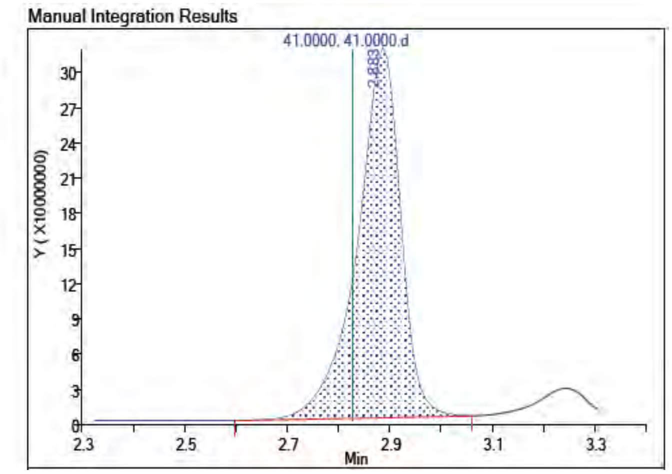
Software Data Processing:

RT: 2.88
Area: 1882027750
Amount: 107.4024
Amount Units: ug/ml



Manual Processing:

RT: 2.88
Area: 1830626225
Amount: 104.4716
Amount Units: ug/ml



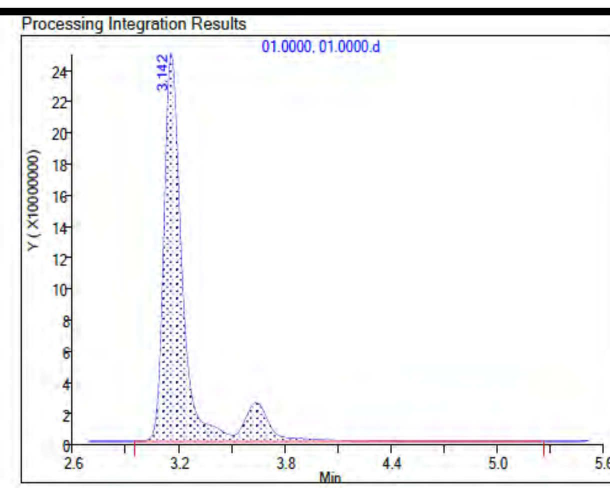
Example #3:

Minor peak to the right of chloride peak not included in area of chloride peak, consistent with calibration standards

Manual Processing would decrease chloride concentration by 4.2%

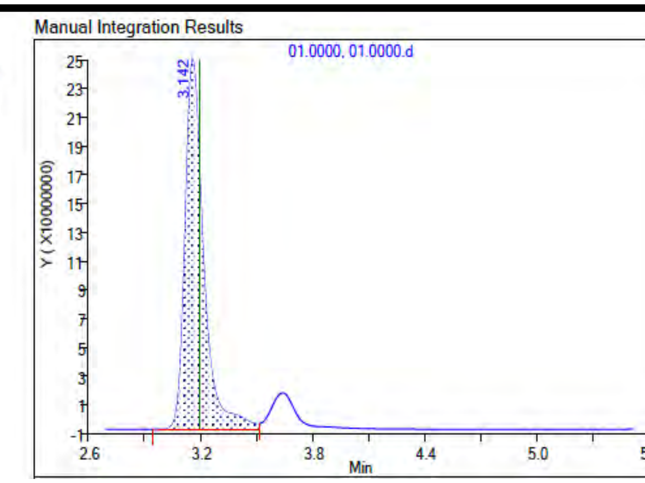
Software Data Processing:

RT: 3.14
Area: 1753223086
Amount: 98.471277
Amount Units: ug/ml



Manual Processing:

RT: 3.14
Area: 1683282689
Amount: 94.545083
Amount Units: ug/ml



CLIENT
Great River Energy Coal Creek Station

PROJECT
Alternative Source Demonstration

CONSULTANT
GOLDER
MEMBER OF WSP

TITLE
Comparison of Ion Chromatograph Software Data Process versus Manual Adjustments

PROJECT NO.	PHASE	REV.	FIGURE
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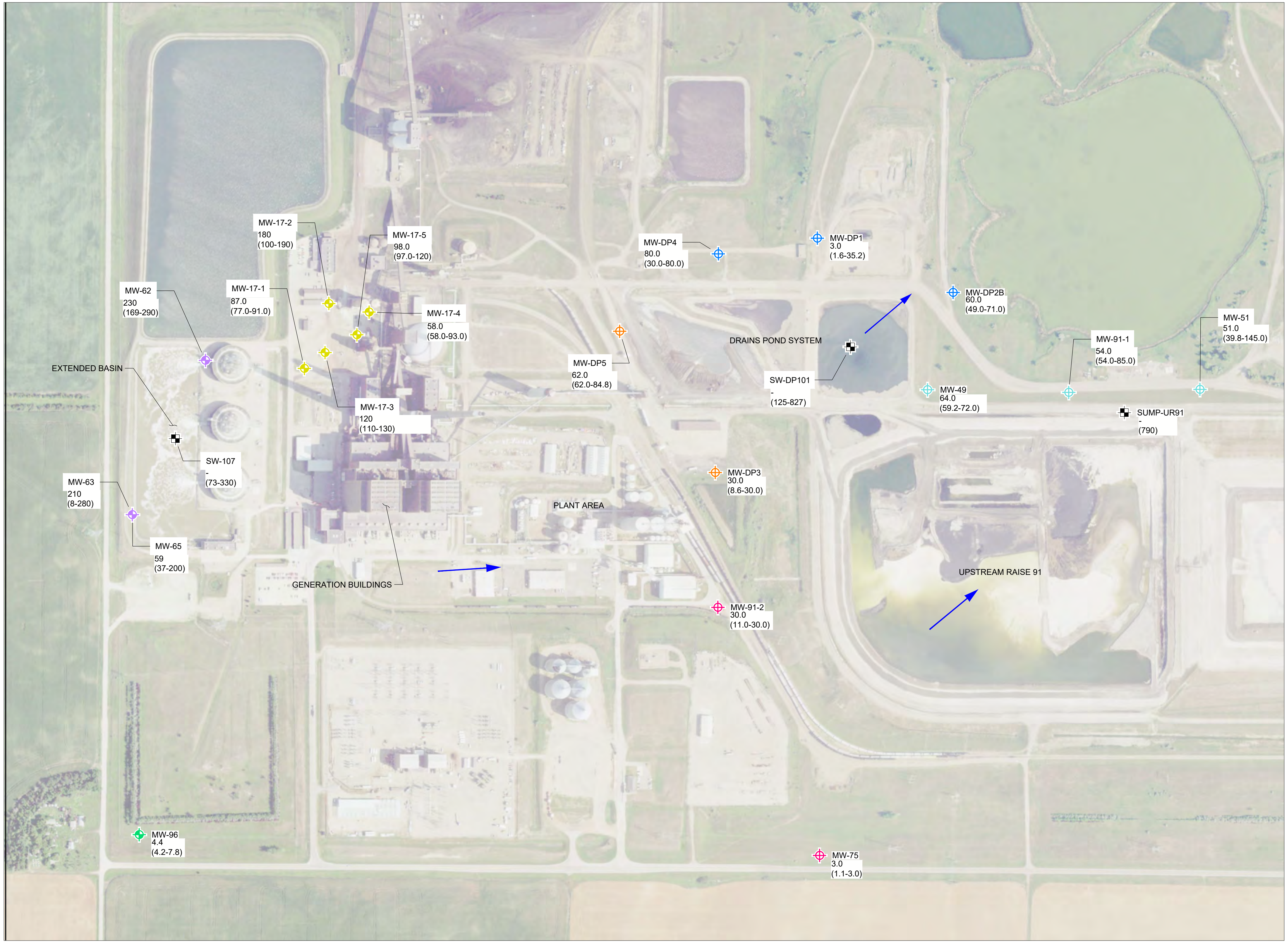

LEGEND

- NDDEQ PLANT AREA UPGRADIENT WELL
- NDDEQ PLANT AREA DOWNGRADIENT WELL
- EEG PROGRAM WELL
- DRAINS POND SYSTEM UPGRADIENT WELL
- DRAINS POND SYSTEM DOWNGRADIENT WELL
- UPSTREAM RAISE 91 UPGRADIENT WELL
- UPSTREAM RAISE 91 DOWNGRADIENT WELL
- OTHER SAMPLING LOCATION
- GENERAL DIRECTION OF GROUNDWATER FLOW

71.0 — OCTOBER 2020 CHLORIDE CONCENTRATION (mg/L)

(59.2-72.0) — RANGE IN CHLORIDE CONCENTRATIONS, (mg/L)

NOTE(S)

1. AERIAL IMAGERY OBTAINED FROM UNITED STATES DEPARTMENT OF AGRICULTURE, NATIONAL AGRICULTURE IMAGERY PROGRAM, 2018.
2. SAMPLES FROM MW-DP5, MW-DP3, MW-DP2B, MW-DP1, MW-DP4, MW-91-2, MW-75, MW-49, MW-91-1, AND MW-51 WERE COLLECTED BETWEEN SEPTEMBER 2015 AND OCTOBER 2020. JUNE 2019 SAMPLES FROM MW-91-1 AND MW-91-2 WERE NOT USED BECAUSE OF SUSPECTED QUALITY CONTROL ISSUE.
3. SAMPLES FROM SW-DP101 WERE COLLECTED BETWEEN 2014 AND APRIL 2020.
4. SAMPLE FROM SUMP-UR91 WAS COLLECTED FROM NOVEMBER 2018. THE RANGE SHOWN FOR SUMP-UR91 REPRESENTS THE SINGLE CHLORIDE SAMPLE COLLECTED FROM THE LOCATION.
5. SAMPLES FROM MW-17-1, MW-17-2, MW-17-3, MW-17-4, AND MW-17-5 WERE COLLECTED BETWEEN JANUARY 2018 AND OCTOBER 2020.
6. SAMPLES FROM MW-96, MW-62, MW-63, AND MW-65 WERE COLLECTED BETWEEN OCTOBER 1988 AND OCTOBER 2020.
7. SAMPLES WERE COLLECTED FROM SW-107 BETWEEN OCTOBER 1988 AND APRIL 2020.

0 300 600
1" = 600' FEET

CLIENT
GREAT RIVER ENERGY
COAL CREEK STATION

PROJECT
ALTERNATIVE SOURCE DEMONSTRATION

CONSULTANT

GOLDER
MEMBER OF WSP

YYYY-MM-DD	2021-05-11
DESIGNED	DVS
PREPARED	BJP
REVIEWED	CCS
APPROVED	TJS

TITLE
CHLORIDE CONCENTRATIONS

PROJECT NO.	PHASE	REV.	FIGURE
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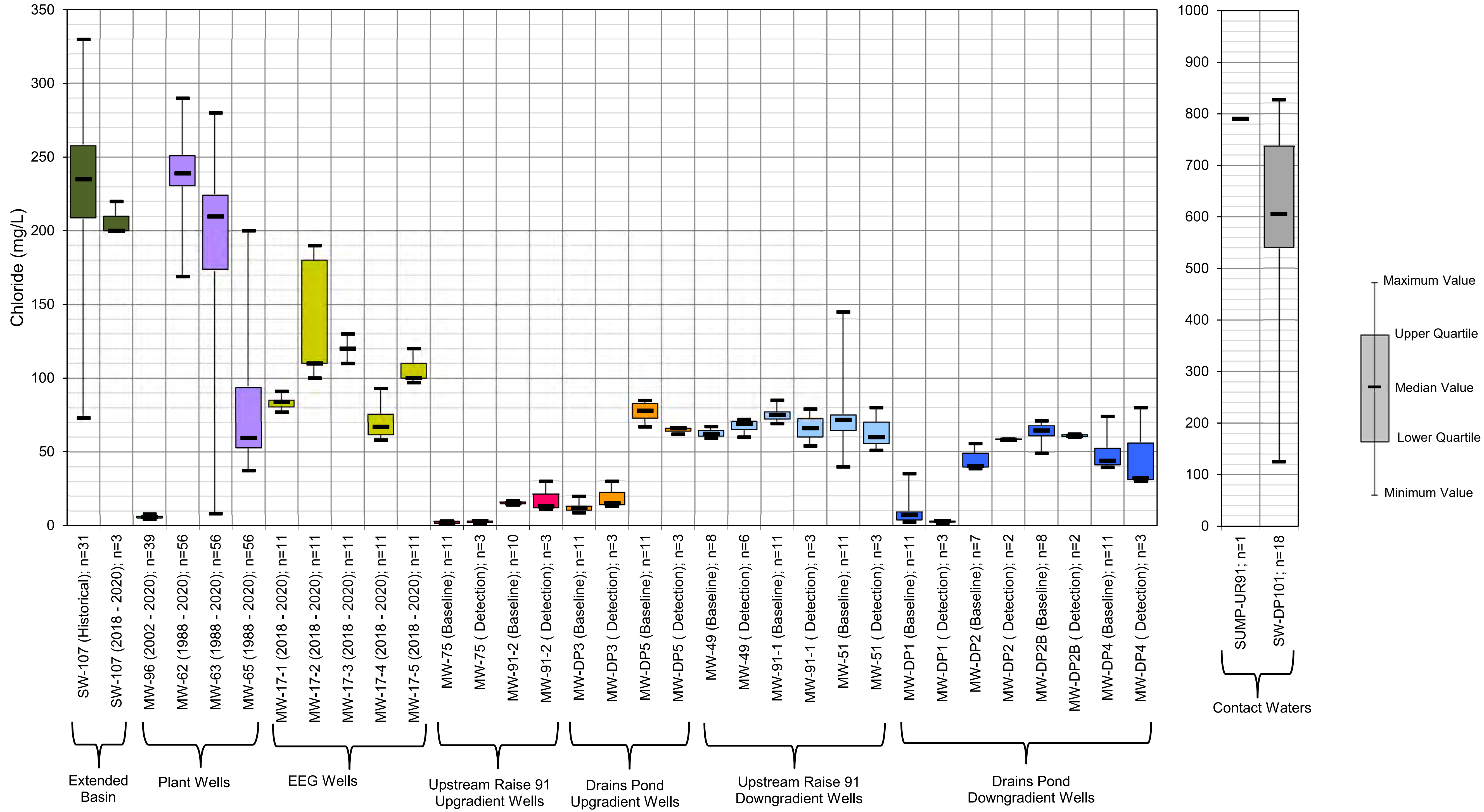

CLIENT
Great River Energy Coal Creek Station

PROJECT
Alternative Source Demonstration

CONSULTANT
GOLDER
MEMBER OF WSP

TITLE
Box and Whisker Plot for Chloride

PROJECT NO.	PHASE	REV.	FIGURE
21451024	--		6

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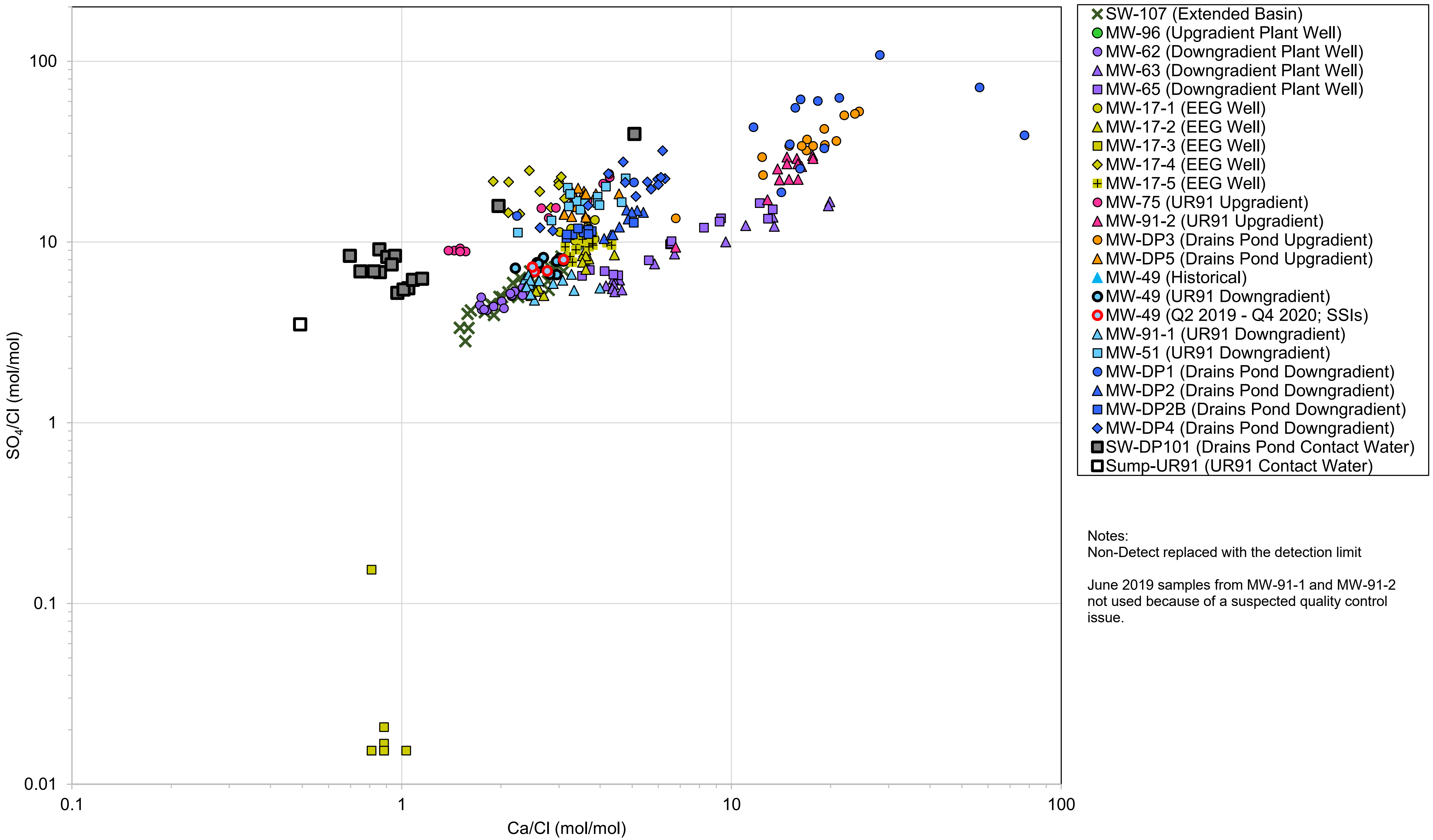


Notes:
Non-Detect replaced with the detection limit

June 2019 samples from MW-91-1 and MW-91-2 not used because of a suspected quality control issue.

CLIENT
Great River Energy Coal Creek Station

PROJECT
Alternative Source Demonstration

CONSULTANT
GOLDER MEMBER OF WSP

TITLE
Sulfate-Chloride versus Calcium-Chloride Ratio

PROJECT NO.	PHASE	REV.	FIGURE
21450124	--	0	7

GOLDER
MEMBER OF WSP

golder.com

REPORT

Alternative Source Demonstration for Fluoride and Field pH in Monitoring Well MW-DP4

Great River Energy – Coal Creek Station

Submitted to:

Great River Energy

Coal Creek Station
2875 Third Street SW
Underwood, North Dakota 58576

Submitted by:

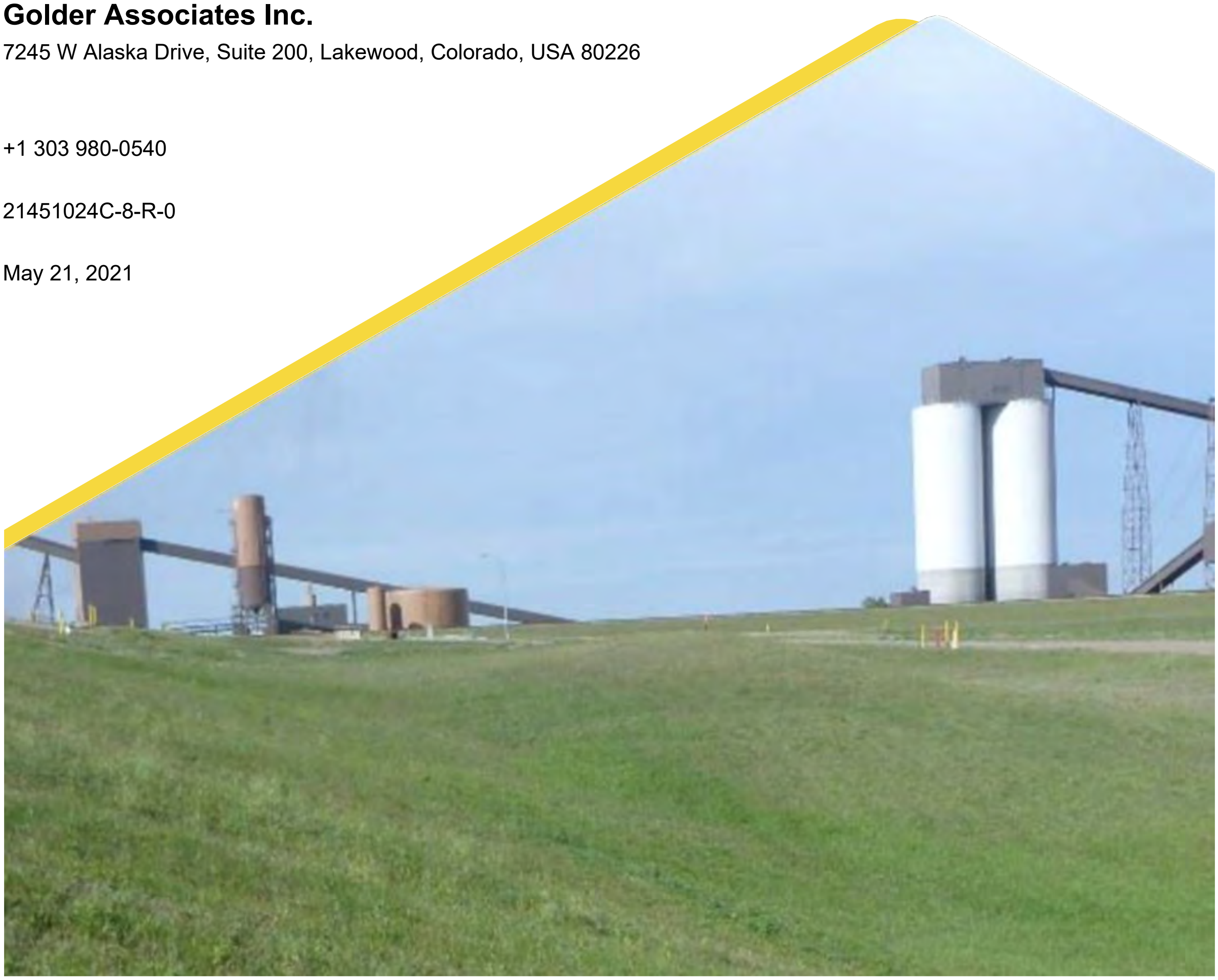
Golder Associates Inc.

7245 W Alaska Drive, Suite 200, Lakewood, Colorado, USA 80226

+1 303 980-0540

21451024C-8-R-0

May 21, 2021



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TABLES

FIGURES

APPENDICES

1.0 INTRODUCTION

On behalf of Great River Energy (GRE), Golder Associates Inc. (Golder) performed a statistical evaluation of groundwater monitoring results from the fourth quarter (Q4) 2020 groundwater detection monitoring event at Coal Creek Station's (CCS's) Drains Pond System coal combustion residual (CCR) surface impoundment. The statistical evaluation was performed as described in the Coal Combustion Residuals Groundwater Statistical Method Certification for Coal Creek Station, Revision 1 (Golder 2019a), in accordance with applicable provisions of United States Environmental Protection Agency (USEPA) 40 Code of Federal Regulations (CFR) Part 257, "Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities; Final Rule" (CCR rule), as amended.

Statistical analyses of the Appendix III detection monitoring data for fluoride in groundwater at the downgradient monitoring well MW-DP4 indicated a potential exceedance of the statistical limit based on the parametric Shewhart-CUSUM (cumulative summation) control chart analysis of the Q4 2019 sampling results. This potential exceedance was subsequently verified as a statistically significant increase (SSI) following the Q2 2020 detection monitoring sampling event. The Q4 2020 detection monitoring result for fluoride in MW-DP4 was also a verified SSI. Additionally, field pH in samples collected from monitoring well MW-DP4 was identified as a potential exceedance following the Q2 2020 detection monitoring sampling event and a verified SSI following the Q4 2020 monitoring event. Although determination of a verified SSI generally indicates that the groundwater monitoring program should transition from detection monitoring to assessment monitoring, 40 CFR Part 257.94(e)(2) allows the owner or operator (i.e., GRE) 90 days from the date of determining a verified SSI to demonstrate a source other than the regulated CCR facility caused the SSI or that the SSI is an indication of an error in sampling, analysis, or statistical evaluation or natural variability in groundwater quality that was not fully captured during the baseline data collection period.

Golder's review of the hydrological and geologic conditions at the site indicates the field pH and fluoride SSIs in MW-DP4 are not an indication of impacts from the CCR unit. A desktop study of previously collected CCR-impacted water from the facility, nearby surface water, and groundwater samples was conducted to assess potential fluoride sources. As a part of this work, potential error in the statistical analysis and the natural variability of fluoride concentrations in groundwater were evaluated. Based on this review and in accordance with provisions of the CCR Rule, Golder has prepared this Alternative Source Demonstration (ASD) for field pH and fluoride at MW-DP4.

This ASD conforms to the requirements of 40 CFR Part 257.94(e)(2) and provides the basis for concluding that the verified SSIs for field pH and fluoride at MW-DP4 are not an indication of a release from the Drains Pond System. The following sections provide a summary of the Drains Pond System, analytical and geochemical assessment results, and lines of evidence demonstrating an alternative source is responsible for the field pH and fluoride SSIs at MW-DP4. An ASD was initially developed for fluoride following the Q2 2020 verified SSI (Golder 2020) and was reviewed for ongoing applicability and updated where necessary.

2.0 BAKCGROUND

2.1 Site Background

GRE's CCS is a coal-fired electric generation facility located in McLean County, approximately 10 miles northwest of Washburn, North Dakota. CCRs are managed in composite-lined surface water impoundment cells and dry landfills regulated and permitted by the North Dakota Department of Environmental Quality (NDDEQ) in accordance with North Dakota Administrative Code (NDAC) Title 33.1, Article 33.1-20, Solid Waste Management and Land Protection.

CCS has four CCR facilities that are within the purview of the USEPA CCR rule. This ASD only applies to the Drains Pond System CCR surface impoundment. The Drains Pond System is located in the central portion of the plant site, east of the CCS plant buildings (Figure 1). The Drains Pond System is composed of three cells: west, center, and east. Bottom ash, pulverizer rejects, and economizer ash are conveyed to the west cell where they are dewatered and hauled away to the other CCR facilities. Bottom ash, pulverizer rejects, and economizer ash transport water flows from the west cell to the center cell, which acts as a clarifier facility and also receives minor amounts of sediment via the plant drains system. Water from the center cell flows to the east cell, which is a non-CCR surface impoundment that is part of the plant process water storage inventory, acting as a clarifier for process water. Water from the east cell is recirculated back to the plant for reuse or is pumped to the on-site evaporation ponds or the permitted underground injection well.

2.2 Site Geology

CCS and McLean County are situated at the eastern-most extent of the Williston Basin, a structural and sedimentary basin (USGS 1999). The region is characterized by the presence of glacial drift, reaching thicknesses of several hundred feet and overlying the Sentinel Butte Member, the source of commercially mined coal in the direct vicinity of CCS (Falkirk 1979). The Sentinel Butte Member is the highest strata of the Paleocene Fort Union Formation, overlying the Tongue River, Ludlow, and Cannonball Members (USGS 1999). The Sentinel Butte Member is marked by drab-gray units, demarcating the separation from the lower Tongue River Member.

The site geology of CCS includes unconsolidated surficial deposits of the Coleharbor Formation, consisting of stratified and unstratified glacial drift. The near-surface materials are silty clay and sandy clay till with interbedded lenses (CPA/UPA 1989).

2.3 Site Hydrogeology

Regional groundwater flow of the uppermost water-bearing unit in the vicinity of CCS is a subtle expression of the surface topography, which is influenced by the configuration of the eroded bedrock. Based on available groundwater elevation data, the shallow groundwater at the CCR facilities at CCS generally follows surface topography, flowing east and north towards Lower Samuelson Slough and Sayler Slough. Available groundwater elevation data indicate that groundwater in the area of the Drains Pond System generally flows from the southwest to the northeast, diagonally across the footprint of the facility, towards Lower Samuelson Slough.

Hydraulic conductivities in the area of the Drains Pond System range from 0.35 feet per day (ft/day) to 21.60 ft/day, with calculated groundwater flow rates during the Q4 2020 detection monitoring event ranging from 0.03 ft/day to 1.82 ft/day.

2.4 Groundwater Monitoring Network

The groundwater monitoring network for the Drains Pond System was developed for the size, disposal and operational history, anticipated flow direction, and location of adjacent facilities. Based on these factors, a monitoring well network consisting of two upgradient and four downgradient monitoring wells is used for monitoring the unit under the CCR rule.

The two upgradient monitoring wells (MW-DP3 and MW-DP5) included in the groundwater monitoring network for the Drains Pond System are used to represent upgradient water quality flowing towards the unit from the west and south (Golder 2019b). The four downgradient wells (MW-DP1, MW-DP2, MW DP2B, and MW-DP4) are positioned along the northern and eastern edges of the facility. Following the end of sample collection for the baseline monitoring period, MW-DP2 has had insufficient water to allow for routine sampling; therefore, MW-DP2B was installed in 2019 to provide further coverage for the monitored unit. The Drains Pond System network wells are presented in Figure 1. Other monitoring locations used to support this ASD are also presented in Figure 1 and are discussed further in Section 3.1.

Figure 2 displays a time-series plot of historical water levels in each monitoring well associated with the Drains Pond System. Water levels in upgradient monitoring wells MW-DP3 and MW-DP5 increased by approximately 2 to 5 feet between Q4 2018 and Q4 2019. A similar increase in water level was also observed in downgradient monitoring well MW-DP4 during the same period. Water levels from Q2 and Q4 2020 returned closer to historical values. The recent changes in water levels at upgradient and downgradient monitoring wells around the Drains Pond System and the timing of those changes suggest a change to groundwater flow conditions.

2.5 Groundwater Conditions

Between September 2015 and August 2017, GRE collected nine independent baseline groundwater samples from MW-DP3, MW-DP5, MW-DP1, MW-DP2, and MW-DP4, as required by 40 CFR 257.94, for use within the CCR rule monitoring program. Baseline samples were collected from MW-DP2B between June 2019 and March 2020, following installation of the well in 2019. The results of the CCR baseline monitoring were used to develop statistical limits for each constituent at each monitoring well based on site conditions and parameter-specific characteristics such as the data distribution and detection frequency (Golder 2019a).

Following completion of the baseline monitoring events at each well, GRE began collecting groundwater samples on a semi-annual basis to support the detection monitoring program. Groundwater samples for detection monitoring are collected at each upgradient and downgradient monitoring well and analyzed for 40 CFR Part 257 Appendix III constituents. During the detection monitoring program, groundwater analysis results are compared to the calculated statistical limits to determine whether groundwater quality remains consistent or if changes in groundwater quality are observed.

In accordance with the site Statistical Method Certification (Golder 2019a) and recommendations within the USEPA's Unified Guidance (USEPA 2009), a baseline update was conducted for most well–constituent pairs within the Drains Pond System monitoring network prior to conducting comparative statistical analysis for the Q4 2019 detection monitoring event. As a result of the baseline update, results collected during the detection monitoring program were evaluated to determine if they were from the same statistical population as those collected during the initial baseline monitoring program.

2.5.1 Fluoride at MW-DP4

Fluoride concentrations in groundwater at MW-DP4 during the initial baseline monitoring period ranged between 0.13 and 0.19 milligrams per liter (mg/L) in the nine baseline samples collected as part of the CCR rule monitoring program. Detection monitoring samples collected between October 2017 and June 2019 were incorporated into the updated baseline period, ranging between 0.11 and 0.18 mg/L. Of the four samples collected between October 2017 and June 2019, one result was excluded from the updated baseline data set, having been identified as an outlier. The result identified as an outlier was reported as a non-detect with an elevated reporting limit (ND < 0.5 mg/L). The Shewhart-CUSUM statistical limit for the well–constituent pair was set at 0.24 mg/L following the baseline update.

The Q4 2019 detection monitoring event reported a fluoride concentration of 0.25 mg/L at MW-DP4, with a calculated CUSUM value of 0.23 mg/L, exceeding the statistical limit. Verification resampling was conducted during the Q2 2020 detection monitoring event, confirming the SSI for fluoride at MW-DP4 with a fluoride concentration of 0.28 mg/L and a calculated CUSUM value of 0.34 mg/L. The Q4 2020 detection monitoring result for fluoride at MW-DP4 was lower than Q2 2020 and in the range of the baseline values but was identified as an SSI with a fluoride concentration of 0.16 mg/L and a calculated CUSUM value of 0.32 mg/L.

2.5.2 Field pH at MW-DP4

Field pH values in groundwater at MW-DP4 during the initial baseline monitoring period ranged between 6.87 and 7.08 standard units (s.u.) in the nine baseline samples collected as part of the CCR rule monitoring program. The upper Shewhart-CUSUM statistical limit for the well–constituent pair was set at 7.29 mg/L following baseline establishment. Detection monitoring samples collected between October 2017 and October 2019 ranged between 7.04 and 7.21 s.u.

The Q2 2020 detection monitoring event reported a field pH value of 7.24 s.u. at MW-DP4, with a calculated upper CUSUM value of 7.41 s.u., exceeding the upper statistical limit. Verification resampling was conducted during the Q4 2020 detection monitoring event, confirming the SSI for field pH at MW-DP4 with a pH value of 7.13 s.u. and an upper calculated CUSUM value of 7.47 s.u. While the Q4 2020 field pH value was lower than the Q2 2020 field pH value, field pH was identified as an SSI due to the elevated CUSUM values.

3.0 POTENTIAL SITE FLUORIDE AND pH SOURCES

To assess the potential sources for a change in fluoride concentrations and field pH values at MW-DP4, Golder reviewed recent site changes upgradient of the Drains Pond System, as well as previously collected data from the CCR rule program and other site monitoring data that are collected under other programs. The following sections summarize the supplemental assessment activities.

3.1 Site Changes and Potential Sources

The following sections discuss site changes and potential impacts associated with those changes. Site changes may have affected constituent concentrations entering the groundwater system or the hydrologic and hydrogeologic conditions (water balance) of the site.

3.1.1 Duck Pond and Drains Pond System Construction

Beginning in 2015, the drainages on the south and southwest and sides of the Drains Pond System were modified to allow for construction of an expansion to the Drains Pond System. As a part of this construction, modifications to the existing drainage pathways adjacent to the footprints of the west and center cells of the Drains Pond System were required and the composite-lined west and center cells of the Drains Pond System were constructed.

Historically, the Duck Pond area was a low-lying area southwest of the east cell of the Drains Pond System (Figure 1). The depth of water contained in this area was generally 12 feet (water surface elevation approximately 1,911 feet) and the Duck Pond had a surface area of approximately three acres. As the water level increased, overflow passed through culvert piping to the north under what is now the center cell of the Drains Pond System. As part of the construction in 2015, the Duck Pond was dewatered, the area was graded, and culverts were installed to drain surface water south and east around the south side of Upstream Raise 91.

The recent removal of the Duck Pond and regrading of the area upgradient of the Drains Pond System potentially altered the hydrological flow paths to MW-DP4. In addition to the changing flow paths, the removal of the Duck Pond also eliminated infiltration of water from the Duck Pond to groundwater, which may have provided a dilution effect on groundwater concentrations upgradient of MW-DP4.

3.1.2 Surface Water Drainage Ditch West of Drains Pond System

The west cell of the Drains Pond System is separated from a rail line to the west by a surface water drainage ditch. The rail lines are primarily used to transport coal and fly ash from CCS off site. The haul road directly east of this drainage ditch is used by GRE personnel to load bottom ash, pulverizer rejects, and economizer ash into trucks for disposal in the various CCR containment facilities.

The surface water drainage ditch receives stormwater and snow melt runoff from the rail line slope to the west and the embankment of the west cell of the Drains Pond System to the east. Because there is a potential for runoff into this surface water drainage ditch to contain contact water associated with the loading and hauling of CCR, the drainage ditch was originally designed to flow to the south and east, eventually discharging into the center cell of the Drains Pond System to be managed with other CCR contact waters. Due to operational constraints (pipeline alignments and haul routes), this drainage ditch no longer operates as described above.

In October of 2020, a registered Professional Engineer (PE) from Golder was on site performing the annual PE inspection of the Drains Pond System per USEPA Regulation 40 CFR 257.83(b) requirements (Golder 2021). The annual inspection report noted that bottom ash had accumulated in this ditch and that the ditch lacked an outlet to allow stormwater and snow melt runoff to drain away from the area as originally designed.

Within one month of the observations noted during the 2020 annual PE inspection, corrective measures were designed and implemented. The corrective measures included cleaning out accumulated CCR from the ditch, grading areas to drain, and installing a culvert to allow stormwater drainage from the ditch. Additional information regarding this area, including details about the observations and design and implementation of corrective measures, are included in the Corrective Measures Report (Golder 2021) provided in Appendix A.

3.1.3 Plant Drains Pipe Corridor

Two plant drains pipelines run parallel to the main west–east haul road (Figure 1) and currently end approximately 100 feet to the southwest of MW-DP4. These pipelines consist of a 36-inch-diameter plant drain concrete pipeline (bell and spigot joints) and a 14-inch-diameter chemical drain fiberglass reinforced pipeline, which have each been in service since plant commissioning (approximately 40 years). The 36-inch plant drain pipeline primarily carries flow collected from various floor drains around the industrial block, of which a major contribution to the flow is typically overflow from the bottom ash hoppers. The 14-inch chemical drain pipeline conveys water from the cooling water system (cooling water blowdown) and the chemistry laboratory. Cooling water blowdown is representative of the water contained in the Extended Basin, and water from the chemistry laboratory includes water from the room sink and floor drains as well as demineralizer regen and reverse osmosis clean-in-place waste.

Construction in 2015 modified these pipelines so that they can passively drain into the center cell of the Drains Pond System via a new precast concrete manhole. Upstream of the new precast concrete manhole, the 36-inch plant drain pipeline was cleaned out using high-pressure water. During the cleanout process, a significant amount of sediment was removed; however, it was noted that a significant amount of sediment (likely cemented CCR particles) was difficult to remove and remained in place, making inspection of the physical state of this pipeline (i.e., joint condition, reinforced concrete pipeline wall condition, etc.) difficult.

Due to the low-pressure (gravity) operation and small diameters of these plant drains pipelines, they are difficult to evaluate for potential leaks. In addition, removing these pipelines from service is also difficult during both plant operation and outages. As a result, minimal maintenance has been performed during the life of these systems. Because these pipelines have been in operation for a significant amount of time, it is possible that they have been compromised or have deteriorated due to normal wear and tear over the course of the last 40 years. This could lead to leakage of the water being conveyed and result in changes to water quality adjacent to this piping.

3.2 Data Sources

To determine if recent site changes upgradient of the Drains Pond System have impacted water quality in MW-DP4, the sampling locations and dates for groundwater, surface water, and contact water results were reviewed for each potential source provided herein.

3.2.1 Groundwater

Data collected between September 2015 and October 2020 for the CCR rule monitoring program were considered in the evaluation. As part of the monitoring program, field personnel collected groundwater samples from the following monitoring wells:

- upgradient to the Drains Pond System: MW-DP3 and MW-DP5
- upgradient to Upstream Raise 91: MW-75 and MW-91-2
- downgradient from the Drains Pond System: MW-DP1, MW-DP2, MW-DP2B, and MW-DP4

3.2.2 Drains Pond System (East Cell)

Nineteen samples collected between Q3 2014 and Q2 2020 of ash contact water from the surface of the east cell of the Drains Pond System (SW-DP101) were used in the evaluation. Seventeen of these samples were analyzed for fluoride and seven samples have field pH measurements.

3.2.3 Coal Combustion Residual Short-Term Leach Testing

Short-term leach testing of the CCR materials by the synthetic precipitation leaching procedure (SPLP) was performed by using USEPA Method 1312 (USEPA 1994). The SPLP simulates the interaction between a solid and meteoric water, which provides a screening-level estimate of ash effluent water quality.

CCR materials were collected by site personnel between 2012 and 2017. Details about the collection procedure are listed by material type as follows:

- Three bottom ash samples from Section 26 (a historic containment area for CCRs in a previously mined area) were collected in situ at the facility in May 2017.
- One bottom ash sample was collected from the Drains Pond System west cell in May 2017.
- Two fly ash samples were collected from the fly ash silos (one sample was collected in November 2017 and one was collected in May 2017).
- Three coal rejects samples (combination of pulverizer rejects, economizer ash, and air jig rejects) were collected from Ash Pond 91 (also referred to as Upstream Raise 91) in June 2013.
- One coal rejects sample was collected from Upstream Raise 91 in May 2017.
- One flue gas desulfurization (FGD) material sample was collected from the FGD material blowdown line at the scrubbers in May 2017.

3.2.4 Upgradient Plant Cooling Water

Plant cooling water is contained in the Extended Basin, which is located on the western side of the property and upgradient of the CCS plant. Groundwater nearby and potentially influenced by the Extended Basin is monitored at the following locations:

- upgradient to the powerplant: MW-96
- downgradient from the Extended Basin: MW-62, MW-63, and MW-65
- EEG wells: MW-17-1, MW-17-2, MW-17-3, MW-17-4, and MW-17-5 (these wells were installed to monitor a historic leak in the fuel line to the Emergency Engine Generator)

For the plant wells, results from samples collected between October 1988 and October 2020 were considered for this evaluation. The EEG wells were installed in the fourth quarter of 2017, and results included in this evaluation were for samples collected between January 2018 and October 2020.

Additionally, results for samples collected between October 1988 and April 2020 of surface water collected from the Extended Basin (SW-107) were used in the evaluation.

3.3 Evaluation of Potential Sources

As shown in Figure 1, groundwater generally flows from the southwest to the northeast. To assist with the identification of potential fluoride sources to MW-DP4, Figure 3 and Figure 4 compare the ranges of fluoride concentrations and field pH values for the monitoring wells and surface water sources on the site (as described in Section 3.1) with box and whisker plots. Figure 5 displays a Piper diagram as a method of comparing water qualities between locations.

Several potential sources could contribute to changes in fluoride concentrations and field pH values in groundwater at CCS, including infiltration of plant cooling water via the Extended Basin, infiltration of surface water collected in the surface water drainage ditches upstream of the Drains Pond System, leakage from the plant drains pipelines, and seepage from the Drains Pond System. These potential sources of fluoride are described in the following subsections.

