2017 ANNUAL GROUNDWATER REPORT

Prepared For

Camp Stanley Storage Activity
Boerne, Texas

Prepared By
PARSONS

Austin, Texas

April 2018

EXECUTIVE SUMMARY

This report provides an evaluation of results from groundwater monitoring conducted in 2017 at Camp Stanley Storage Activity (CSSA). Groundwater monitoring was performed on-post and off-post during the months of March, June, September, and December 2017. The CSSA groundwater monitoring program objectives are to determine groundwater flow direction and elevations, determine groundwater contaminant concentrations for characterization purposes, and identify meteorological and seasonal variations in physical and chemical properties. This report describes the physical and chemical characteristics of the groundwater monitoring results and changes occurring to the program during 2017.

- After enduring one of the most severe droughts in Central Texas history in 2011, followed by average to below average rainfall from 2012 to 2014, then record rainfall in 2015 and 2016, the Middle Trinity aquifer started 2017 in a saturated state. In 2017, the rainfall total measured at CSSA was 28.31 inches from the B-3 Weather Station (WS). This total was approximately 8 inches below the 30-year average of 36.26 inches for the Boerne weather station monitored by the National Weather Service (NWS). During the same timeframe, 27.33 inches of rain fell at the San Antonio International Airport.

- Quarterly rainfall was consistent throughout 2017 with an average of 7 inches of rainfall each quarter. October through December reported the lowest total of 4.36 inches from the B-3 WS. The most significant quarterly decline happened from April to June with the aquifer falling 62.72 feet. With the total rainfall being below average in 2017; the Middle Trinity aquifer sustained a net loss of 134.98 feet in the average elevation beneath CSSA, and fell 67 feet below its 14-year average (2003-2017).

- Both on- and off-post groundwater samples were collected quarterly in 2017 (March, June, September, and December) in accordance with the approved CSSA Long-Term Monitoring Optimization (LTMO) program. This plan was updated in 2015 along with the project DQO's and approved by the TCEQ and EPA in May and April of 2016. The updated sampling schedule was implemented in September 2016 with most wells scheduled for sampling on a quarterly, 15-month, or 30-month interval. Results from March, June, and September 2017 have been reported in previous quarterly reports. December 2017 data is presented in this annual report.

- In 2017, a total of 56 samples were collected from 43 on-post wells. Contaminant concentrations above drinking water standards were detected at 4 on-post wells. Wells (CS-D, CS-MW1-LGR, CS-MW5-LGR, and CS-MW36-LGR) exceeded drinking water standards for volatile organic compounds (VOCs). No wells exceeded drinking water standards for metals in 2017.

- A total of 39 samples were collected from 39 Westbay zones in 2017. VOC concentrations above drinking water standards were detected in a total of 11 zones at all four Westbay locations.

- In 2017, a total of 50 samples were collected from 16 off-post wells and 6 granular activated carbon (GAC) wellhead treatment locations. VOC concentrations above drinking water standards were detected at two off-post wells (OFR-3 and RFR-10). OFR-3 and RFR-10 had GAC units installed at the wellheads in 2002 and 2001 respectively. These GAC filtration units remove VOC contamination prior to use. Samples collected after the treatment systems at OFR-3 and RFR-10 (post-GAC samples) continue to show that all VOC are being removed from the well, and the treatment is effective. Off-post wells were not sampled for metals content as part of the groundwater program.

GEOSCIENTIST CERTIFICATION

2017 Annual Groundwater Monitoring Report

For

Department of the Army
Camp Stanley Storage Activity
Boerne, Texas

I, Adrien Lindley, P.G., hereby certify that the 2017 Annual Groundwater Monitoring Report for the Camp Stanley Storage Activity installation in Boerne, Texas accurately represents the site conditions of the subject area. This certification is limited only to geoscientific products contained in the subject report and is made on the basis of written and oral information provided by the Camp Stanley Storage Activity Environmental Office, laboratory data provided by APPL, and field data obtained during groundwater monitoring conducted at the site in 2017, and is true and accurate to the best of my knowledge and belief.

Adrien Lindley, P.G.
State of Texas
Geology License No. 10487

4-9-18

Date

STATE OF TEXAS
ADRIEN L. LINDLEY
GEOLOGY
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LICENSED
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TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF TABLES

LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS

µg/L	Microgram Per Liter
§3008(h) Order	RCRA 3008(h) Administrative Order on Consent
AL	Action Level
AOC	Area of Concern
APPL	Agriculture and Priority Pollutants Laboratories, Inc.
BS	Bexar Shale
CC	Cow Creek
cis-1,2-DCE	*cis*-1,2-Dichloroethene
COC	Contaminants Of Concern
CSSA	Camp Stanley Storage Activity
DCP	Drought Contingency Plan
DQO	Data Quality Objectives
DVR	Data Validation Report
EXW	Extraction Well
GAC	Granular Activated Carbon
GPM	Gallons Per Minute
ISCO	In-Situ Chemical Oxidation
KSAT	San Antonio International Airport
LGR	Lower Glen Rose
LTMO	Long Term Monitoring Optimization
MCL	Maximum Contaminant Level
MDL	Method Detection Limit
MSL	Mean Sea Level
NCDC	National Climatic Data Center
NWS	National Weather Service
PCE	Tetrachloroethene
Plan	CSSA Off-Post Monitoring Program and Response Plan
QAPP	Quality Assurance Program Plan
RCRA	Resource Conservation and Recovery Act
RL	Reporting Limit
SAWS	San Antonio Water System
SCADA	Supervisory Control and Data Acquisition
SS	Secondary Standard
SVOC	Semivolatile Organic Compound
SWMU	Solid Waste Management Unit
TCE	Trichloroethene
TCEQ	Texas Commission on Environmental Quality
TGRGCD	Trinity-Glen Rose Groundwater Conservation District

ACRONYMS AND ABBREVIATIONS *(continued)*

UGR	Upper Glen Rose
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound
WS	Weather Station

1.0 INTRODUCTION

This report provides an evaluation of results from groundwater monitoring conducted in 2017 at Camp Stanley Storage Activity (CSSA). Groundwater monitoring was performed on-post and off-post during the months of March, June, September, and December. All wells sampled in 2017 are shown on **Figure 1.1**. This report describes the physical and chemical characteristics of the groundwater monitoring results and changes occurring to the program throughout 2017.