3.3.1 Drains Pond System

The fluoride concentrations measured in the samples from the east cell of the Drains Pond System (1.9 to 68 mg/L) are higher than samples collected from MW-DP4 and therefore indicates that seepage (if occurring) from the Drains Pond System could increase the fluoride concentrations in MW-DP4 (Figure 3). Likewise, the field pH values in the samples from the east cell of the Drains Pond System (8.08 to 8.50 mg/L) are higher than samples collected from MW-DP4. However, the presence of the liner systems described herein for each cell of the Drains Pond System reduces the likelihood of seepage to groundwater.

The west cell of the Drains Pond System has a liner system consisting of (from bottom to top):

- two feet of compacted clay-rich material with a hydraulic conductivity of 1×10^{-7} centimeters/second (cm/sec)
- sixty-mil high-density polyethylene (HDPE) geomembrane liner
- geocomposite drainage layer
- geosynthetic clay liner (GCL)
- sixty-mil HDPE geomembrane liner

As indicated previously, the west cell of the Drains Pond System was constructed as a double composite liner system with a drainage layer between the upper and lower composite liner systems. The double composite liner system is more protective of the environment because any water (i.e., leakage) passing through the upper geomembrane liner and GCL will be collected by the geocomposite drainage layer and is conveyed passively (via gravity pipelines) to the center cell of the Drains Pond System. Any small amount of water passing through the upper composite liner will quickly and passively drain away, resulting in minimal head on the lower composite liner. Liner leakage is directly proportional to the head on the liner; therefore, with minimal to no head on the lower liner, very little if any leakage is anticipated.

The center cell of the Drains Pond System has a liner system consisting of (from bottom to top):

- two feet of compacted clay-rich material with a hydraulic conductivity of 1 x 10^{-7} cm/sec
- sixty-mil HDPE geomembrane liner

The east cell of the Drains Pond System has a liner system consisting of (from bottom to top):

- two feet of compacted clay-rich material with a hydraulic conductivity of 1 x 10^{-7} cm/sec
- forty-mil HDPE geomembrane liner

The relative proportion of major ion concentrations in groundwater samples and potential sources are depicted in a Piper diagram in Figure 5. The Piper diagram indicates that contact water in the Drains Pond System and CCR material SPLP leachates are calcium-sulfate and magnesium-sulfate dominant. Groundwater samples collected from MW-DP4 have a higher proportion of sodium, potassium, and bicarbonate than the contact water and CCR SPLP leachates. Additionally, between 2007 and Q2 2020, the major ion chemistry progressively shifted to a higher proportion of sodium relative to calcium and magnesium in the samples identified as SSIs. This shift indicates the water samples collected from MW-DP4 were progressing away from the ash contact water signature and Drains Pond System water samples (SW-DP101) on the Piper diagram. This same pattern is observed at MW-DP1. If seepage from the Drains Pond System was impacting groundwater at MW-DP4, the groundwater geochemistry would be expected to shift towards the major ion signature of ash contact waters and Drains Pond System water samples (SW-DP101) on the Piper diagram. Therefore, it is unlikely that water from the Drains Pond System is the source of the change in fluoride concentrations or field pH values leading to the identification of the SSIs. As discussed in Section 2.5, the fluoride concentration and field pH value for the Q4 2020 sample collected from MW-DP4 was lower than the Q2 2020 values and in the range of baseline measurements. The Q4 2020 major ion signature for MW-DP4 shifted back towards the 2017 signature on the Piper diagram, suggesting the groundwater quality change may be temporary.

3.3.2 Upgradient Plant Cooling Water

To the west of the Drains Pond System and Coal Creek Station, water used for plant cooling is contained in the Extended Basin, which holds approximately 60 million gallons and is a clay-lined facility. This water originates from the Missouri River, but is cycled up to 15 times through the cooling towers. As the water is cycled, heat from the power plant drives evaporation, which concentrates the constituents in the Extended Basin. Between 1980 and 2020, fluoride concentrations in the Extended Basin ranged between 2.9 and 6.4 mg/L and field pH values ranged between 7.20 and 8.80 s.u.

The pattern of recent groundwater changes at MW-DP4 illustrated in the Piper diagram (Figure 5) indicates water samples collected from MW-DP4 are progressing away from the Extended Basin chemical signature; therefore, it is unlikely that recent increases in fluoride concentrations or field pH values are due to groundwater derived from the Extended Basin.

3.3.3 Other Potential Sources

Based on the Piper diagram (Figure 5), water contained in either the Drains Pond System or Extended Basin are unlikely to be potential sources of the fluoride and field pH SSIs at MW-DP4. As mentioned in Section 2.4, water levels in upgradient and downgradient monitoring wells increased by approximately two to five feet between Q4 2018 and Q2 2020 (Figure 2). The recent changes in water levels at upgradient and downgradient monitoring wells around the Drains Pond System and the timing of those changes suggest a change in the hydrological regime. The following site changes and sources may have contributed to the increase in fluoride concentrations and field pH values:

- The recent removal of the Duck Pond and regrading of the area directly upgradient of the Drains Pond System potentially altered the hydrological flow paths to MW-DP4. In addition to the changing flow paths, the removal of the Duck Pond also eliminated infiltration of water from the Duck Pond to groundwater. The infiltration may have provided a dilution effect on groundwater concentrations upgradient of MW-DP4. Elimination of this dilution source may have resulted in the increase in fluoride concentration or change in field pH that led to the identification of the SSIs.
- The surface water drainage ditch west of Drains Pond System (Section 3.1.2) has intermittently contained standing water from stormwater and snow melt runoff. The stagnant water accumulating in this drainage ditch has historically not been removed prior to infiltration. While no water samples were collected prior to when corrective measures were implemented in the fall of 2020 (Golder 2021), the location immediately upgradient of MW-DP4 suggests that localized infiltration from this ditch could influence groundwater concentrations.
- The two plant drains pipelines (Section 3.1.3) approximately 100 feet to the southwest of MW-DP4 are difficult to evaluate for potential leaks. These pipelines have been in operation for approximately 40 years; therefore, it is possible that they have been compromised or have deteriorated due to normal operation since installation. While no water samples have been collected to date, the location upgradient of MW-DP4 suggests that if water leaked from the pipes it could infiltrate to groundwater and influence groundwater concentrations at the well. Therefore, it is possible that leakage from the pipes has changed groundwater quality leading to the identification of the SSIs at this well.

4.0 EVIDENCE OF AN ALTERNATIVE SOURCE

Based on the review of potential alternative site sources of fluoride and field pH presented in this report, primary lines of evidence and conclusions drawn from the evidence used to support this ASD are provided in Table 1.

In summary, Golder has concluded that the Drains Pond System is not likely the cause of the SSIs. Instead, variation in the background water quality related to recent changes in the site hydrology and/or potential leaks in sub-surface piping likely caused a change in fluoride concentrations and field pH values and identification of the SSIs at MW-DP4.

Table 1: Primary and Supporting Lines of Evidence from ASD Analysis

Key Line of Evidence	Supporting Evidence	Description
Hydrogeology	Groundwater elevations at monitoring wells around the Drains Pond System	Recent increases in water levels in upgradient and downgradient monitoring wells (2019 and 2020) indicate there may be changes in the hydrological flow regime surrounding Drains Ponds System and MW-DP4.
	Recent construction upgradient of MW-DP4 has the potential to alter the groundwater flow regime near MW-DP4	The draining of the Duck Pond to the southwest of MW-DP4 and the intermittent filling of the surface water drainage ditch west of the Drains Pond System have altered the locations of standing water upgradient of MW-DP4, potentially influencing where surface water may infiltrate and affecting the hydrological flow regime surrounding the Drains Pond System and MW-DP4. This change in the flow regime could influence fluoride concentrations and field pH values observed in samples collected from MW-DP4 leading to identification of the SSIs.
Engineering controls	Drains Pond System is lined	Each of the three cells of the Drains Pond System has a composite liner system, which decreases the likelihood of seepage from this facility. In addition, the west cell of the Drains Pond System has a double composite liner system with a drainage system between the liners. Observations of this drainage system have not indicated leakage through the upper composite liner system since operations began in late 2015.
Water chemistry	Relative ion abundances in groundwater differ from Drains Pond System water	The water quality signature of groundwater samples collected from downgradient well MW-DP4 are not consistent with the signature of potential seepage from the Drains Pond System. As presented in Figure 5, the Piper diagram shows that groundwater from MW-DP4 is distinctly different from ash-impacted waters. This suggests that the Drains Pond System is not the cause of the change in fluoride concentrations.
	Geochemistry results from MW-DP4 are shifting away from Drains Pond System water	Major ion chemistry in MW-DP4 samples identified as SSIs has shifted to a higher proportion of sodium relative to calcium and magnesium and samples collected from MW-DP4 are progressing away from the ash contact water signature in the Piper diagram.

5.0 CONCLUSIONS

In accordance with §257.95(g)(3), this ASD has been prepared in response to the identification of verified SSIs for fluoride and field pH at monitoring well MW-DP4 following the Q4 2020 sampling event for the Drains Pond System at Coal Creek Station.

A review of historical analytical results indicates that the groundwater geochemistry at MW-DP4 is shifting so as to be less similar to Drains Pond System water or CCR contact water, and thus the recent changes in fluoride and field pH are not expected to be from releases from the Drains Pond System. The increase in fluoride concentrations and field pH values in groundwater at MW-DP4 likely reflect variability in upgradient groundwater sources and recent changes to site hydrogeology. Therefore, no further action (i.e., transition to assessment monitoring) is warranted, and the Drains Pond System at CCS will remain in detection monitoring.

6.0 REFERENCES

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Signature Page

Golder Associates Inc.

Gregory Lehn, PhD
Staff Geochemist

Sara Harkins, PG (WY)
Senior Project Geochemist

Todd Stong
Associate and Senior Consultant

GL/SH/TS/af

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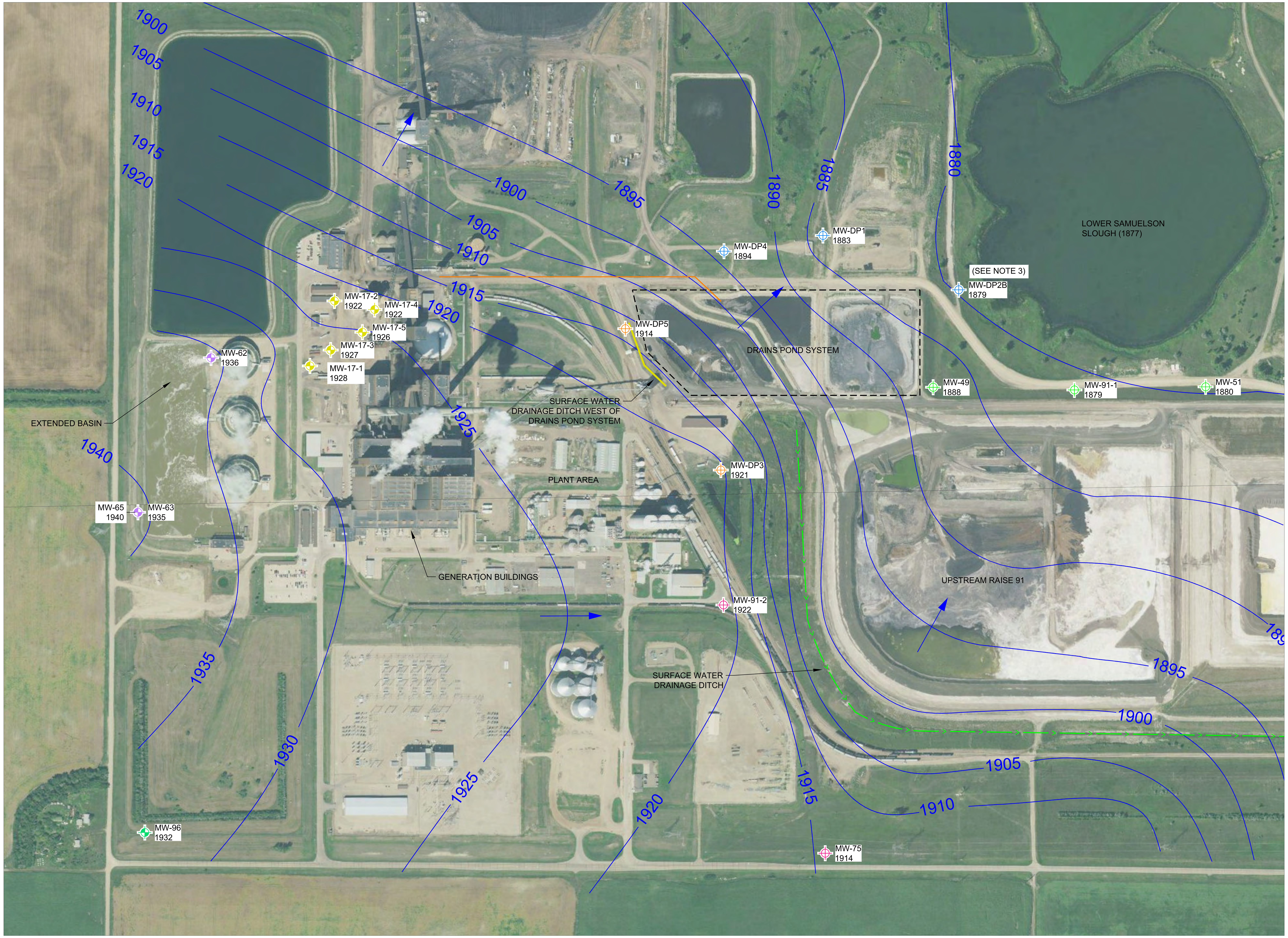
Figures



LEGEND

- NDDEQ PLANT AREA UPGRADIENT WELL
- NDDEQ PLANT AREA DOWNGRADIENT WELL
- EEG PROGRAM WELL
- DRAINS POND SYSTEM UPGRADIENT WELL
- DRAINS POND SYSTEM DOWNGRADIENT WELL
- UPSTREAM RAISE 91 UPGRADIENT WELL
- UPSTREAM RAISE 91 DOWNGRADIENT WELL
- GENERAL DIRECTION OF GROUNDWATER FLOW
- 1930 — POTENTIOMETRIC SURFACE CONTOURS
- DRAINS POND SYSTEM BOUNDARY
- PLANT DRAINS PIPING (APPROXIMATE LOCATION)
- SURFACE WATER DRAINAGE DITCH - DRAINS POND SYSTEM
- SURFACE WATER DRAINAGE DITCH - UPSTREAM RAISE 91

NOTE(S)

1. GROUNDWATER ELEVATIONS WERE MEASURED OCTOBER-NOVEMBER 2020, ELEVATION FEET ABOVE MEAN SEA LEVEL.
2. POTENTIOMETRIC SURFACE CONTOURS WERE CREATED FROM WATER LEVEL INFORMATION FROM THE OCTOBER-NOVEMBER 2020 GROUNDWATER ELEVATIONS SHOWN, AS WELL AS SURVEYED SURFACE WATER EXPRESSIONS, ADDITIONAL SITE WELLS, AND PIEZOMETERS NOT SHOWN. CONTOUR INTERVAL IS 5 FEET.
3. AERIAL IMAGERY OBTAINED FROM UNITED STATES DEPARTMENT OF AGRICULTURE, NATIONAL AGRICULTURE IMAGERY PROGRAM, 2019.

0 300 600
1" = 300' FEET

CLIENT
GREAT RIVER ENERGY
COAL CREEK STATION

PROJECT
ALTERNATIVE SOURCE DEMONSTRATION

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2021-05-20
DESIGNED	BJP
PREPARED	AGD
REVIEWED	CCS
APPROVED	TJS

TITLE
OCTOBER - NOVEMBER 2020 GROUNDWATER CONTOURS AND SAMPLING LOCATIONS

PROJECT NO.	REV.	FIGURE
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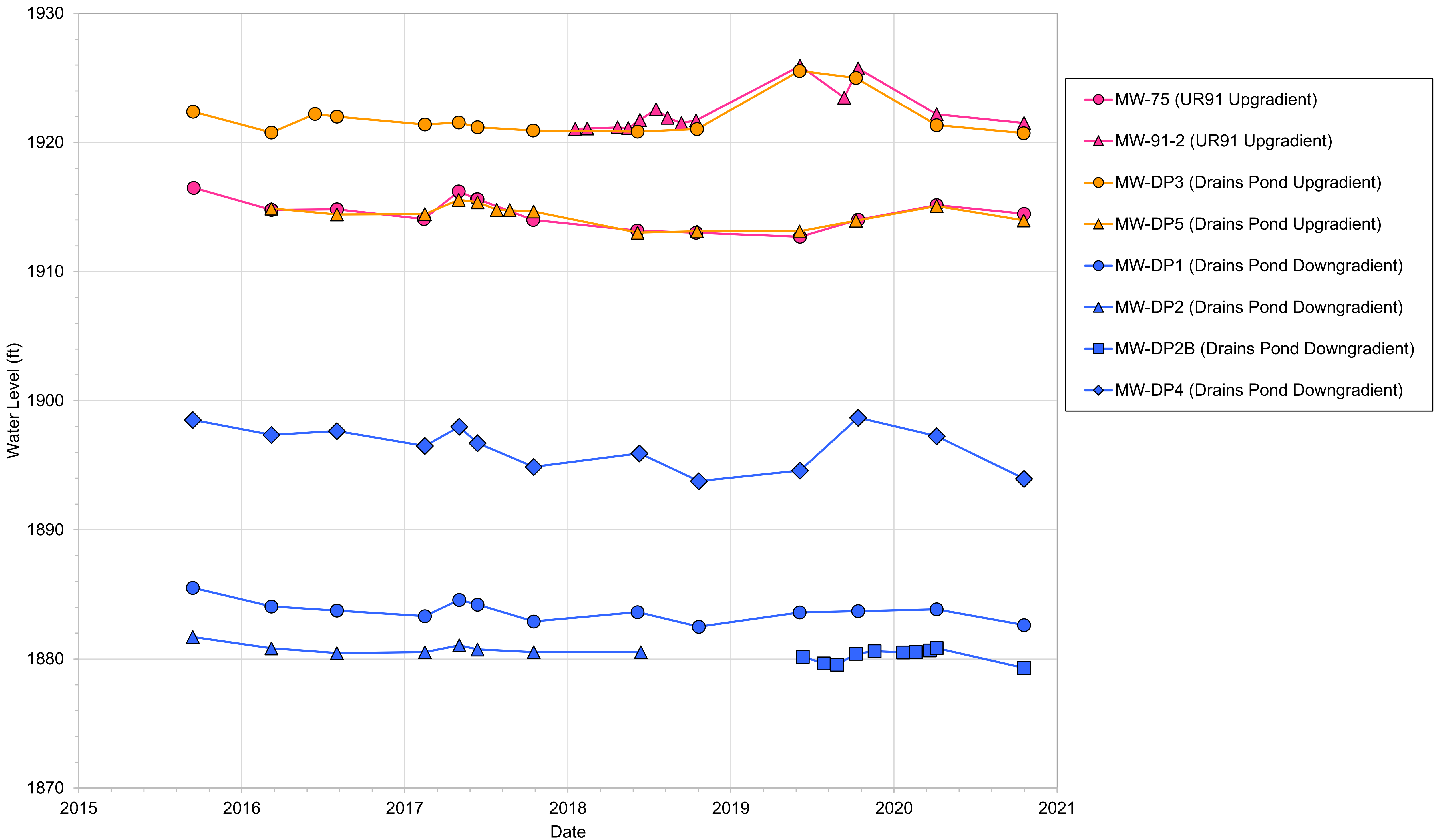

CLIENT
Great River Energy Coal Creek Station

PROJECT
Alternative Source Demonstration

CONSULTANT
GOLDER
MEMBER OF WSP

TITLE
Time Series of Groundwater Elevations

PROJECT NO.	PHASE	REV.	FIGURE
21451024	--	0	2

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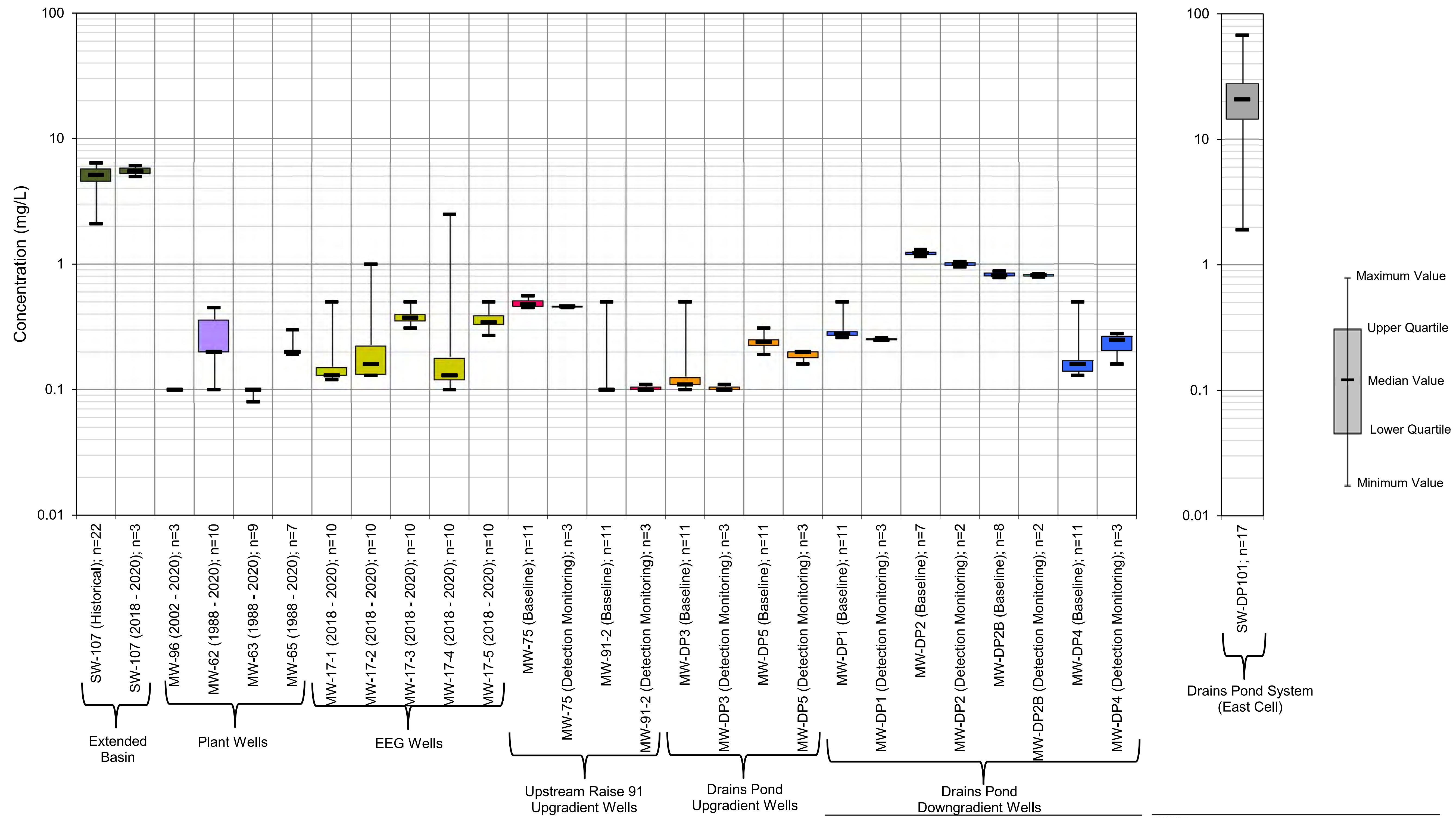

CLIENT
Great River Energy Coal Creek Station

PROJECT
Alternative Source Demonstration

CONSULTANT
GOLDER
MEMBER OF WSP

TITLE
Box and Whisker Plot of Fluoride Concentrations

PROJECT NO.	PHASE	REV.	FIGURE
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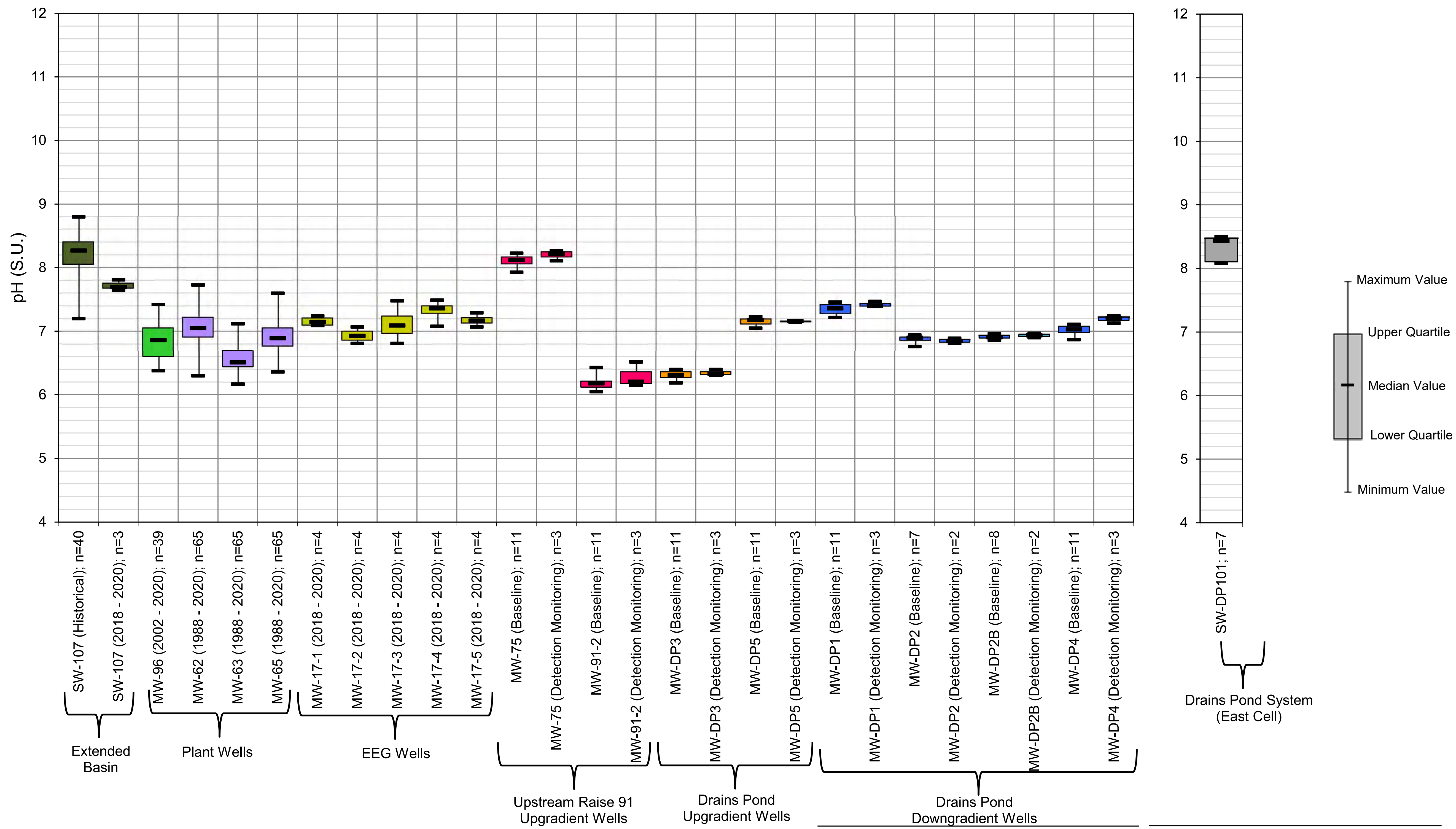
PATH: https://golderassociates.sharepoint.com/sites/140044/Project Files/5 Technical Work/6 - Water Quality/Q4 2020 ASDs/MW-DP4/excel and GWB | FILE NAME: CCS_Box and Whisker_F.xlsm



CLIENT
Great River Energy Coal Creek Station

PROJECT
Alternative Source Demonstration

CONSULTANT
GOLDER
MEMBER OF WSP

TITLE
Box and Whisker Plot of pH Values

PROJECT NO.	PHASE	REV.	FIGURE
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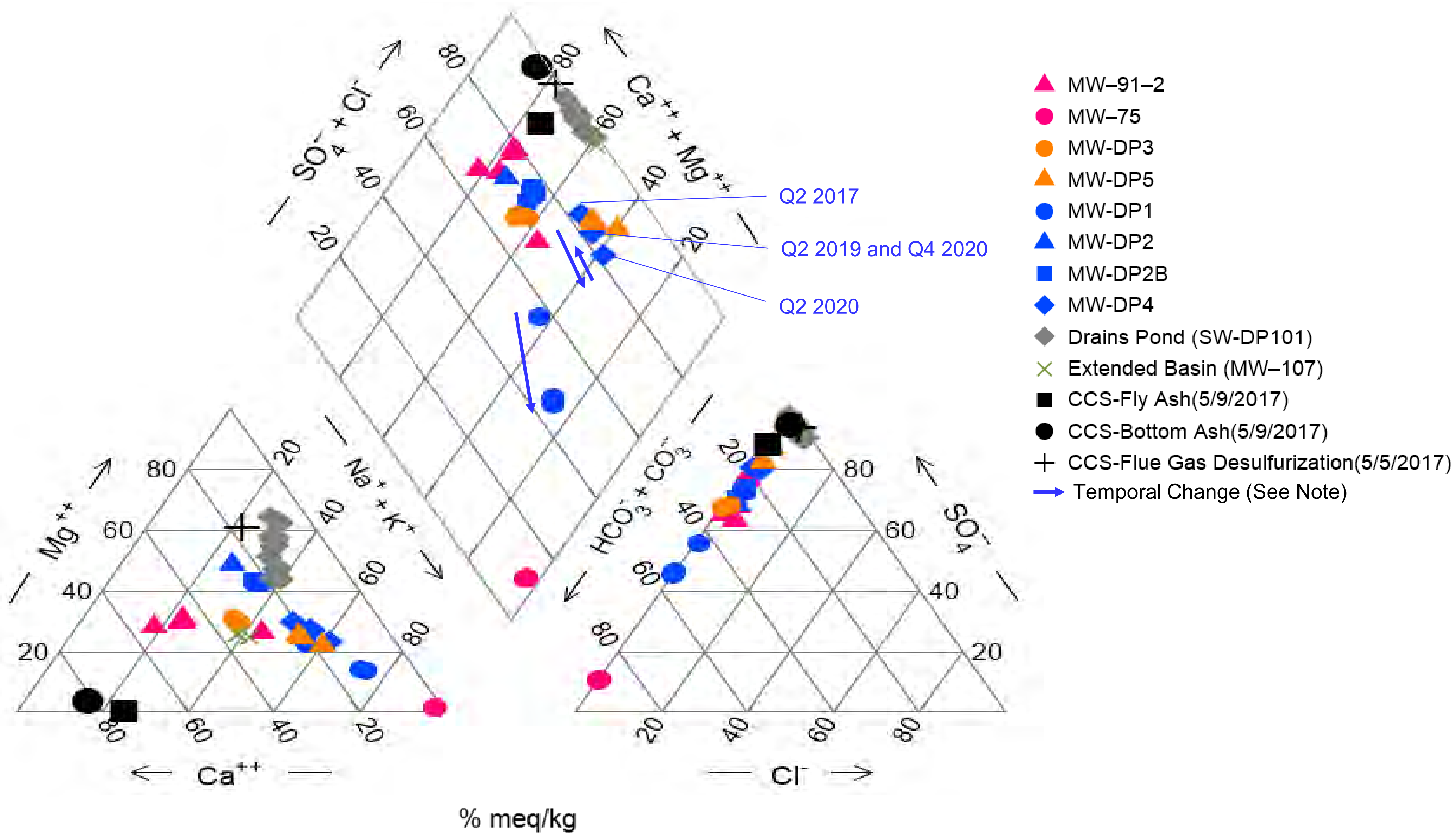

Note:
Arrows display the change in groundwater geochemistry at MW-DP4 and MW-DP1 with time. The arrows indicate that the most recent samples collected at MW-DP4 and MW-DP1 (2019 - 2020) are less similar to Drains Pond water or CCR SPLP leachates, compared to the samples collected in 2017.

CLIENT	PROJECT
Great River Energy Coal Creek Station	Alternative Source Demonstration
CONSULTANT	TITLE
GOLDER MEMBER OF WSP	Piper Diagram

PROJECT NO.	PHASE	REV.	FIGURE
21451024	--	0	5

APPENDIX A

Corrective Measures Report, Coal Creek Station – Drains Pond System West Ditch

REPORT

Corrective Measures Report

Coal Creek Station – Drains Pond System West Ditch

Submitted to:

Great River Energy

2875 Third Street SW
Underwood, North Dakota 58576

Submitted by:

Golder Associates Inc.

7245 W Alaska Drive, Suite 200, Lakewood, Colorado, USA 80226

+1 303 980-0540

21451024-5-R-0

May 21, 2021

Table of Contents

1.0 INTRODUCTION

Golder Associates Inc. (Golder) has prepared this report to document corrective measures implemented at the Drains Pond System Coal Combustion Residual (CCR) Impoundment's west cell at Great River Energy's (GRE) Coal Creek Station (CCS). Corrective measures were implemented in response to a potential non-groundwater release of contact water (stormwater coming in contact with CCR) within a perimeter surface water ditch located on the west side of the west cell identified during a periodic facility inspection. This report has been prepared in accordance with the United States Environmental Protection Agency's (USEPA's) CCR Rule, 40 CFR Part 257.83(b)(5), which states, "If a deficiency or release is identified during an inspection, the owner or operator must remedy the deficiency or release as soon as feasible and prepare documentation detailing the corrective measures taken" (USEPA 2015).

2.0 BACKGROUND

CCS is a coal-fired electric generation facility located in McLean County, approximately 10 miles northwest of Washburn, North Dakota. CCRs are managed in composite-lined surface water impoundment cells and dry waste facilities regulated and permitted by the North Dakota Department of Environmental Quality (NDDEQ) in accordance with North Dakota Administrative Code (NDAC) Title 33.1, Article 33.1-20, Solid Waste Management and Land Protection.

2.1 Facility Location and Operation

CCS has four CCR facilities that are within the purview of the USEPA CCR rule (see Figure 1):

- The Drains Pond System CCR Surface Impoundment (Drains Pond System) is located in the south-central portion of the plant site, northeast of the plant buildings.
- The Upstream Raise 91 CCR Surface Impoundment (Upstream Raise 91) is located in the south-central portion of the plant site, east of the plant buildings.
- The Upstream Raise 92 CCR Surface Impoundment (Upstream Raise 92) is located in the southeast portion of the plant site, between Upstream Raise 91 and Southeast Section 16 CCR Landfill.
- Southeast Section 16 CCR Landfill (Southeast 16) is located in the southeast portion of the plant site, east of Upstream Raise 92.

The Drains Pond System is located in Section 17, Township 145N, Range 82W, and covers approximately 22 acres. The Drains Pond System is designed as three interconnected cells (west cell, center cell, east cell) that may be used to dewater CCRs, including bottom ash and economizer ash, as well as non-CCR materials such as coal rejects. The west cell was constructed in 2015 and is used as a combined dewatering and storage facility for CCRs, which most commonly includes hydraulically conveyed bottom ash, pulverizer rejects, and economizer ash.

2.2 Surface Water Drainage Ditch West of Drains Pond System

The west cell of the Drains Pond System is separated from rail lines to the west by a surface water drainage ditch (see Figure 2). The rail lines are primarily used to transport coal and fly ash from CCS off site. The haul road directly east of this drainage ditch is used by GRE personnel to load bottom ash, pulverizer rejects, and economizer ash into trucks for disposal in the various CCR containment facilities. Wind-blown CCR and minor spillage that occurs during normal loading and hauling operations may contribute to minor amounts of CCR material encroaching on the west drainage ditch crest or along the west downstream slope of the west cell of the Drains Pond System.

The surface water drainage ditch receives stormwater and snow melt runoff from the rail line slope to the west and the embankment of the west cell of the Drains Pond System to the east. Because there is a potential for runoff into this surface water drainage ditch to contain contact water associated with the loading and hauling of CCR, the drainage ditch was originally designed to flow to the south and east, eventually discharging into the center cell of the Drains Pond System to be managed with other CCR contact waters. Due to operational constraints (pipeline alignments and haul routes), this drainage ditch no longer operates as described above. Water has been noted to accumulate in this drainage ditch, potentially infiltrating into the shallow subsurface.

2.3 Evidence of Contact Water Release

In October of 2020, a registered professional engineer (PE) from Golder was on site performing the annual PE inspection of the Drains Pond System per USEPA Regulation 40 CFR 257.83(b) requirements. The annual inspection report noted the following:

> *"The west downstream slope is shallow, and a surface water drainage ditch is located along this side. At the time of the inspection, there was poor vegetation along this west slope. The drainage ditch along this west side was also isolated, allowing ponding of water after large precipitation events. In addition, it appeared that bottom ash had eroded into this drainage ditch."*
> (Golder 2021)

Regular heavy traffic along the west crest of the west berm of the Drains Pond System has led to situations when drainage along this berm crest is graded with little or no slope toward the CCR surface impoundment. Rutting of heavy haul trucks requires this area be occasionally regraded. In combination with potential wind-blown CCR and spillage during loading discussed above, regrading and maintenance of this berm crest has appeared to have led to minor amounts of bottom ash accumulating on the downstream slope and within the drainage ditch west of the west cell of the Drains Pond System as noted during the 2020 annual PE inspection.

Precipitation and/or snow melt accumulating in the area may come into contact with bottom ash. Without positive drainage, this water likely either evaporates or infiltrates into underlying soil, potentially affecting groundwater quality.

Photographs from the October 2020 annual PE inspection are included in Appendix A.

3.0 CORRECTIVE MEASURES

The 2020 annual PE inspection provided some recommendations for improving the drainage ditch west of the west cell of the Drains Pond System. These recommendations included:

- Removing CCR that appears to have accumulated in the area.
- Grading the area to improve drainage and limit ponding of stormwater.
- Applying soil and seed to promote vegetative growth and limit accumulation of stormwater.

3.1 Design of Corrective Measures

Based on site observations, Golder prepared a sketch for GRE approximately one week after the inspection outlining the design concept for implementing the recommended corrective measures noted during the 2020 annual PE inspection. A refined version of this initial sketch is included as Appendix B. The following summarizes design elements conveyed via this figure:

- Clean out CCR from the existing drainage ditch.
- Import suitable soil to place on the downstream slope of the west cell of the Drains Pond System as needed to grade the area to drain to the south and to provide a location for vegetative growth. Areas near the crest were indicated to drain toward the surface impoundment to limit water flowing toward the drainage ditch and potential spillage of CCR near or onto the downstream slope of the Drains Pond System.
- Install a culvert beneath the access/haul road crossing at the south end of the drainage ditch to allow stormwater runoff to drain away from the area.

3.2 Construction of Corrective Measures

In early November, GRE (assisted by a third-party contractor) completed the corrective measures repairs as outlined in Section 3.1. Soil suitable for vegetative growth was imported and placed in general accordance with the recommendations figure (Appendix B) and an 18-inch culvert was installed at the south end of the drainage ditch to allow water to drain into the contact water ditch that discharges into the center cell of the Drains Pond System.

Photographs taken during the construction activities are provided in Appendix C.

4.0 MONITORING OF THE CORRECTIVE ACTION PLAN

GRE personnel will perform visual observations of the area to evaluate the effectiveness of the corrective measures and their resiliency to storm events and snow melt. Specifically, the drainage ditch will be observed for signs of accumulated water, the presence of CCR within the drainage ditch, and signs of vegetative growth.

5.0 CONCLUSIONS

Based on observations made by GRE and Golder personnel, infiltration of stormwater that had contacted CCRs may have occurred in the drainage ditch west of the Drains Pond System, driven by the lack of an outlet from the drainage ditch and CCR accumulation in that drainage ditch due to heavy traffic and regular loading operations. In accordance with the USEPA's CCR Rule, 40 CFR Part 257.83(b)(5), which states, "If a deficiency or release is identified during an inspection, the owner or operator must remedy the deficiency or release as soon as feasible and prepare documentation detailing the corrective measures taken," (USEPA 2015) GRE took the following steps after identifying the suspected release:

- Developed plans to repair and install the drainage ditch.
- Worked with a third-party contractor to implement the construction plans.
- Documented the implemented corrective measures with this report.

As a result of these actions, the newly graded area and installed culvert should limit the accumulation and potential infiltration of water. Continued monitoring of the newly installed contact water control features coupled with ongoing surface water and groundwater monitoring at nearby locations will continue to determine the efficacy of corrective measures.

6.0 REFERENCES

Golder (Golder Associates Inc.). 2021. Annual Inspection, Coal Creek Station – Drains Pond System CCR Surface Impoundment. January 2021.

United States Environmental Protection Agency (USEPA). 2015. Code of Federal Regulations Title 40 Part 257: Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities. April 17.

Signature Page

Golder Associates Inc.

Kevin Cernik
Staff Engineer

Todd Stong, PE
Senior Consultant and Associate

KAC/TJS/mp

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https://golderassociates.sharepoint.com/sites/140044/project files/6 deliverables/reports/5-r-west_ditch_corrective_measures/5-r-0/21451024-5-r-a-west_ditch_corrective_measures_13may21.docx

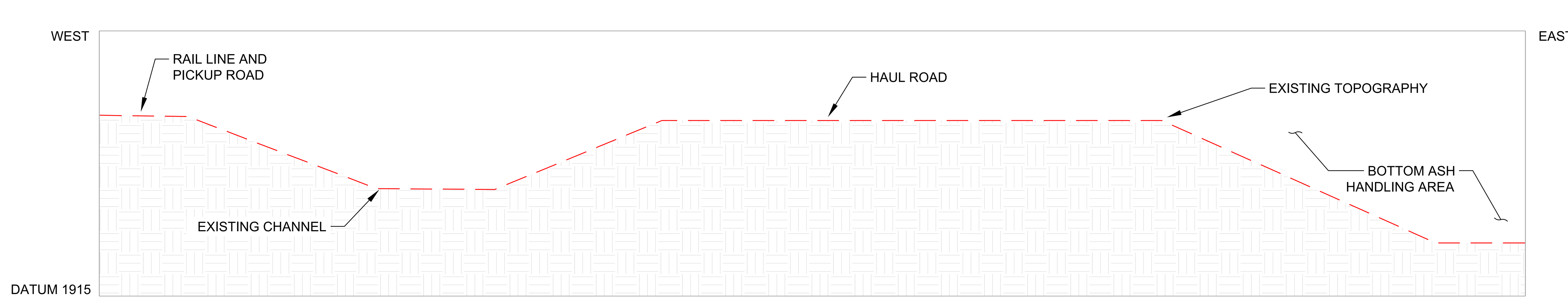
Figures

GOLDER
MEMBER OF WSP

NOTE(S)
1. AERIAL IMAGE FROM UNITED STATES DEPARTMENT OF AGRICULTURE NATIONAL AGRICULTURE AERIAL IMAGERY PROGRAM, TAKEN IN 2020.

GREAT RIVER ENERGY - COAL CREEK STATION
SITE OVERVIEW

FIGURE 1



NOT TO SCALE (A / 2) WEST DITCH CHANNEL CROSS-SECTION

LEGEND

EMBANKMENT AND/OR EXISTING GROUND

MONITORING WELL

NOTE(S)

1. AERIAL IMAGERY OBTAINED FROM DRONE SURVEYS BY GREAT RIVER ENERGY TAKEN ON JULY 16, 2020.
2. EXISTING GROUND TOPOGRAPHY PROVIDED BY GREAT RIVER ENERGY. SURVEYS WERE PERFORMED BETWEEN 2015 AND 2017.

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GREAT RIVER ENERGY - COAL CREEK STATION
WEST DITCH AREA CONDITIONS PRIOR TO IMPLEMENTATION OF CORRECTIVE MEASURES

FIGURE 2

APPENDIX A

Photographs from the 2020 Annual PE Inspection

LEGEND

(#) PHOTOGRAPH LOCATION

NOTE(S)

1. AERIAL IMAGERY OBTAINED FROM DRONE SURVEYS BY GREAT RIVER ENERGY TAKEN ON JULY 16, 2020.

GOLDER
MEMBER OF WSP

GREAT RIVER ENERGY - COAL CREEK STATION
WEST DITCH CORRECTIVE MEASURES - 2020 ANNUAL PE INSPECTION
PHOTOGRAPH LOG

Drains Pond System - West Cell West Ditch

Photograph 1
Downstream slope and stormwater drainage, poor vegetation on slope. (IMGP7360.JPG)

Photograph 2
Downstream slope and stormwater drainage, erosion rills from haul road. (IMGP7361.JPG)

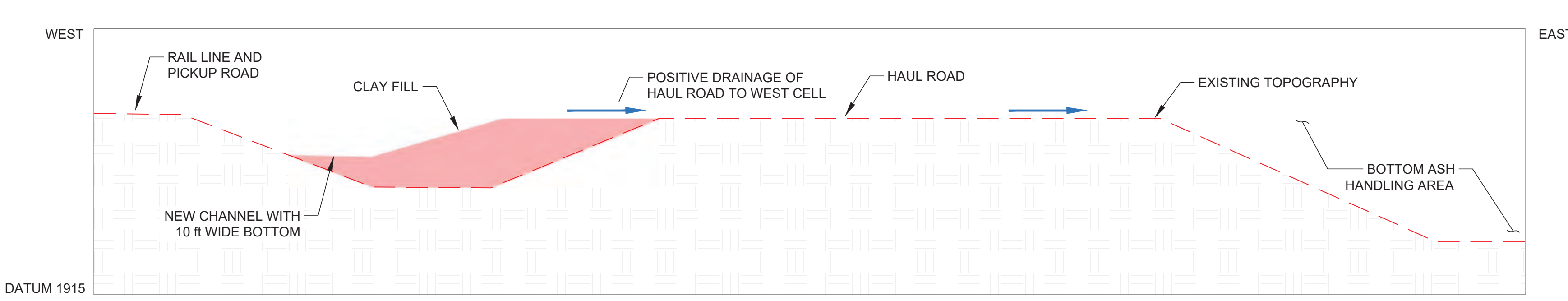
Drains Pond System - West Cell West Ditch

Photograph 3
Downstream slope and stormwater drainage, bottom ash (CCR) accumulated in the drainage ditch. (IMGP7364.JPG)

Photograph 4
Downstream slope and stormwater drainage, erosion rills from haul road. (IMGP7367.JPG)

APPENDIX B

West Ditch Corrective Measures Recommendations Figure



NOT TO SCALE A/1 WEST DITCH CHANNEL CROSS-SECTION

LEGEND

- CLAY FILL
- EMBANKMENT AND/OR EXISTING GROUND
- SURFACE WATER FLOW
- CULVERT

NOTE(S)

1. AERIAL IMAGERY OBTAINED FROM DRONE SURVEYS BY GREAT RIVER ENERGY TAKEN ON JULY 16, 2020.
2. EXISTING GROUND TOPOGRAPHY PROVIDED BY GREAT RIVER ENERGY. SURVEYS WERE PERFORMED BETWEEN 1996 AND 2017.

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GREAT RIVER ENERGY - COAL CREEK STATION
WEST DITCH CORRECTIVE MEASURES RECOMMENDATIONS

FIGURE B1

APPENDIX C

Photographs from Corrective Measures Implementation

LEGEND

PHOTOGRAPH LOCATION

NOTE(S)

1. AERIAL IMAGERY OBTAINED FROM DRONE SURVEYS BY GREAT RIVER ENERGY TAKEN ON JULY 16, 2020.

GOLDER
MEMBER OF WSP

GREAT RIVER ENERGY - COAL CREEK STATION
WEST DITCH CORRECTIVE MEASURES - CORRECTIVE MEASURES IMPLEMENTATION
PHOTOGRAPH LOG

Drains Pond System - West Cell West Ditch

Photograph 1
Cleanout and stockpiling of bottom ash and affected soil, facing south. (IMG_3051.JPG)

Photograph 2
Cleanout of west ditch grades prior to clay material placement, facing south. (IMG_3060.JPG)

Drains Pond System - West Cell West Ditch

Photograph 3
Cleanout of west ditch grades prior to clay material placement, facing south-southeast. (IMG_3061.JPG)

Photograph 4
Cleanout of west ditch grades prior to clay material placement, facing north. (IMG_3062.JPG)

Drains Pond System - West Cell West Ditch

Photograph 5
Post-cleanout and placement of soil at the west ditch, facing south. (RF-1.JPG)

Photograph 6
Post-cleanout and placement of soil at the west ditch, facing south. (RF-2.JPG)

Drains Pond System - West Cell West Ditch

Photograph 7
Post-cleanout and placement of soil at the west ditch, facing southeast. (RF-3.JPG)

Photograph 8
Post-cleanout and placement of soil at the west ditch and newly installed culvert inlet, facing southeast. (RF-4.JPG)

Drains Pond System - West Cell West Ditch

Photograph 9
Post-cleanout and placement of soil at the west ditch, facing north. (RF-5.JPG)

Photograph 10
Post-cleanout and placement of soil at the west ditch and newly installed culvert outlet, facing northeast. (RF-6.JPG)

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APPENDIX B

ALTERNATIVE SOURCE DEMONSTRATIONS – Q2 2021

REPORT

Alternate Source Demonstration for Monitoring Wells MW-10 and MW-16-1

Great River Energy - Coal Creek Station

Submitted to:

Great River Energy

Coal Creek Station
2875 Third Street SW
Underwood, North Dakota 58576

Submitted by:

Golder Associates USA Inc.

7245 W Alaska Drive, Suite 200, Lakewood, Colorado, USA 80226

+1 303 980-0540

21451024C-11-R-0

January 6, 2022

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TABLES

FIGURES

1.0 INTRODUCTION

On behalf of Great River Energy (GRE), Golder Associates USA Inc. (Golder), member of WSP, performed a statistical evaluation of groundwater monitoring results from the second quarter (Q2) 2021 groundwater detection monitoring event at Coal Creek Station's Upstream Raise 92 coal combustion residual (CCR) surface impoundment. The statistical evaluation was performed as described in the Coal Combustion Residuals Groundwater Statistical Method Certification for Coal Creek Station (Golder 2021c), in accordance with applicable provisions of 40 Code of Federal Regulations (CFR) Part 257, Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities; Final Rule (CCR Rule), as amended.

Statistical analyses of the Appendix III detection monitoring data indicated potential exceedances of the statistical limits based on the parametric Shewhart-CUSUM (Cumulative Summation) control chart analysis for the following parameters and monitoring wells in the fourth quarter (Q4) 2019 sampling results:

- fluoride in samples collected from monitoring well MW-10
- boron in samples collected from monitoring well MW-10
- field pH in samples collected from monitoring well MW-10
- field pH in samples collected from monitoring well MW-16-1

These potential exceedances were subsequently verified as statistically significant increases (SSIs) following the Q2 2020 detection monitoring sampling event. The Q4 2020 and Q2 2021 detection monitoring results for the above were also verified SSIs. Additionally, boron in samples collected from monitoring well MW-16-1 was identified as a potential exceedance following the Q2 2020 detection monitoring sampling event and a verified SSI following both the Q4 2020 and Q2 2021 monitoring events.

Although determination of a verified SSI generally indicates that the groundwater monitoring program should transition from detection monitoring to assessment monitoring, 40 CFR Part 257.94(e)(2) allows the owner or operator (i.e., GRE) 90 days from the date of determining a verified SSI to demonstrate that a source other than the regulated CCR facility 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 the baseline data collection period.

Golder's review of the hydrological and geologic conditions at the site indicates the SSIs are likely a result of a temporary impact due to a stormwater runoff event. As described below, the response to this runoff event was conducted as outlined in 40 CFR Part 257.83(b)(5). A desktop study of previously collected CCR-impacted water from the facility, nearby surface water and groundwater samples was conducted to assess potential fluoride, boron, and field pH sources. As part of this work, potential errors in the statistical analysis and the natural variability of concentrations in groundwater were also evaluated. CCR-impacted water from the facility is broken into three categories for this demonstration. Contact water is defined as stormwater that comes in contact with CCR materials. Porewater is defined as water collected from piezometers screened within the CCR deposition zone of the facility. Sump water is defined as water collected from the sumps overlying the composite liner system of the facility. Sump water and porewater samples have extended contact times with CCR materials while contact water has limited contact time with CCR materials. Based upon this review and in accordance with provisions of the CCR Rule, Golder prepared this Alternative Source Demonstration (ASD) for monitoring wells MW-10 and MW-16-1 at Upstream Raise 92. An ASD was initially developed following the Q2 2020 verified SSIs

(Golder 2020d, Golder 2021a), was reviewed for ongoing applicability, and updated where necessary for the Q4 2020 samples (Golder 2021b). Here, Golder further assesses and modifies, where needed, the previous ASD reports with the statistical evaluation of data collected in Q2 2021.

This ASD conforms to the requirements of 40 CFR Part 257.94(e)(2) and provides the basis for concluding that the verified SSIs at MW-10 and MW-16-1 are not an indication of a seepage release from Upstream Raise 92. The following sections provide a summary of the CCR facilities, a storm event in September 2019, analytical and geochemical assessment results, and lines of evidence demonstrating stormwater that contacted CCR materials (contact water) are likely responsible for the SSIs at MW-10 and MW-16-1.

2.0 BACKGROUND

2.1 Site Background

GRE's Coal Creek Station (CCS) is a coal-fired electric generation facility located in McLean County, approximately 10 miles northwest of Washburn, North Dakota. CCRs are managed in composite-lined surface water impoundment cells and dry landfills regulated and permitted by the North Dakota Department of Environmental Quality (NDDEQ) in accordance with North Dakota Administrative Code (NDAC) Title 33.1, Article 33.1-20, Solid Waste Management and Land Protection.

CCS has four CCR facilities that are within the purview of the United States Environmental Protection Agency (USEPA) CCR Rule. This ASD applies to the Upstream Raise 92 CCR surface impoundment. Upstream Raise 92 is located in the south-central portion of the plant site, east of the CCS plant buildings (Figure 1) and was used as a combined dewatering and storage facility for CCR including fly ash, bottom ash, economizer ash, and flue gas desulfurization (FGD) material. In early April 2021, disposal of CCR and non-CCR waste ceased, and closure was initiated at Upstream Raise 92. Upstream Raise 92 will be closed with CCR in-place.

2.2 Site Geology

CCS and McLean County are situated at the eastern-most extent of the Williston Basin, a structural and sedimentary basin (United States Geological Survey [USGS] 1999). The region is characterized by the presence of glacial drift, reaching thicknesses of several hundred feet, and overlying the Sentinel Butte Member, the source of commercially mined coal in the direct vicinity of CCS (Falkirk 1979). The Sentinel Butte Member is the highest strata of the Paleocene Fort Union Formation, overlying the Tongue River, Ludlow, and Cannonball Members (USGS 1999). The Sentinel Butte Member is marked by drab-gray units, demarcating the separation from the lower Tongue River Member.

The site geology of CCS includes unconsolidated surficial deposits of the Coleharbor formation, consisting of stratified and unstratified glacial drift. The near-surface materials are silty clay and sandy clay till with interbedded lenses (Cooperative Power Association and United Power Association 1989).

2.3 Site Hydrogeology

Regional groundwater flow of the uppermost water-bearing unit in the vicinity of CCS is a subtle expression of the surface topography, which is influenced by the configuration of the eroded bedrock. Based on available groundwater elevation data, the shallow groundwater at the CCR facilities at CCS generally follows surface topography, flowing east and north towards Lower Samuelson Slough and Sayler Slough. Available groundwater elevation data indicate that groundwater in the area of Upstream Raise 92 generally flows from the southwest to the northeast, diagonally across the footprint of the facility.

Hydraulic conductivities in the area of the Upstream Raise 92 range from 0.09 feet per day (ft/day) to 56.69 ft/day, with calculated groundwater flow rates during the Q2 2021 detection monitoring event ranging from 0.003 to 2.25 ft/day.

2.4 Groundwater Monitoring Network

The groundwater monitoring network for Upstream Raise 92 was developed with consideration for the size, disposal and operational history, anticipated flow direction, and location of adjoining facilities. Based on these factors, the Upstream Raise 92 monitoring well network consists of two upgradient and three downgradient monitoring wells used for monitoring the unit under the CCR Rule.

The two upgradient monitoring wells (MW-16-6, MW-16-7) included in the groundwater monitoring network for Upstream Raise 92 are used to represent upgradient water flowing towards the unit from the west and south. The three downgradient wells (MW-10, MW-16-0, MW-16-1) are spaced along the north side of the facility. Upstream Raise 92 directly abuts Southeast Section 16 on its eastern edge, preventing installation of monitoring wells along the eastern side of Upstream Raise 92 without jeopardizing the integrity of the liner system. The Upstream Raise 92 monitoring network wells are presented in Figure 1. Other monitoring locations used to support this ASD are also presented in Figure 1.

2.5 Groundwater Conditions

Between September 2015 and June 2017, GRE collected nine independent baseline groundwater samples from MW-16-6, MW-16-7, MW-10, MW-16-0, and MW-16-1, as required by 40 CFR Part 257.94, for use within the CCR Rule monitoring program. The results of the CCR baseline monitoring were used to develop statistical limits for each constituent at each monitoring well, based on site conditions and parameter specific characteristics such as the data distribution and detection frequency (Golder 2021c).

Following completion of the baseline monitoring events at each well, GRE began collecting groundwater samples on a semi-annual basis to support the detection monitoring program. Groundwater samples for detection monitoring are collected at each upgradient and downgradient monitoring well and analyzed for 40 CFR Part 257 Appendix III constituents. During the detection monitoring program, results from groundwater analysis are compared to the statistical limits to determine whether groundwater quality remains consistent, or if changes in groundwater quality are observed.

In accordance with the site Statistical Method Certification (Golder 2021c) and recommendations within the USEPA Unified Guidance (USEPA 2009), a baseline update was conducted for most well-constituent pairs within the Upstream Raise 92 monitoring network prior to conducting comparative statistical analysis for the Q4 2019 detection monitoring event. As a result of the baseline update, results collected during the detection monitoring program were evaluated to determine if they were from the same statistical population as those collected during the initial baseline monitoring program.

Figure 2 displays a time-series plot of water levels from 2015 to 2021 in each monitoring well. MW-51 (downgradient monitoring well for Upstream Raise 91, adjacent to and west of Upstream Raise 92) was also included on figures in this report for comparison, given its close proximity to the Upstream Raise 92 downgradient wells. Water levels in both upgradient and downgradient wells increased before the Q4 2019 sampling event. Most of the groundwater levels remained elevated above pre-2019 levels during the Q2 2020 sampling event. During the Q4 2020 and Q2 2021 sampling events water levels were generally similar to pre-2019 levels.

As discussed below and presented in Figure 3, the boron, fluoride, and field pH values in samples collected from MW-10 and MW-16-1 increased between the Q2 2019 and Q4 2019 sampling events. However, the boron, fluoride, and field pH values have generally decreased back towards the range of baseline measurements from Q4 2020 through Q2 2021 and have in some cases decreased below those baseline levels.

2.5.1 Boron at MW-10

Boron concentrations in groundwater at MW-10 during the initial baseline monitoring period ranged between 1.8 and 3.0 milligrams per liter (mg/L) in the nine baseline samples collected as part of the CCR Rule monitoring program. The boron concentrations of detection monitoring samples collected between October 2017 and June 2019 that were incorporated into the updated baseline period ranged between 2.0 and 2.8 mg/L. The Shewhart-CUSUM statistical limit for boron in well MW-10 was set at 3.7 mg/L following the baseline update.

A summary of the concentrations and calculated CUSUM values for boron at MW-10 are as follows:

- The Q4 2019 detection monitoring event reported a boron concentration of 6.4 mg/L at MW-10, with a calculated CUSUM value of 6.0 mg/L, exceeding the statistical limit.
- Verification resampling was conducted during the Q2 2020 detection monitoring event, confirming the SSI for boron at MW-10 with a boron concentration of 4.6 mg/L and a calculated CUSUM value of 8.0 mg/L.
- During the Q4 2020 detection monitoring event, boron was also identified as a verified SSI with a concentration of 2.6 mg/L and a calculated CUSUM value of 8.0 mg/L.
- During the Q2 2021 detection monitoring event, boron had a measured concentration of 2.6 mg/L, with a CUSUM value of 8.0 mg/L, which is a verified SSI.

2.5.2 Fluoride at MW-10

Fluoride concentrations in groundwater at MW-10 during the initial baseline monitoring period ranged between 0.19 and 0.23 mg/L in the nine baseline samples collected as part of the CCR Rule monitoring program. The fluoride concentration of detection monitoring samples collected between October 2017 and June 2019 that were incorporated into the updated baseline period ranged between 0.17 mg/L and non-detect with a detection limit of 0.50 mg/L. The Shewhart-CUSUM statistical limit for fluoride in well MW-10 was set at 0.29 mg/L following the baseline update.

A summary of the concentrations and calculated CUSUM values for fluoride at MW-10 are as follows:

- The Q4 2019 detection monitoring event reported a fluoride concentration of 0.47 mg/L at MW-10, with a calculated CUSUM value of 0.45 mg/L, exceeding the statistical limit.
- Verification resampling was conducted during the Q2 2020 detection monitoring event, confirming the SSI for fluoride at MW-10 with a fluoride concentration of 0.37 mg/L and a calculated CUSUM value of 0.59 mg/L.
- During the Q4 2020 detection monitoring event, fluoride was also identified as a verified SSI with a concentration of 0.17 mg/L and a calculated CUSUM value of 0.53 mg/L.
- During the Q2 2021 detection monitoring event, fluoride had a measured concentration of 0.18 mg/L, with a CUSUM value of 0.48 mg/L, which is a verified SSI.

2.5.3 Field pH at MW-10

Field pH in groundwater at MW-10 during the initial baseline monitoring period ranged between 6.72 and 6.95 standard units (SU) in the nine baseline samples collected as part of the CCR Rule monitoring program. Detection monitoring samples collected between October 2017 and June 2019 that were incorporated into the updated baseline period had field pH values between 6.81 and 6.92 SU. The Shewhart-CUSUM upper statistical limit for the well-constituent pair was set at 7.10 SU following the baseline update.

A summary of the concentrations and calculated CUSUM values for field pH at MW-10 are as follows:

- The Q4 2019 detection monitoring event reported a pH value of 7.49 SU at MW-10, with a calculated upper CUSUM value of 7.42 SU, exceeding the upper statistical limit.
- Verification resampling was conducted during the Q2 2020 detection monitoring event, confirming the SSI for field pH at MW-10 with field pH of 7.54 SU and calculated upper CUSUM value of 8.06 SU.
- During the Q4 2020 detection monitoring event, field pH was also identified as a verified SSI with a value of 6.81 SU and a calculated upper CUSUM value of 7.97 SU.
- During the Q2 2021 detection monitoring event, field pH had a measured value of 6.74 SU and an upper CUSUM value of 7.81 SU, which is a verified SSI.

2.5.4 Field pH at MW-16-1

During the initial baseline monitoring period, field pH in groundwater at MW-16-1 ranged between 7.06 and 7.21 SU in the nine baseline samples collected as part of the CCR Rule monitoring program. Detection monitoring samples collected between October 2017 and June 2019 that were incorporated into the updated baseline period had field pH values between 7.13 and 7.16 SU. The Shewhart-CUSUM upper statistical limit for the well-constituent pair was set at 7.34 SU following the baseline update.

A summary of the concentrations and calculated CUSUM values for field pH at MW-16-1 are as follows:

- The Q4 2019 detection monitoring event reported a pH value of 7.60 SU at MW-16-1, with a calculated upper CUSUM value of 7.55 SU, exceeding the upper statistical limit.
- Verification resampling was conducted during the Q2 2020 detection monitoring event, confirming the SSI for field pH at MW-16-1 with a field pH of 7.43 SU and calculated upper CUSUM value of 7.80 SU.
- During the Q4 2020 detection monitoring event, field pH was also identified as a verified SSI with a value of 7.24 SU and a calculated upper CUSUM value of 7.86 SU.
- During the Q2 2021 detection monitoring event, field pH had a measured value of 7.13 SU and an upper CUSUM value of 7.81 SU, which is a verified SSI.

2.5.5 Boron at MW-16-1

During the initial baseline monitoring period, boron in groundwater at MW-16-1 ranged between 5.26 and 13.6 mg/L in the nine baseline samples collected as part of the CCR Rule monitoring program. The Shewhart-CUSUM statistical limit for the well-constituent pair was set at 20.7 mg/L. Detection monitoring samples collected between October 2017 and October 2019 had boron values between 13 and 16.8 mg/L.

A summary of the concentrations and calculated CUSUM values for boron at MW-16-1 are as follows:

- The Q2 2020 detection monitoring event reported a boron value of 16 mg/L at MW-16-1, with a calculated CUSUM value of 22 mg/L, exceeding the statistical limit.
- Verification resampling was conducted during the Q4 2020 detection monitoring events, confirming the SSI for boron at MW-16-1 with boron concentration of 15 mg/L and a calculated CUSUM value of 24 mg/L.
- During the Q2 2021 detection monitoring event, boron had a measured concentration of 13 mg/L, with a CUSUM value of 25 mg/L, which is a verified SSI.

3.0 POTENTIAL SITE FLUORIDE, BORON, AND FIELD PH SOURCES

To assess the potential sources for a change in fluoride and boron concentrations, and field pH values at MW-10 and boron concentrations and field pH values at MW-16-1, Golder reviewed previously collected data and performed supplemental assessment activities. The following sections summarize the supplemental assessment activities.

3.1 Overview of September 20-21, 2019 Storm Event

Between Friday, September 20, 2019 and Saturday, September 21, 2019, a large thunderstorm system affected central North Dakota. The National Weather Service (NWS) described the storm event in the following excerpt (NWS 2019):

> *"A large mid to upper level low pressure system moved across North Dakota on September 20th through September 21st, 2019. This low pressure system led to excessive rain across much of central North Dakota, as the atmosphere featured anomalously high moisture with a low level jet impinging on a stationary frontal boundary. These ingredients created a perfect scenario for thunderstorm training, which generally occurred in a line extending from Morton through Burleigh, Kidder, Stutsman, Sheridan, Wells, and Foster counties. The hardest hit areas were in portions of Sheridan and Wells counties, where some areas received over 7 inches of rain in less than 15 hours."*

Figure 4 shows a times series of monthly precipitation records from CCS between 2016 and 2020 and Turtle Lake, North Dakota (approximately 20 miles northeast of the site) between 1993 and 2021. The contribution from the storm on September 20 and September 21, 2019, made September 2019 the wettest month over the period of record (7.4 inches of rain at CCS and 8.7 inches of rain at Turtle Lake). The average rainfall for September at Turtle Lake between 1993 and 2018 is 1.3 inches.

Three days after the storm event (September 24, 2019), a registered professional engineer (PE) from Golder was on site performing the annual PE inspection of Upstream Raise 91 and Upstream Raise 92 per USEPA Regulation 40 CFR Part 257.83(b) requirements. In the annual PE inspection reports (Golder 2020a and Golder 2020b), the Golder representatives noted the following:

- Standing water in the drainage ditches around Upstream Raise 91 and Upstream Raise 92
- Erosion of the fly ash cover along the inside of the ramp on the north side of Upstream Raise 92

Given the observed erosion, precipitation falling on the north side of Upstream Raise 92 (including a haul road ramp) likely contributed to significant runoff from exposed CCR slopes. Contact water was designed to flow from the inside of this ramp into a perimeter ditch at the toe of the CCR slope that is within the composite-lined footprint of the CCR surface impoundment. However, due to significant haul traffic over the course of several years and rounding off of the haul ramp and road near the toe of the facility, contact water appears to have had an opportunity to flow off of the lined footprint, especially in the case of a significant rain event (Figure 5). Although not directly observed, contact water is suspected to have flowed down the upper ramp and onto the lower ramp and lower perimeter berm slopes. Standing water was observed in the ditch near the lower ramp of Upstream Raise 92 that is meant to collect and route non-contact water from grass-covered slopes of the perimeter berm of the CCR surface impoundment.

Based on these observations, GRE personnel reviewed the contact water runoff controls for this area of Upstream Raise 92 and developed a plan to repair and improve contact water controls. Beginning in May 2020, once weather conditions allowed, these contact water controls were implemented to prevent contact water runoff during future storm events. The repairs are outlined in the Corrective Measures Report (Golder 2020c). The response to this event outlined in the Corrective Measures Report was consistent with the requirements of 40 CFR Part 257.83(b)(5) which states, “If a deficiency or release is identified during an inspection, the owner or operator must remedy the deficiency or release as soon as feasible and prepare documentation detailing the corrective measures taken.”

Monitoring wells MW-10 and MW-16-1 were in low areas in close proximity to the northern lower ramp of Upstream Raise 92 and contact water flowing off of the facility is likely to have accumulated in the area around these wells.

3.2 Data Sources Used in Alternative Source Review

To evaluate potential site sources of fluoride, boron, and field pH near Upstream Raise 91 and Upstream Raise 92, Golder reviewed the following groundwater, surface water, and CCR-impacted water results (see Figure 1 and Figure 5 for locations).

3.2.1 Groundwater Monitoring Data

Data collected between September 2015 and June 2021 for the CCR Rule monitoring program were considered in the evaluation. As part of the monitoring program, field personnel collected groundwater samples from the following monitoring wells:

- Upgradient to Upstream Raise 92: MW-16-6 and MW-16-7
- Downgradient to Upstream Raise 92: MW-10, MW-16-0, and MW-16-1
- Downgradient to Upstream Raise 91: MW-51 (the eastern-most downgradient monitoring well of Upstream Raise 91 that is within the surface water drainage ditch at the toe of the perimeter berm slope at the border between Upstream Raise 91 and Upstream Raise 92)

3.2.2 CCR-Impacted Waters

Sump water and porewater collected from Upstream Raise 92 were used to characterize waters in extended contact with CCR materials and include the following:

- Upstream Raise 92 north sump (Sump-N-AP92)
- Upstream Raise 92 east sumps (Sump-NW-SW16 and Sump-SE-SW16)
- Porewater from Upstream Raise 92 piezometers (PZ-1, PZ-11, and PZ-13) screened within the deposited CCR

While MW-10 and MW-16-1 are downgradient wells for Upstream Raise 92, sump water from Upstream Raise 91 was also included to increase the sample size and capture potential variability in sump water and porewater samples, especially given the drainage and process water systems for Upstream Raise 91 are connected to Upstream Raise 92 via piping:

- Upstream Raise 91 sump (Sump-UR91)

3.2.3 Short Term Leach Testing of CCR Materials

Short-term leach testing of the CCR materials by the synthetic precipitation leaching procedure (SPLP) was performed by USEPA Method 1312 (USEPA 1994). The SPLP simulates the interaction between a solid and meteoric water, which provides a screening-level estimate of ash effluent water quality.

CCR materials were collected by site personnel between 2012 and 2017. Details about the collection procedure are listed by material type below:

- Three bottom ash samples from Section 26 (a historic containment area for CCRs in a previously mined area) were collected in-situ at the facility in May 2017.
- One bottom ash sample was collected from the Drains Pond System west cell in May 2017.
- Two fly ash samples were collected from the fly ash silos (one sample was collected in November 2017 and one was collected in May 2017).
- One fly ash sample was collected from Section 26 (a historic containment area for CCRs in a previously mined area) in May 2017.
- Three coal rejects samples were collected from Ash Pond 91 (also referred to as Upstream Raise 91) in June 2013.
- One coal rejects sample was collected from Upstream Raise 91 in May 2017.

3.2.4 Ditch on the North Side of Upstream Raise 92

As part of the investigation of Upstream Raise 92 (Golder 2020c), standing water was observed in the ditch near the lower ramp of Upstream Raise 92. A water sample was collected from this drainage ditch located on the north side of Upstream Raise 92 (Ditch_N_UR92, see Figure 5), herein referred to as ditch water. This water likely represents contact water runoff from Upstream Raise 92.

3.3 Evaluation of Potential Sources of Boron, Fluoride, and Field pH

The relative proportion of major ion concentrations in groundwater samples and potential sources are depicted on a Piper diagram in Figure 6. This Piper diagram compares water quality results from groundwater, sump water, CCR material SPLP leachates, and Upstream Raise 92 ditch water to evaluate potential sources of boron, fluoride, and field pH. The results from the more recent downgradient groundwater sampling events are marked with different colored symbols to distinguish between older and more recent samples (Q4 2019 to Q2 2021 colored purple to dark blue to light blue to green). Figure 7 presents a scatter plot of the sulfate to chloride ratio versus the boron to chloride ratio as an additional method to compare site sources. The data suggests the SSIs identified for samples collected from MW-10 and MW-16-1 can be primarily attributed to a contact water runoff event associated with a significant rain event in September 2019.

3.3.1 Contact Water Runoff Event from Upstream Raise 92

Based on the magnitude of the September 2019 storm event and site observations of the CCR slopes and haul road ramp on the north side of Upstream Raise 92 after this event, contact water runoff from Upstream Raise 92 was evaluated as a potential source for the changing boron and fluoride concentrations and field pH values at the downgradient monitoring wells.

The conceptual model for contact water runoff impacting the shallow groundwater wells assumes that:

1) Due to failure of the contact water controls during a significant precipitation event, contact water flowing down existing CCR slopes and the upper haul road ramp on the north side of Upstream Raise 92 was able to bypass the controls, flow off the composite lined footprint along the north side of Upstream Raise 92, and pond near the downgradient monitoring wells.

2) This ponded contact water then partially infiltrated into the shallow groundwater monitored by the downgradient wells, resulting in a change in water quality monitored during the Q4 2019, Q2 2020, and Q4 2020 sampling events.

3) Because of the transient nature of this event, it is expected that water quality in the downgradient wells will shift towards contact water quality immediately after the event, and then would shift back towards historical water quality after the event. A shift towards historical water quality is observed in the Q2 2021 sampling event where measured field pH, boron, and fluoride are within the range of baseline values (Figure 3) collected during the monitoring period. Additionally, the relative proportions of major ion concentrations have shifted back towards the pre-September 2019 signature (see Figures 6 and 7).

Boron and fluoride concentrations and pH values in samples collected from ditch water (water that has been in short-term contact with CCR and expected to be similar to the water that was released during the storm event), in MW-10, and MW-16-1 are presented in Table 1. Concentrations are generally higher in samples collected from ditch water than the monitoring wells, indicating that contact water runoff from Upstream Raise 92 could be responsible for elevated boron and fluoride concentrations and field pH values observed in recent samples collected from MW-10 and MW-16-1.

Table 1: Summary of Select Concentrations in Potential Contact Water Runoff and Downgradient Wells

Analyte	Units	Ditch water (Ditch_N_UR92) (10/24/2019)	MW-10 (Baseline and Detection Monitoring)	MW-16-1 (Baseline and Detection Monitoring)
pH	SU	8.1 (Lab)	6.74 – 7.54 (Field)	7.06 – 7.60 (Field)
Boron	mg/L	12.0	1.8 – 6.4	5.3 – 16.8
Fluoride	mg/L	0.26	0.17 – 0.47	0.16 – 0.77

Notes:
Lab: pH measured in laboratory
Field: pH measured in the field

SPLP testing was also used to assess the water quality expected from short-term interactions of water with CCR. As concentrations observed in SPLP leachates are partly a function of the liquid to solid ratio of the test conducted, results should not be directly compared to site waters. Instead, Piper diagrams and ion ratios allow for comparisons of relative concentrations of site waters to SPLP leachates.

The relative proportion of major ion concentrations in groundwater samples and potential boron, fluoride, and field pH sources are depicted on a Piper diagram in Figure 6. The Piper diagram indicates that the Q4 2019 groundwater samples from MW-10 shifted towards a more sulfate dominant signature, and closer to the CCR SPLP leachates and ditch water (Ditch_N_UR92) sample (surrogates for contact water) on the plot. The major ion signature of the Q2 2020, Q4 2020, and Q2 2021 groundwater samples shifted back towards the historical (May 2017 to June 2019) signatures, suggesting the groundwater quality change was temporary and transient. Similar proportions of major ions between MW-16-1 samples and surrogates for contact water (CCR SPLP leachates and the ditch water sample) limit the ability to make similar observations related to MW-16-1. As discussed in Section 2.5, the boron, fluoride, and field pH concentrations in Q2 2020, Q4 2020, and Q2 2021 groundwater samples generally shifted back towards the range of baseline measurements.

The shift in groundwater quality toward a potential source and then back toward the historical chemical signature is consistent with what would be expected if a stormwater runoff event temporarily influenced groundwater concentrations. If contact water flowed down existing CCR slopes and the haul road ramp on the north side of Upstream Raise 92 and ponded near the downgradient monitoring wells, the water is likely to have partially infiltrated into groundwater and influenced concentrations in nearby wells. After the storm and short-term contact water runoff infiltration event, the water quality signature of samples collected from a given downgradient well would return closer to the historical signature as the “plug” of infiltrated contact water migrates downgradient. A similar shift towards the CCR SPLP and ditch water sample signature in Q4 2019 samples and then back towards the historical signature in Q2 2020, Q4 2020, and Q2 2021 was also observed for the same sampling events in samples collected from nearby wells MW-51 and MW-16-0, which are also located to have seen potential contact water runoff from the north haul road ramp at Upstream Raise 92. The widespread observation of water quality changes in the area likely affected by contact water runoff on the north side of Upstream Raise 92 suggests a temporary change in groundwater quality due to ponding and infiltration of contact water.

A return towards the historical chemical signature would not be expected if an ongoing source, such as seepage from the CCR facility, caused the initial change in the major ion signature. Furthermore, if seepage from a CCR facility was impacting groundwater at MW-10 or MW-16-1, the groundwater geochemistry would be expected to shift towards the major ion signature of sump samples on the Piper diagram (Figure 6), which is not observed.

Figure 7 presents an ion ratio plot to further highlight differences between estimated contact water chemistry (based on CCR material SPLPs and ditch water) and facility seepage chemistry (based on sump water and porewater samples). Sump water and porewater samples have extended contact times with CCR materials and have higher chloride to sulfate and chloride to boron ratios relative to groundwater samples, CCR material SPLP leachates and ditch water. The groundwater samples collected in Q4 2019 from MW-10 and MW-16-1 appear to be impacted by a water source with higher concentrations of sulfate and boron relative to chloride (shifting to the upper-right), indicating impacts likely due to contact water runoff. Similar to observations from the Piper diagram, the groundwater samples collected in Q2 and Q4 2020 from MW-10 and MW-16-1 shift back towards their historical chemical signatures. The Q2 2021 samples from MW-10 and MW-16-1 overlap their historical (pre-2019) concentrations, which appears to indicate that the "plug" of infiltrated contact water is migrating away from these wells. These same temporal patterns are observed in MW-51 and to a lesser extent in MW-16-0, which are near MW-10 and MW-16-1 and likely experienced the same temporary impacts from contact water runoff during the September 2019 rain event.

3.3.2 Seepage from Upstream Raise 92

Seepage from Upstream Raise 92 has the potential to impact downgradient monitoring wells experiencing SSIs. The range of boron and fluoride concentrations, and pH values in samples collected from sumps and piezometers (porewater), MW-10, and MW-16-1 are presented in Table 2. Sump water and piezometer water (porewater) concentrations and pH values are elevated above groundwater concentrations and pH values in samples collected from MW-10 and MW-16-1. Therefore, seepage, if occurring, could increase concentrations at MW-10 and MW-16-1. However, as discussed in Section 3.3.1, the ion ratios presented in Figure 7 show that the Q4 2019 groundwater samples at MW-10 and MW-16-1 shifted away from the sump water and porewater signatures, making leakage from Upstream Raise 92 an unlikely source for the observed changes in boron, fluoride, and field pH.

The presence of the composite liner systems at Upstream Raise 92 reduces the likelihood of seepage. The composite liner on the west side of Upstream Raise 92 includes a 2-foot-thick compacted clay liner with a hydraulic conductivity of $1x10^{-7}$ centimeters per second (cm/sec) or less underlying a 40-mil high density polyethylene (HDPE) geomembrane. The composite liner on the east side of Upstream Raise 92 includes a 1-foot-thick compacted clay liner with a hydraulic conductivity of $1x10^{-7}$ cm/sec or less underlying a 60-mil linear-low density polyethylene (LLDPE) geomembrane.

Table 2: Summary of Select Concentrations in Sumps and Piezometers and Downgradient Well

Analyte	Units	Sumps and Piezometers Samples from Upstream Raise 91, Upstream Raise 92, and Southwest 16 (2018 – 2019)	MW-10 (Baseline and Detection Monitoring)	MW-16-1 (Baseline and Detection Monitoring)
pH	SU	7.5 – 10.5 (Lab)	6.74 – 7.54 (Field)	7.06 – 7.60 (Field)
Boron	mg/L	3.7 - 50	1.8 – 6.4	5.3 – 16.8
Fluoride	mg/L	0.18 - 70	0.17 – 0.47	0.16 – 0.77

4.0 EVIDENCE OF AN ALTERATIVE SOURCE

Primary lines of evidence and conclusions drawn from the evidence used to support this ASD are provided in Table 3. In summary, the SSIs identified for samples collected from MW-10 and MW-16-1 were not an indication of seepage from the CCR unit and can be primarily attributed to a contact water runoff event associated with a significant rain event in September 2019.

Table 3: Primary and Supporting Lines of Evidence from ASD Analysis

Key Line of Evidence	Supporting Evidence	Description
Hydrogeology	Groundwater elevations at monitoring wells around Upstream Raise 92	Q4 2019 increases in water levels in downgradient monitoring wells indicate a change in the hydrological regime downgradient of Upstream Raise 92, potentially reflecting the infiltration of contact water runoff from the upper CCR slopes and the north Upstream Raise 92 haul road ramp.
Engineering Controls	Upstream Raise 92 has a composite liner system	Upstream Raise 92 has composite liner systems consisting of compacted clay liner with a hydraulic conductivity of 1x10-7 cm/sec or less underlying a geomembrane, which decreases the likelihood of seepage from the facility.
Water Geochemistry	Relative ion abundances in groundwater differs from CCR facility porewater and sump water samples	The water quality signature of groundwater samples collected from downgradient wells MW-10 and MW-16-1 are not consistent with the signature of potential seepage from Upstream Raise 92, which is shown in two different ways on Figure 6 (Piper diagram) and Figure 7 (ion ratio plot). Groundwater chemistry results from MW-10 and MW-16-1 in Q4 2019 shift towards contact water (SPLP leachates and ditch water consistent with contact water runoff from the surface of the facility). In the Q2 2020, Q4 2020, and Q2 2021 samples, the groundwater chemistry associated with MW-10 and MW-16-1 shifted back towards their historical chemical signature, indicating a short-term impact, from infiltration of contact water runoff.

5.0 CONCLUSIONS

In accordance with 40 CFR Part 257.95(g)(3), this ASD has been prepared in response to the identification of verified SSIs for boron, fluoride, and field pH at monitoring well MW-10 and field pH and boron at monitoring well MW-16-1 following the Q2 2020, Q4 2020, and Q2 2021 sampling events for Upstream Raise 92 at Coal Creek Station.

Based on review of site analytical results, recent changes to boron, fluoride, and field pH concentrations in groundwater downgradient of Upstream Raise 92 are likely not a result of leakage from a CCR facility but instead can be attributed to a contact water runoff event associated with a significant rain event in September 2019. As a result, GRE performed the actions outlined in the Corrective Measures Report (Golder 2020c) to prevent runoff from CCR slopes or the Upstream Raise 92 north haul road ramp from migrating off the composite-lined facility footprint during future storm events. Therefore, no further action (i.e., a transition to assessment monitoring) is warranted, and Upstream Raise 92 will remain in detection monitoring.

6.0 REFERENCES

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Signature Page

Golder Associates USA Inc.