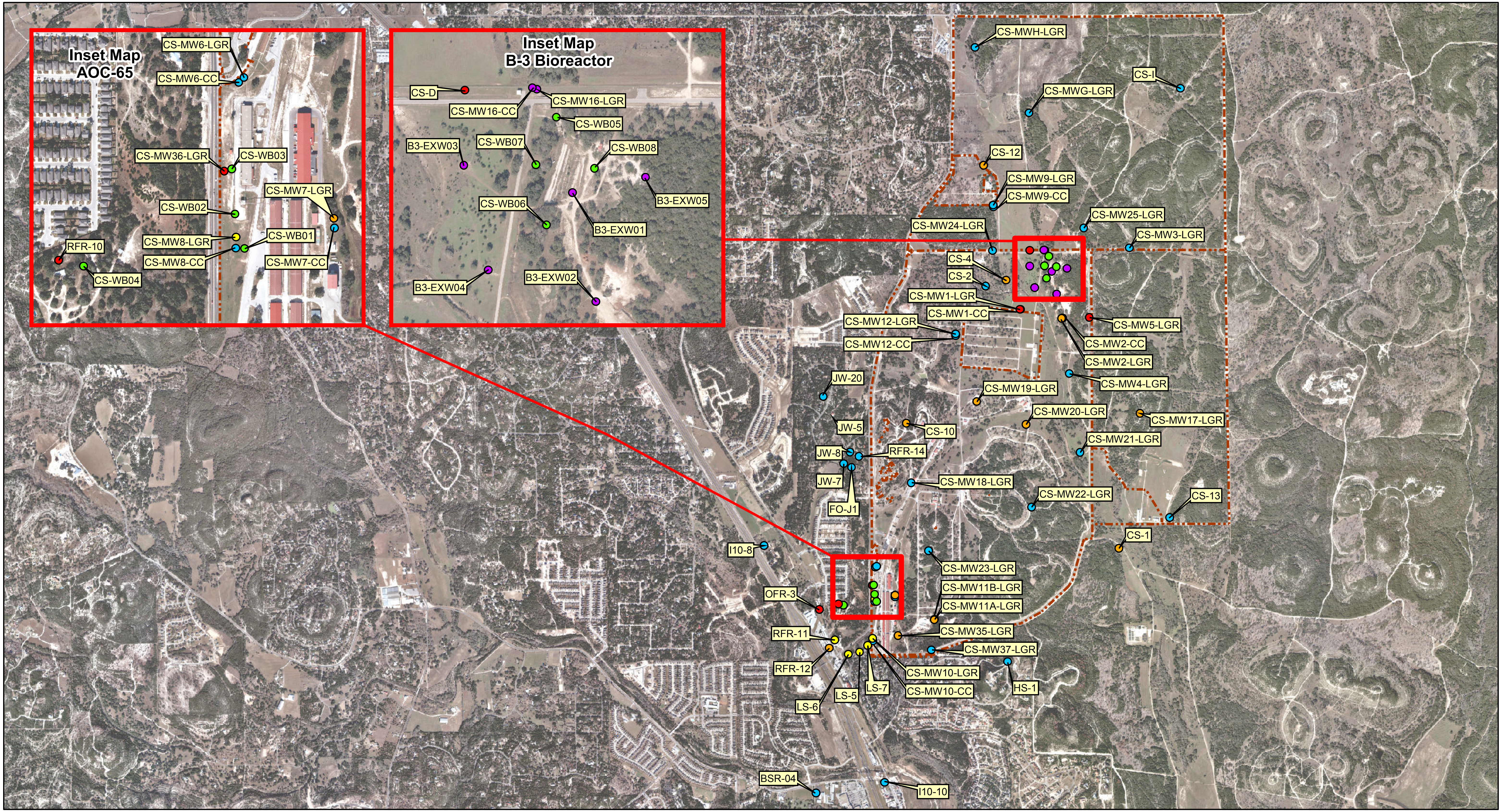
1.1 On-Post Groundwater Monitoring

The current objectives of the CSSA on-post groundwater monitoring program are to monitor groundwater flow direction trends and elevations, determine groundwater contaminant concentrations for characterization purposes, and identify meteorological and seasonal variations in physical and chemical properties of the groundwater. The objectives incorporate and comply with the Resource Conservation and Recovery Act (RCRA) §3008(h) Administrative Order on Consent (§3008(h) Order) issued by the United States Environmental Protection Agency (USEPA) on May 5, 1999.

On-post groundwater monitoring was initiated in 1992 in response to volatile organic compound (VOC) contamination detected in CSSA drinking water supply well CS-MW16-LGR and continued periodically until the current CSSA quarterly groundwater monitoring program for on-post wells was initiated in December 1999.

The CSSA groundwater monitoring program follows the provisions of the groundwater monitoring program *Final Data Quality Objectives (DQO) for the Groundwater Monitoring Program* (Parsons 2016a) in **Appendix A**, as well as the recommendations of the *Three-Tiered Long Term Monitoring Network Optimization Evaluation* (Parsons 2016b) which provided recommendations for sampling based on a long-term monitoring optimization (LTMO) study performed for the CSSA groundwater monitoring program. LTMO study sampling frequencies were initially implemented on-post in December 2005, as approved by the Texas Commission on Environmental Quality (TCEQ) and the USEPA. The LTMO evaluation was updated in 2010 using groundwater data from monitoring conducted between 2005 and 2009. It was approved by the TCEQ and USEPA and was implemented on- and off-post in June 2011 (**Appendix I**). The current versions of the LTMO and DQOs were updated with monitoring data collected between 2010 and 2014 and subsequently approved by the regulators for incorporation in the groundwater monitoring program in April and May 2016, respectively. Implementation of the latest revisions to the LTMO and DQOs began in September 2016 following approval from the USEPA and the TCEQ.

A comprehensive summary of the results from the 2017 on-post groundwater sampling events is presented in **Appendix B**. **Appendices C** and **D** present Westbay analytical results in tabular and graphical format, respectively. Abbreviated tables showing only the detected compounds are included in the groundwater results discussions in Section 2.2.1 of this report. **Appendix E** includes the potentiometric groundwater maps.



Aerial Photo Date: 2013

N W E S

0 0.5 1 2 Miles

- Wells with VOC concentrations > MCL
- Wells with VOC concentrations between RL and MCL
- Wells with VOC concentrations < RL
- Non-detect
- Mulit-port Westbay Wells
- Other wells

MCL= maximum contaminant level
RL= laboratory analytical reporting limit

Fence Line

Figure 1.1

2017 Sampled On-Post and Off-Post Groundwater Wells Camp Stanley Storage Activity

PARSONS

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Off-post results for groundwater sampling and Granular Activated Carbon (GAC) maintenance are included as **Appendices F** and **G**. Laboratory data packages for 2017 were submitted to CSSA in electronic format separately from this report. **Appendix H** presents the associated data validation reports (DVR) for the December 2017 analytical package submittals. The March, June, and September DVRs are included with the quarterly groundwater reports.

1.2 Off-Post Groundwater Monitoring

The primary objective of the off-post groundwater monitoring program is to determine whether concentrations of VOCs detected in off-post public and private drinking water wells exceed safe drinking water standards. In off-post groundwater, the primary contaminants of concern (COC) are tetrachloroethene (PCE) and trichloroethene (TCE). A secondary objective of the off-post groundwater monitoring program is to determine the lateral and vertical extent of the contaminant plumes associated with past releases near Area of Concern (AOC)-65 or from Solid Waste Management Units (SWMU) B-3 and O-1. A third objective of the off-post groundwater monitoring program is to assess whether there are apparent trends in contaminant levels (decreasing or increasing) over time in the sampled wells.

CSSA was required by the §3008(h) Order to identify and locate both privately and publicly owned groundwater wells within ¼-mile of CSSA. The Offsite Well Survey Report (Parsons 2001) was submitted to fulfill this requirement. This survey was updated in 2010 to capture any new wells that have been added in the area and to extend the ¼-mile to ½-mile of CSSA (Parsons 2010). In total, 97 well locations are identified in the updated 2010 Well Survey. A total of 47 locations (45 active and 2 plugged) were identified within a ¼-mile radius, and another 39 locations (33 active and 6 plugged) are believed to exist between ¼ to ½-mile away from CSSA. Finally, a total of 11 locations (10 active and 1 plugged) were identified in a special interest area beyond the ½-mile survey that is considered to be downgradient of the CSSA VOC plumes.

After the 2010 Well Survey, the USEPA requested that CSSA identify additional wells beyond the ½-mile border to the south and west of the post. As a result, CSSA identified and added five wells that follow the Boerne Stage Road corridor, ranging in distance between 0.75 and 3 miles from CSSA. In accordance with the current DQO update, wells greater than 1.5 miles from CSSA or have a 5 year non-detect history are excluded from the sampling program. Some exceptions have been made to these stipulations based on proximity to the plume.

Additional background information regarding off-post private and public water supply wells is located in the ***CSSA Environmental Encyclopedia, Volume 5 Groundwater***. Some off-post wells were initially sampled in 1995 and quarterly sampling of off-post wells began in 2001 in accordance with the *Off-Post Monitoring Program and Response Plan* (CSSA 2002a) (Plan).

Under the Plan, the following criteria are used to determine the action levels for detected VOCs and to determine which off-post wells are sampled:

- If VOC contaminant levels are ≥90 percent of the maximum contaminant levels (MCL) based on preliminary data received from the laboratory and the well is used as a potable water source, the well will be taken offline and bottled water will be supplied within 24 hours after receipt of the data. For PCE and TCE, 90 percent of the MCL is 4.5 micrograms per liter (µg/L). A confirmation sample will be collected from the well within 14 days of receipt of the final validated analytical report. If the confirmation sample confirms COCs are at or above 90 percent of the MCLs, the well will be evaluated, and either installation of an appropriate method for wellhead treatment or connection to an alternative water source will be performed.
- If VOC contaminant levels are ≥80 but ≤90 percent of the MCL (>4.0 and <4.5 µg/L for PCE and TCE) during any single monitoring event based on preliminary data from the laboratory, and the well is used as a potable water source, it will be monitored monthly. If the monthly follow-up sampling confirms that COCs are ≥80 but ≤90 percent of the MCL, it will continue to be sampled monthly until the VOC levels fall below the 80 percent value.
- If any COC is detected at levels greater than or equal to the analytical method detection limit (MDL) (historically 0.06 µg/L for PCE and 0.05 µg/L for TCE), and <80 percent of the MCL, the well will be sampled on a quarterly basis. This sampling will be conducted concurrently with on-post sampling events and will be used to develop historical trends in the area. Quarterly sampling will continue for a minimum of 1 year, after which the sampling frequency will be reviewed and may be decreased.
- If COCs are not detected during the initial sampling event (i.e., no VOC contaminant levels above the MDL), further sampling of the well will be reconsidered. A well with no detectable VOCs may be removed from the sampling list. However, if analytical data suggest future plume migration could negatively influence the well, it will be re-sampled as needed. The well owner, USEPA, and TCEQ will be apprised of any re-sampling decisions regarding the non-detect wells.
- For locations where a wellhead treatment system has been installed, post-treatment samples will be collected and analyzed after initial system start-up and at 6-month intervals to confirm the system is effectively removing VOCs.