Gregory Lehn
Project Geochemist

Sara Harkins
Senior Geochemist

Todd Stong, PE
Associate and Senior Consultant

GL/SH/TS/df

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https://golderassociates.sharepoint.com/sites/140044/project files/6 deliverables/21451024c/reports/11-r-ccs_asd_mw10_mw16-1/11-r-0/21451024c-11-r-a-ccs_asd_mw10_mw16-1_29dec21.docx

Figures

LEGEND

- UPGRADIENT MONITORING WELL
- DRAINS POND SYSTEM DOWNGRADIENT WELL
- UPSTREAM RAISE 91 DOWNGRADIENT WELL
- UPSTREAM RAISE 92 DOWNGRADIENT WELL
- SOUTHEAST 16 DOWNGRADIENT WELL
- UPSTREAM RAISE 92 BOUNDARY
- 1890 POTENTIOMETRIC SURFACE CONTOURS (SEE NOTE 2)
- GENERAL DIRECTION OF GROUNDWATER FLOW

NOTE(S)

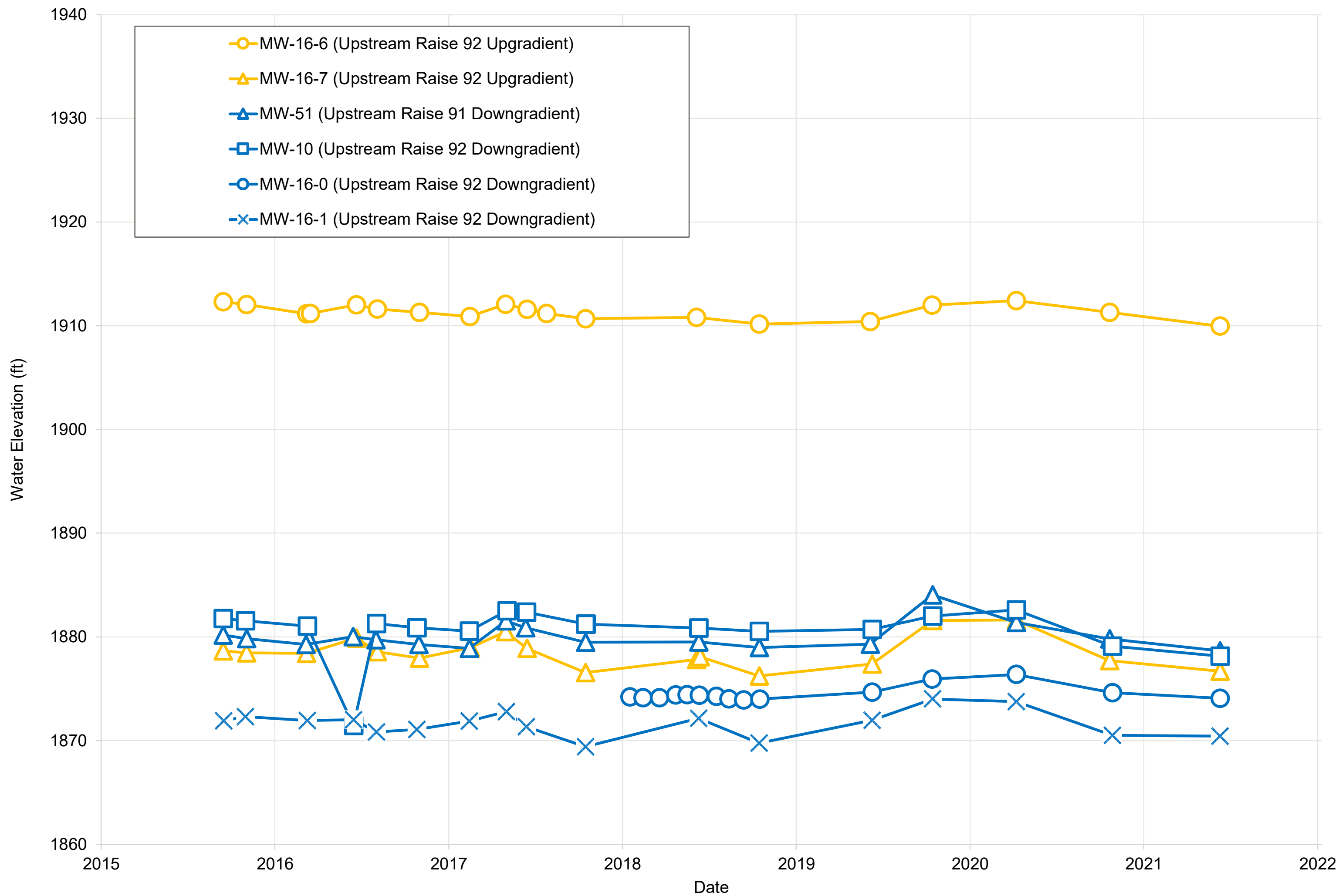
1. GROUNDWATER ELEVATIONS SHOWN WERE MEASURED MAY/JUNE 2021.
2. POTENTIOMETRIC SURFACE CONTOURS WERE CREATED USING WATER LEVEL INFORMATION FROM THE MAY/JUNE 2021 GROUNDWATER ELEVATIONS SHOWN, AS WELL AS SURVEYED SURFACE WATER EXPRESSIONS, ADDITIONAL SITE WELLS, AND PIEZOMETERS NOT SHOWN. CONTOUR INTERVAL IS 5 FEET.
3. AERIAL IMAGERY OBTAINED FROM UNITED STATES DEPARTMENT OF AGRICULTURE, NATIONAL AGRICULTURE IMAGERY PROGRAM, 2020.

0 200 400
1" = 200' FEET

GOLDER
MEMBER OF WSP

ALTERNATIVE SOURCE DEMONSTRATION
MAY-JUNE 2021 GROUNDWATER CONTOURS AND SAMPLING LOCATIONS

FIGURE 1



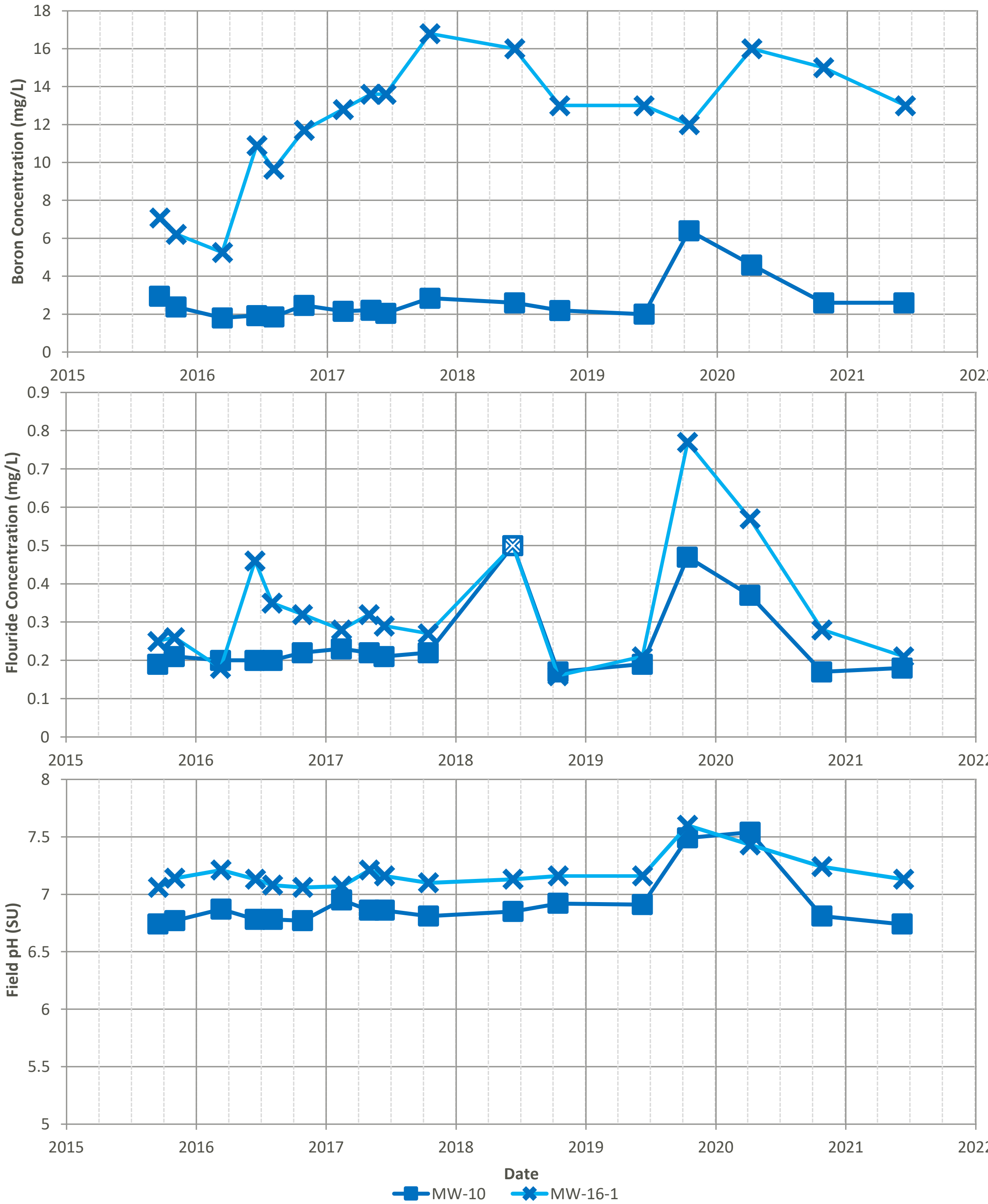
CLIENT
Great River Energy Coal Creek Station

PROJECT
Alternative Source Demonstration

CONSULTANT
GOLDER MEMBER OF WSP

TITLE
Time Series of Groundwater Elevations in Network Wells

PROJECT NO.	PHASE	REV.	FIGURE
21451024C	--	0	2



Note: Open symbol denotes measurement below the detection limit

CLIENT
Great River Energy Coal Creek Station

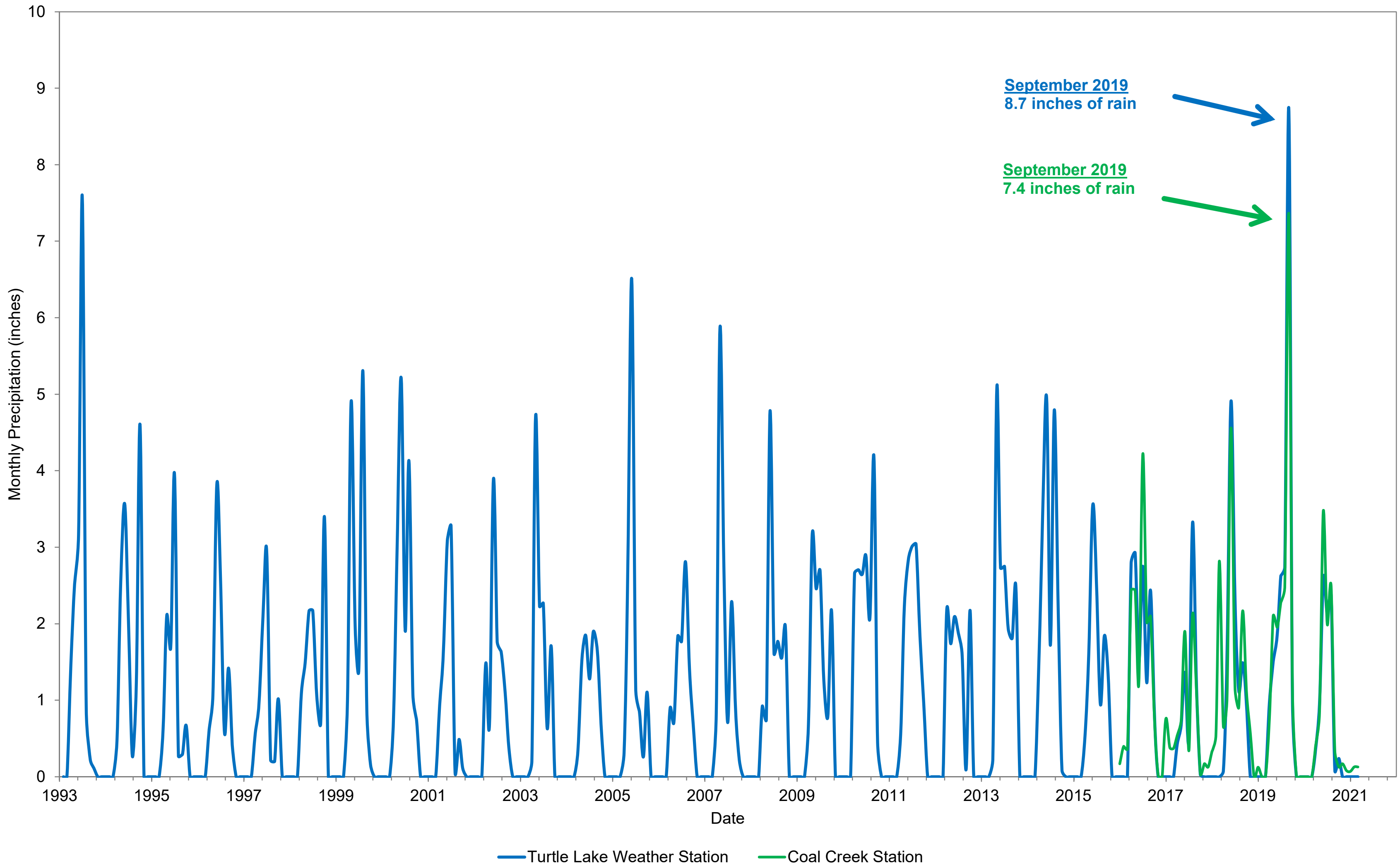
PROJECT
Alternative Source Demonstration

CONSULTANT
GOLDER MEMBER OF WSP

TITLE
Time Series of Boron, Fluoride, and pH in MW-10 and MW-16-1

PROJECT NO.	PHASE	REV.	FIGURE
21451024C	--	0	3

PATH: https://golderassociates.sharepoint.com/sites/140044/Project Files/5 Technical Work/6 - Water Quality/Q2 2021 ASDs | FILE NAME: CCS Q2 2021 ASD Working Data.xlsm



Note: Turtle Lake Weather Station is located approximately 20 miles northwest of Coal Creek Station.

CLIENT	PROJECT
Great River Energy Coal Creek Station	Alternative Source Demonstration

CONSULTANT: GOLDER MEMBER OF WSP

TITLE: Time Series of Monthly Precipitation at CCS and Turtle Lake, ND Weather Stations

PROJECT NO.	PHASE	REV.	FIGURE
21451024C	--	0	4

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A

LEGEND

- DOWNGRADIENT MONITORING WELL - UPSTREAM RAISE 91
- DOWNGRADIENT MONITORING WELL - UPSTREAM RAISE 92
- OTHER SAMPLING LOCATION
- DESIGNED CONTACT WATER FLOW PATH
- SUSPECTED CONTACT WATER RUNOFF

NOTE(S)

1. AERIAL IMAGERY OBTAINED FROM UNITED STATES DEPARTMENT OF AGRICULTURE, NATIONAL AGRICULTURE IMAGERY PROGRAM, 2019.

CLIENT
GREAT RIVER ENERGY
COAL CREEK STATION

PROJECT
ALTERNATIVE SOURCE DEMONSTRATION

CONSULTANT

GOLDER
MEMBER OF WSP

YYYY-MM-DD	2021-05-07
DESIGNED	DVS
PREPARED	DVS
REVIEWED	CCS
APPROVED	TJS

TITLE
UPSTREAM RAISE 92 NORTH RAMP

PROJECT NO.	PHASE	REV.	FIGURE
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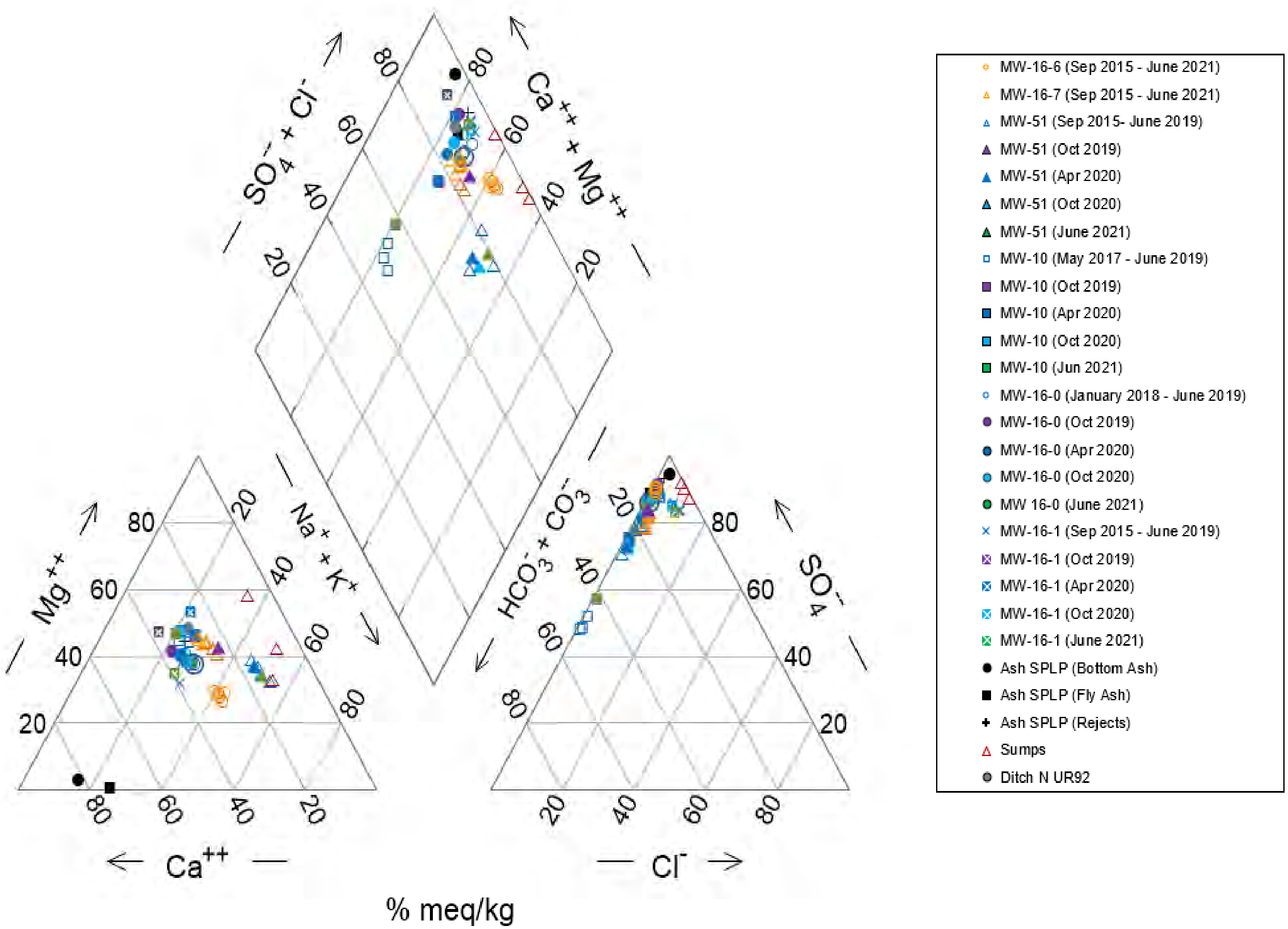
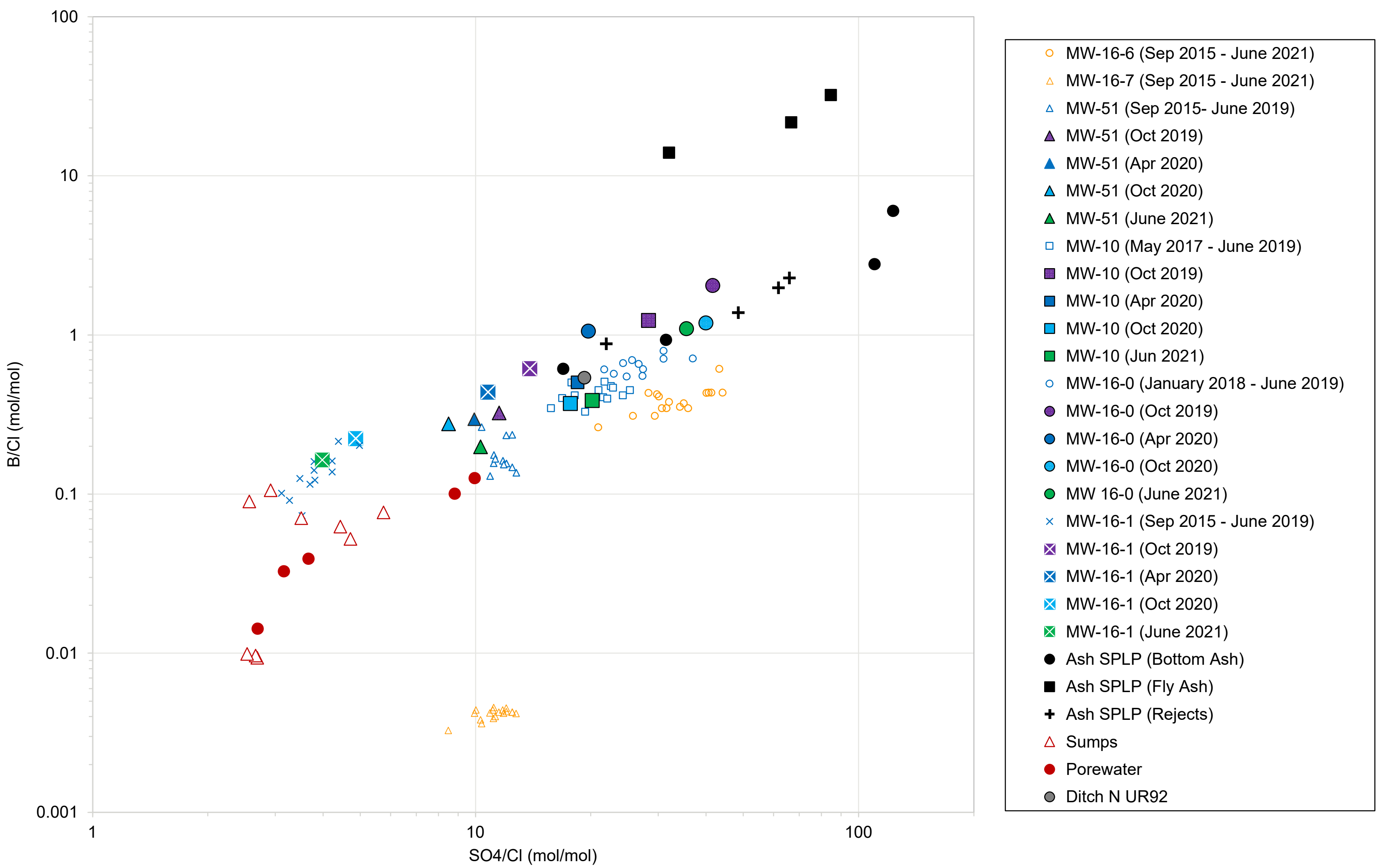


Note:
* Samples from Oct 2019 did not have alkalinity measurements so alkalinity was estimated as the difference between major cations (Ca, Mg, Na, K) and major anions (SO_4, Cl, F). This technique is less precise and should be regarded as a high-level estimate.

CLIENT	PROJECT
Great River Energy Coal Creek Station	Alternative Source Demonstration
CONSULTANT	TITLE
GOLDER MEMBER OF WSP	Piper Diagram

PROJECT NO.	PHASE	REV.	FIGURE
21451024C	--	0	6

PATH: https://golderassociates.sharepoint.com/sites/140044/Project Files/5 Technical Work/6 - Water Quality/Q2 2021 ASDs | FILE NAME: CCS Q2 2021 ASD Working Data.xlsm



Note: For concentrations measured below the detection limit, the detection limit was used to calculate the ratios.

CLIENT	PROJECT
Great River Energy Coal Creek Station	Alternative Source Demonstration

CONSULTANT: GOLDER MEMBER OF WSP

TITLE: Boron-Chloride versus Sulfate-Chloride Ratio Plot

PROJECT NO.	PHASE	REV.	FIGURE
21451024C	--	0	7

GOLDER
MEMBER OF WSP

golder.com

REPORT

Alternative Source Demonstration for Chloride in Monitoring Well MW-49

Great River Energy - Coal Creek Station

Submitted to:

Great River Energy

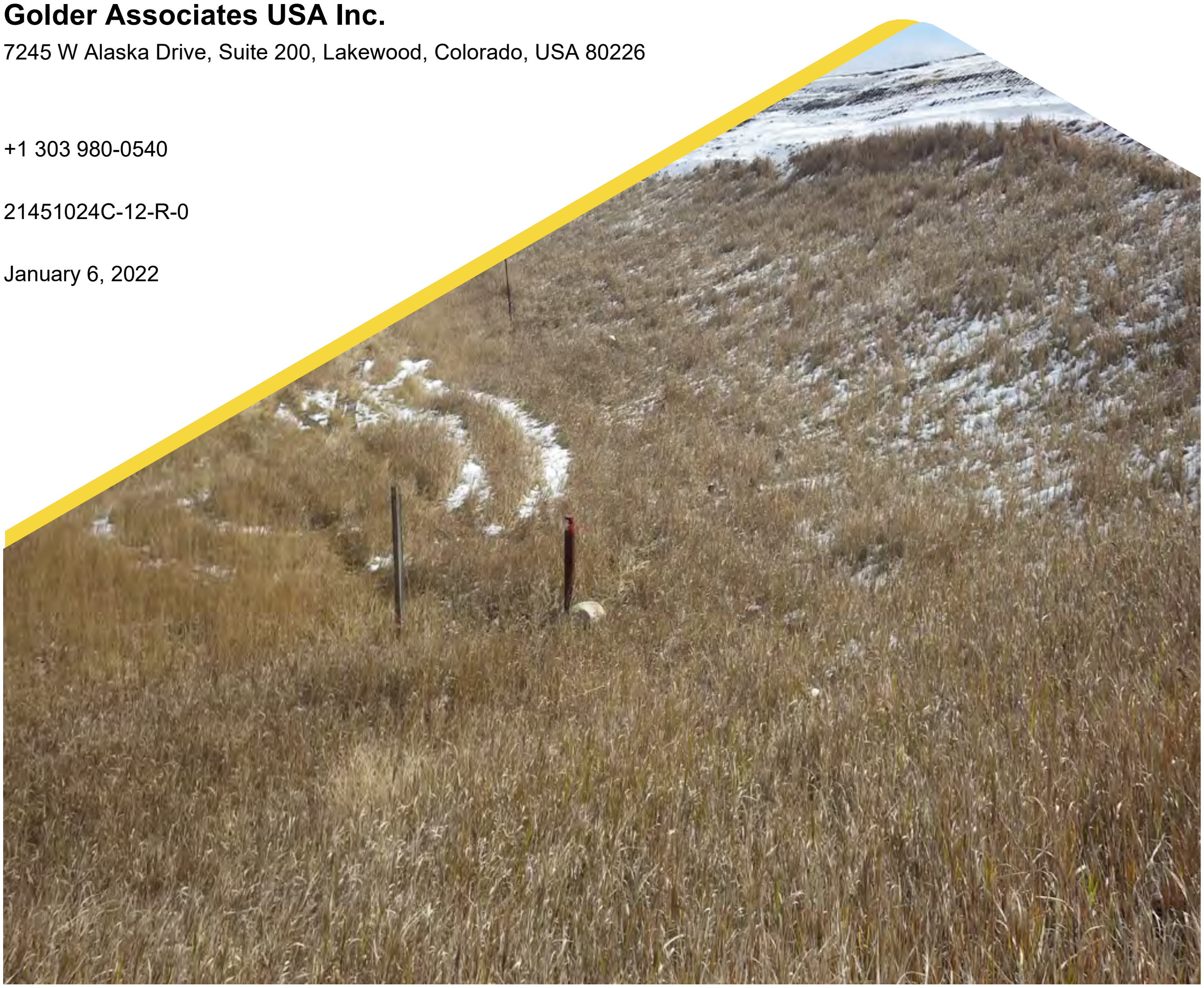
Coal Creek Station
2875 Third Street SW
Underwood, North Dakota 58576

Submitted by:

Golder Associates USA Inc.

7245 W Alaska Drive, Suite 200, Lakewood, Colorado, USA 80226

+1 303 980-0540



21451024C-12-R-0

January 6, 2022

Table of Contents

TABLES

FIGURES

1.0 INTRODUCTION

On behalf of Great River Energy (GRE), Golder Associates USA Inc. (Golder), member of WSP, performed a statistical evaluation of groundwater monitoring results from the second quarter (Q2) 2021 groundwater detection monitoring event at Coal Creek Station's (CCS's) Upstream Raise 91 coal combustion residual (CCR) surface impoundment. The statistical evaluation was performed as described in the Coal Combustion Residuals Groundwater Statistical Method Certification for Coal Creek Station, Revision 2 (Golder 2021b), in accordance with applicable provisions of United States Environmental Protection Agency (USEPA) 40 Code of Federal Regulations (CFR) Part 257, "Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities; Final Rule" (CCR Rule), as amended.

Statistical analyses of the Appendix III detection monitoring data for chloride in groundwater at the downgradient monitoring well MW-49 indicated a potential exceedance of the statistical limit based on the parametric Shewhart-CUSUM (cumulative summation) control chart analysis of the Q2 2019 sampling results. This potential exceedance was subsequently verified as a statistically significant increase (SSI) following the fourth quarter (Q4) 2019 detection monitoring sampling event. The Q2 2020, Q4 2020, and Q2 2021 detection monitoring results for chloride at MW-49 were also verified SSIs. Although determination of a verified SSI generally indicates that the groundwater monitoring program should transition from detection monitoring to assessment monitoring, 40 CFR Part 257.94(e)(2) allows the owner or operator (i.e., GRE) 90 days from the date of determining a verified SSI (October 8, 2021) to demonstrate a source other than the regulated CCR facility 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 the baseline data collection.

Golder's review of the hydrological and geologic conditions at the site and the sampling and analytical procedures indicates the SSI is not an indication of impacts from the CCR unit. A desktop study of previously collected CCR-impacted water from the facility, nearby surface water, and groundwater samples was conducted to assess potential chloride sources. As a part of this work, potential error in the statistical analysis, laboratory methods, and the natural variability of chloride concentrations in groundwater were evaluated. Based on this review and in accordance with provisions of the CCR Rule, Golder prepared this Alternative Source Demonstration (ASD) for chloride at MW-49 and the Upstream Raise 91 CCR surface impoundment. An ASD was initially developed following the Q4 2019 verified SSI (Golder 2020a) and updated and reissued following the Q2 2020 and Q4 2020 SSIs (Golder 2020b, Golder 2021a). In response to the identification of a verified SSI for the Q2 2021 detection monitoring event, the ASD was reviewed for ongoing applicability and updated where necessary.

This ASD conforms to the requirements of 40 CFR Part 257.94(e)(2) and provides the basis for concluding that the verified SSI for chloride at MW-49 is not an indication of a release from Upstream Raise 91. The following sections provide a summary of Upstream Raise 91, sampling procedures and analytical methods, analytical and geochemical assessment results, and lines of evidence demonstrating an alternative source for the increased chloride concentrations at MW-49.

2.0 BACKGROUND

2.1 Site Background

GRE's CCS is a coal-fired electric generation facility located in McLean County, approximately 10 miles northwest of Washburn, North Dakota. CCRs are managed in composite-lined surface water impoundment cells and dry landfills regulated and permitted by the North Dakota Department of Environmental Quality (NDDEQ) in accordance with North Dakota Administrative Code (NDAC) Article 33.1-20, Solid Waste Management and Land Protection.

CCS has four CCR facilities that are within the purview of the USEPA CCR Rule. This ASD only applies to the Upstream Raise 91 CCR surface impoundment. Upstream Raise 91 is located in the south-central portion of the plant site, east of the CCS plant buildings (Figure 1) and is used as a combined dewatering and storage facility for CCR including fly ash, bottom ash, economizer ash, and flue gas desulfurization (FGD) material.

2.2 Site Geology

CCS and McLean County are situated at the eastern-most extent of the Williston Basin, a structural and sedimentary basin (United States Geological Survey [USGS] 1999). The region is characterized by the presence of glacial drift, reaching thicknesses of several hundred feet and overlying the Sentinel Butte Member, the source of commercially mined coal in the direct vicinity of CCS (Falkirk 1979). The Sentinel Butte Member is the highest strata of the Paleocene Fort Union Formation, overlying the Tongue River, Ludlow, and Cannonball Members (USGS 1999). The Sentinel Butte Member is marked by drab-gray units, demarcating the separation from the lower Tongue River Member.

The site geology of CCS includes unconsolidated surficial deposits of the Coleharbor Formation, consisting of stratified and unstratified glacial drift. The near-surface materials are silty clay and sandy clay till with interbedded lenses (Cooperative Power Association and United Power Association [CPA/UPA] 1989).

2.3 Site Hydrogeology

Regional groundwater flow of the uppermost water-bearing unit in the vicinity of CCS is a subtle expression of the surface topography, which is influenced by the configuration of the eroded bedrock. Based on available groundwater elevation data, the shallow groundwater at the CCR facilities at CCS generally follows surface topography, flowing east and north towards Lower Samuelson Slough and Sayler Slough. Available groundwater elevation data indicate that groundwater in the area of Upstream Raise 91 generally flows from the southwest to northeast, diagonally across the footprint of the facility, towards Lower Samuelson Slough.

Hydraulic conductivities in the area of Upstream Raise 91 range from 0.01 feet per day (ft/day) to 56.69 ft/day, with calculated groundwater flow rates during Q2 2021 detection monitoring event ranging from 0.0004 to 1.93 ft/day.

2.4 Groundwater Monitoring Network

The groundwater monitoring network for Upstream Raise 91 was developed with consideration for the size, disposal and operational history, anticipated flow direction, and location of adjoining facilities. Based on these factors, a monitoring well network consisting of three downgradient monitoring wells is used for monitoring the unit under the CCR Rule. Groundwater upgradient of Upstream Raise 91 is monitored with two existing upgradient wells (Golder 2019).

The two upgradient monitoring wells (MW-75, MW-91-2) included in the groundwater monitoring network for Upstream Raise 91 are used to represent upgradient water quality flowing towards the unit from the west and south. The three downgradient wells (MW-49, MW-51, MW-91-1) are spaced along the northern edge of the facility. Upstream Raise 91 directly abuts Upstream Raise 92 on its eastern edge, preventing installation of monitoring wells along the eastern side of Upstream Raise 91 without jeopardizing the integrity of the liner system. The Upstream Raise 91 network wells are presented in Figure 1. Other monitoring locations used to support this ASD are also presented in Figure 1 and are discussed further in Section 5.0.

2.5 Groundwater Conditions

Between September 2015 and June 2017, GRE collected nine independent baseline groundwater samples from MW-75, MW-49, and MW-51, as required by 40 CFR Part 257.94, for use within the CCR Rule monitoring program. Baseline samples were collected from MW-91-2 and MW-91-1 between January 2018 and October 2018 following installation of the wells in late 2017. Prior to installation of MW-91-2 and MW-91-1 and completion of the baseline monitoring at the wells, Upstream Raise 91 and Upstream Raise 92 were monitored jointly under a monitoring network consisting of the wells near both units (Golder 2019). The results of the CCR baseline monitoring were used to develop appropriate statistical limits for each constituent at each monitoring well based on site and parameter specific conditions (Golder 2021b).

Following completion of the baseline monitoring events at each well, GRE began collecting groundwater samples on a semi-annual basis to support the detection monitoring program. Groundwater samples for detection monitoring are collected at each upgradient and downgradient monitoring well and analyzed for 40 CFR Part 257 Appendix III constituents. During the detection monitoring program, results from groundwater analysis are compared to the statistical limits calculated from the baseline monitoring results to determine whether groundwater quality remains consistent, or if changes in groundwater quality are observed.

Chloride concentrations in groundwater at MW-49 during the baseline monitoring period ranged between 59.2 and 67.1 milligrams per liter (mg/L) in the nine baseline samples collected as part of the CCR Rule monitoring program. The Shewhart-CUSUM statistical limit for the well-constituent pair was set at 73.9 mg/L.

The Q2 2019 detection monitoring event reported a chloride concentration of 70.0 mg/L at MW-49, with a calculated CUSUM value of 77.4 mg/L, exceeding the statistical limit. Verification resampling was conducted during the Q4 2019 detection monitoring event, confirming the SSI for chloride at MW-49 with a chloride concentration of 71.0 mg/L and a calculated CUSUM value of 83.8 mg/L. The Q2 2020, Q4 2020, and Q2 2021 chloride results at MW-49 were within the range of baseline analytical values, with chloride concentrations of 60.0 mg/L, 64.0 mg/L, and 65.0 mg/L. However, the results remain verified SSIs based on the calculated CUSUM values of 85.3 mg/L, 84.2 mg/L, and 84.0 mg/L, which were greater than the statistical limit.

2.6 Sampling and Laboratory Testing Procedures

As part of the ASD, a review was conducted of the sampling and laboratory testing procedures used throughout baseline monitoring and detection monitoring to date, along with the collected results. A review of the statistical assessment methods and associated results found the procedures followed during baseline and detection monitoring to be consistent with the stated procedures listed in the published Groundwater Statistical Methods Certification (Golder 2021b). Calculated limits were found to be consistent with the chosen statistical procedures and recommended methodology found within the Unified Guidance (USEPA 2009).

In review of the analytical results, a shift in the MW-49 chloride concentrations was noted between data collected prior to June 2018 and data collected after June 2018. This shift was evaluated with a Wilcoxon rank-sum test, which showed statistical significance at the 95 percent confidence level (Figure 2). The Wilcoxon rank-sum test determines if measurements from one population are significantly different than measurements from another population. This test is non-parametric, meaning that the data are not assumed to fit a specific distribution, such as a normal distribution.

Beginning in June 2018 (Q2 2018, the second semi-annual detection monitoring event), GRE switched sampling staff. The potential impacts of this change are evaluated in Section 3.0. Also beginning in June 2018 (Q2 2018, the second semi-annual detection monitoring event), GRE switched analytical laboratories from Minnesota Valley Testing Laboratories, Inc. (MVTL; Bismarck, North Dakota) to Eurofins TestAmerica (TestAmerica; Denver laboratory in Arvada, Colorado). There are differences between the testing methodologies used for chloride by the two laboratories. An evaluation of the methods and their associated differences is discussed in Section 4.1.

3.0 POTENTIAL SAMPLING CAUSES

Between September 2015 and May 2018, sampling of the CCR Rule wells and other wells and surface water sampling locations at CCS was conducted by outside contractors from the Bismarck, North Dakota, location of MVTL. Beginning with the samples collected in June 2018, sampling has been conducted in-house by GRE employees. Low-flow pumps and sampling methods have been used to collect groundwater samples throughout the monitoring program for the CCR Rule, following manufacturer recommendations (Geotech 2015) and USEPA guidance (USEPA Region I 2017). Although using the same sampling methods, there is a potential for minor differences in sampling technique between sampling personnel. The timing of the change in sampling personnel coincides with both the June 2018 shift in chloride concentrations and the change in laboratories described in Section 2.6.

4.0 POTENTIAL LABORATORY SOURCES

4.1 Changes in Testing Methodology

Prior to June 2018, GRE contracted MVTL as their analytical testing laboratory for the monitoring program for the CCR Rule. For analysis of chloride, MVTL used a variation of the SM4500-Cl- method (published variations of the method are labeled SM4500-Cl-A through SM4500-Cl-I; Standard Methods Online 2018). In the most recent sampling prior to the analytical laboratory switch, MVTL used method SM4500-Cl- E, Chloride by Automated Ferricyanide Method. Instrumentation for the method is an automated spectrophotometer, as the method is a colorimetric means of measuring chloride in water. All variations of SM4500-Cl are only applicable for testing chloride and are not indicated for use for other analytes.

Under typical use of the method, the applicable concentration range is 1 to 200 mg/L of chloride, which can be extended to higher and lower concentrations by dilution, adjustment of sample size, and other typical testing adjustments (USGS 2002a). The typical chloride reporting limit provided by MVTL was 1.0 mg/L. Although not reported within MVTL's laboratory information management system at the time of testing, dilutions to the sample results are likely to have occurred, given the range in chloride concentrations reported using the method between 2015 and 2018 (1.1 to 697 mg/L for samples collected as part of the monitoring program at CCS for the CCR Rule).

Beginning with the June 2018 sampling events for the CCR Rule groundwater monitoring program, GRE contracted TestAmerica as their analytical testing laboratory. For analysis of chloride, TestAmerica has used method SW9056A, the Determination of Inorganic Anions by Ion Chromatography (USEPA 2007). Ion chromatography identifies and separates different ions based on their affinity to an ion exchanging resin, which is packed in a flow-through column. The separated ions elute off the column at different times, characteristic to the ion size and charge, and are measured using an electrical conductivity meter, generating a series of peaks as the different ions leave the column (Figure 3). Relative to a baseline level of conductivity, the area of each peak is proportional to the ion's concentration in the sample. The peak area is compared to the peak areas generated by known concentrations in calibration standards to derive a sample concentration. In the case of method SW9056A, the specified analytical column (i.e., the ion exchanger), is required to be suitable for analyzing for chloride, fluoride, bromide, nitrate, nitrite, phosphate, and sulfate.

The typical chloride reporting limit provided by TestAmerica at the Denver laboratory was 3.0 mg/L. Dilutions have varied across samples, ranging from 1x dilution factors (i.e., no dilution and a reporting limit of 3.0 mg/L) to 50x dilution factors (with a corresponding reporting limit of 150 mg/L). Due to the capacity of the method for testing multiple anions, indiscriminate dilution intended to account for high concentrations of one anion, particularly in accounting for samples with higher sulfate concentrations as found at CCS, can negatively impact outcomes for the other anions measured by the method, resulting in non-detect results with excessive dilutions. This aspect is particularly salient due to the base application of the method, as loading of the ion exchange column within the ion chromatograph should not exceed concentrations of approximately 500 parts per million (ppm) (equivalent to 500 mg/L) of total anions within the sample when the sample to be tested is undiluted (USGS 2002b).

In comparing the methodologies used by the two laboratories, a few specific differences are apparent. First, the two methods analyze for chloride using fundamentally different mechanisms. Method SM4500-Cl- E uses spectrophotometry, which measures to what extent a chemical of interest absorbs light by passing a light source through a sample. Differentiation of chemical compounds is based on the principle that each compound will absorb light over a specific range of wavelengths (Standard Methods Online 2018; USGS 2002a). Method SW9056A uses ion chromatography, quantifying the species of interest based on their affinity for an ion exchanger (USEPA 2007; USGS 2002b). Due to the difference in mechanisms between the methods, samples that are analyzed by the two methods would be anticipated to show slightly different results, even if tested portions are drawn from the same sample.

Second, larger differences between quantified results could be anticipated in samples with complex matrices, particularly those with large concentrations of other anions measured through the SW9056A methodology. Although the ion exchangers used within ion chromatography are specific to each method, the column specified by SW9056A is intended to account for the affinity of the complete list of analytes specified by the method in sequential order (USEPA 2007). In samples at CCS, concentrations of sulfate alone, as the final sequential anion within the method, often exceed the total anion loading of the methodology prior to dilution of samples. As the concentrations of chloride are less than those of sulfate within samples from CCS based on previously collected information and geochemical water-typing, masking of the intended analyte by other anions intended for quantification could skew results. Appropriate calibration across multiple concentration ranges is intended to prevent this issue. However, based on past included laboratory qualifiers and explanations within laboratory narratives, pinpointing a group of ranges across samples can prove difficult.

One further difference between the results from the two laboratories are the number of significant digits reported within sample results. Results for chloride using method SM4500-Cl-E from MVTL were reported with three significant digits, while TestAmerica reports results for chloride using method SW9056A using only two significant digits. This difference in precision between the two laboratories may be subtle given the concentrations of chloride across samples, but could result in a difference in population medians, signifying a shift in concentrations with no cause from the facility. Similar differences are noted in the number of significant digits reported for boron, calcium, sulfate, and total dissolved solids between reporting from the two analytical laboratories.

4.2 Ion Chromatography

In addition to comparing differences between the chloride methods, Golder reviewed TestAmerica's SW9056A standard operating protocols and reviewed the ion chromatography output data to look for practices that have the potential to bias chloride concentrations towards higher values.

The quality of ion chromatography measurements is dependent on consistency in data processing, especially with respect to the peak area conversion to concentration. For example, the following aspects should be handled consistently:

- the time window used to calculate the area under a peak
- the method for determining baseline conductivity
- the approach for dealing with minor peaks that elute from the column at the same time as an analyte of interest

These data processing calculations are automatically performed by the instrument software and can result in minor differences between samples and standards. While TestAmerica checks ion chromatograph data to confirm that the instrument software is functioning consistently, there is a range of variability in the software data processing practices that is tolerated and the decision on whether to manually adjust the software-calculated concentrations by manually selecting peaks is the responsibility of TestAmerica personnel.

Golder's review of the TestAmerica ion chromatography data identified several data processing practices that have the potential to bias towards higher chloride concentrations (Figure 4). These include:

- using a longer integration time for samples compared to calibration standards
- selecting a lower baseline in samples relative to calibration standards
- including minor shoulder peaks in sample chloride peaks when they were excluded from calibration standard chloride peaks

These practices were implemented in the processing of the ion chromatographs for the MW-49 samples collected between June 2018, and October 2019, and have the potential to bias high the chloride concentrations by up to 4.2 percent. Golder discussed the data processing practices with TestAmerica after an internal review, and TestAmerica deemed the practices as within the range of acceptable variability and a revision to the originally reported values was not warranted (D. Bieniulis, personal communication, May 8, 2020). While up to a 4.2 percent difference is relatively small, this difference could account for part of the June 2018 shift in MW-49 chloride concentrations described in Section 2.5 and result in identification of an SSI. Data collected in Q2 2020, Q4 2020, and Q2 2021 suggest the laboratory is more closely monitoring the peak selection process for the ion chromatographs, but these laboratory practices will continue to be monitored for changes in future analysis.

5.0 POTENTIAL SITE CHLORIDE SOURCES

To assess the potential sources for a change in chloride concentrations at MW-49, Golder reviewed recent site changes upgradient of Upstream Raise 91, as well as previously collected data from the CCR Rule program and other site monitoring data that are collected under other programs. The following sections summarize the supplemental assessment activities.

5.1 Site Changes and Potential Impacts

The following sections discuss site changes and potential impacts associated with those changes over the last 40 years. Site changes may have affected constituent concentrations entering the groundwater system or the hydrologic and hydrogeologic conditions (water balance) of the site.

5.1.1 Construction History and Liner System

Upstream Raise 91 was constructed on the historic footprint of the South Ash Pond, which was built in the late 1970s on a foundation of re-compacted site soils (glacial tills) and put into service in 1979. In 1981, the South Ash Pond was taken out of service to reconstruct the clay liner and was put back into service from 1982 until 1987, at which point CCR materials were removed, and the geometry of the South Ash Pond footprint was modified. Monitoring wells MW-49, MW-51, and MW-75 were installed near Upstream Raise 91 in 1988 and chloride has been analyzed since that time on an approximately semi-annual basis as part of the NDDEQ monitoring program.

Chloride concentrations in MW-49 increased significantly shortly after monitoring began in the late 1980s due to likely impacts from the South Ash Pond. In 1993, Upstream Raise 91 was deepened and a new composite liner consisting of a 2-foot-thick compacted clay liner underlying a 40-mil high-density polyethylene (HDPE) geomembrane was installed. Beginning in 1996, chloride concentrations started a downward trend, decreasing by approximately 50 percent over a 10-year period (approximately from a high of 170 mg/L to 85 mg/L). This decrease in chloride concentrations is likely a result of construction of the composite liner system. Overall, chloride concentrations decreased approximately 60 percent from 1996 to 2020 (from a high of approximately 170 mg/L to 70 mg/L).

5.1.2 Duck Pond and Drains Pond System Construction

Beginning in 2015, the drainages on the west and northwest sides of Upstream Raise 91 were modified to allow for construction of an expansion to the Drains Pond System. As a part of this construction, modifications to the existing drainage upgradient of Upstream Raise 91 were required and the composite-lined west and center cells of the Drains Pond System were constructed. In late 2019, the east cell of the Drains Pond System was closed by removal of CCR. In early 2020, the east cell was returned to operation as a non-CCR surface impoundment for the management of site process water and continues to be monitored by the Drains Pond System groundwater monitoring network.

Historically, the Duck Pond area was a low-lying area west of Upstream Raise 91. The depth of water contained in this area was generally 12 feet (water surface elevation approximately 1,911 feet) and the Duck Pond had a surface area of approximately three acres. As the water level increased, overflow passed through culvert piping to the north under what is now the center cell of the Drains Pond System. As part of the construction in 2015, the Duck Pond was dewatered, the area was graded, and culverts were installed to drain surface water south and east around the south side of Upstream Raise 91.

5.2 Data Sources

To determine if recent site changes upgradient of Upstream Raise 91 have impacted water quality in MW-49, the sampling locations and dates for groundwater, surface water, and contact water results were reviewed for each potential source provided below (see Figure 1 for locations).

5.2.1 Upstream Raise 91

Data collected between September 2015 and June 2021[1] for the CCR Rule monitoring program were considered in the evaluation. As part of the monitoring program, field personnel collected groundwater samples from the following monitoring wells:

- upgradient to Upstream Raise 91: MW-75 and MW-91-2
- downgradient from Upstream Raise 91: MW-49, MW-51, and MW-91-1

Additionally, results for three samples of ash contact water collected between 2018 and August 2021 from the Upstream Raise 91 sump (Sump-UR91) were available for the evaluation.

5.2.2 Drains Pond System

Data collected between September 2015 and June 2021 for the CCR Rule monitoring program were considered in the evaluation. As part of the monitoring program, field personnel collected groundwater samples from the following monitoring wells:

- upgradient to the Drains Pond System: MW-DP3 and MW-DP5
- downgradient from the Drains Pond System: MW-DP1, MW-DP2, MW-DP2B, and MW-DP4

Additionally, results for 20 samples collected between 2014 and 2021 of ash contact water collected from the surface of the east cell of the Drains Pond System (Drains Pond, SW-DP101) were used in the evaluation.

5.2.3 Upgradient Plant Cooling Water

Groundwater potentially influenced by upgradient plant cooling water is monitored at the following locations:

- Upgradient to the powerplant: MW-96
- Downgradient from the Extended Basin: MW-62, MW-63, and MW-65
- EEG wells: MW-17-1, MW-17-2, MW-17-3, MW-17-4, and MW-17-5 (these wells were installed to monitor a historical leak in the fuel line to the Emergency Engine Generator)

For the plant wells, results from samples collected between October 1988 and May 2021 were considered for this evaluation. The EEG wells were installed in Q4 2017, and results included in this evaluation were for samples collected between January 2018 and June 2021.

Additionally, results for samples collected between May 1980 and June 2021 from the Extended Basin (SW-107) were used in the evaluation.

5.3 Evaluation of Potential Sources

Figure 5 displays a map of the locations and observed chloride concentrations (both the Q2 2021 concentration and the range of chloride values observed in baseline and detection monitoring) for the monitoring wells and surface water sources described in Section 5.2. As shown in Figure 1, groundwater generally flows from the southwest to the northeast. To assist with the identification of potential chloride sources to MW-49, Figure 6 compares the ranges of chloride concentrations for the monitoring wells and surface water sources on the site

[1] June 2019 samples from MW-91-1 and MW-91-2 not used because of a suspected quality control issue.

with a box and whisker plot. Figure 7 displays a scatter plot of the sulfate to chloride ratio versus the calcium to chloride ratio as a method of comparing water qualities across the site. Piper plots were not used due to the lack of consistently having the full suite of cations and anions for the different potential chloride sources at the site.

Several potential sources can influence chloride concentrations in groundwater at CCS, including infiltration of plant cooling water via the Extended Basin, seepage from the Drains Pond System, and seepage from Upstream Raise 91. These three potential sources of chloride are described in the following subsections. The data suggests that the increase in chloride concentration at MW-49 chloride is due to a change in the hydrological flow regime caused by the 2015 removal of the Duck Pond. This change likely increased the proportion of water with elevated chloride from the Extended Basin, affecting chloride concentrations at MW-49 that resulted in the SSIs.

5.3.1 Upstream Raise 91

The chloride concentrations measured in the samples from the Sump-UR91 (790 to 950 mg/L) are higher than groundwater concentrations and indicates that seepage (if occurring) from Upstream Raise 91 could increase chloride concentrations in MW-49. The presence of the liner system at Upstream Raise 91 (a 2-foot-thick compacted clay liner with a hydraulic conductivity of 1×10^{-7} centimeters per second [cm/sec] or less underlying a 40-mil HDPE geomembrane) reduces the likelihood of seepage to groundwater. Figure 7 indicates that contact water in the Sump-UR91 sump has lower calcium to chloride ratios and lower sulfate to chloride ratios than water observed at MW-49. If seepage from Upstream Raise 91 was impacting groundwater at MW-49, a shift in both of these ratios in samples identified as SSIs from MW-49 (Q4 2018 through Q2 2021) towards those observed from the Sump-UR91 would be expected. A shift towards the Sump-UR91 signature was not observed in Figure 7 for the samples identified as SSIs.

5.3.2 Drains Pond System

Given the physical proximity of the east cell of the Drains Pond System to MW-49 and the elevated chloride concentrations observed in the surface water of the east cell of the Drains Pond System (125 to 827 mg/L), seepage (if occurring) from the east cell of the Drains Pond System could have the potential to elevate chloride concentrations at MW-49. The presence of the liner system of the east cell of the Drains Pond System (a 2-foot-thick compacted clay liner with a hydraulic conductivity of 1×10^{-7} cm/sec or less underlying a 40-mil HDPE geomembrane) reduces the likelihood of seepage to groundwater. Contact water in the east cell of the Drains Pond System has lower calcium to chloride ratios than water observed in MW-49 (Figure 7). If seepage from the Drains Pond System was impacting groundwater at MW-49 a shift in the calcium to chloride ratios in the samples identified as SSIs from MW-49 (Q4 2018 through Q2 2021) towards those observed from the east cell of the Drains Pond System would be expected. A shift towards the Drains Pond System signature was not observed in Figure 7 for the samples identified as SSIs.

5.3.3 Upgradient Plant Cooling Water

To the west of CCS, water used for plant cooling is contained in the Extended Basin, which holds approximately 60 million gallons and is clay lined. The Extended Basin water originates from the Missouri River but is cycled up to 15 times through the cooling towers. As the water is cycled, heat from the powerplant drives evaporation, which concentrates the constituents in the Extended Basin. Between 1980 and 2021, chloride concentrations in the Extended Basin ranged between 73 and 330 mg/L.

Nearby monitoring wells (MW-62, MW-63, and MW-65) located upgradient of the powerplant and immediately adjacent to the Extended Basin also have elevated chloride concentrations ranging from 8.0 to 290 mg/L indicating that water from the Extended Basin is impacting groundwater chloride concentrations. The elevated chloride concentrations from the Extended Basin show considerable increases relative to MW-96, a background well for the plant that is side-gradient to the Extended Basin. Chloride concentrations at MW-96 range between 4.2 and 7.8 mg/L.

The water from the Extended Basin also appears to be impacting wells further downgradient. The concentrations observed along the flow path from the Extended Basin towards MW-49 include the following:

- The EEG wells located east of the Extended Basin have chloride concentrations ranging between 58 and 190 mg/L.
- Well MW-DP5 downgradient from the plant and upgradient of the Drains Pond System has chloride concentrations ranging between 62.0 and 84.8 mg/L. Well MW-DP3 also upgradient of the Drains Pond has chloride concentrations ranging between 8.6 and 30 mg/L, where the highest value (30 mg/L) represents a non-detect value. The highest detected chloride concentration in samples from MW-DP3 was 19.8 mg/L
- Wells MW-91-2 and MW-75 upgradient of Upstream Raise 91 and side gradient to the Extended Basin have chloride concentrations between 1.1 and 30 mg/L, where the highest value (30 mg/L) represents a non-detect value at MW-91-2. The highest detected chloride concentration in samples from MW-91-2 was 16.8 mg/L.

Variations in screened lithology and preferential flow paths in the glacial till may explain why some wells downgradient of the Extended Basin show elevated chloride concentrations while other wells (MW-DP3, MW 91-2, and MW-75) have chloride concentrations similar to MW-96.

Figure 7 demonstrates that surface waters from the Extended Basin may be influencing ion ratios in groundwater samples from monitoring wells upgradient of Upstream Raise 91, including MW-62, MW-63, MW-65, MW-17-2, and MW-17-5, and monitoring wells downgradient of Upstream Raise 91, including MW-49 and MW-91-1.

The recent removal of the Duck Pond and regrading of the area directly upgradient of the Drains Pond System potentially altered the hydrological flow paths to MW-49 and increased the proportion of water with elevated chloride from the Extended Basin relative to other groundwater sources monitored at MW-49. In addition to the changing flow paths, the removal of the Duck Pond also eliminated infiltration of water from the Duck Pond to groundwater, which may have provided a dilution effect on groundwater concentrations upgradient of MW-49.

6.0 EVIDENCE OF AN ALTERNATIVE SOURCE

Primary lines of evidence and conclusions drawn from the evidence used to support this ASD are provided in Table 1. In summary, the chloride SSI in MW-49 is not likely an indication of a release from Upstream Raise 91. Instead, the change in chloride concentration is potentially a reflection of sampling and laboratory changes and/or changes in the groundwater flow regime related to the removal of the Duck Pond that have increased the proportion of water with elevated chloride from the Extended Basin relative to other groundwater sources monitored at MW-49.

Table 1: Primary and Supporting Lines of Evidence from ASD Analysis

Key Line of Evidence	Supporting Evidence	Description
Change in field personnel	Changed to site personnel from MVTL	Although using the same sampling methods, there is a potential for minor differences in sampling technique between sampling personnel. The timing of the change in sampling personnel coincides with the June 2018 shift in chloride concentrations.
Change in laboratory and methodology	Changed to TestAmerica from MVTL	The timing of the change in laboratory coincides with the June 2018 shift in chloride concentrations.
	Change from potentiometric method (SRM 4500-CL) to ion chromatography method (SRM 9056A)	Prior to June 2018, MVTL used method SM4500-Cl- E to measure chloride concentrations. Starting in June 2018, TestAmerica analyzed chloride concentrations by SW9056A. These methods have different mechanisms, detection limits, and matrix effects. The timing of the change in methodology coincides with the June 2018 shift in chloride concentrations.
Laboratory artifact biasing high sample concentrations	Ion chromatographs reflecting different data processing practices between some calibration standards and samples	Golder's review of the TestAmerica ion chromatography data identified several data processing practices (integration time length, baseline selection, and treatment of minor peaks) that have the potential to bias high chloride concentrations (Figure 4).
Groundwater geochemistry	Relative ion abundances in groundwater differs from Upstream Raise 91 sump water and surface water collected from the east cell of the Drains Pond system	The water quality signature of groundwater samples collected from downgradient well MW-49 are not consistent with the signature of potential seepage from Upstream Raise 91 or the east cell of the Drains Pond System. As presented in Figure 7, differences in calcium–chloride and sulfate–chloride ratios are distinctly different between the ash-impacted waters and the downgradient groundwater samples, including from MW-49.
Local sources of chloride	Elevated chloride concentrations in the Extended Basin and other wells downgradient of the Extended Basin	Figure 6 suggests that chloride concentrations in the plant cooling water (Extended Basin) are impacting groundwater chloride concentrations in wells downgradient from the Extended Basin. Similarities in the ion ratios between water samples collected from MW-49, the Extended Basin, and wells immediately downgradient of the Extended Basin (Figure 7) suggest that the Extended Basin may be a potential source of elevated chloride at MW-49.
	Hydrogeology	The removal of the Duck Pond in 2015 and regrading of the area directly upgradient of the Drains Pond System potentially altered the hydrological flow paths, resulting in higher chloride concentrations at MW-49. This would be due to an increase in the proportion of groundwater potentially impacted by the Extended Basin and the removal of the more dilute water infiltrating from the Duck Pond.

7.0 CONCLUSION

In accordance with 40 CFR Part 257.95(g)(3), this ASD has been prepared in response to the identification of a verified SSI for chloride at monitoring well MW-49 following the Q2 2021 sampling event for Upstream Raise 91 at CCS.

Based on review of historical analytical results and testing procedures, recent changes to chloride concentrations in groundwater at MW-49 are likely not a result of seepage from Upstream Raise 91. There are two potential alternative sources, laboratory and sampling artifacts and variability in the upgradient groundwater sources. Therefore, no further action (i.e., a transition to assessment monitoring) is warranted, and Upstream Raise 91 will remain in detection monitoring.

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Signature Page

Golder Associates USA Inc.

Gregory Lehn, PhD
Project Geochemist

Todd Stong, PE
Associate and Senior Consultant

Sara Harkins, PG (WY)
Senior Geochemist

GL/TS/SH/df

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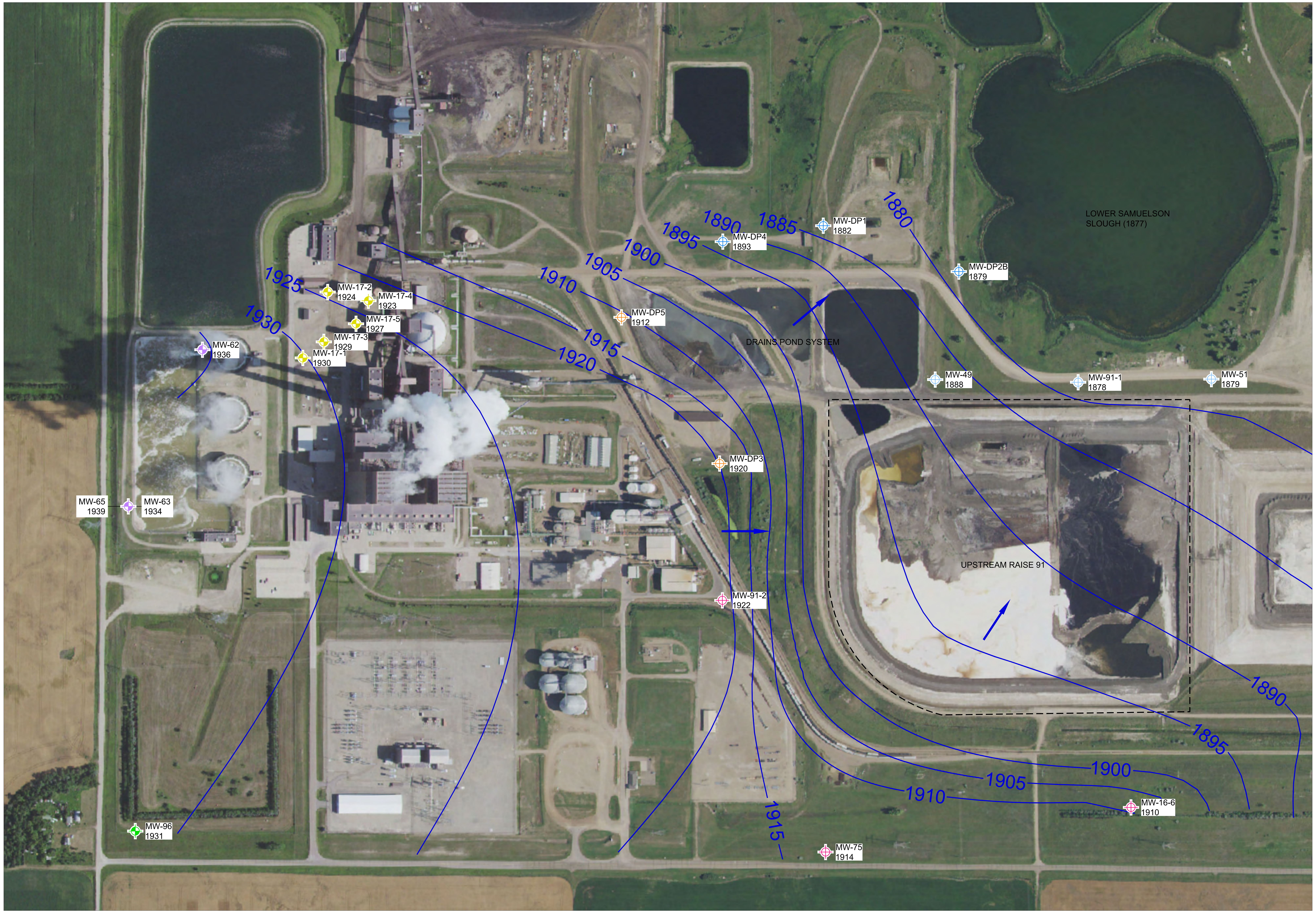
https://golderassociates.sharepoint.com/sites/140044/project files/6 deliverables/21451024c/reports/12-r-ccs_asd_chloride_mw49/12-r-0/21451024c-12-r-0_asd_chloride_mw49_06jan22.docx

Figures



LEGEND

- NDDEQ PLANT AREA UPGRADIENT WELL
- NDDEQ PLANT AREA DOWNGRADIENT WELL
- EEG PROGRAM WELL
- DRAINS POND SYSTEM UPGRADIENT WELL
- DRAINS POND SYSTEM DOWNGRADIENT WELL
- UPSTREAM RAISE 91 UPGRADIENT WELL
- UPSTREAM RAISE 91 DOWNGRADIENT WELL
- GENERAL DIRECTION OF GROUNDWATER FLOW
- 1890 POTENTIOMETRIC SURFACE CONTOURS (SEE NOTE 2)
- UPSTREAM RAISE 91 BOUNDARY

NOTE(S)

1. GROUNDWATER ELEVATIONS SHOWN WERE MEASURED MAY/JUNE 2021.
2. POTENTIOMETRIC SURFACE CONTOURS WERE CREATED USING WATER LEVEL INFORMATION FROM THE MAY/JUNE 2021 GROUNDWATER ELEVATIONS SHOWN, AS WELL AS SURVEYED SURFACE WATER EXPRESSIONS, ADDITIONAL SITE WELLS, AND PIEZOMETERS NOT SHOWN. CONTOUR INTERVAL IS 5 FEET.
3. AERIAL IMAGERY OBTAINED FROM UNITED STATES DEPARTMENT OF AGRICULTURE, NATIONAL AGRICULTURE IMAGERY PROGRAM, 2020.

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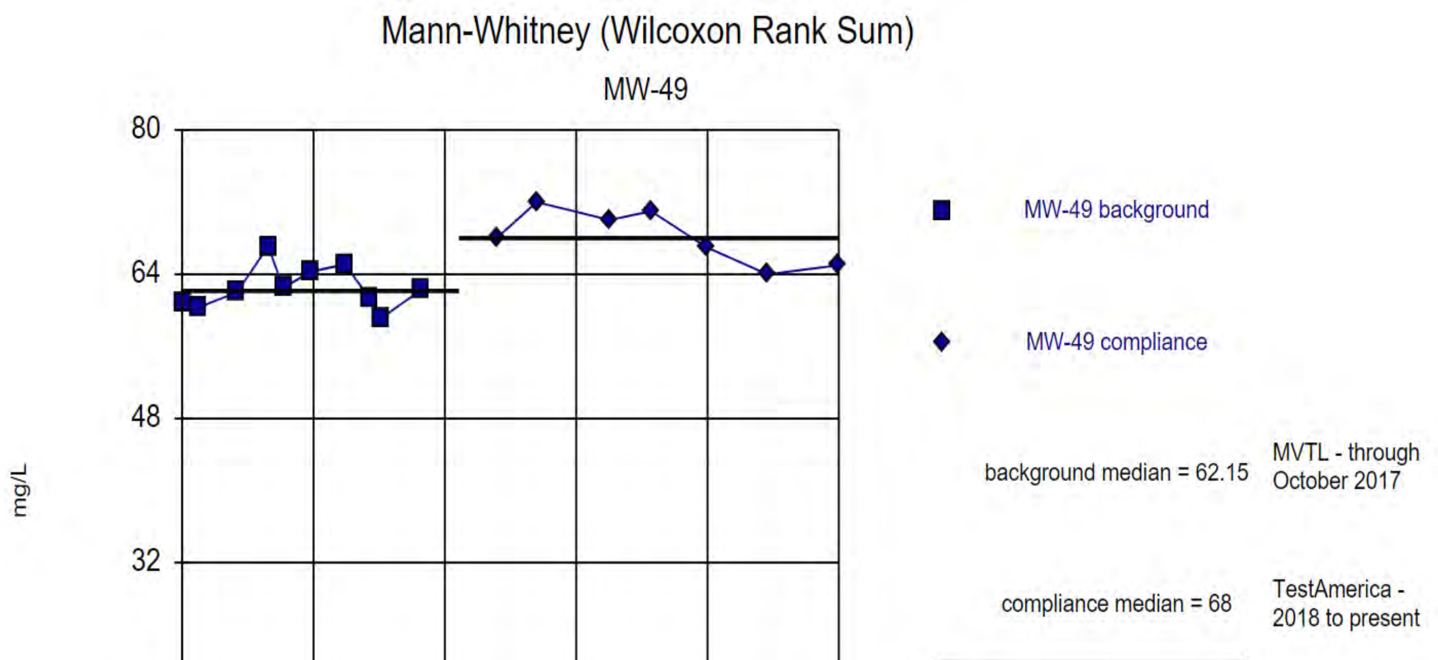
1" = 300' FEET

Path: \\Denver\acad\GREAT RIVER ENERGY\COAL CREEK\99_PROJECTS\21451024\21451024CASD (Q2 2021) | File Name: Figure_Q2 2021 ASD MW49.dwg

GOLDER
MEMBER OF WSP

ALTERNATIVE SOURCE DEMONSTRATION
MAY-JUNE 2021 GROUNDWATER CONTOURS AND SAMPLING LOCATIONS

FIGURE 1



Alpha	Table	Sig.
0.1	1.282	Yes
0.05	1.645	Yes
0.025	1.96	Yes
0.01	2.326	Yes

CLIENT
Great River Energy Coal Creek Station

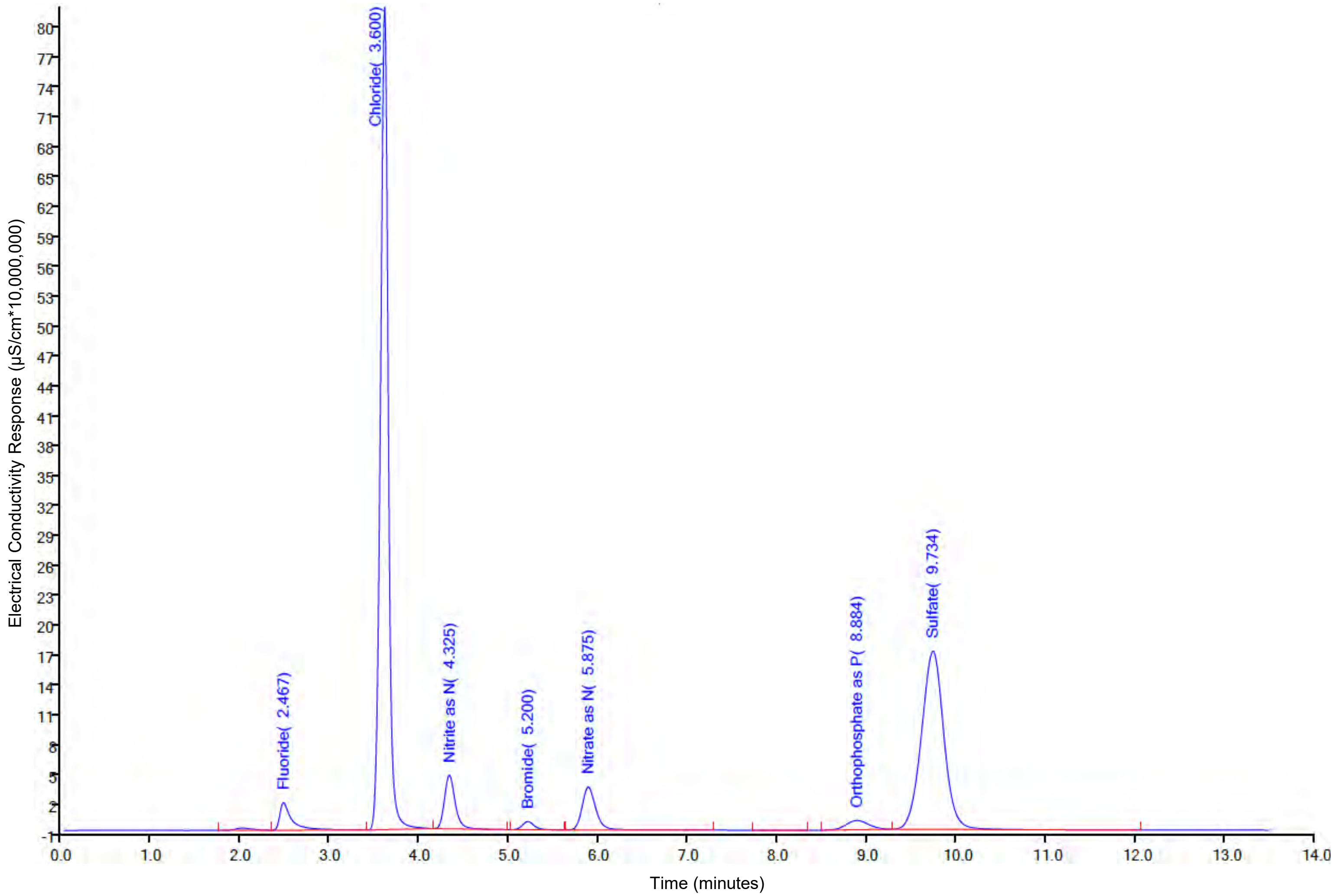
PROJECT
Alternative Source Demonstration

CONSULTANT
GOLDER
MEMBER OF WSP

TITLE
Wilcoxon Rank-Sum Test for MW-49 Chloride Concentrations

PROJECT NO.	PHASE	REV.	FIGURE
21451024C	--	0	2

PATH: https://golderassociates.sharepoint.com/sites/140044/Project Files/5 Technical Work/6 - Water Quality/Q2 2021 ASDs/MW-49/Excel Sheets | FILE NAME: Figures2 &4-7.xlsm



IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A

CLIENT	PROJECT
Great River Energy Coal Creek Station	Alternative Source Demonstration

CONSULTANT

GOLDER
MEMBER OF WSP

TITLE
Example of Ion Chromatograph Data

PROJECT NO.	PHASE	REV.	FIGURE
21450124C	--	0	3

	Software Data Processing	Manual Processing

Example #1:

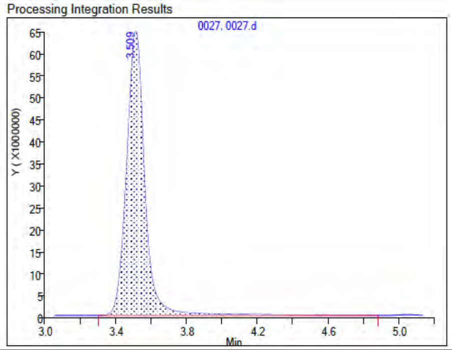
Shortened peak integration time to match calibration standards

Manual processing would decrease chloride concentration by 1.8%

Software Data Processing:

RT:	3.51
Area:	457407359
Amount:	71.627674
Amount Units:	ug/ml

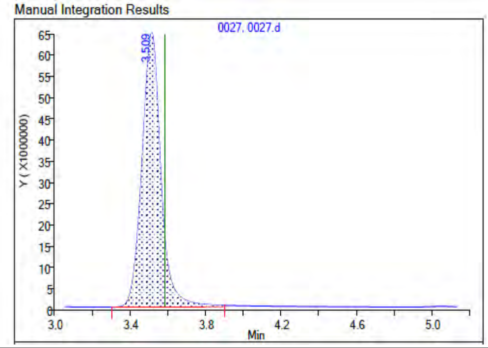
Processing Integration Results



Manual Processing:

RT:	3.51
Area:	449145333
Amount:	70.344660
Amount Units:	ug/ml

Manual Integration Results



Example #2:

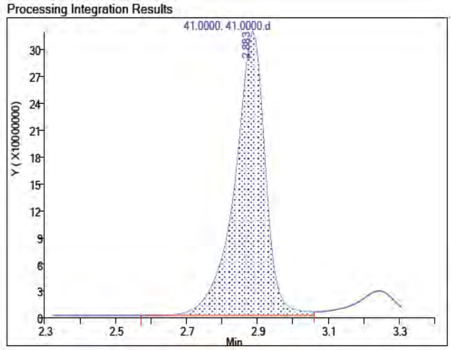
Right side of baseline brought up to minimum signal valley (not below valley), consistent with calibration standards

Manual Processing would decrease chloride concentration by 2.8%

Software Data Processing:

RT:	2.88
Area:	1882027750
Amount:	107.4024
Amount Units:	ug/ml

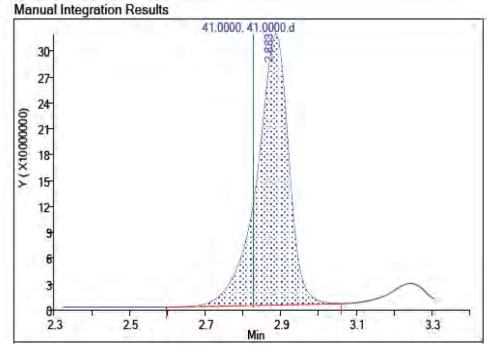
Processing Integration Results



Manual Processing:

RT:	2.88
Area:	1830626225
Amount:	104.4716
Amount Units:	ug/ml

Manual Integration Results



Example #3:

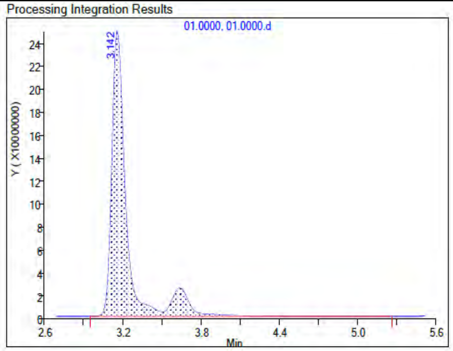
Minor peak to the right of chloride peak not included in area of chloride peak, consistent with calibration standards

Manual Processing would decrease chloride concentration by 4.2%

Software Data Processing:

RT:	3.14
Area:	1753223086
Amount:	98.471277
Amount Units:	ug/ml

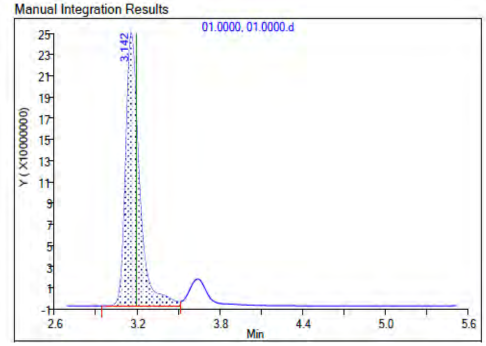
Processing Integration Results



Manual Processing:

RT:	3.14
Area:	1683282689
Amount:	94.545083
Amount Units:	ug/ml

Manual Integration Results



CLIENT Great River Energy Coal Creek Station	PROJECT Alternative Source Demonstration
CONSULTANT GOLDER MEMBER OF WSP	TITLE Comparison of Ion Chromatograph Software Data Process versus Manual Adjustments

PROJECT NO.	PHASE	REV.	FIGURE
21450124C	--	0	4

LEGEND

- NDDEQ PLANT AREA UPGRADIENT WELL
- NDDEQ PLANT AREA DOWNGRADIENT WELL
- EEG PROGRAM WELL
- DRAINS POND SYSTEM UPGRADIENT WELL
- DRAINS POND SYSTEM DOWNGRADIENT WELL
- UPSTREAM RAISE 91 UPGRADIENT WELL
- UPSTREAM RAISE 91 DOWNGRADIENT WELL
- OTHER SAMPLING LOCATION
- GENERAL DIRECTION OF GROUNDWATER FLOW

71.0 — Q2 2021 CHLORIDE CONCENTRATION (mg/L)
(59.2-72.0) — RANGE IN CHLORIDE CONCENTRATIONS, (mg/L)

NOTE(S)

1. AERIAL IMAGERY OBTAINED FROM UNITED STATES DEPARTMENT OF AGRICULTURE, NATIONAL AGRICULTURE IMAGERY PROGRAM, 2020.
2. SAMPLES FROM MW-DP5, MW-DP3, MW-DP2B, MW-DP1, MW-DP4, MW-91-2, MW-75, MW-49, MW-91-1, AND MW-51 WERE COLLECTED BETWEEN SEPTEMBER 2015 AND JUNE 2021. JUNE 2019 SAMPLES FROM MW-91-1 AND MW-91-2 WERE NOT USED BECAUSE OF SUSPECTED QUALITY CONTROL ISSUE.
3. SAMPLES FROM SW-DP101 WERE COLLECTED BETWEEN 2014 AND JUNE 2021.
4. SAMPLES FROM SUMP-UR91 WAS COLLECTED BETWEEN NOVEMBER 2018 AND JUNE 2021.
5. SAMPLES FROM MW-17-1, MW-17-2, MW-17-3, MW-17-4, AND MW-17-5 WERE COLLECTED BETWEEN JANUARY 2018 AND JUNE 2021.
6. SAMPLES FROM MW-96, MW-62, MW-63, AND MW-65 WERE COLLECTED BETWEEN OCTOBER 1988 AND JUNE 2021.
7. SAMPLES WERE COLLECTED FROM SW-107 BETWEEN MAY 1980 AND JUNE 2021.
8. FOR CONCENTRATIONS MEASURED BELOW THE DETECTION LIMIT, THE DETECTION LIMIT WAS USED.

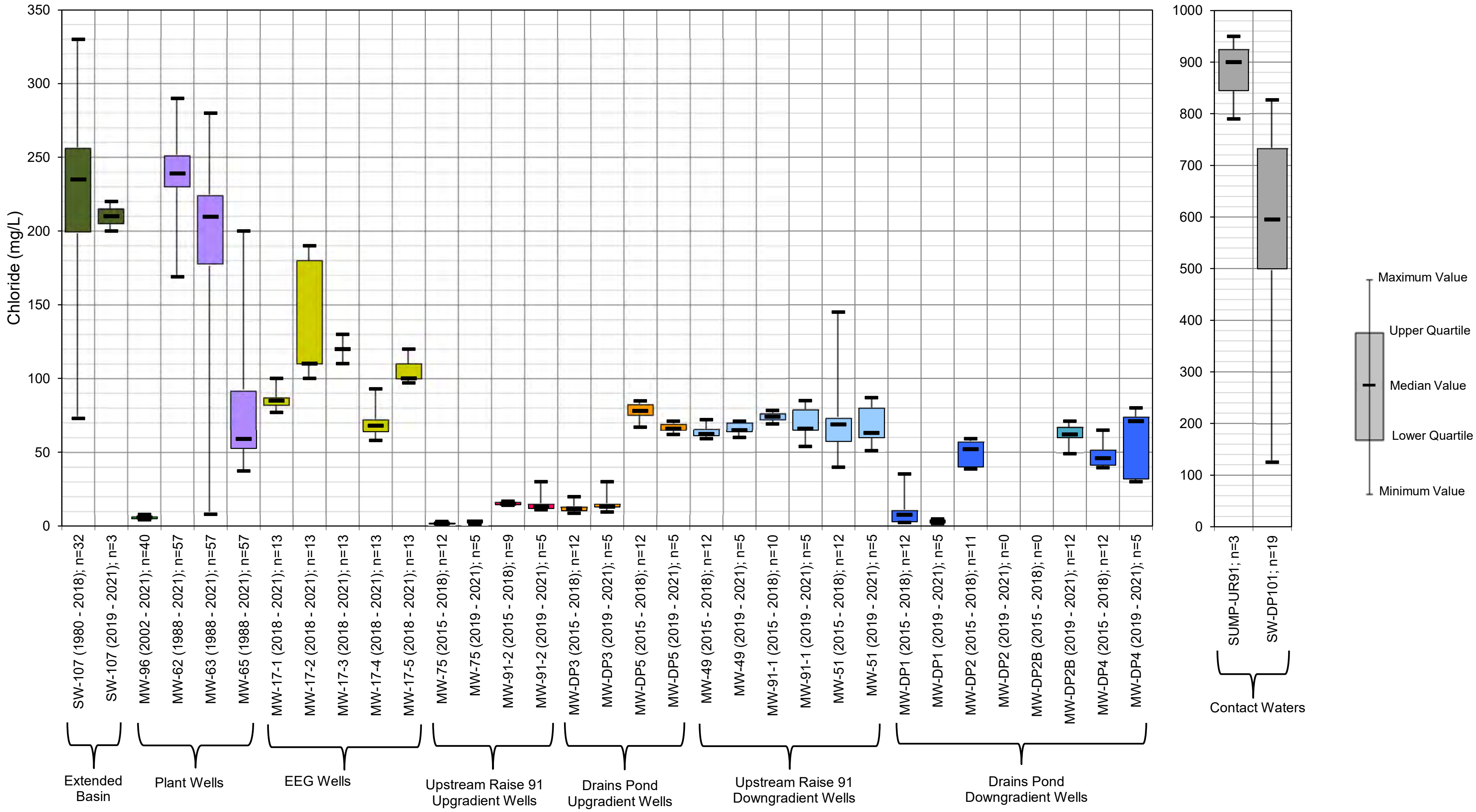
N

0 300 600
1" = 600' FEET

GOLDER
MEMBER OF WSP

ALTERNATIVE SOURCE DEMONSTRATION
CHLORIDE CONCENTRATIONS

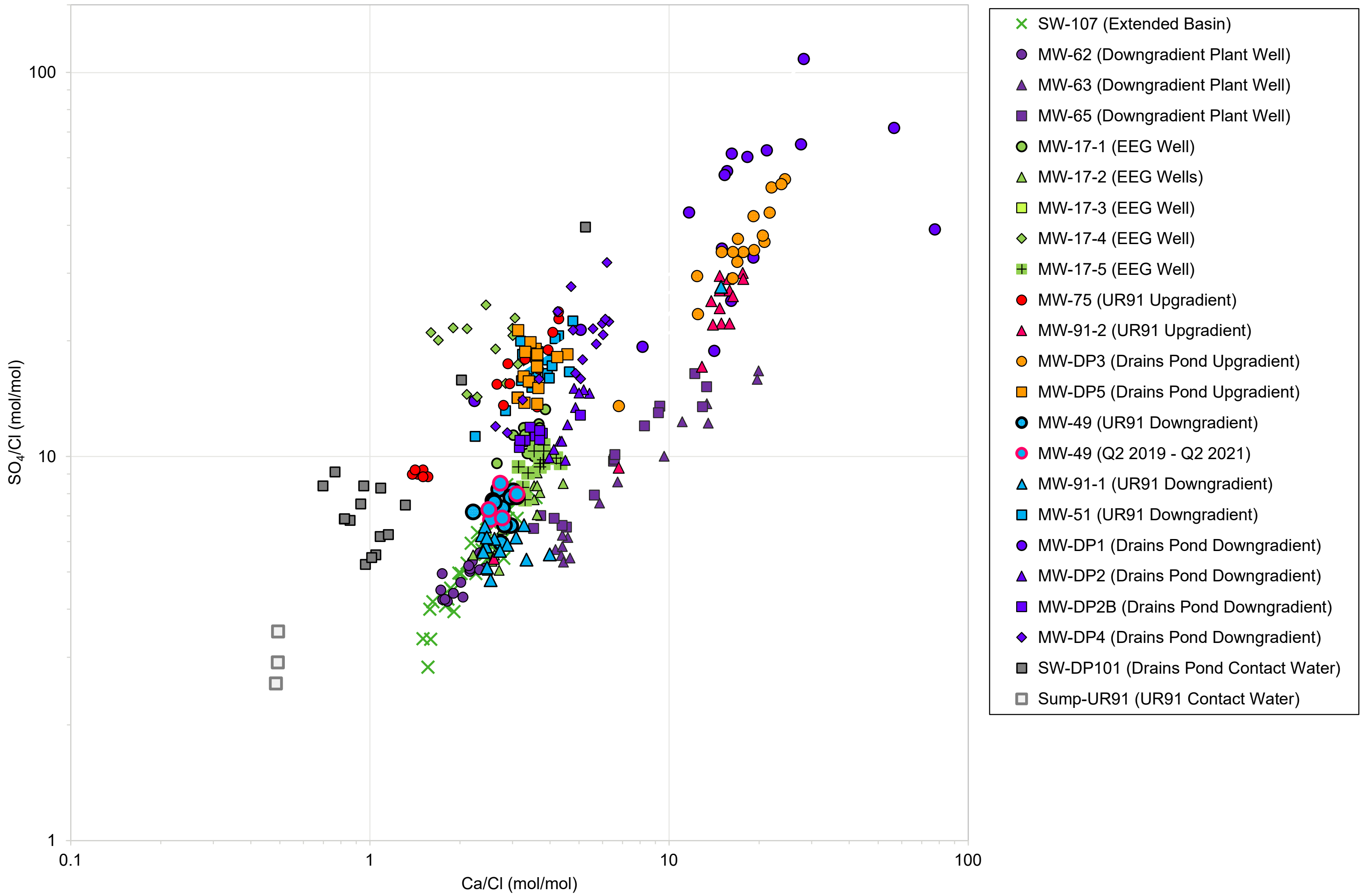
FIGURE 5



Note: For concentrations measured below the detection limit, the detection limit was used

CLIENT Great River Energy Coal Creek Station	PROJECT Alternative Source Demonstration
CONSULTANT GOLDER MEMBER OF WSP	TITLE Box and Whisker Plot for Chloride
	PROJECT NO. 21451024C · PHASE -- · REV. · FIGURE 6

PATH: https://golderassociates.sharepoint.com/sites/140044/Project Files/5 Technical Work/6 - Water Quality/Q2 2021 ASDs | FILE NAME: CCS Q2 2021 ASD Working Data.xlsm



Note: For concentrations measured below the detection limit, the detection limit was used to calculate the ratios

CLIENT
Great River Energy Coal Creek Station

PROJECT
Alternative Source Demonstration

CONSULTANT
GOLDER MEMBER OF WSP

TITLE
Sulfate-Chloride versus Calcium-Chloride Ratio

PROJECT NO.	PHASE	REV.	FIGURE
21451024C	--	0	7

GOLDER
MEMBER OF WSP

golder.com

REPORT

Alternative Source Demonstration for Fluoride and Field pH in Monitoring Well MW-DP4

Great River Energy - Coal Creek Station

Submitted to:

Great River Energy

Coal Creek Station
2875 Third Street SW
Underwood, North Dakota 58576

Submitted by:

Golder Associates USA Inc.