A comprehensive summary of the results from the 2017 off-post groundwater sampling events is presented in **Appendix F**. Abbreviated tables showing only the detected compounds are included in the groundwater results discussions in Section 2.2.2 of this report. **Appendix G** summarizes pre- and post-GAC filtration system sampling results.

The cumulative historical results from both on- and off-post groundwater monitoring are presented in summary tables located in the Introduction to the *On-Post and Off-Post Quarterly Groundwater Monitoring Program* (Tables 6 through 9), ***CSSA Environmental Encyclopedia, Volume 5 Groundwater.***

2.0 GROUNDWATER MONITORING RESULTS

2.1 Physical Characteristics

2.1.1 Water Level Measurements

Water level measurements were recorded during the March, June, September, and December 2017 events. A total of 56 water level measurements made from all monitoring wells and drinking water wells listed are in **Table 2.1**. Water levels from one off-post well (FO-20) are used to develop the northern perimeter of the gradient maps. Water levels were measured by either e-line indicator or collected from a permanently installed transducer.

Water level elevations and quarterly elevation changes are summarized in **Table 2.1**. The average groundwater elevation measurements for each of the Lower Glen Rose (LGR), Bexar Shale (BS), and Cow Creek (CC) intervals of the Middle Trinity aquifer are provided in **Table 2.2**. The averages were calculated using groundwater elevations from wells screened in only one of the three intervals. Water elevations from 5 wells completed with open boreholes over multiple formations were not used. Total precipitation recorded in 2017 was about 8 inches below the average annual for the area.

CSSA operates two weather stations to monitor and record climatic conditions across the post, although the AOC-65 WS had battery issues and did not record a complete set of data for the year. For the purposes of this discussion, the CSSA precipitation record has been utilized from the B-3 WS located at the northern end of the inner cantonment. For longer term precipitation data, this report also utilizes precipitation data from the San Antonio International Airport (KSAT) because of the completeness and accuracy of the data.

The total amount of precipitation that fell in 2017 was 28.31 inches at the B-3 WS, which was significantly below 45.76 inches (B-3 WS) that fell in 2016. For the same 2017 time period, 27.33 inches of precipitation was measured at the KSAT location at the international airport. In 2016 the aquifer elevations remained elevated due to above average rainfall. With a below average rainfall year, the aquifer declined significantly in 2017. According to the National Weather Service (NWS), the 30-year average (1988-2017) for the Boerne, TX weather station is 36.26 inches.

The aquifer levels fell slightly during the first quarter of 2017, which received 7.6 inches of rainfall for the 3-month period (B-3 WS). Less than an inch of rain fell in June (0.83 inches). As a result, quarterly groundwater monitoring showed average aquifer levels decreased by 62.7 feet from March to June 2017. From July through September only 9.5 inches of rain fell, sending the aquifer levels down another 48.8 feet. This final quarter of the year recorded 4.36 inches of rainfall, the lowest quarterly total for 2017. Dropping the aquifer another 14.9 feet from September to December.