7245 W Alaska Drive, Suite 200, Lakewood, Colorado, USA 80226

+1 303 980-0540

21451024C-13-R-0

January 6, 2022

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TABLES

FIGURES

1.0 INTRODUCTION

On behalf of Great River Energy (GRE), Golder Associates USA Inc. (Golder), member of WSP, performed a statistical evaluation of groundwater monitoring results from the second quarter (Q2) 2021 groundwater detection monitoring event at Coal Creek Station's (CCS's) Drains Pond System coal combustion residual (CCR) surface impoundment. The statistical evaluation was performed as described in the Coal Combustion Residuals Groundwater Statistical Method Certification for Coal Creek Station (Golder 2021e), in accordance with applicable provisions of 40 Code of Federal Regulations (CFR) Part 257, "Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities; Final Rule" (CCR Rule), as amended.

Statistical analyses of the Appendix III detection monitoring data for fluoride in groundwater at the downgradient monitoring well MW-DP4 indicated a potential exceedance of the statistical limit based on the parametric Shewhart-CUSUM (Cumulative Summation) control chart analysis of the fourth quarter (Q4) 2019 sampling results. This potential exceedance was subsequently verified as a statistically significant increase (SSI) following the Q2 2020 detection monitoring sampling event. The Q4 2020 and Q2 2021 detection monitoring results for fluoride in MW-DP4 were also verified SSIs. Field pH in samples collected from monitoring well MW-DP4 was identified as a potential exceedance following the Q2 2020 detection monitoring sampling event and was a verified SSI following the Q4 2020 monitoring event. The Q2 2021 field pH value and CUSUM were within the statistical limits; however, field pH is included in the report since it is a previously verified SSI without consecutive data points within the statistical limits.

Although determination of a verified SSI generally indicates that the groundwater monitoring program should transition from detection monitoring to assessment monitoring, 40 CFR Part 257.94(e)(2) allows the owner or operator (i.e., GRE) 90 days from the date of determining a verified SSI to demonstrate a source other than the regulated CCR facility caused the SSI or that the SSI is an indication of an error in sampling, analysis, or statistical evaluation or natural variability in groundwater quality that was not fully captured during the baseline data collection period.

Golder's review of the hydrological and geologic conditions at the site indicates the field pH and fluoride SSIs in MW-DP4 are not indications of impacts from the CCR unit. A desktop study of previously collected CCR-impacted water from the facility, nearby surface water, and groundwater samples was conducted to assess potential fluoride sources. As a part of this work, potential error in the statistical analysis and the natural variability of fluoride concentrations in groundwater were evaluated. Based upon this review and in accordance with provisions of the CCR Rule, Golder prepared this Alternative Source Demonstration (ASD) for field pH and fluoride at MW-DP4.

This ASD conforms to the requirements of 40 CFR Part 257.94(e)(2) and provides the basis for concluding that the verified SSIs for field pH and fluoride at MW-DP4 are not indications of a release from the Drains Pond System. The following sections provide a summary of the Drains Pond System, analytical and geochemical assessment results, and lines of evidence demonstrating an alternative source is responsible for the field pH and fluoride SSIs at MW-DP4. An ASD was initially developed for fluoride following the Q2 2020 verified SSI (Golder 2020, Golder 2021a), reviewed for ongoing applicability, and updated following the Q4 2020 sampling event to include field pH (Golder 2021c), Herein, the ASD was reviewed for ongoing applicability and updated where necessary.

2.0 BACKGROUND

2.1 Site Background

GRE's CCS is a coal-fired electric generation facility located in McLean County, approximately 10 miles northwest of Washburn, North Dakota. CCRs are managed in composite-lined surface water impoundment cells and dry landfills regulated and permitted by the North Dakota Department of Environmental Quality (NDDEQ) in accordance with North Dakota Administrative Code (NDAC) Title 33.1, Article 33.1-20, Solid Waste Management and Land Protection.

CCS has four CCR facilities that are within the purview of the United States Environmental Protection Agency (USEPA) CCR Rule. This ASD applies only to the Drains Pond System CCR surface impoundment. The Drains Pond System is in the central portion of the plant site, east of the CCS plant buildings (Figure 1). The Drains Pond System is comprised of three cells: west, center, and east. Bottom ash, pulverizer rejects, and economizer ash are conveyed to the west cell where they are dewatered and hauled away to the other CCR facilities. Bottom ash, pulverizer rejects, and economizer ash transport water flow from the west cell to the center cell which acts as a clarifier facility and receives minor amounts of sediment via the plant drains system. Water from the center cell flows to the east cell. The east cell is a non-CCR surface impoundment that is part of the plant process water storage inventory, acting as a clarifier for process water. Water from the east cell is recirculated back to the plant for reuse or is pumped to the onsite evaporation ponds or the permitted underground injection well.

2.2 Site Geology

CCS and McLean County are situated at the eastern-most extent of the Williston Basin, a structural and sedimentary basin (United States Geological Survey [USGS] 1999). The region is characterized by the presence of glacial drift, reaching thicknesses of several hundred feet and overlying the Sentinel Butte Member, the source of commercially mined coal in the direct vicinity of CCS (Falkirk 1979). The Sentinel Butte Member is the highest strata of the Paleocene Fort Union Formation, overlying the Tongue River, Ludlow, and Cannonball Members (USGS 1999). The Sentinel Butte Member is marked by drab-gray units, demarcating the separation from the lower Tongue River Member.

The site geology of CCS includes unconsolidated surficial deposits of the Coleharbor formation, consisting of stratified and unstratified glacial drift. The near-surface materials are silty clay and sandy clay till with interbedded lenses (Cooperative Power Association and United Power Association [CPA/UPA] 1989).

2.3 Site Hydrogeology

Regional groundwater flow of the uppermost water-bearing unit in the vicinity of CCS is a subtle expression of the surface topography, which is influenced by the configuration of the eroded bedrock. Based on available groundwater elevation data, the shallow groundwater at the CCR facilities at CCS generally follows surface topography, flowing east and north towards Lower Samuelson Slough and Sayler Slough. Available groundwater elevation data indicate that groundwater in the area of the Drains Pond System generally flows from the southwest to the northeast, diagonally across the footprint of the facility, towards Lower Samuelson Slough.

Hydraulic conductivities in the area of the Drains Pond System range from 0.01 feet per day (ft/day) to 2.83 ft/day, with calculated groundwater flow rates during the Q2 2021detection monitoring event ranging from 0.001 to 0.25 ft/day.

2.4 Groundwater Monitoring Network

The groundwater monitoring network for the Drains Pond System was developed for the size, disposal and operational history, anticipated flow direction, and location of adjacent facilities. Based on these factors, a monitoring well network consisting of two upgradient and four downgradient monitoring wells is used for monitoring the unit under the CCR Rule.

The two upgradient monitoring wells (MW-DP3, MW-DP5) included in the groundwater monitoring network for the Drains Pond System are used to represent upgradient water quality flowing towards the unit from the west and south (Golder 2019). The four downgradient wells (MW-DP1, MW-DP2, MW DP2B, MW-DP4) are positioned along the northern and eastern edges of the facility. Beginning in Q4 2018, MW-DP2 has had insufficient water to allow for routine sampling. Therefore, MW-DP2B was installed in 2019 adjacent to MW-DP2 to provide further coverage for the monitored unit. The Drains Pond System network wells are presented in Figure 1. Other monitoring locations used to support this ASD are also presented in Figure 1 and are discussed further in Section 3.2.

Figure 2 displays a time-series plot of historical water levels in each monitoring well associated with the Drains Pond System. Water levels in upgradient monitoring wells MW-DP3 and MW-DP5 increased by approximately 2 to 5 feet between Q4 2018 and Q4 2019. A similar increase in water level was also observed in downgradient monitoring well MW-DP4 during the same period. Water levels from Q2 2020, Q4 2020, and Q2 2021 returned closer to historical values. The recent changes in water levels at upgradient and downgradient monitoring wells around the Drains Pond System and the timing of those changes suggest a change to groundwater flow conditions.

2.5 Groundwater Conditions

Between September 2015 and August 2017, GRE collected nine independent baseline groundwater samples from MW-DP3, MW-DP5, MW-DP1, MW-DP2, and MW-DP4, as required by 40 CFR Part 257.94, for use within the CCR Rule monitoring program. Baseline samples were collected from MW-DP2B between June 2019 and March 2020, following installation of the well in 2019. The results of the CCR baseline monitoring were used to develop statistical limits for each constituent at each monitoring well, based on site conditions and parameter specific characteristics such as the data distribution and detection frequency (Golder 2021e).

Following completion of the baseline monitoring events at each well, GRE began collecting groundwater samples on a semi-annual basis to support the detection monitoring program. Groundwater samples for detection monitoring are collected at each upgradient and downgradient monitoring well and analyzed for 40 CFR Part 257 Appendix III constituents. During the detection monitoring program, groundwater analysis results are compared to the calculated statistical limits to determine whether groundwater quality remains consistent or if changes in groundwater quality are observed.

In accordance with the site Statistical Method Certification (Golder 2021e) and recommendations within the USEPA's Unified Guidance (USEPA 2009), a baseline update was conducted for most well-constituent pairs within the Drains Pond System monitoring network prior to conducting comparative statistical analysis for the Q4 2019 detection monitoring event. As a result of the baseline update, results collected during the detection monitoring program were evaluated to determine if they were from the same statistical population as those collected during the initial baseline monitoring program.

2.5.1 Fluoride at MW-DP4

Fluoride concentrations in groundwater at MW-DP4 during the initial baseline monitoring period ranged between 0.13 and 0.19 milligrams per liter (mg/L) in the nine baseline samples collected as part of the CCR Rule monitoring program. Detection monitoring samples collected between October 2017 and June 2019 were incorporated into the updated baseline period, ranging between 0.11 and 0.18 mg/L. Of the four samples collected between October 2017 and June 2019, one result was excluded from the updated baseline data set, having been identified as an outlier. The result identified as an outlier was reported as a non-detect with an elevated reporting limit (ND less than 0.5 mg/L). The Shewhart-CUSUM statistical limit for the well-constituent pair was set at 0.24 mg/L following the baseline update.

The Q4 2019 detection monitoring event reported a fluoride concentration of 0.25 mg/L at MW-DP4, with a calculated CUSUM value of 0.23 mg/L, exceeding the statistical limit. Verification resampling was conducted during the Q2 2020 detection monitoring event, confirming the SSI for fluoride at MW-DP4 with a fluoride concentration of 0.28 mg/L and a calculated CUSUM value of 0.34 mg/L. The Q4 2020 detection monitoring result for fluoride at MW-DP4 was lower than Q2 2020 and in the range of the baseline values, but was identified as an SSI with a fluoride concentration of 0.16 mg/L and a calculated CUSUM value of 0.32 mg/L. The 0.15 mg/L fluoride concentration for the sample collected form MW-DP4 during the Q2 2021 detection monitoring event was also within the range of baseline values; however, the CUSUM value of 0.30 mg/L was greater than the statistical limit, indicating an SSI.

2.5.2 Field pH at MW-DP4

Field pH values in groundwater at MW-DP4 during the initial baseline monitoring period ranged from 6.87 to 7.08 standard units (SU) in the nine baseline samples collected as part of the CCR Rule monitoring program. The upper Shewhart-CUSUM statistical limit for the well-constituent pair was set at 7.29 mg/L following baseline establishment. The lower Shewhart-CUSUM statistical limit for the well-constituent pair was set at 6.70 mg/L following baseline establishment. Detection monitoring samples collected between October 2017 and October 2019 ranged between 7.04 and 7.21 SU.

The Q2 2020 detection monitoring event reported a field pH value of 7.24 SU at MW-DP4, with a calculated upper CUSUM value of 7.41 SU, exceeding the upper statistical limit. Verification resampling was conducted during the Q4 2020 detection monitoring event, confirming the SSI for field pH at MW-DP4 with a field pH value of 7.13 SU and an upper calculated CUSUM value of 7.47 SU. While the Q4 2020 field pH value was lower than the Q2 2020 field pH value, field pH was identified as an SSI due to the elevated CUSUM values. During the Q2 2021 sampling event, the pH was 6.87 SU, which is within the statistical limit of 6.70 to 7.29 SU and the CUSUM values for the Q2 2021 sampling event were 6.94 and 7.28 for the lower and upper values, respectively. Both the detection monitoring results and CUSUM values for the Q2 2021 sampling event are within the statistical limits for this well; however, field pH is included in this discussion since it is a previously verified SSI without consecutive data points within the statistical limits.

3.0 POTENTIAL SITE FLUORIDE AND FIELD PH SOURCES

To assess the potential sources for a change in fluoride concentrations and field pH values at MW-DP4, Golder reviewed recent site changes upgradient of the Drains Pond System, as well as previously collected data from the CCR Rule program and other site monitoring data that are collected under other programs. The following sections summarize the supplemental assessment activities.

3.1 Site Changes and Potential Sources

The following sections discuss site changes and potential impacts associated with those changes. Site changes may have affected constituent concentrations entering the groundwater system or the hydrologic and hydrogeologic conditions (water balance) of the site.

3.1.1 Duck Pond and Drains Pond System Construction

Beginning in 2015, the drainages on the south and west sides of the Drains Pond System were modified to allow for construction of an expansion to the Drains Pond System. As a part of this construction, modifications to the existing drainage pathways adjacent to the footprints of the west and center cells of the Drains Pond System were required and the composite-lined west and center cells of the Drains Pond System were constructed.

Historically, the Duck Pond area was a low-lying area southwest of the east cell of the Drains Pond System (Figure 1). The depth of water contained in this area was generally 12 feet (water surface elevation approximately 1911 feet) and the Duck Pond had a surface area of approximately three acres. As the water level increased, overflow passed through culvert piping to the north under what is now the center cell of the Drains Pond System. As part of the construction in 2015, the Duck Pond was dewatered, the area was graded, and culverts were installed to drain surface water south and east around the south side of Upstream Raise 91.

The recent removal of the Duck Pond and regrading of the area upgradient of the Drains Pond System potentially altered the hydrological flow paths to MW-DP4. In addition to the changing flow paths, the removal of the Duck Pond also eliminated infiltration of water from the Duck Pond to groundwater, which may have provided a dilution effect on groundwater concentrations upgradient of MW-DP4.

3.1.2 Surface Water Drainage Ditch West of Drains Pond System

The west cell of the Drains Pond System is separated from a rail line to the west by a surface water drainage ditch. The rail lines are primarily used to transport coal and fly ash from CCS off site. The haul road directly east of this drainage ditch is used by GRE personnel to load bottom ash, pulverizer rejects, and economizer ash into trucks for disposal in the various CCR containment facilities.

The surface water drainage ditch receives stormwater and snow melt runoff from the rail line slope to the west and the embankment of the west cell of the Drains Pond System to the east. Since there is a potential for runoff into this surface water drainage ditch to contain contact water associated with the loading and hauling of CCR, the drainage ditch was originally designed to flow to the south and east, eventually discharging into the center cell of the Drains Pond System to be managed with other CCR contact waters. Due to operational constraints (pipeline alignments and haul routes), this drainage ditch no longer operates as described above.

In October 2020, a registered professional engineer (PE) from Golder was on site performing the annual PE inspection of the Drains Pond System per USEPA Regulation 40 CFR Part 257.83(b) requirements (Golder 2021b). The annual inspection report noted that bottom ash had accumulated in this ditch and that the ditch lacked an outlet to allow stormwater and snow melt runoff to drain away from the area as originally designed.

Within one month of the observations noted during the 2020 annual PE inspection, corrective measures were designed and implemented. The corrective measures included cleaning out accumulated CCR from the ditch, grading areas to drain, and installing a culvert to allow stormwater drainage from the ditch. Additional information regarding this area, including details about the observations and design and implementation of corrective measures are included in the Corrective Measures Report (Golder 2021d).

3.1.3 Plant Drains Pipe Corridor

Two “plant drains” pipelines run parallel to the main west-east haul road (Figure 1) and currently end approximately 100 feet to the southwest of MW-DP4. These pipelines consist of a 36-inch diameter “plant drain” concrete pipeline (bell and spigot joints) and a 14-inch diameter “chemical drain” fiberglass reinforced pipeline which have each been in service since plant commissioning (approximately 40 years). The 36-inch “plant drain” pipeline primarily carries flow collected from various floor drains around the industrial block, of which a major contribution to the flow is typically overflow from the bottom ash hoppers. The 14-inch “chemical drain” pipeline conveys water from the cooling water system (cooling water blowdown) and the chemistry laboratory. Cooling water blowdown is representative of the water contained in the Extended Basin. Water from the chemistry laboratory includes water from the room sink and floor drains as well as demineralizer regen and reverse osmosis “clean in place” waste.

Construction in 2015 modified these pipelines so that they can passively drain into the center cell of the Drains Pond System via a new precast concrete manhole. Upstream of the new precast concrete manhole, the 36-inch “plant drain” pipeline was cleaned out using high-pressure water. During the cleanout process, a significant amount of sediment was removed; however, it was noted that a significant amount of sediment (likely cemented CCR particles) was difficult to remove and remained in place, making inspection of the physical state of this pipeline (i.e., joint condition, reinforced concrete pipeline wall condition, etc.) difficult.

Due to the low-pressure (gravity) operation and small diameters of these plant drains pipelines, they are difficult to evaluate for potential leaks. In addition, removing these pipelines from service is also difficult during both plant operation and outages. As a result, minimal maintenance has been performed during the life of these systems. Since these pipelines have been in operation for a significant amount of time, it is possible that they have been compromised or have deteriorated due to normal wear and tear over the course of the last 40 years. This could lead to leakage of the water being conveyed and result in changes to water quality adjacent to this piping.

3.2 Data Sources

To determine if recent site changes upgradient of the Drains Pond System have impacted water quality in MW-DP4, the sampling locations and dates for groundwater, surface water, and contact water results were reviewed for each potential source provided below. The below section describes the data reviewed; however, due to reduced analyte lists analyte lists not all samples have sufficient data to be displayed on every figure.

3.2.1 Drains Pond System and Upstream Raise 91 Groundwater

Data collected between September 2015 and June 2021 for the CCR Rule monitoring program were considered in the evaluation. As part of the monitoring program, field personnel collected groundwater samples from the following monitoring wells:

- upgradient to the Drains Pond System: MW-DP3 and MW-DP5
- upgradient to Upstream Raise 91: MW-75 and MW-91-2
- downgradient from the Drains Pond System: MW-DP1, MW-DP2, MW-DP2B, and MW-DP4

3.2.2 Drains Pond System (East Cell)

Twenty samples collected between third quarter (Q3) 2014 and Q2 2021 of ash contact water from the surface of the east cell of the Drains Pond System (SW-DP101) were used in the evaluation. Eighteen of these samples were analyzed for fluoride and eight samples have field pH measurements.

3.2.3 CCR Short Term Leach Testing

Short-term leach testing of the CCR materials by the synthetic precipitation leaching procedure (SPLP) was performed by USEPA method 1312 (USEPA 1994). The SPLP simulates the interaction between a solid and meteoric water, which provides a screening-level estimate of ash effluent water quality.

CCR materials were collected by site personnel between 2012 and 2017. Details about the collection procedure are listed by material type below:

- Three bottom ash samples from Section 26 (a historic containment area for CCRs in a previously mined area) were collected in situ at the facility in May 2017.
- One bottom ash sample was collected from the Drains Pond System west cell in May 2017.
- Two fly ash samples were collected from the fly ash silos (one sample was collected in November 2017 and one was collected in May 2017).
- Three coal rejects samples (combination of pulverizer rejects, economizer ash, and air jig rejects) were collected from Ash Pond 91 (also referred to as Upstream Raise 91) in June 2013.
- One coal rejects sample was collected from Upstream Raise 91 in May 2017.

3.2.4 Upgradient Plant Cooling Water

Plant cooling water is contained in the Extended Basin, which is located on the western side of the property and upgradient of the CCS plant. Groundwater nearby and potentially influenced by the Extended Basin is monitored at the following locations:

- upgradient to the powerplant: MW-96
- downgradient from the Extended Basin: MW-62, MW-63, and MW-65
- EEG Wells: MW-17-1, MW-17-2, MW-17-3, MW-17-4, and MW-17-5 (these wells were installed to monitor a historic leak in the fuel line to the Emergency Engine Generator)

For the plant wells, results from samples collected between October 1988 and June 2021 were considered for this evaluation. The EEG wells were installed in Q4 2017, and results included in this evaluation were for samples collected between January 2018 and June 2021.

Additionally, results for samples collected from the Extended Basin (SW-107) between May 1980 and June 2021 were used in the evaluation.

3.3 Evaluation of Potential Sources

As shown in Figure 1, groundwater generally flows from the southwest to the northeast. To assist with the identification of potential fluoride sources to MW-DP4, Figure 3 displays a times series of MW-DP4 fluoride and field pH values from 2015 to Q2 2021. Figures 4 and Figure 5 compare the ranges of fluoride concentrations and field pH values for the monitoring wells and surface water sources on the site (as described in Section 3.1) with box and whisker plots. Figure 6 displays a Piper diagram as a method of comparing water qualities between locations.

Several potential sources could contribute to changes in fluoride concentrations and field pH values in groundwater at CCS, including infiltration of plant cooling water via the Extended Basin, infiltration of surface water collected in the surface water drainage ditches upstream of the Drains Pond System, leakage from the "plant drains" pipelines, and seepage from the Drains Pond System. These potential sources of fluoride and increased field pH values are described below.

3.3.1 Drains Pond System

The fluoride concentrations measured in samples from the east cell of the Drains Pond System (1.9 to 68 mg/L) are higher than samples collected from MW-DP4 and therefore indicates that seepage (if occurring) from the Drains Pond System could increase the fluoride concentrations in MW-DP4 (Figure 4). Likewise, the field pH values in the samples from the east cell of the Drains Pond System (8.08 to 8.50 SU) are higher than samples collected from MW-DP4. However, the presence of the liner systems described below for each cell of the Drains Pond System reduces the likelihood of seepage to groundwater.

The west cell of the Drains Pond System has a liner system consisting of (from bottom to top):

- 2 feet of compacted clay rich material with a hydraulic conductivity of $1x10^{-7}$ centimeters per second (cm/sec)
- 60-mil high density polyethylene (HDPE) geomembrane liner
- Geocomposite drainage layer
- Geosynthetic clay liner (GCL)
- 60-mil HDPE geomembrane liner

As indicated above, the west cell of the Drains Pond System was constructed as a double composite liner system with a drainage layer between the upper and lower composite liner systems. The double composite liner system is more protective of the environment since any water (i.e., leakage) passing through the upper geomembrane liner and GCL will be collected by the geocomposite drainage layer and is conveyed passively (via gravity pipelines) to the center cell of the Drains Pond System. Any small amount of water passing through the upper composite liner will quickly and passively drain away, resulting in minimal head on the lower composite liner. Liner leakage is directly proportional to the head on the liner; therefore, with no to minimal head on the lower liner, very little if any leakage is anticipated.

The center cell of the Drains Pond System has a liner system consisting of (from bottom to top):

- 2 feet of compacted clay rich material with a hydraulic conductivity of $1x10^{-7}$ cm/sec
- 60-mil HDPE geomembrane liner

The east cell of the Drains Pond System has a liner system consisting of (from bottom to top):

- 2 feet of compacted clay rich material with a hydraulic conductivity of $1x10^{-7}$ cm/sec
- 40-mil HDPE geomembrane liner

The relative proportion of major ion concentrations in groundwater samples and potential sources are depicted on a Piper diagram in Figure 6. The Piper diagram indicates that contact water in the Drains Pond System and CCR material SPLP leachates are calcium-sulfate and magnesium-sulfate dominant. Groundwater samples collected from MW-DP4 have a higher proportion of sodium, potassium, and bicarbonate than the contact water and CCR

SPLP leachates. Additionally, between 2017 and Q2 2020 the major ion chemistry progressively shifted to a higher proportion of sodium relative to calcium and magnesium in the samples identified as SSIs. This shift indicates the water samples collected from MW-DP4 were progressing away from the ash contact water signature and Drains Pond System water samples (SW-DP101) on the Piper diagram. This same pattern is observed at MW-DP1. If seepage from the Drains Pond System was impacting groundwater at MW-DP4, the groundwater geochemistry would be expected to shift towards the major ion signature of ash contact waters and Drains Pond System water samples (SW-DP101) on the Piper diagram. Therefore, it is unlikely that water from the Drains Pond System is the source of the change in fluoride concentrations or field pH values leading to the identification of the SSIs. As discussed in Section 2.5, the fluoride concentration and field pH value for the Q4 2020 and Q2 2021 samples collected from MW-DP4 were lower than the Q2 2020 values and in the range of baseline measurements. The Q4 2020 and Q2 2021 major ion signatures for MW-DP4 are shifted back towards the 2017 signature on the Piper diagram, suggesting the groundwater quality change may be temporary.

3.3.2 Upgradient Plant Cooling Water

To the west of the Drains Pond System and CCS, water used for plant cooling is contained in the Extended Basin, which holds approximately 60 million gallons and is a clay lined facility. This water originates from the Missouri River but is cycled up to 15 times through the cooling towers. As the water is cycled, heat from the powerplant drives evaporation, which concentrates the constituents in the Extended Basin. Between 1980 and 2020, fluoride concentrations in the Extended Basin ranged between 2.9 and 6.4 mg/L and field pH values ranged between 7.20 and 8.80 SU. These values are higher than samples collected from MW-DP4 and therefore indicates that the Extended Basin could be influencing fluoride concentration and field pH in MW-DP4.

The pattern of recent groundwater changes at MW-DP4 illustrated on the Piper diagram (Figure 6) indicates water samples collected from MW-DP4 are progressing away from the Extended Basin chemical signature; therefore, it is unlikely that recent increases in fluoride concentrations or field pH values are due to groundwater derived from the Extended Basin.

3.3.3 Other Potential Sources

Based on the Piper diagram (Figure 6), water contained in either the Drains Pond System or Extended Basin are unlikely to be potential sources of the fluoride and field pH SSIs at MW-DP4. As mentioned in Section 2.4, water levels in upgradient and downgradient monitoring wells increased by approximately two to five feet between Q4 2018 and Q4 2019 (Figure 2). From Q2 2020 to Q2 2021, water levels have been decreasing in both upgradient and downgradient wells. Changes in water levels at upgradient and downgradient monitoring wells around the Drains Pond System and the timing of those changes suggest a change in the hydrological regime. The following site changes and sources may have contributed to the increase in fluoride concentrations and field pH values:

- The recent removal of the Duck Pond and regrading of the area directly upgradient of the Drains Pond System potentially temporarily altered the hydrological flow paths to MW-DP4 (Section 3.1.1). In addition to the changing flow paths, the removal of the Duck Pond eliminated infiltration of water from the Duck Pond to groundwater. This infiltration may have provided a dilution effect on groundwater concentrations upgradient of MW-DP4. Elimination of this dilution source may have resulted in an increase of fluoride concentration or a change in field pH that led to the identification of the SSIs.
- The surface water drainage ditch west of Drains Pond System (Section 3.1.2) has intermittently contained standing water from stormwater and snow melt runoff. The stagnant water accumulating in this drainage

ditch has historically not been removed prior to infiltration. While no water samples were collected prior to when corrective measures were implemented in the fall of 2020 (Golder 2021d), the location immediately upgradient of MW-DP4 suggests that localized infiltration from this ditch could influence groundwater concentrations.

- The two plant drains pipelines (Section 3.1.3) approximately 100 feet to the southwest of MW-DP4 are difficult to evaluate for potential leaks. These pipelines have been in operation for approximately 40 years; therefore, it is possible that they have been compromised or have deteriorated due to normal operation since installation. While, no water samples have been collected to date, the location upgradient of MW-DP4 suggests that if water leaked from the pipes, it could infiltrate to groundwater and influence groundwater concentrations at the well. Therefore, it is possible that leakage from the pipes has changed groundwater quality leading to the identification of the SSIs at this well.

4.0 EVIDENCE OF AN ALTERNATIVE SOURCE

Based on the review of potential alternative site sources of fluoride and field pH presented in this report, primary lines of evidence and conclusions drawn from the evidence used to support this ASD are provided in Table 1.

In summary, we have concluded that the Drains Pond System is not likely the cause of the SSIs. Instead, variation in the background water quality related to recent changes in the site hydrology and/or potentially leaks in sub-surface piping likely caused a change in fluoride concentrations and field pH values and identification of the SSIs at MW-DP4.

Table 1: Primary and Supporting Lines of Evidence from ASD Analysis

Key Line of Evidence	Supporting Evidence	Description
Hydrogeology	Groundwater elevations at monitoring wells around the Drains Pond System	Increases in water levels in upgradient and downgradient monitoring wells in 2019, followed by subsequent decreases in 2020 and 2021 indicate there may be changes in the hydrological flow regime surrounding Drains Ponds System and MW-DP4.
	Recent construction upgradient of MW-DP4 has the potential to alter the groundwater flow regime near MW-DP4	The draining of the Duck Pond to the southwest of MW-DP4 and the intermittent filling of the surface water drainage ditch west of the Drains Pond System have altered the locations of standing water upgradient of MW-DP4, potentially influencing where surface water may infiltrate and affecting the hydrological flow regime surrounding the Drains Pond System and MW-DP4. This change in the flow regime could influence fluoride concentrations and field pH values observed in samples collected from MW-DP4 leading to identification of the SSIs.
Engineering Controls	Drains Pond System is lined	Each of the three cells of the Drains Pond System has a composite liner system, which decreases the likelihood of seepage from this facility. Additionally, the west cell of the Drains Pond System has a double composite liner system with a drainage system between the liners. Observations of this drainage system have not indicated leakage through the upper composite liner system since operations began in late 2015.
Water Chemistry	Relative ion abundances in groundwater differ from Drains Pond System water	The water quality signature of groundwater samples collected from downgradient well MW-DP4 are not consistent with the signature of potential seepage from the Drains Pond System. As presented in Figure 6, the Piper diagram shows that groundwater from MW-DP4 is distinctly different from ash-impacted waters. This suggests that the Drains Pond System is not the cause of the change in fluoride concentrations.
	Geochemistry results from MW-DP4 are shifting away from Drains Pond System water	Major ion chemistry in MW-DP4 samples identified as SSIs has shifted to a higher proportion of sodium relative to calcium and magnesium and samples collected from MW-DP4 are progressing away from the ash contact water signature on the Piper diagram.

5.0 CONCLUSIONS

In accordance with 40 CFR Part 257.95(g)(3), this ASD has been prepared in response to the identification of verified SSIs for fluoride and field pH at monitoring well MW-DP4 following the Q2 2021 sampling event for the Drains Pond System at CCS.

A review of historical analytical results indicates that the groundwater geochemistry at MW-DP4 is shifting away from Drains Pond System water or CCR contact water. Therefore, increases in fluoride and field pH are not expected to be associated with releases from the Drains Pond System. The increase in fluoride concentrations and field pH values in groundwater at MW-DP4 likely reflect variability of upgradient groundwater sources and recent changes to site hydrogeology. No further action (i.e., transition to assessment monitoring) is warranted, and the Drains Pond System at CCS will remain in detection monitoring.

6.0 REFERENCES

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Signature Page

Golder Associates USA Inc.

Gregory Lehn, PhD
Project Geochemist

Sara Harkins, PG (WY)
Senior Geochemist

Todd Stong, PE
Associate and Senior Consultant

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https://golderassociates.sharepoint.com/sites/140044/project files/6 deliverables/21451024c/reports/13-r-ccs_asd_fluoride_field_ph_mw-dp4/13-r-0/21451024c-13-r-0-ccs_asd_fluoride_field_ph_mw-dp4_06jan22.docx

Figures

LEGEND

- NDDEQ PLANT AREA UPGRADIENT WELL
- NDDEQ PLANT AREA DOWNGRADIENT WELL
- EEG PROGRAM WELL
- DRAINS POND SYSTEM UPGRADIENT WELL
- DRAINS POND SYSTEM DOWNGRADIENT WELL
- UPSTREAM RAISE 91 UPGRADIENT WELL
- UPSTREAM RAISE 91 DOWNGRADIENT WELL
- GENERAL DIRECTION OF GROUNDWATER FLOW
- 1890 POTENTIOMETRIC SURFACE CONTOURS (SEE NOTE 2)
- DRAINS POND SYSTEM BOUNDARY
- PLANT DRAINS PIPING (APPROXIMATE LOCATION)
- SURFACE WATER DRAINAGE DITCH - DRAINS POND SYSTEM
- SURFACE WATER DRAINAGE DITCH - UPSTREAM RAISE 91

NOTE(S)

1. GROUNDWATER ELEVATIONS SHOWN WERE MEASURED MAY/JUNE 2021.
2. POTENTIOMETRIC SURFACE CONTOURS WERE CREATED USING WATER LEVEL INFORMATION FROM THE MAY/JUNE 2021 GROUNDWATER ELEVATIONS SHOWN, AS WELL AS SURVEYED SURFACE WATER EXPRESSIONS, ADDITIONAL SITE WELLS, AND PIEZOMETERS NOT SHOWN. CONTOUR INTERVAL IS 5 FEET.
3. AERIAL IMAGERY OBTAINED FROM UNITED STATES DEPARTMENT OF AGRICULTURE, NATIONAL AGRICULTURE IMAGERY PROGRAM, 2020.

N

0 300 600
1" = 300' FEET

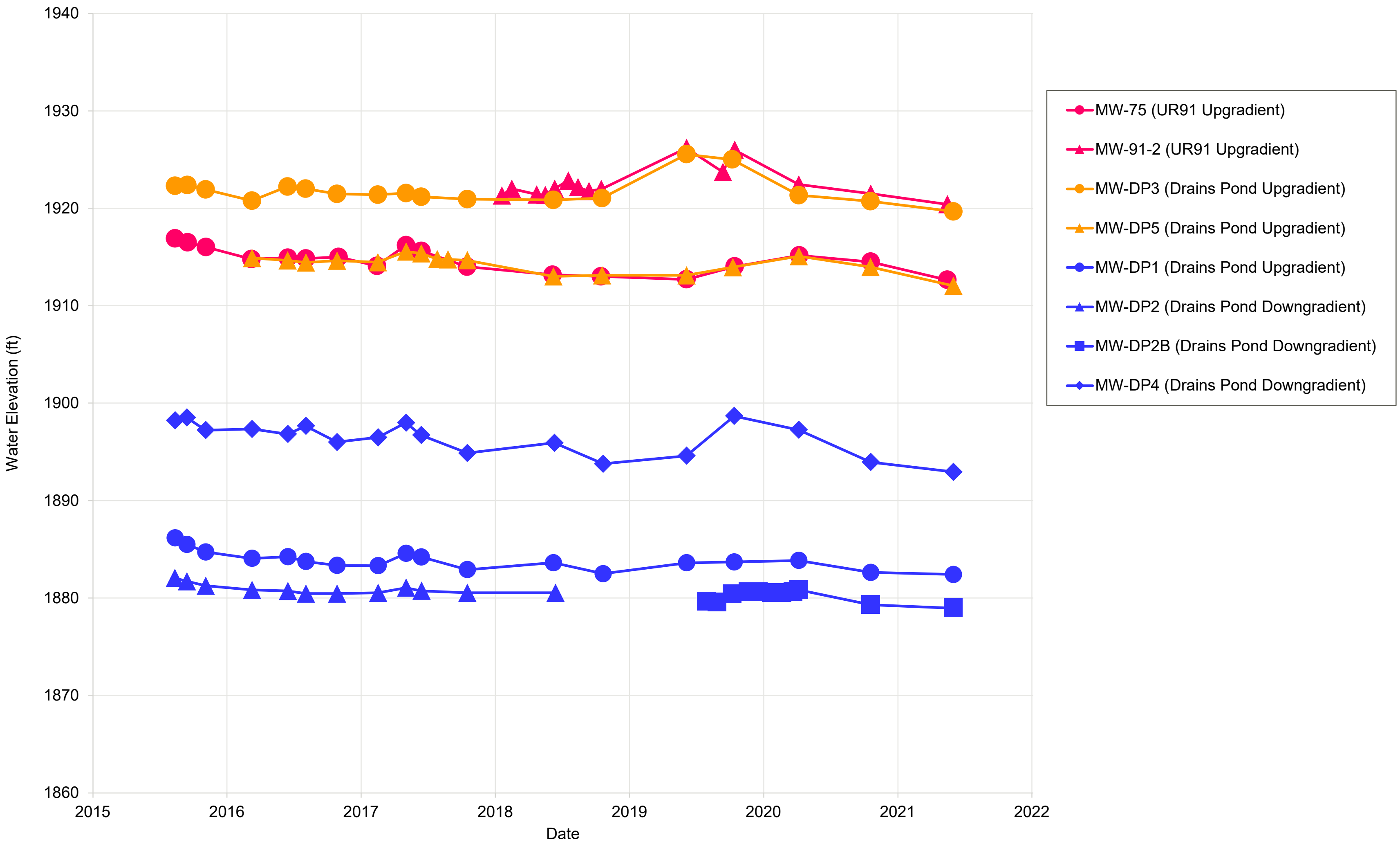
GOLDER
MEMBER OF WSP

ALTERNATIVE SOURCE DEMONSTRATION
MAY-JUNE 2021 GROUNDWATER CONTOURS AND SAMPLING LOCATIONS

FIGURE 1

Path: \\Denver\acad\GREAT RIVER ENERGY\COAL CREEK\99_PROJECTS\21451024\21451024C\ASD (Q2 2021) | File Name: Figure_Q2 2021 ASD DP4.dwg

PATH: https://golderassociates.sharepoint.com/sites/140044/Project Files/5 Technical Work/6 - Water Quality/Q2 2021 ASDs | FILE NAME: CCS Q2 2021 ASD Working Data.xlsm



CLIENT
Great River Energy Coal Creek Station

PROJECT
Alternative Source Demonstration

CONSULTANT
GOLDER
MEMBER OF WSP

TITLE
Time Series of Groundwater Elevations in Network Wells

PROJECT NO.	PHASE	REV.	FIGURE
21451024C	--	0	2

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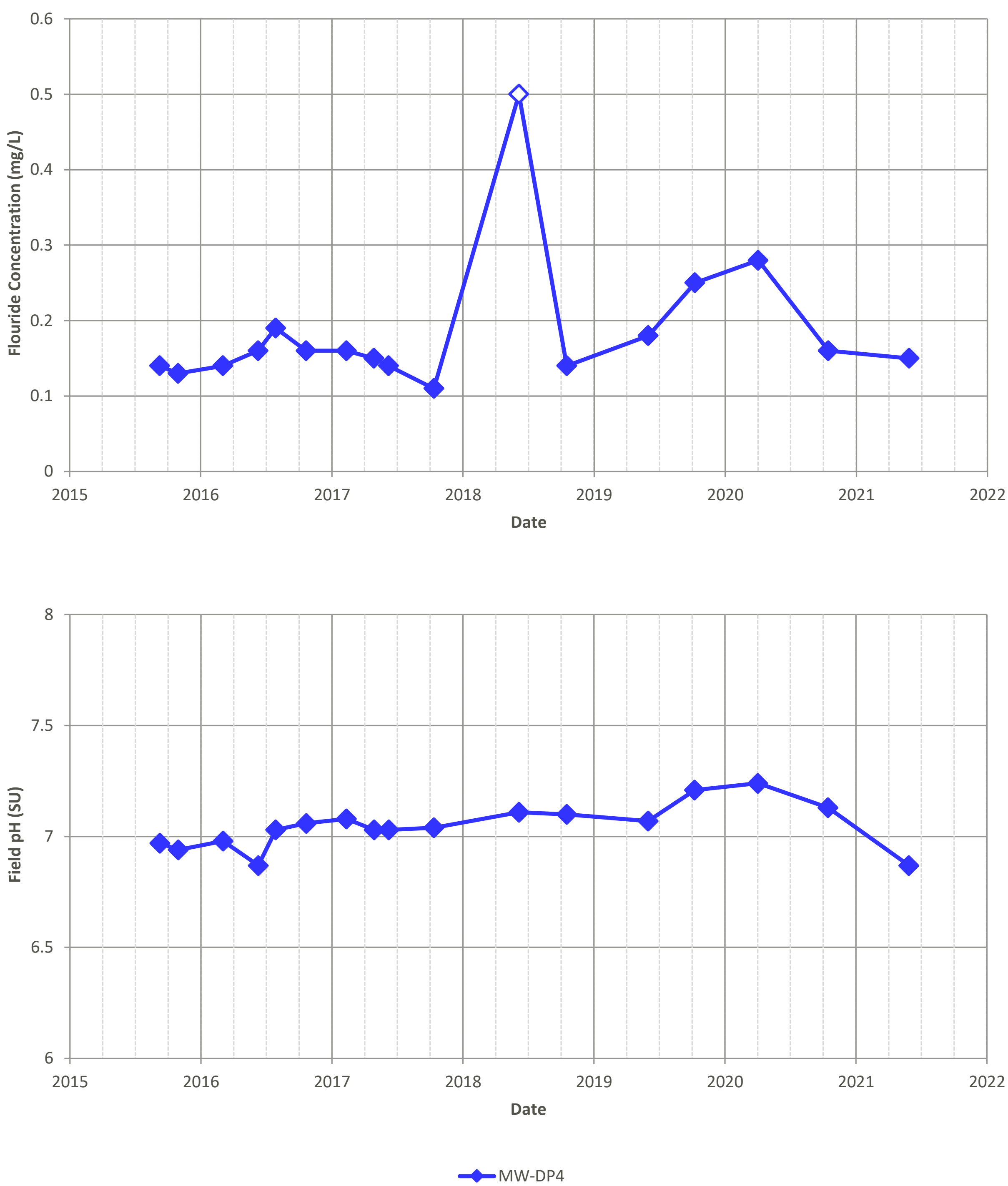
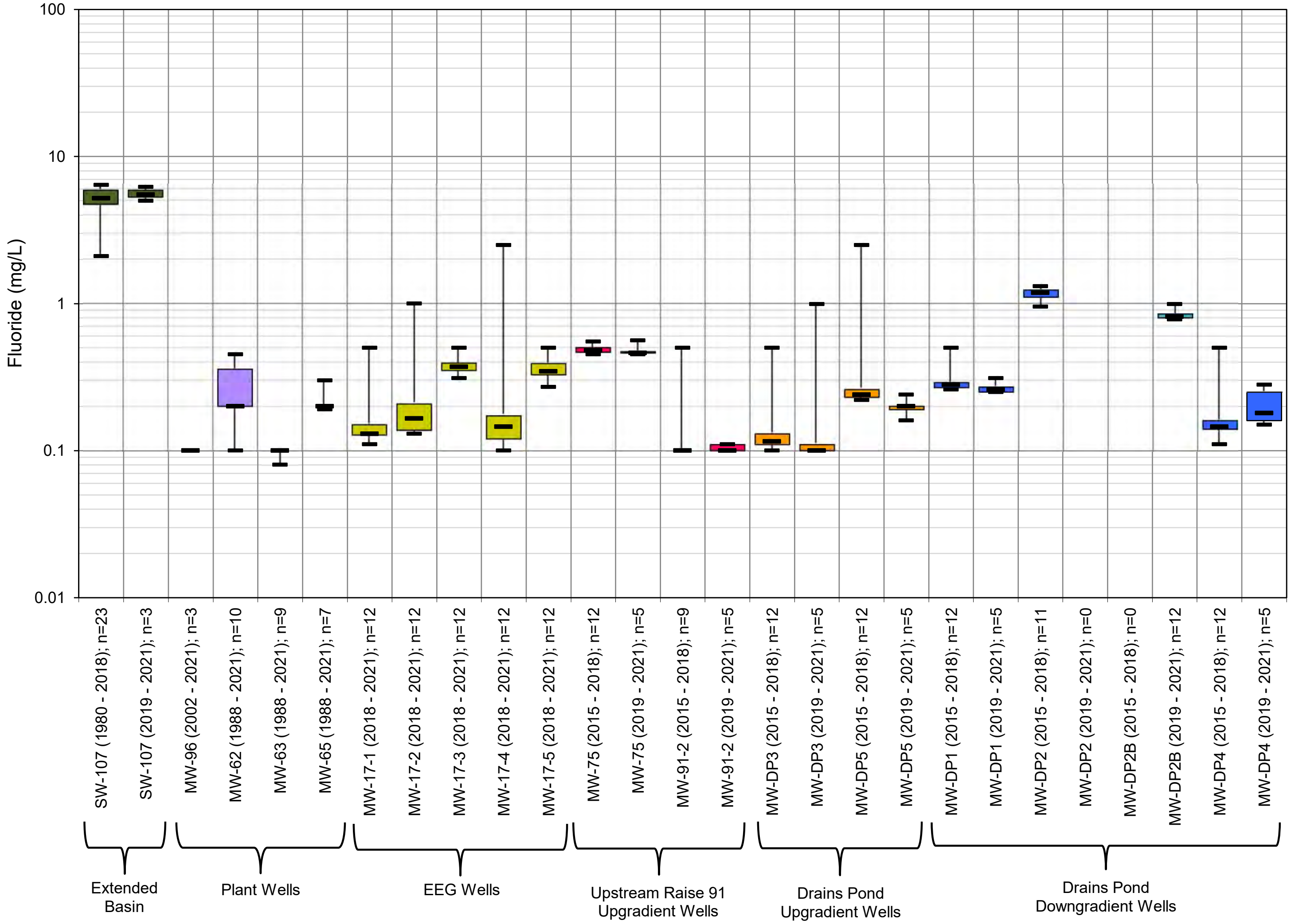


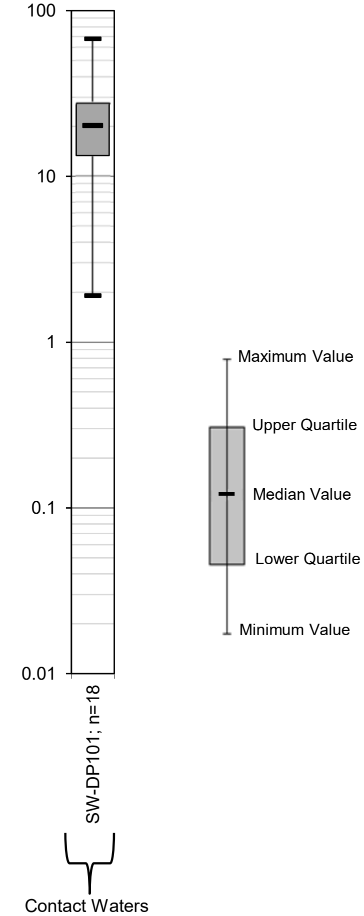
Note: Open symbol denotes measurement below the detection limit

CLIENT Great River Energy Coal Creek Station	PROJECT Alternative Source Demonstration
CONSULTANT GOLDER MEMBER OF WSP	TITLE Time Series of Fluoride and Field pH in MW-DP4

PROJECT NO.	PHASE	REV.	FIGURE
21451024C	--	0	3

PATH: https://golderassociates.sharepoint.com/sites/140044/Project Files/5 Technical Work/6 - Water Quality/Q2 2021 ASDs/MW-49/Excel Sheets | FILE NAME: CCS_Box and Whisker.xlsm





Note: For concentrations measured below the detection limit, the detection limit was used

CLIENT
Great River Energy Coal Creek Station

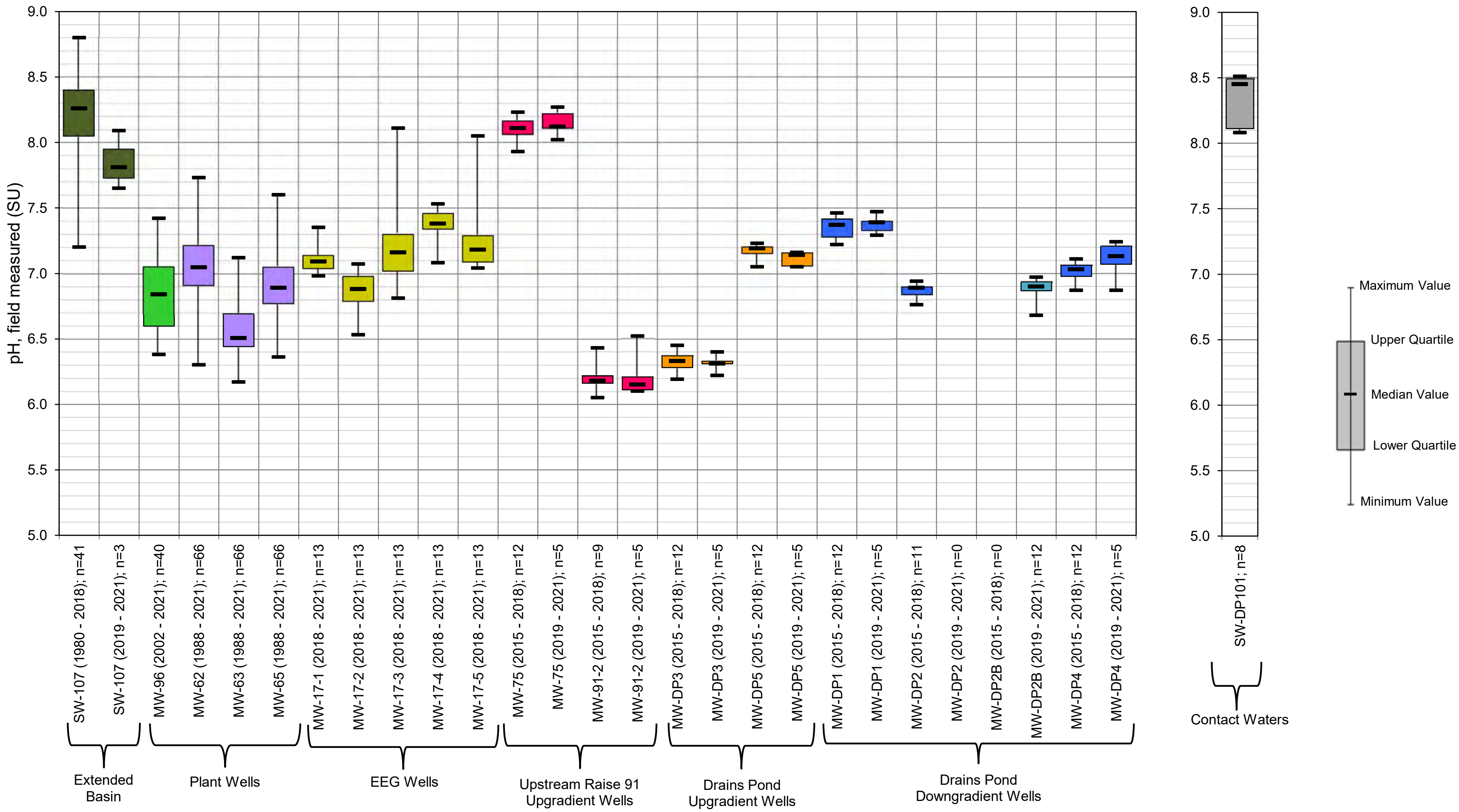
PROJECT
Alternative Source Demonstration

CONSULTANT
GOLDER MEMBER OF WSP

TITLE
Box and Whisker Plot for Fluoride

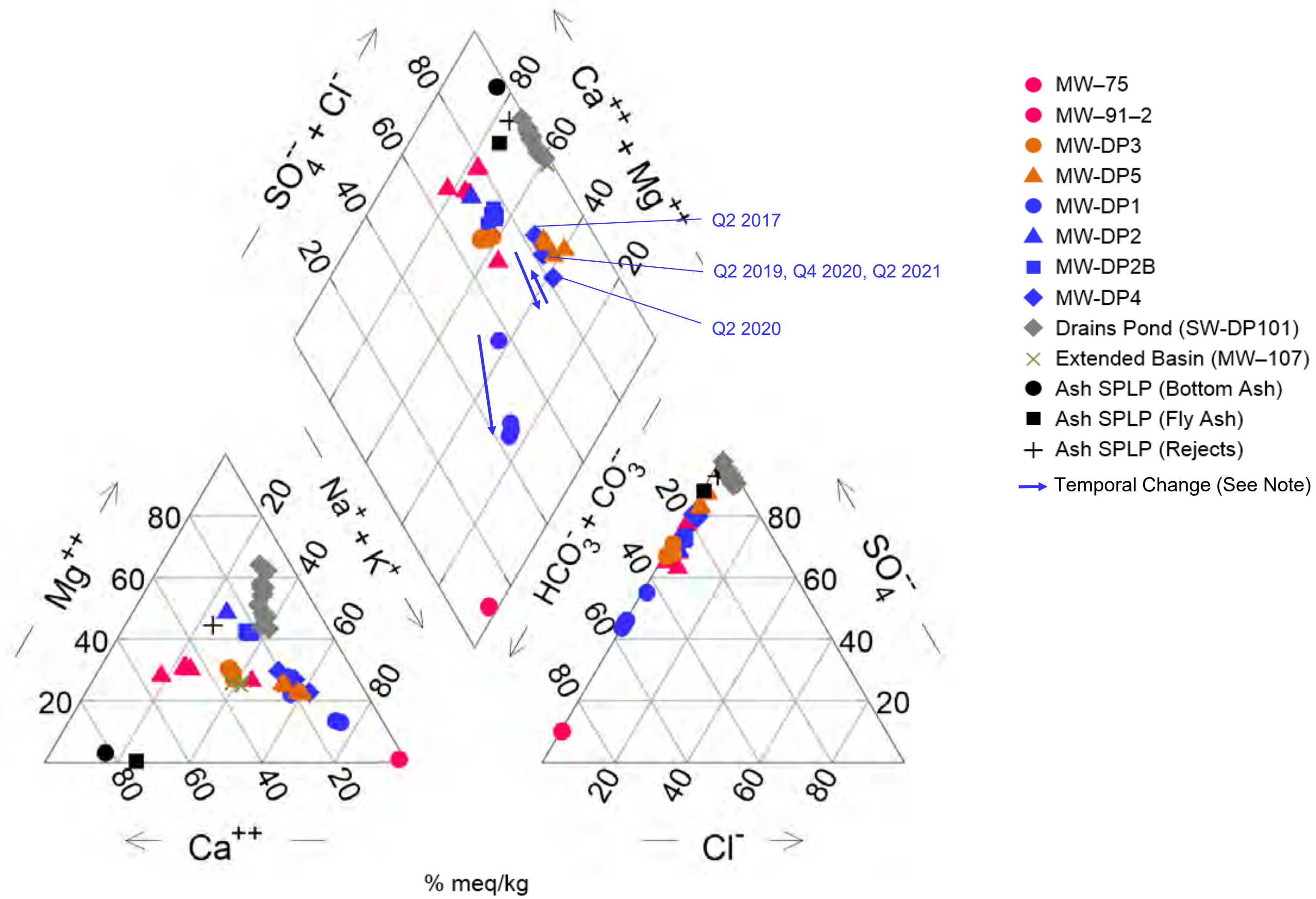
PROJECT NO.	PHASE	REV.	FIGURE
21451024C	--	0	4

PATH: https://golderassociates.sharepoint.com/sites/140044/Project Files/5 Technical Work/6 - Water Quality/Q2 2021 ASDs/MW-49/Excel Sheets | FILE NAME: CCS_Box and Whisker.xlsm



CLIENT	PROJECT
Great River Energy Coal Creek Station	Alternative Source Demonstration
CONSULTANT	TITLE
GOLDER MEMBER OF WSP	Box and Whisker Plot for Field pH

PROJECT NO.	PHASE	REV.	FIGURE
21451024C	--	0	5



Note:
Arrows display the change in groundwater geochemistry at MW-DP4 and MW-DP1 with time. The arrows indicate that the most recent samples collected at MW-DP4 and MW-DP1 (2019 - 2021) are less similar to Drains Pond water or CCR SPLP leachates, compared to the samples collected in 2017.

* Some samples from October 2018, June 2019, and October 2019 did not have alkalinity measurements so alkalinity was estimated as the difference between major cations (Ca, Mg, Na, K) and major anions (SO4, Cl, F). This technique is less precise and should be regarded as a high-level estimate.

CLIENT
Great River Energy Coal Creek Station

CONSULTANT
GOLDER
MEMBER OF WSP

PROJECT
Alternative Source Demonstration

TITLE
Piper Diagram

PROJECT NO.	PHASE	REV.	FIGURE
21451024C	--	0	6

golder.com

REPORT

Alternative Source Demonstration for Chloride in Monitoring Well MW-DP4

Great River Energy - Coal Creek Station

Submitted to:

Great River Energy

Coal Creek Station
2875 Third Street SW
Underwood, North Dakota 58576

Submitted by:

Golder Associates USA Inc.

7245 W Alaska Drive, Suite 200, Lakewood, Colorado, USA 80226

+1 303 980-0540

21451024C-14-R-0

January 6, 2022

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TABLES

FIGURES

1.0 INTRODUCTION

On behalf of Great River Energy (GRE), Golder Associates USA Inc. (Golder), member of WSP, performed a statistical evaluation of groundwater monitoring results from the second quarter (Q2) 2021 groundwater detection monitoring event at Coal Creek Station's (CCS's) Drains Pond System coal combustion residual (CCR) surface impoundment. The statistical evaluation was performed as described in the Coal Combustion Residuals Groundwater Statistical Method Certification for Coal Creek Station (Golder 2021e), in accordance with applicable provisions of 40 Code of Federal Regulations (CFR) Part 257, "Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities; Final Rule" (CCR Rule), as amended.

Statistical analyses of the Appendix III detection monitoring data for chloride in groundwater at the downgradient monitoring well MW-DP4 indicated a potential exceedance of the statistical limit based on the parametric Shewhart-CUSUM (Cumulative Summation) control chart analysis of the fourth quarter (Q4) 2020 sampling results. This potential exceedance was subsequently verified as a statistically significant increase (SSI) following the Q2 2021 detection monitoring sampling event.

Although determination of a verified SSI generally indicates that the groundwater monitoring program should transition from detection monitoring to assessment monitoring, 40 CFR Part 257.94(e)(2) allows the owner or operator (i.e., GRE) 90 days from the date of determining a verified SSI to demonstrate a source other than the regulated CCR facility caused the SSI or that the SSI is an indication of an error in sampling, analysis, or statistical evaluation or natural variability in groundwater quality that was not fully captured during the baseline data collection period.

Golder's review of the hydrological and geologic conditions at the site indicates the chloride SSI in MW-DP4 is not an indication of impacts from the CCR unit. A desktop study of previously collected CCR-impacted water from the facility, nearby surface water, and groundwater samples was conducted to assess potential chloride sources. As a part of this work, potential errors in the statistical analysis and the natural variability of chloride concentrations in groundwater were evaluated. Based upon this review and in accordance with provisions of the CCR Rule, Golder prepared this Alternative Source Demonstration (ASD) for chloride at MW-DP4.

This ASD conforms to the requirements of 40 CFR Part 257.94(e)(2) and provides the basis for concluding that the verified SSI for chloride at MW-DP4 is not an indication of a release from the Drains Pond System. The following sections provide a summary of the Drains Pond System, analytical and geochemical assessment results, and lines of evidence demonstrating an alternative source is responsible for a chloride SSI at MW-DP4.

2.0 BACKGROUND

2.1 Site Background

GRE's CCS is a coal-fired electric generation facility located in McLean County, approximately 10 miles northwest of Washburn, North Dakota. CCRs are managed in composite-lined surface water impoundment cells and dry landfills regulated and permitted by the North Dakota Department of Environmental Quality (NDDEQ) in accordance with North Dakota Administrative Code (NDAC) Title 33.1, Article 33.1-20, Solid Waste Management and Land Protection.

CCS has four CCR facilities that are within the purview of the United States Environmental Protection Agency (USEPA) CCR Rule. This ASD applies only to the Drains Pond System CCR surface impoundment. The Drains Pond System is in the central portion of the plant site, east of the CCS plant buildings (Figure 1). The Drains Pond System is comprised of three cells: west, center, and east. Bottom ash, pulverizer rejects, and economizer ash are conveyed to the west cell where they are dewatered and hauled away to the other CCR facilities. Bottom ash, pulverizer rejects, and economizer ash transport water flows from the west cell to the center cell which acts as a clarifier facility and receives minor amounts of sediment via the plant drains system. Water from the center cell flows to the east cell. The east cell is a non-CCR surface impoundment that is part of the plant process water storage inventory. Water from the east cell is recirculated back to the plant for reuse or is pumped to the on-site evaporation ponds or the permitted underground injection well.

2.2 Site Geology

CCS and McLean County are situated at the eastern-most extent of the Williston Basin, a structural and sedimentary basin (United States Geological Survey [USGS] 1999). The region is characterized by the presence of glacial drift, reaching thicknesses of several hundred feet and overlying the Sentinel Butte Member, the source of commercially mined coal in the direct vicinity of CCS (Falkirk 1979). The Sentinel Butte Member is the highest strata of the Paleocene Fort Union Formation, overlying the Tongue River, Ludlow, and Cannonball Members (USGS 1999). The Sentinel Butte Member is marked by drab-gray units, demarcating the separation from the lower Tongue River Member.

The site geology of CCS includes unconsolidated surficial deposits of the Coleharbor formation, consisting of stratified and unstratified glacial drift. The near-surface materials are silty clay and sandy clay till with interbedded lenses (Cooperative Power Association and United Power Association [CPA/UPA] 1989).

2.3 Site Hydrogeology

Regional groundwater flow of the uppermost water-bearing unit in the vicinity of CCS is a subtle expression of the surface topography, which is influenced by the configuration of the eroded bedrock. Based on available groundwater elevation data, the shallow groundwater at the CCR facilities at CCS generally follows surface topography, flowing east and north towards Lower Samuelson Slough and Sayler Slough. Available groundwater elevation data indicate that groundwater in the area of the Drains Pond System generally flows from the southwest to the northeast, diagonally across the footprint of the facility, towards Lower Samuelson Slough.

Hydraulic conductivities in the area of the Drains Pond System range from 0.01 feet per day (ft/day) to 2.83 ft/day, with calculated groundwater flow rates during the Q2 2021 detection monitoring event ranging from 0.001 to 0.25 ft/day.

2.4 Groundwater Monitoring Network

The groundwater monitoring network for the Drains Pond System was developed for the size, disposal and operational history, anticipated flow direction, and location of adjacent facilities. Based on these factors, a monitoring well network consisting of two upgradient and four downgradient monitoring wells is used for monitoring the unit under the CCR Rule.

The two upgradient monitoring wells (MW-DP3 and MW-DP5) included in the groundwater monitoring network for the Drains Pond System are used to represent upgradient water quality flowing towards the unit from the west and south (Golder 2019). The four downgradient wells (MW-DP1, MW-DP2, MW-DP2B, and MW-DP4) are positioned along the northern and eastern edges of the facility. Beginning in Q4 2018, MW-DP2 has had insufficient water to allow for routine sampling; therefore, MW-DP2B was installed in 2019 adjacent to MW-DP2 to provide further coverage for the monitored unit. The Drains Pond System network wells are presented in Figure 1. Other monitoring locations used to support this ASD are also presented in Figure 1 and are discussed further in Section 5.2.

Figure 2 displays a time-series plot of historical water levels in each monitoring well associated with the Drains Pond System. Water levels in upgradient monitoring wells MW-DP3 and MW-DP5 increased by approximately 2 to 5 feet between Q4 2018 and Q4 2019. A similar increase in water level was also observed in downgradient monitoring well MW-DP4 during the same period. Water levels from Q2 2020, Q4 2020, and Q2 2021 returned closer to historical values. The recent changes in water levels at upgradient and downgradient monitoring wells around the Drains Pond System and the timing of those changes suggest a change to groundwater flow conditions.

2.5 Groundwater Conditions

Between September 2015 and August 2017, GRE collected nine independent baseline groundwater samples from MW-DP3, MW-DP5, MW-DP1, MW-DP2, and MW-DP4, as required by 40 CFR Part 257.94, for use within the CCR Rule monitoring program. Baseline samples were collected from MW-DP2B between June 2019 and March 2020, following installation of the well in 2019. The results of the CCR baseline monitoring were used to develop statistical limits for each constituent at each monitoring well, based on site conditions and parameter specific characteristics such as the data distribution and detection frequency (Golder 2021e).

Following completion of the baseline monitoring events at each well, GRE began collecting groundwater samples on a semi-annual basis to support the detection monitoring program. Groundwater samples for detection monitoring are collected at each upgradient and downgradient monitoring well and analyzed for 40 CFR Part 257 Appendix III constituents. During the detection monitoring program, groundwater analysis results are compared to the calculated statistical limits to determine whether groundwater quality remains consistent or if changes in groundwater quality are observed.

In accordance with the site Statistical Method Certification (Golder 2021e) and recommendations within the USEPA's Unified Guidance (USEPA 2009), a baseline update was conducted for most well-constituent pairs within the Drains Pond System monitoring network prior to conducting comparative statistical analysis for the Q4 2019 detection monitoring event. However, the baseline period for chloride at MW-DP4 was not included in this update due to a potential exceedance identified in Q2 2019. This potential exceedance was identified as a false positive following confirmatory resampling in Q4 2019, and the original baseline period was retained for comparative statistics.

Chloride concentrations in groundwater at MW-DP4 during the baseline monitoring period ranged between 39.5 and 56.0 milligrams per liter (mg/L) in the nine baseline samples collected as part of the CCR Rule monitoring program. The Shewhart-CUSUM statistical limit for the well-constituent pair was set at 74 mg/L.

The Q4 2020 detection monitoring event reported a chloride concentration of 80 mg/L at MW-DP4, with a calculated CUSUM value of 74 mg/L, indicating a potential exceedance. Verification resampling was conducted during the Q2 2021 detection monitoring event, confirming the SSI for chloride at MW-DP4 with a chloride concentration of 71 mg/L and a calculated CUSUM value of 95 mg/L.

2.6 Sampling and Laboratory Testing Procedures

As part of the ASD, a review was conducted of the sampling and laboratory testing procedures used throughout baseline monitoring and detection monitoring to date, along with the collected results. A review of the statistical assessment methods and associated results found the procedures followed during baseline and detection monitoring to be consistent with the stated procedures listed in the published Groundwater Statistical Methods

Certification (Golder 2021e). Calculated limits were found to be consistent with the chosen statistical procedures and recommended methodology found within the Unified Guidance (USEPA 2009).

Beginning in June 2018 (Q2 2018, the second semi-annual detection monitoring event), GRE switched sampling staff. The potential impacts of this change are evaluated in Section 3.0. Also, beginning in June 2018 (Q2 2018, the second semi-annual detection monitoring event), GRE switched analytical laboratories from Minnesota Valley Testing Laboratories, Inc. (MVTL; Bismarck, North Dakota) to Eurofins TestAmerica (TestAmerica; Denver laboratory in Arvada, Colorado). There are differences between the testing methodologies used for chloride by the two laboratories. An evaluation of the methods and their associated differences is discussed in Section 4.0.

In review of the analytical results, a shift in the MW-DP4 chloride concentrations was noted between data collected prior to June 2018 and data collected after June 2018 (Figure 3). The Q4 2019 and Q2 2020 chloride results are not consistent with the upward shift, rather they are significantly lower than the baseline. These lower chloride concentrations correspond with a period of increased fluoride concentrations which has been attributed to the recent changes in the site hydrology and hydrogeology as detailed in the ASDs for fluoride in MW-DP4 (Golder 2020, Golder 2021c, and Golder 2022).

3.0 POTENTIAL SAMPLING CAUSES

Between September 2015 and May 2018, sampling of the CCR Rule wells and other wells and surface water sampling locations at CCS was conducted by outside contractors from the Bismarck, North Dakota location of MVTL. Beginning with the samples collected in June 2018, sampling has been conducted in-house by GRE employees. Low-flow pumps and sampling methods have been used to collect groundwater samples throughout the monitoring program for the CCR Rule, following manufacturer recommendations (Geotech 2015) and USEPA guidance (USEPA Region I 2017). Although using the same sampling methods, there is a potential for minor differences in sampling technique between sampling personnel. The timing of the change in sampling personnel coincides with both the June 2018 shift in chloride concentrations and the change in laboratories noted described in Section 2.6.

4.0 POTENTIAL LABORATORY SOURCES

4.1 Changes in Testing Methodology

Prior to June 2018, GRE contracted MVTL as their analytical testing laboratory for the monitoring program for the CCR Rule. For analysis of chloride, MVTL used a variation of the SM4500-Cl- method (published variations of the method are labeled SM4500-Cl-A through SM4500-Cl-I; Standard Methods Online 2018). In the most recent sampling prior to the analytical laboratory switch, MVTL used method SM4500-Cl-E, Chloride by Automated Ferricyanide Method. Instrumentation for the method is an automated spectrophotometer, as the method is a colorimetric means of measuring chloride in water. All variations of SM4500-Cl are only applicable for testing chloride and are not indicated for use for other analytes.

Under typical use of the method, the applicable concentration range is 1 to 200 mg/L of chloride, which can be extended to higher and lower concentrations by dilution, adjustment of sample size, and other typical testing adjustments (USGS 2002a). The typical chloride reporting limit provided by MVTL was 1.0 mg/L. Although not reported within MVTL's laboratory information management system at the time of testing, dilutions to the sample results are likely to have occurred, given the range in chloride concentrations reported using the method between 2015 and 2018 (1.1 to 697 mg/L across CCS samples collected as part of the monitoring program for the CCR Rule).

Beginning with the June 2018 sampling events for the CCR Rule groundwater monitoring program, GRE contracted TestAmerica as their analytical testing laboratory. For analysis of chloride, TestAmerica has used method SW9056A, the Determination of Inorganic Anions by Ion Chromatography (USEPA 2007). Ion chromatography identifies and separates different ions based on their affinity to an ion exchanging resin, which is packed in a flow-through column. The separated ions elute off the column at different times, characteristic to the ion size and charge, and are measured using an electrical conductivity meter, generating a series of peaks as the different ions leave the column (Figure 4). Relative to a baseline level of conductivity, the area of each peak is proportional to the ion’s concentration in the sample. The peak area is compared to the peak areas generated by known concentrations in calibration standards to derive a sample concentration. In the case of method SW9056A, the specified analytical column (i.e., the ion exchanger), is required to be suitable for analyzing for chloride, fluoride, bromide, nitrate, nitrite, phosphate, and sulfate.

The typical chloride reporting limit provided by TestAmerica at the Denver laboratory was 3.0 mg/L. Dilutions have varied across samples, ranging from 1x dilution factors (i.e., no dilution and a reporting limit of 3.0 mg/L) to 50x dilution factors (with a corresponding reporting limit of 150 mg/L). Due to the capacity of the method for testing multiple anions, indiscriminate dilution intended to account for high concentrations of one anion, particularly in accounting for samples with higher sulfate concentrations as found at CCS, can negatively impact outcomes for the other anions measured by the method, resulting in non-detect results with excessive dilutions. This aspect is particularly salient due to the base application of the method, as loading of the ion exchange column within the ion chromatograph should not exceed concentrations of approximately 500 parts per million (ppm) (equivalent to 500 mg/L) of total anions within the sample when the sample to be tested is undiluted (USGS 2002b).

In comparing the methodologies used by the two laboratories, a few specific differences are apparent. First, the two methods analyze for chloride using fundamentally different mechanisms. Method SM4500-Cl- E uses spectrophotometry, which measures to what extent a chemical of interest absorbs light by passing a light source through a sample. Differentiation of chemical compounds is based on the principle that each compound will absorb light over a specific range of wavelengths (Standard Methods Online 2018; USGS 2002a). Method SW9056A uses ion chromatography, quantifying the species of interest based on their affinity for an ion exchanger (USEPA 2007; USGS 2002b). Due to the difference in mechanisms between the methods, samples that are analyzed by the two methods would be anticipated to show slightly different results, even if tested portions are drawn from the same sample.

Second, larger differences between quantified results could be anticipated in samples with complex matrices, particularly those with large concentrations of other anions measured through the SW9056A methodology. Although the ion exchangers used within ion chromatography are specific to each method, the column specified by SW9056A is intended to account for the affinity of the complete list of analytes specified by the method in sequential order (USEPA 2007). In samples at CCS, concentrations of sulfate alone, as the final sequential anion within the method, often exceed the total anion loading of the methodology prior to dilution of samples. As the concentrations of chloride are less than those of sulfate within samples from CCS based on previously collected information and geochemical water-typing, masking of the intended analyte by other anions intended for quantification could skew results. Appropriate calibration across multiple concentration ranges is intended to prevent this issue. However, based on past included laboratory qualifiers and explanations within laboratory narratives, pinpointing a group of ranges across samples can prove difficult.

One further difference between the results from the two laboratories are the number of significant digits reported within sample results. Results for chloride using method SM4500-Cl- E from MVTL were reported with three significant digits, while TestAmerica reports results for chloride using method SW9056A using only two significant digits. This difference in precision between the two laboratories may be subtle given the concentrations of chloride across samples, but could result in a difference in population medians, signifying a shift in concentrations with no cause from the facility. Similar differences are noted in the number of significant digits reported for boron, calcium, sulfate, and total dissolved solids between reporting from the two analytical laboratories.

4.2 Ion Chromatography

In addition to comparing differences between the chloride methods, Golder reviewed TestAmerica's SW9056A standard operating protocols and reviewed the ion chromatography output data to look for practices that have the potential to bias chloride concentrations towards higher values.

The quality of ion chromatography measurements is dependent on consistency in data processing, especially with respect to peak conversion to concentration. For example, the following aspects should be handled consistently:

- the time window used to calculate the area under a peak
- the method for determining baseline conductivity
- the approach for dealing with minor peaks that elute from the column at the same time as an analyte of interest

These data processing calculations are automatically performed by the instrument software and can result in minor differences between samples and standards. While TestAmerica checks ion chromatograph data to confirm that the instrument software is functioning consistently, there is a range of variability in the software data processing practices that is tolerated and the decision on whether to manually adjust the software-calculated concentrations by manually selecting peaks is the responsibility of TestAmerica personnel.

Golder's review of the TestAmerica ion chromatography data identified several data processing practices that have the potential to bias towards higher chloride concentrations (Figure 5) include:

- using a longer integration time for samples compared to calibration standards
- selecting a lower baseline in samples relative to calibration standards
- including minor shoulder peaks in sample chloride peaks when they were excluded from calibration standard chloride peaks

These practices were implemented in the processing of the ion chromatographs for the MW-DP4 samples collected between June 2018 to October 2019 and have the potential to cause chloride concentrations variations by up to 4.2 percent. Golder discussed the data processing practices with TestAmerica after an internal review, and TestAmerica deemed the practices as within the range of acceptable variability and a revision to the originally reported values was not warranted (D. Bieniulis, personal communication, May 8, 2020). While up to a 4.2 percent difference is relatively small, this difference could account for part of the shift in MW-DP4 chloride concentrations described in Section 2.6 and result in identification of an SSI. Data collected since Q2 2020 suggest the laboratory is more closely monitoring the peak selection process for the ion chromatographs, but these laboratory practices will continue to be monitored for changes in future analysis.

5.0 POTENTIAL SITE CHLORIDE SOURCES

To assess the potential sources for a change in chloride concentrations at MW-DP4, Golder reviewed recent site changes upgradient of the Drains Pond System, as well as previously collected data from the CCR Rule program and other site monitoring data that are collected under other programs. The following sections summarize the supplemental assessment activities.

5.1 Site Changes and Potential sources

The following sections discuss site changes and potential impacts associated with those changes. Site changes may have affected constituent concentrations entering the groundwater system or the hydrologic and hydrogeologic conditions (water balance) of the site.

5.1.1 Duck Pond and Drains Pond System Construction

Beginning in 2015, the drainages on the south and west sides of the Drains Pond System were modified to allow for construction of an expansion to the Drains Pond System. As a part of this construction, modifications to the existing drainage pathways adjacent to the footprints of the west and center cells of the Drains Pond System were required and the composite-lined west and center cells of the Drains Pond System were constructed.

Historically, the Duck Pond area was a low-lying area southwest of the east cell of the Drains Pond System (Figure 1). The depth of water contained in this area was generally 12 feet (water surface elevation approximately 1911 feet) and the Duck Pond had a surface area of approximately three acres. As the water level increased, overflow passed through culvert piping to the north under what is now the center cell of the Drains Pond System. As part of the construction in 2015, the Duck Pond was dewatered, the area was graded, and culverts were installed to drain surface water south and east around the south side of Upstream Raise 91.

The recent removal of the Duck Pond and regrading of the area upgradient of the Drains Pond System potentially altered the hydrological flow paths to MW-DP4. In addition to the changing flow paths, the removal of the Duck Pond also eliminated infiltration of water from the Duck Pond to groundwater, which may have provided a dilution effect on groundwater concentrations upgradient of MW-DP4.

5.1.2 Surface Water Drainage Ditch West of Drains Pond System

The west cell of the Drains Pond System is separated from a rail line to the west by a surface water drainage ditch. The rail lines are primarily used to transport coal and fly ash from CCS off site. The haul road directly east of this drainage ditch is used by GRE personnel to load bottom ash, pulverizer rejects, and economizer ash into trucks for disposal in the various CCR containment facilities.

The surface water drainage ditch receives stormwater and snow melt runoff from the rail line slope to the west and the embankment of the west cell of the Drains Pond System to the east. Since there is a potential for runoff into this surface water drainage ditch to contain contact water associated with the loading and hauling of CCR, the drainage ditch was originally designed to flow to the south and east, eventually discharging into the center cell of the Drains Pond System to be managed with other CCR contact waters. Due to operational constraints (pipeline alignments and haul routes), this drainage ditch no longer operates as described above.

In October 2020, a registered professional engineer (PE) from Golder was on site performing the annual PE inspection of the Drains Pond System per USEPA Regulation 40 CFR Part 257.83(b) requirements (Golder 2021b). The annual inspection report noted that bottom ash had accumulated in this ditch and that the ditch lacked an outlet to allow stormwater and snow melt runoff to drain away from the area as originally designed.

Within one month of the observations noted during the 2020 annual PE inspection, corrective measures were designed and implemented. The corrective measures included cleaning out accumulated CCR from the ditch, grading areas to drain, and installing a culvert to allow stormwater drainage from the ditch. Additional information regarding this area, including details about the observations and design and implementation of corrective measures are included in the Corrective Measures Report (Golder 2021d).

5.1.3 Plant Drains Pipe Corridor

Two “plant drains” pipelines run parallel to the main west-east haul road (Figure 1) and currently end approximately 100 feet to the southwest of MW-DP4. These pipelines consist of a 36-inch diameter “plant drain” concrete pipeline (bell and spigot joints) and a 14-inch diameter “chemical drain” fiberglass reinforced pipeline which have each been in service since plant commissioning (approximately 40 years). The 36-inch “plant drain” pipeline primarily carries flow collected from various floor drains around the industrial block, of which a major contribution to the flow is typically overflow from the bottom ash hoppers. The 14-inch “chemical drain” pipeline conveys water from the cooling water system (cooling water blowdown) and the chemistry laboratory. Cooling water blowdown is representative of the water contained in the Extended Basin. Water from the chemistry laboratory includes water from the room sink and floor drains as well as demineralizer regen and reverse osmosis “clean in place” waste.

Construction in 2015 modified these pipelines so that they can passively drain into the center cell of the Drains Pond System via a new precast concrete manhole. Upstream of the new precast concrete manhole, the 36-inch “plant drain” pipeline was cleaned out using high-pressure water. During the cleanout process, a significant amount of sediment was removed; however, it was noted that a significant amount of sediment (likely cemented CCR particles) was difficult to remove and remained in place, making inspection of the physical state of this pipeline (i.e., joint condition, reinforced concrete pipeline wall condition, etc.) difficult.

Due to the low-pressure (gravity) operation and small diameters of these plant drains pipelines, they are difficult to evaluate for potential leaks. In addition, removing these pipelines from service is also difficult during both plant operation and outages. As a result, minimal maintenance has been performed during the life of these systems. Since these pipelines have been in operation for a significant amount of time, it is possible that they have been compromised or have deteriorated due to normal wear and tear over the course of the last 40 years. This could lead to leakage of the water being conveyed and result in changes to water quality adjacent to this piping.

5.2 Data Sources

To determine if recent site changes upgradient of the Drains Pond System have impacted water quality in MW-DP4, the sampling locations and dates for groundwater, surface water, and contact water results were reviewed for each potential source provided below (see Figure 1 for locations).

5.2.1 Drains Pond System

Data collected between September 2015 and June 2021 for the CCR Rule monitoring program were considered in the evaluation. As part of the monitoring program, field personnel collected groundwater samples from the following monitoring wells:

- upgradient to the Drains Pond System: MW-DP3 and MW-DP5
- downgradient from the Drains Pond System: MW-DP1, MW-DP2, MW-DP2B, and MW-DP4

Additionally, results for 20 samples collected between 2014 and 2021 of ash contact water collected from the surface of the east cell of the Drains Pond System (Drains Pond, SW-DP101) were used in the evaluation.

5.2.2 Upstream Raise 91

Data collected between September 2015 and June 2021[1] for the CCR Rule monitoring program were considered in the evaluation. As part of the monitoring program, field personnel collected groundwater samples from the following monitoring wells:

- upgradient to Upstream Raise 91: MW-75 and MW-91-2
- downgradient from Upstream Raise 91: MW-49, MW-51, and MW-91-1

Additionally, results for three samples of ash contact water collected between 2018 and August 2021 from the Upstream Raise 91 sump (Sump-UR91) were available for the evaluation.

5.2.3 Upgradient Plant Cooling Water

Plant cooling water is contained in the Extended Basin, which is located on the western side of the property and upgradient of the CCS plant. Groundwater nearby and potentially influenced by the Extended Basin is monitored at the following locations:

- Upgradient to the powerplant: MW-96
- Downgradient from the Extended Basin: MW-62, MW-63, and MW-65
- EEG Wells: MW-17-1, MW-17-2, MW-17-3, MW-17-4, and MW-17-5 (these wells were installed to monitor a historic leak in the fuel line to the Emergency Engine Generator)

For the plant wells, results from samples collected between October 1988 and June 2021 were considered for this evaluation. The EEG wells were installed in Q4 2017, and results included in this evaluation were for samples collected between January 2018 and June 2021.

Additionally, results for samples collected from the Extended Basin (SW-107) between October 1980 and April 2020 were used in the evaluation.

5.3 Evaluation of Potential Sources

Figure 6 displays a map of the locations and observed chloride concentrations (both the Q2 2021 concentration and the range of chloride values observed in baseline and detection monitoring) for the monitoring wells and surface water sources described in Section 5.2. As shown in Figure 1, groundwater generally flows from the southwest to the northeast. To assist with the identification of potential chloride sources to MW-DP4, Figure 7 compares the ranges of chloride concentrations for the monitoring wells and surface water sources on the site with box and whisker plots. Figure 8 displays a scatter plot of the sulfate to chloride ratio versus the calcium to chloride ratio as a method of comparing water qualities across the site. Piper plots were not used due to the lack of consistently having the full suite of cations and anions for the different potential chloride sources at the site. Several potential sources could contribute to changes in chloride concentrations in groundwater at CCS, including infiltration of plant cooling water via the Extended Basin, infiltration of surface water collected in the surface water

[1] June 2019 samples from MW-91-1 and MW-91-2 not used because of a suspected quality control issue.

drainage ditches upstream of the Drains Pond System, leakage from the “plant drains” pipelines, and seepage from the Drains Pond System. These potential sources of chloride are described in the sections below.

5.3.1 Drains Pond System

The chloride concentrations measured in samples from the east cell of the Drains Pond System (125 to 827 mg/L) are higher than samples collected from MW-DP4 and therefore indicate that seepage (if occurring) from the Drains Pond System could increase the chloride concentrations in MW-DP4 (Figure 7). However, the presence of the liner systems described below for each cell of the Drains Pond System reduces the likelihood of seepage to groundwater.

The west cell of the Drains Pond System has a liner system consisting of (from bottom to top):

- 2 feet of compacted clay rich material with a hydraulic conductivity of $1x10^{-7}$ centimeters/second (cm/sec)
- 60-mil high density polyethylene (HDPE) geomembrane liner
- geocomposite drainage layer
- geosynthetic clay liner (GCL)
- 60-mil HDPE geomembrane liner

As indicated above, the west cell of the Drains Pond System was constructed as a double composite liner system with a drainage layer between the upper and lower composite liner systems. The double composite liner system is more protective of the environment since any water (i.e., leakage) passing through the upper geomembrane liner and GCL will be collected by the geocomposite drainage layer and is conveyed passively (via gravity pipelines) to the center cell of the Drains Pond System. Any small amount of water passing through the upper composite liner will quickly and passively drain away, resulting in minimal head on the lower composite liner. Liner leakage is directly proportional to the head on the liner; therefore, with no to minimal head on the lower liner, very little if any leakage is anticipated.

The center cell of the Drains Pond System has a liner system consisting of the following (from bottom to top):

- 2 feet of compacted clay rich material with a hydraulic conductivity of $1x10^{-7}$ cm/sec
- 60-mil HDPE geomembrane liner

The east cell of the Drains Pond System has a liner system consisting of the following (from bottom to top):

- 2 feet of compacted clay rich material with a hydraulic conductivity of $1x10^{-7}$ cm/sec
- 40-mil HDPE geomembrane liner

Contact water in the east cell of the Drains Pond System has lower calcium to chloride and sulfate to chloride ratios than water observed in MW-DP4 (Figure 8). If seepage from the Drains Pond System was impacting groundwater at MW-DP4, a more distinct shift in the calcium to chloride and sulfate to chloride ratios in the samples identified as SSIs from MW-DP4 (Q4 2020 and Q2 2021) towards those observed from the east cell of the Drains Pond System would be expected.

5.3.2 Upgradient Plant Cooling Water

To the west of the Drains Pond System and CCS, water used for plant cooling is contained in the Extended Basin, which holds approximately 60 million gallons and is a clay lined facility. The Extended Basin water originates from the Missouri River but is cycled up to 15 times through the cooling towers. As the water is cycled, heat from the powerplant drives evaporation, which concentrates the constituents in the Extended Basin. Between 1988 and 2021, chloride concentrations in the Extended Basin ranged between 73 and 330 mg/L.

Nearby monitoring wells (MW-62, MW-63, and MW-65) located upgradient of the powerplant and immediately adjacent to the Extended Basin also have elevated chloride concentrations ranging from 8.0 to 290 mg/L indicating that water from the Extended Basin is impacting groundwater chloride concentrations. The elevated chloride concentrations from the Extended Basin show considerable increases relative to MW-96, a background well for the plant that is side-gradient to the Extended Basin. Chloride concentrations at MW-96 range between 4.2 and 7.8 mg/L.

The water from the Extended Basin also appears to be impacting wells further downgradient. The concentrations observed along the flow path from the Extended Basin towards MW-DP4 include the following:

- The EEG wells located east of the Extended Basin have chloride concentrations ranging between 58 and 190 mg/L.
- Well MW-DP5 downgradient from the plant and upgradient of the Drains Pond System has chloride concentrations ranging between 62.0 and 84.8 mg/L. Well MW-DP3 also upgradient of the Drains Pond System has chloride concentrations ranging between 8.6 and 30 mg/L (30 mg/L represents a non-detect value). The highest detected chloride concentration in samples from MW-DP3 was 19.8 mg/L.
- Wells MW-91-2 and MW-75 upgradient of Upstream Raise 91 and side gradient to the Extended Basin have chloride concentrations between 1.1 and 30 mg/L (30 mg/L represents a non-detect value at MW-91-2). The highest detected chloride concentration in samples from MW-91-2 was 16.8 mg/L.

Variations in screened lithology and preferential flow paths in the glacial till may explain why some wells downgradient of the Extended Basin show elevated chloride concentrations (MW-DP5) while other wells (MW-DP3, MW-91-2, and MW-75) have chloride concentrations more similar to MW-96.

The recent removal of the Duck Pond and regrading of the area directly upgradient of the Drains Pond System potentially altered the hydrological flow paths to MW-DP4 and increased the proportion of water with elevated chloride from the Extended Basin relative to other groundwater sources monitored at MW-DP4. In addition to the changing flow paths, the removal of the Duck Pond also eliminated infiltration of water from the Duck Pond to groundwater, which may have provided a dilution effect on groundwater concentrations upgradient of MW-DP4.

Figure 7 and Figure 8 demonstrate that water from the Extended Basin may be influencing ion ratios in groundwater samples from monitoring wells upgradient of Drains Pond System, including MW-62, MW-63, MW-65, MW-17-2, MW-17-5 and MW-DP5, and monitoring wells downgradient of Drains Pond System. A shift in the ion ratios in the samples identified as SSIs from MW-DP4 (Q4 2020 and Q2 2021) is observed toward the ion ratios seen in both the Extended Basin and nearby wells that appear to have been influenced by infiltration from the Extended Basin.

5.3.3 Other Potential Sources

As mentioned in Section 2.4, water levels in upgradient and downgradient monitoring wells increased by approximately two to five feet between Q4 2018 and Q2 2020 (Figure 2). From Q2 2020 to Q2 2021 water levels have been decreasing in both upgradient and downgradient wells. Changes in water levels at upgradient and downgradient monitoring wells around the Drains Pond System and the timing of those changes suggest a change in the hydrological regime. The following site changes and sources may have contributed to the increase of chloride concentrations:

- The recent removal of the Duck Pond and regrading of the area directly upgradient of the Drains Pond System potentially temporarily altered the hydrological flow paths to MW-DP4 (Section 5.1.1). In addition to the changing flow paths, the removal of the Duck Pond eliminated infiltration of water from the Duck Pond to groundwater. This infiltration may have provided a dilution effect on groundwater concentrations upgradient of MW-DP4. Elimination of this dilution source may have resulted in an increase of chloride concentration that led to the identification of the SSIs.
- The surface water drainage ditch west of Drains Pond System (Section 5.1.2) has intermittently contained standing water from stormwater and snow melt runoff. The stagnant water accumulating in this drainage ditch has historically not been removed prior to infiltration. While no water samples were collected prior to when corrective measures were implemented in the fall of 2020 (Golder 2021d), the location immediately upgradient of MW-DP4 suggests that localized infiltration from this ditch could influence groundwater concentrations.
- The two plant drains pipelines (Section 5.1.3) approximately 100 feet to the southwest of MW-DP4 are difficult to evaluate for potential leaks. These pipelines have been in operation for approximately 40 years; therefore, it is possible that they have been compromised or have deteriorated due to normal operation since installation. While no water samples have been collected to date, the location upgradient of MW-DP4 suggests that if water leaked from the pipes, it could infiltrate to groundwater and influence groundwater concentrations at the well. Therefore, it is possible that leakage from the pipes has changed groundwater quality leading to the identification of the SSIs at this well.

6.0 EVIDENCE OF AN ALTERNATIVE SOURCE

Based on the review of potential alternative site sources of chloride presented in this report, primary lines of evidence and conclusions drawn from the evidence used to support this ASD are provided in Table 1.

In summary, the chloride SSI in MW-DP4 is not likely an indication of a release from the Drains Pond System. Instead, the change in chloride concentration is potentially a reflection of sampling and laboratory changes and/or changes in the groundwater flow regime related to the removal of the Duck Pond that have increased the proportion of water with elevated chloride from the Extended Basin relative to other groundwater sources monitored at MW-DP4.

Table 1: Primary and Supporting Lines of Evidence from ASD Analysis

Key Line of Evidence	Supporting Evidence	Description
Change in field personnel	Changed to site personnel from MVTL	Although using the same sampling methods, there is a potential for minor differences in sampling technique between sampling personnel. The timing of the change in sampling personnel coincides with the June 2018 shift in chloride concentrations.
Change in laboratory and methodology	Changed to TestAmerica from MVTL	The timing of the change in laboratory coincides with a shift in chloride concentrations.
	Change from potentiometric method (SRM 4500-CL) to ion chromatography method (SRM 9056A)	Prior to June 2018, MVTL used method SM4500-Cl-E to measure chloride concentrations. Starting in June 2018, TestAmerica analyzed chloride concentrations by SW9056A. These methods have different mechanisms, detection limits, and matrix effects. The timing of the change in methodology coincides with a shift in chloride concentrations.
Laboratory artifact biasing sample concentrations	Ion chromatographs reflecting different data processing practices between some calibration standards and samples	Golder's review of the TestAmerica ion chromatography data identified several data processing practices (integration time length, baseline selection, and treatment of minor peaks) that have the potential to bias chloride concentrations (Figure 5).
Hydrogeology	Groundwater elevations at monitoring wells around the Drains Pond System	Increases in water levels in upgradient and downgradient monitoring wells in 2019 and 2020, followed by subsequent decreases indicate there may be changes in the hydrological flow regime surrounding Drains Ponds System and MW-DP4.
	Recent construction upgradient of MW-DP4 has the potential to alter the groundwater flow regime near MW-DP4	The draining of the Duck Pond to the southwest of MW-DP4 and the intermittent filling of the surface water drainage ditch west of the Drains Pond System have altered the locations of standing water upgradient of MW-DP4, potentially influencing where surface water may infiltrate and affecting the hydrological flow regime surrounding the Drains Pond System and MW-DP4. This change in the flow regime could influence chloride concentrations in samples collected from MW-DP4 leading to identification of the SSIs.
Engineering Controls	Drains Pond System is lined	Each of the three cells of the Drains Pond System has a composite liner system, which decreases the likelihood of seepage from this facility. Additionally, the west cell of the Drains Pond System has a double composite liner system with a drainage system between the liners. Observations of this drainage system have not indicated leakage through the upper composite liner system since operations began in late 2015.
Local sources of chloride	Elevated chloride concentrations in the Extended Basin and other wells downgradient of the Extended Basin	Figure 7 suggests that chloride concentrations in the plant cooling water (Extended Basin) are impacting groundwater chloride concentrations in wells downgradient from the Extended Basin. Similarities in the ion ratios between water samples collected from MW-DP4, the Extended Basin, and wells immediately downgradient of the Extended Basin (Figure 8) suggest that the Extended Basin may be a potential source of elevated chloride at MW-DP4.

7.0 CONCLUSIONS

In accordance with 40 CFR Part 257.95(g)(3), this ASD has been prepared in response to the identification of verified SSIs for chloride at monitoring well MW-DP4 following the Q2 2021 sampling event for the Drains Pond System at CCS.

Based on review of historical analytical results and testing procedures, recent changes to chloride concentrations in groundwater at MW-DP4 are likely not a result of seepage from the Drains Pond System. There are two likely alternative sources, laboratory and sampling artifacts and variability in the upgradient groundwater sources. Therefore, no further action (i.e., a transition to assessment monitoring) is warranted, and the Drains Pond System at CCS will remain in detection monitoring

8.0 REFERENCES

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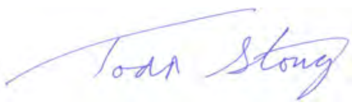
Signature Page

Golder Associates USA Inc.

Gregory Lehn, PhD
Project Geochemist

Sara Harkins, PG (WY)
Senior Geochemist



Todd Stong, PE
Associate and Senior Consultant

GL/SH/TS/df

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https://golderassociates.sharepoint.com/sites/140044/project files/6 deliverables/21451024c/reports/14-r-ccs_asd_q2_mw-dp4/14-r-0/21451024c-14-r-0_asd_q2_mw-dp4_06jan22.docx

Figures

LEGEND

- NDDEQ PLANT AREA UPGRADIENT WELL
- NDDEQ PLANT AREA DOWNGRADIENT WELL
- EEG PROGRAM WELL
- DRAINS POND SYSTEM UPGRADIENT WELL
- DRAINS POND SYSTEM DOWNGRADIENT WELL
- UPSTREAM RAISE 91 UPGRADIENT WELL
- UPSTREAM RAISE 91 DOWNGRADIENT WELL
- GENERAL DIRECTION OF GROUNDWATER FLOW
- 1890 — POTENTIOMETRIC SURFACE CONTOURS (SEE NOTE 2)
- DRAINS POND SYSTEM BOUNDARY
- PLANT DRAINS PIPING (APPROXIMATE LOCATION)
- SURFACE WATER DRAINAGE DITCH - DRAINS POND SYSTEM
- SURFACE WATER DRAINAGE DITCH - UPSTREAM RAISE 91

NOTE(S)

1. GROUNDWATER ELEVATIONS SHOWN WERE MEASURED MAY/JUNE 2021.
2. POTENTIOMETRIC SURFACE CONTOURS WERE CREATED USING WATER LEVEL INFORMATION FROM THE MAY/JUNE 2021 GROUNDWATER ELEVATIONS SHOWN, AS WELL AS SURVEYED SURFACE WATER EXPRESSIONS, ADDITIONAL SITE WELLS, AND PIEZOMETERS NOT SHOWN. CONTOUR INTERVAL IS 5 FEET.
3. AERIAL IMAGERY OBTAINED FROM UNITED STATES DEPARTMENT OF AGRICULTURE, NATIONAL AGRICULTURE IMAGERY PROGRAM, 2020.

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0 300 600
1" = 300' FEET

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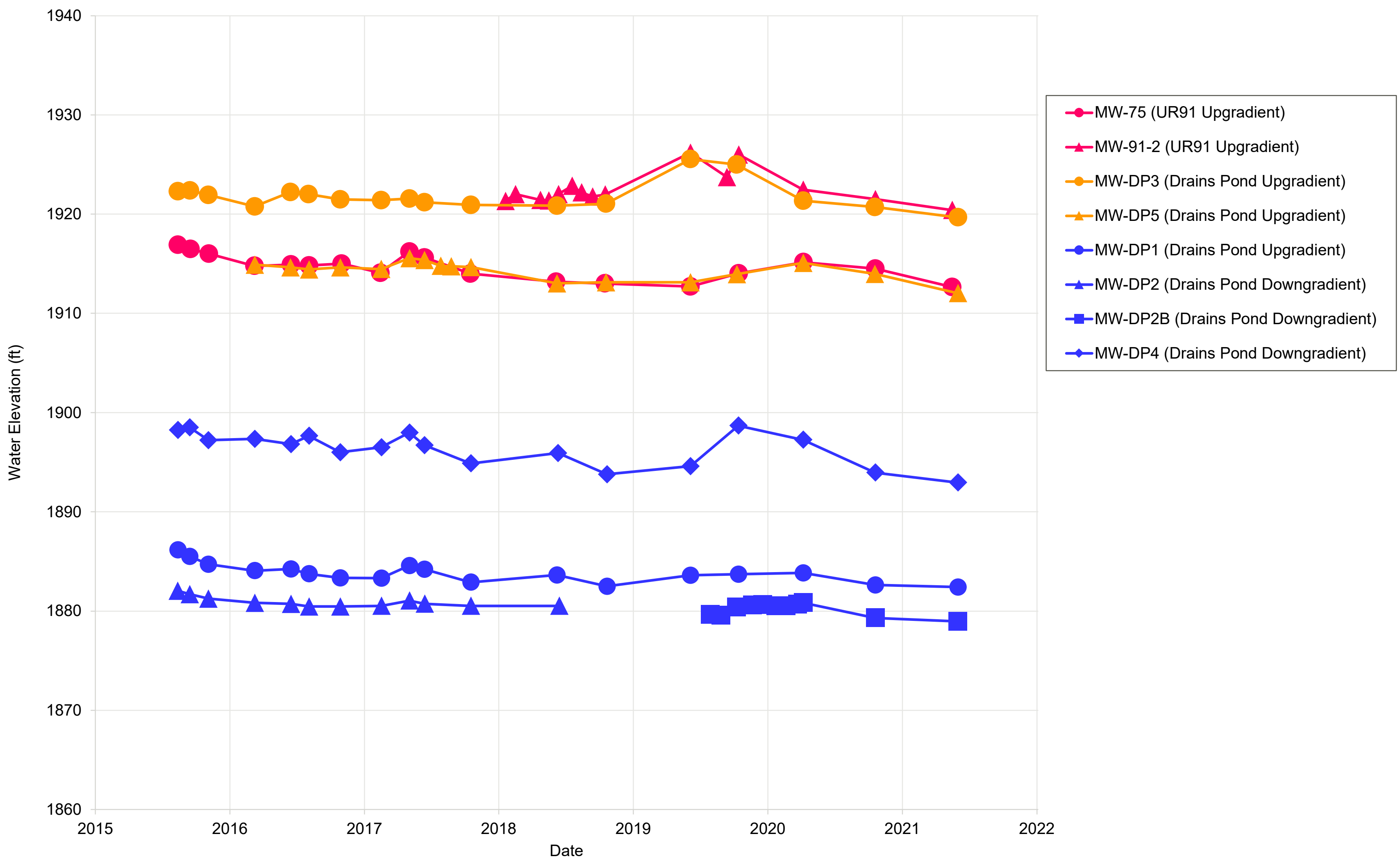
ALTERNATIVE SOURCE DEMONSTRATION
MAY-JUNE 2021 GROUNDWATER CONTOURS AND SAMPLING LOCATIONS

FIGURE 1



CLIENT	PROJECT
Great River Energy Coal Creek Station	Alternative Source Demonstration

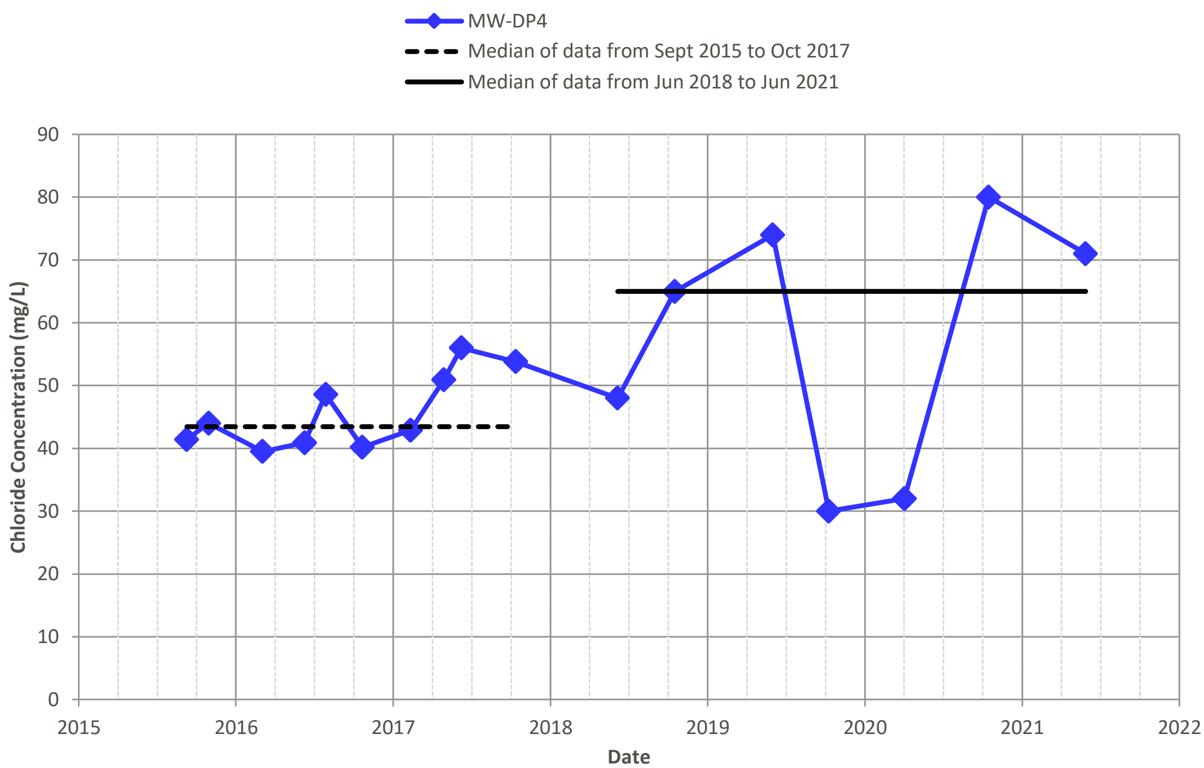
CONSULTANT

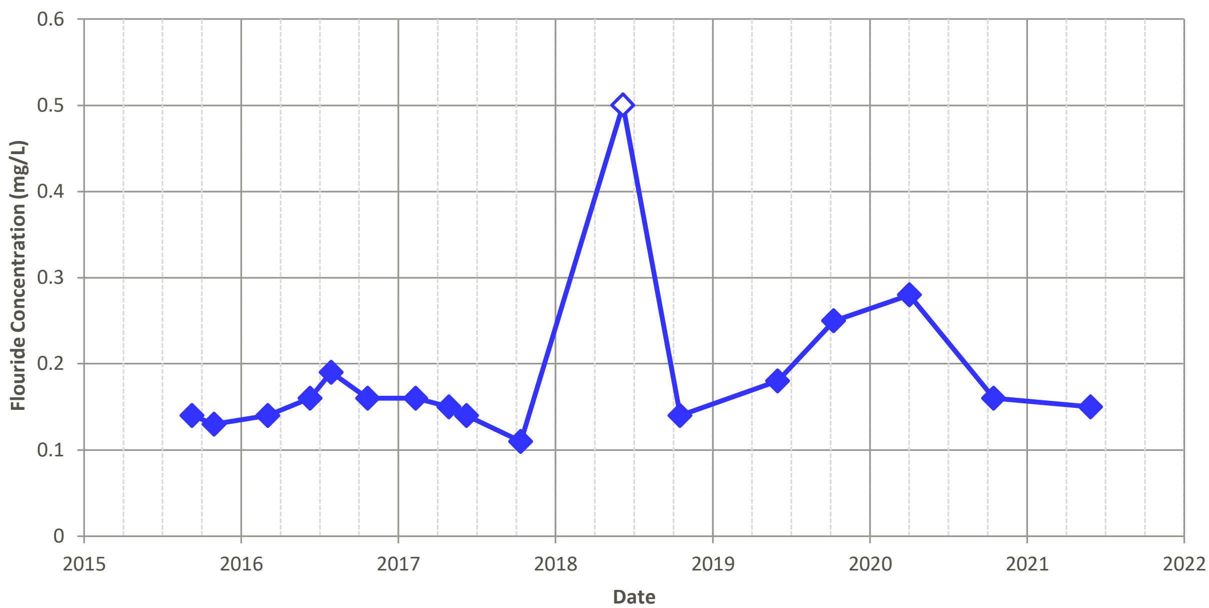
GOLDER
MEMBER OF WSP

TITLE
Time Series of Groundwater Elevations

PROJECT NO.	PHASE	REV.	FIGURE
21451024C	--	0	2

PATH: https://golderassociates.sharepoint.com/sites/140044/Project Files/5 Technical Work/6 - Water Quality/Q2 2021 ASDs | FILE NAME: CCS Q2 2021 ASD Working Data.xlsm





Note: Open symbol denotes measurement below the detection limit

CLIENT
Great River Energy Coal Creek Station

PROJECT
Alternative Source Demonstration

CONSULTANT
GOLDER
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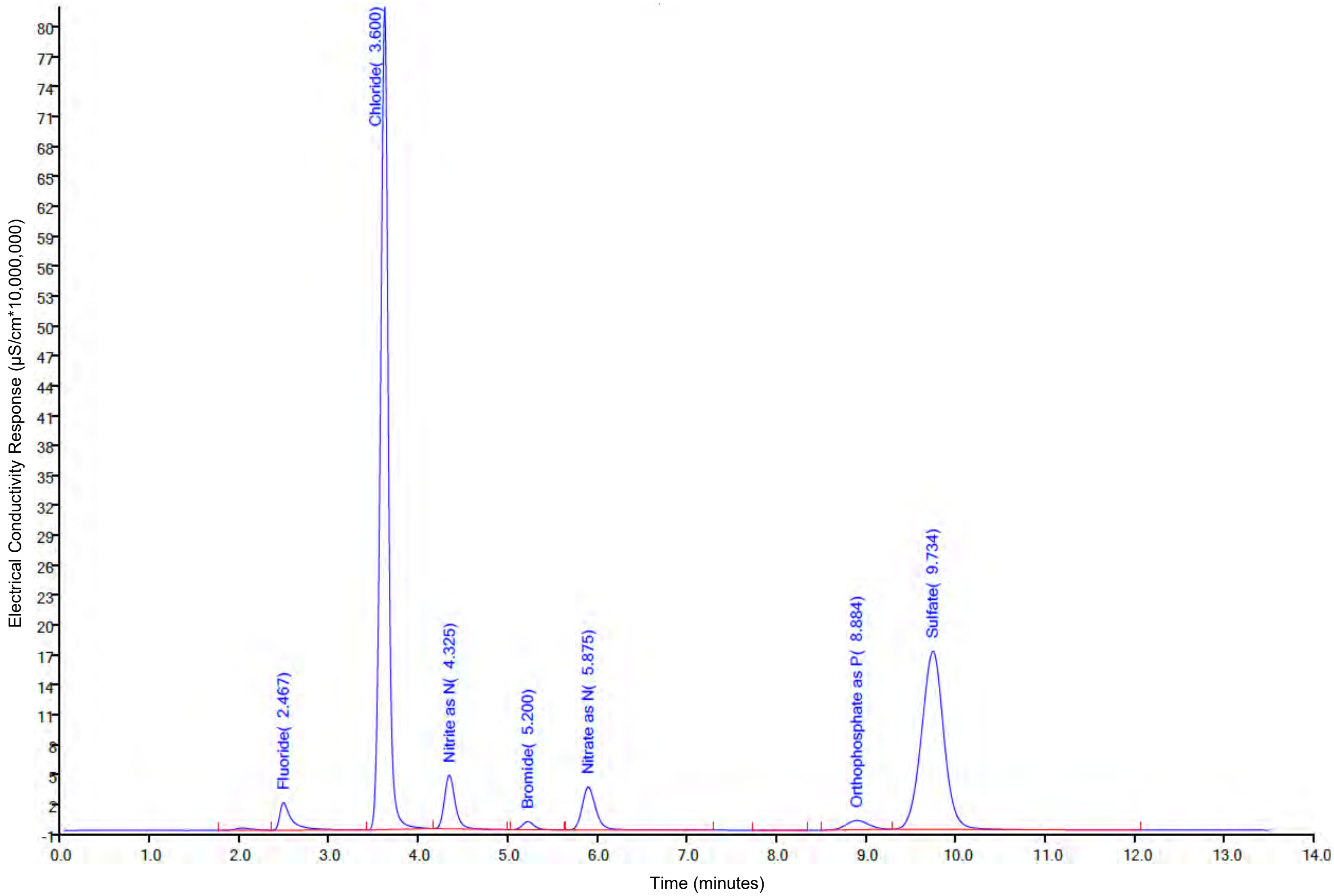
TITLE
Time Series of MW-DP4 Chloride and Fluoride Concentrations

PROJECT NO.	PHASE	REV.	FIGURE
21451024C	--	0	3



CLIENT
Great River Energy Coal Creek Station

PROJECT
Alternative Source Demonstration

CONSULTANT
GOLDER
MEMBER OF WSP

TITLE
Example of Ion Chromatograph Data

PROJECT NO.	PHASE	REV.	FIGURE
21450124C	--	0	4

	Software Data Processing	Manual Processing

Example #1:

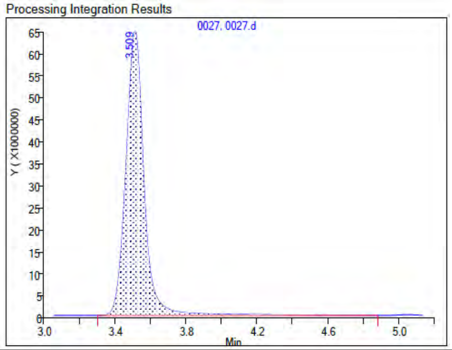
Shortened peak integration time to match calibration standards

Manual processing would decrease chloride concentration by 1.8%

Software Data Processing:

RT: 3.51
Area: 457407359
Amount: 71.627674
Amount Units: ug/ml

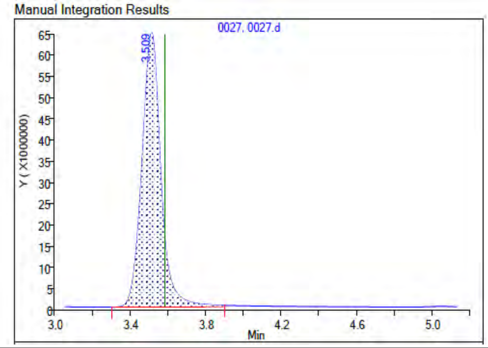
Processing Integration Results



Manual Processing:

RT: 3.51
Area: 449145333
Amount: 70.344660
Amount Units: ug/ml

Manual Integration Results



Example #2:

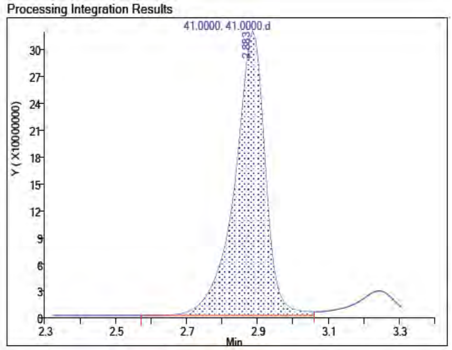
Right side of baseline brought up to minimum signal valley (not below valley), consistent with calibration standards

Manual Processing would decrease chloride concentration by 2.8%

Software Data Processing:

RT: 2.88
Area: 1882027750
Amount: 107.4024
Amount Units: ug/ml

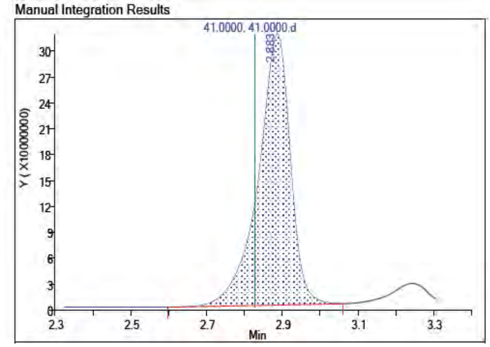
Processing Integration Results



Manual Processing:

RT: 2.88
Area: 1830626225
Amount: 104.4716
Amount Units: ug/ml

Manual Integration Results



Example #3:

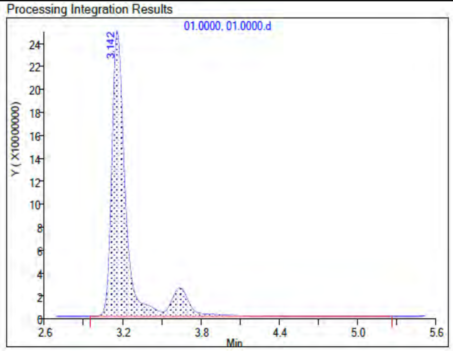
Minor peak to the right of chloride peak not included in area of chloride peak, consistent with calibration standards

Manual Processing would decrease chloride concentration by 4.2%

Software Data Processing:

RT: 3.14
Area: 1753223086
Amount: 98.471277
Amount Units: ug/ml

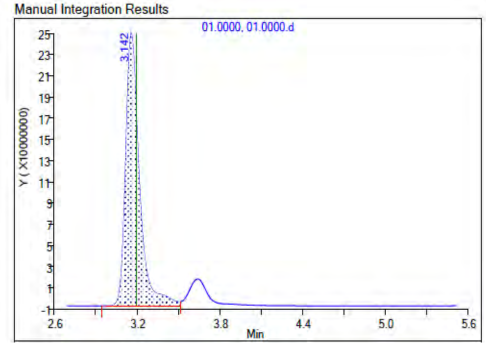
Processing Integration Results



Manual Processing:

RT: 3.14
Area: 1683282689
Amount: 94.545083
Amount Units: ug/ml

Manual Integration Results



CLIENT
Great River Energy Coal Creek Station

PROJECT
Alternative Source Demonstration

CONSULTANT
GOLDER
MEMBER OF WSP

TITLE
Comparison of Ion Chromatograph Software Data Process versus Manual Adjustments

PROJECT NO.	PHASE	REV.	FIGURE
21450124C	--	0	5

LEGEND

- NDDEQ PLANT AREA UPGRADIENT WELL
- NDDEQ PLANT AREA DOWNGRADIENT WELL
- EEG PROGRAM WELL
- DRAINS POND SYSTEM UPGRADIENT WELL
- DRAINS POND SYSTEM DOWNGRADIENT WELL
- UPSTREAM RAISE 91 UPGRADIENT WELL
- UPSTREAM RAISE 91 DOWNGRADIENT WELL
- OTHER SAMPLING LOCATION
- GENERAL DIRECTION OF GROUNDWATER FLOW

71.0 Q2 2021 CHLORIDE CONCENTRATION (mg/L)

(59.2-72.0) RANGE IN CHLORIDE CONCENTRATIONS, (mg/L)

NOTE(S)

1. AERIAL IMAGERY OBTAINED FROM UNITED STATES DEPARTMENT OF AGRICULTURE, NATIONAL AGRICULTURE IMAGERY PROGRAM, 2020.
2. SAMPLES FROM MW-DP5, MW-DP3, MW-DP2B, MW-DP1, MW-DP4, MW-91-2, MW-75, MW-49, MW-91-1, AND MW-51 WERE COLLECTED BETWEEN SEPTEMBER 2015 AND JUNE 2021. JUNE 2019 SAMPLES FROM MW-91-1 AND MW-91-2 WERE NOT USED BECAUSE OF SUSPECTED QUALITY CONTROL ISSUE.
3. SAMPLES FROM SW-DP101 WERE COLLECTED BETWEEN 2014 AND JUNE 2021.
4. SAMPLES FROM SUMP-UR91 WAS COLLECTED BETWEEN NOVEMBER 2018 AND JUNE 2021.
5. SAMPLES FROM MW-17-1, MW-17-2, MW-17-3, MW-17-4, AND MW-17-5 WERE COLLECTED BETWEEN JANUARY 2018 AND JUNE 2021.
6. SAMPLES FROM MW-96, MW-62, MW-63, AND MW-65 WERE COLLECTED BETWEEN OCTOBER 1988 AND JUNE 2021.
7. SAMPLES WERE COLLECTED FROM SW-107 BETWEEN MAY 1980 AND JUNE 2021.
8. FOR CONCENTRATIONS MEASURED BELOW THE DETECTION LIMIT, THE DETECTION LIMIT WAS USED.

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1" = 600' FEET

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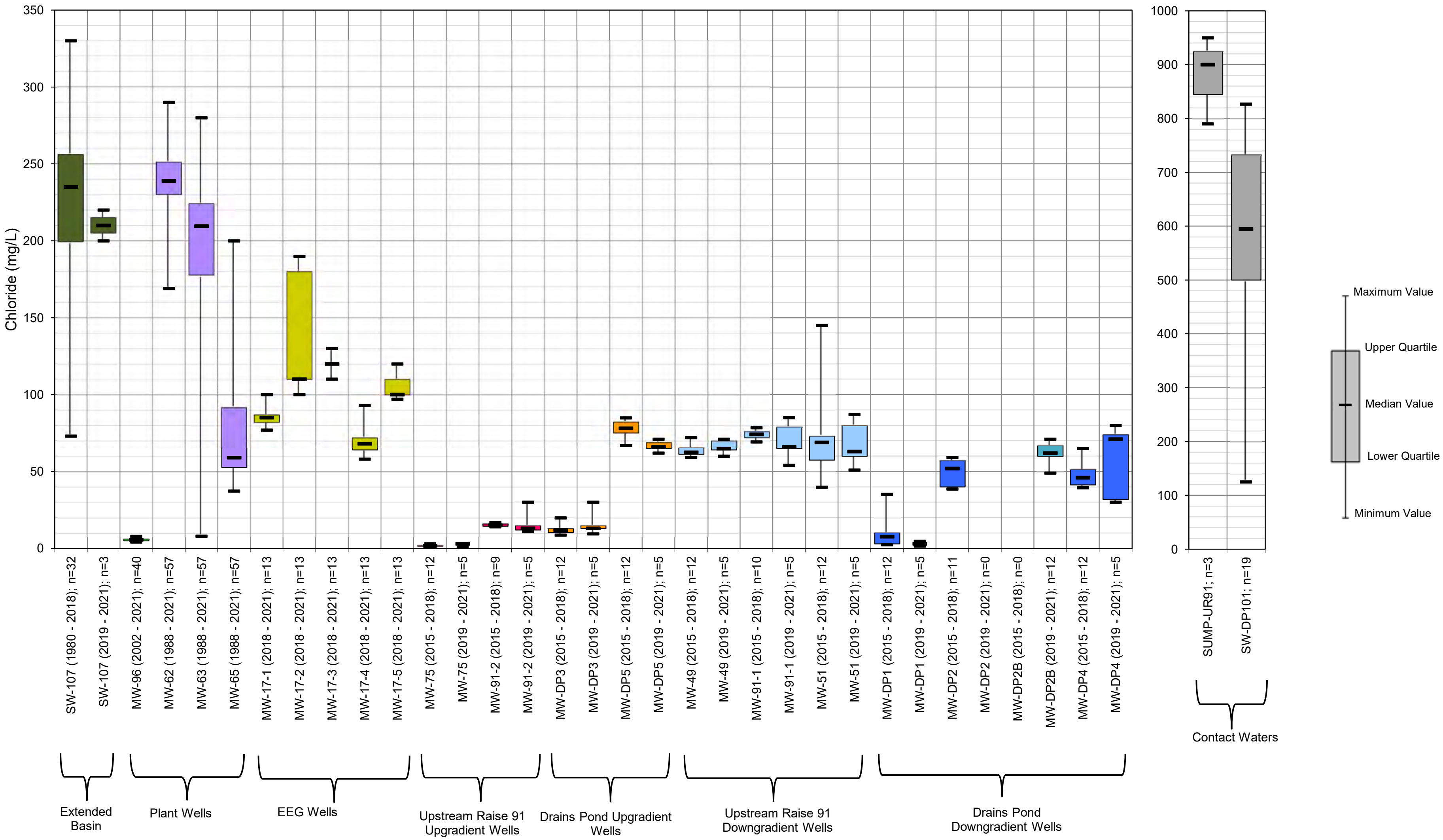
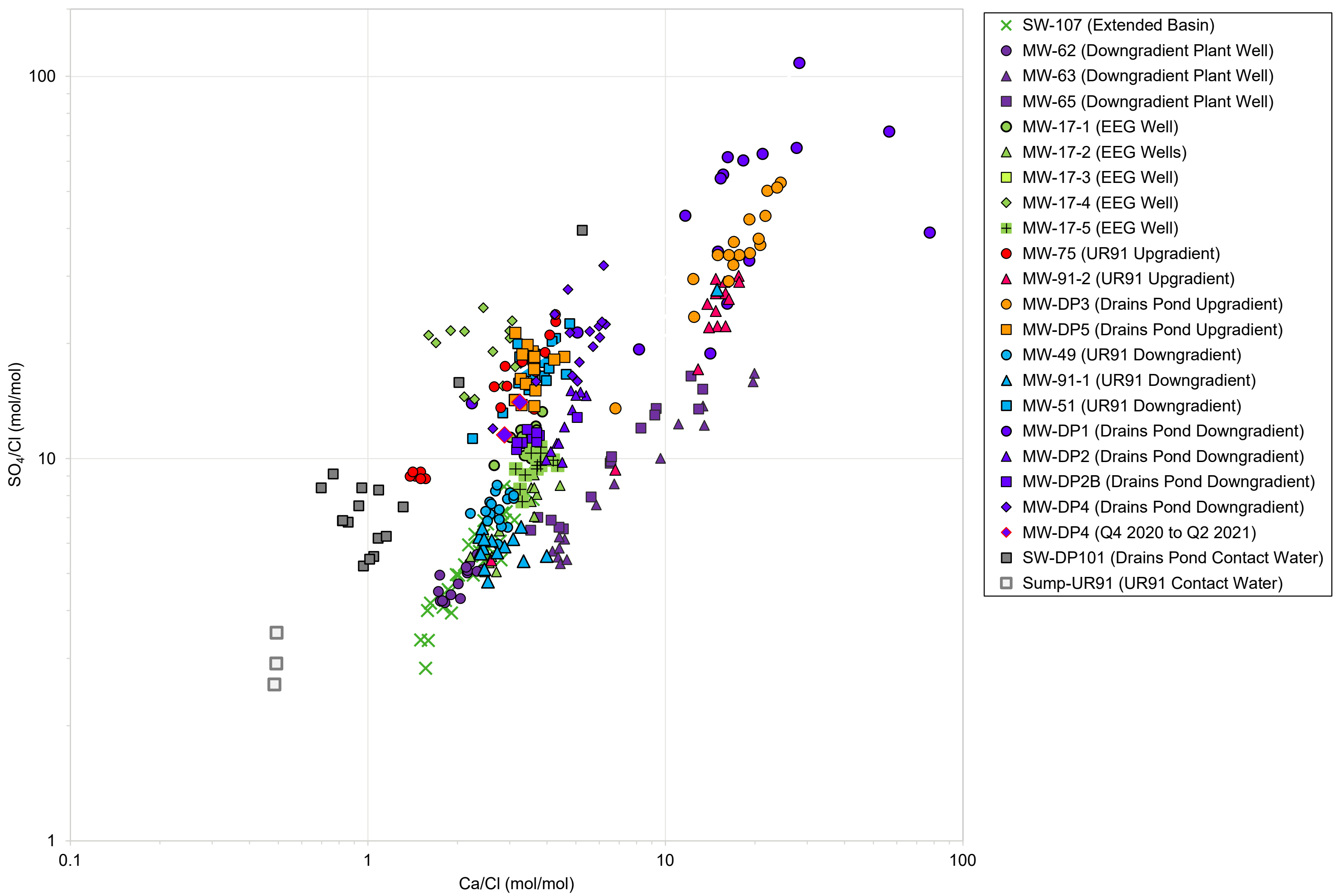
ALTERNATIVE SOURCE DEMONSTRATION
CHLORIDE CONCENTRATIONS

FIGURE 6



Note: For concentrations measured below the detection limit, the detection limit was used

CLIENT Great River Energy Coal Creek Station	PROJECT Alternative Source Demonstration
CONSULTANT GOLDER MEMBER OF WSP	TITLE Box and Whisker Plot for Chloride
	PROJECT NO. 21451024C · PHASE -- · REV. 0 · FIGURE 7



Note: For concentrations measured below the detection limit, the detection limit was used to calculate the ratios

CLIENT	PROJECT
Great River Energy Coal Creek Station	Alternative Source Demonstration
CONSULTANT	TITLE
GOLDER MEMBER OF WSP	Sulfate–Chloride versus Calcium–Chloride Ratio

PROJECT NO.	PHASE	REV.	FIGURE
21451024C	--	0	8

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