Table 2.1
Summary of Groundwater Elevations and Changes, 2017

Well ID	TOC elevation (ft MSL)	March 2017 Elevations	June 2017 Elevations	September 2017 Elevations	December 2017 Elevations	Groundwater Elevation Change: December 16 minus March 17	June minus March	September minus June	December minus September	Formations Screened: LGR	BS	CC
CS-1*	**1169.27**	**1044.97**	**1017.67**	**954.88**	**889.62**	**43.30**	**-27.30**	**-62.79**	**-65.26**	**ALL**		
CS-2	**1237.59**	**1085.93**	**1018.43**	**991.57**	**980.19**	**-17.73**	**-67.50**	**-26.86**	**-11.38**	**X**	**?**	
CS-3	1240.17	1086.24	1022.00	980.76	979.29	-17.93	-64.24	-41.24	-1.47	X		
CS-4	**1229.28**	**1083.11**	**1022.61**	**981.31**	**977.53**	**-19.74**	**-60.50**	**-41.30**	**-3.78**	**X**		
CS-10*	**1331.51**	**1217.90**	**1022.31**	**956.03**	**953.36**	**108.96**	**-195.59**	**-66.28**	**-2.67**	**ALL**		
CS-12	**1274.09**	**1088.99**	**1015.09**	**985.40**	**986.91**	**-4.50**	**-73.90**	**-29.69**	**1.51**	**ALL**		
CS-13	**1193.26**	**1076.39**	**1023.43**	**942.85**	**929.46**	**1.54**	**-52.96**	**-80.58**	**-13.39**	**ALL**		
CS-D	1236.03	1082.65	1019.71	983.06	979.17	-14.81	-62.94	-36.65	-3.89	X		
CS-MWG-LGR	1328.14	1107.03	1041.59	1012.88	1013.34	-3.70	-65.44	-28.71	0.46	X		
CS-MWH-LGR*	1319.19	1103.37	1024.14	1003.54	967.24	-9.48	-79.23	-20.60	-36.30	X		
CS-I	1315.20	1101.25	1039.90	1008.72	1009.73	-2.40	-61.35	-31.18	1.01	X		
CS-MW1-LGR	1220.73	1081.55	1031.77	979.62	977.73	-21.96	-49.78	-52.15	-1.89	X		
CS-MW1-BS	1221.09	1085.15	1039.62	979.19	976.26	21.33	-45.53	-60.43	-2.93		X	
CS-MW1-CC	1221.39	1077.84	1023.12	971.69	967.99	-7.21	-54.72	-51.43	-3.70			X
CS-MW2-LGR	1237.08	1083.57	1035.90	978.97	975.88	-15.49	-47.67	-56.93	-3.09	X		
CS-MW2-CC	1240.11	1075.66	1030.12	978.12	966.36	8.31	-45.54	-52.00	-11.76			X
CS-MW3-LGR	1334.14	1088.99	1028.56	982.92	980.81	-7.13	-60.43	-45.64	-2.11	X		
CS-MW4-LGR	1209.71	1146.56	1078.22	1037.45	1002.50	-11.87	-68.34	-40.77	-34.95	X		
CS-MW5-LGR	1340.24	1087.04	1033.26	974.74	971.57	-8.56	-53.78	-58.52	-3.17	X		
CS-MW6-LGR	1232.25	1097.49	1031.09	982.50	961.74	-13.45	-66.40	-48.59	-20.76	X		
CS-MW6-BS	1232.67	1104.44	1075.96	1018.23	982.27	18.89	-28.48	-57.73	-35.96		X	
CS-MW6-CC	1233.21	1098.01	1030.19	948.51	942.51	3.00	-67.82	-81.68	-6.00			X
CS-MW7-LGR	1202.27	1090.77	1025.55	978.67	946.00	-13.85	-65.22	-46.88	-32.67	X		
CS-MW7-CC	1201.84	1094.04	1025.02	947.25	936.50	-2.41	-69.02	-77.77	-10.75			X
CS-MW8-LGR	1208.35	1095.42	1029.55	980.85	957.71	-13.63	-65.87	-48.70	-23.14	X		
CS-MW8-CC	1206.13	1095.08	1026.20	946.50	938.33	-1.21	-68.88	-79.70	-8.17			X
CS-MW9-LGR	1257.27	1091.27	1020.72	987.99	987.77	-14.86	-70.55	-32.73	-0.22	X		
CS-MW9-BS	1256.73	1104.42	1032.70	989.10	988.27	6.74	-71.72	-43.60	-0.83		X	
CS-MW9-CC	1255.95	1091.13	1021.54	973.07	979.24	-4.52	-69.59	-48.47	6.17			X
CS-MW10-LGR	1189.53	1086.63	1009.77	989.76	926.60	-15.59	-76.86	-20.01	-63.16	X		
CS-MW10-CC	1190.04	1083.04	1014.86	969.09	917.42	-15.84	-68.18	-45.77	-51.67			X
CS-MW11A-LGR	1204.03	1075.45	1015.10	984.47	924.03	-13.58	-60.35	-30.63	-60.44	X		
CS-MW11B-LGR	1203.52	1073.05	1012.41	1003.17	999.26	-21.89	-60.64	-9.24	-3.91	X		
CS-MW12-LGR	1259.07	1092.49	1025.65	976.46	974.87	-16.45	-66.84	-49.19	-1.59	X		
CS-MW12-BS	1258.37	1108.31	1046.42	973.71	977.38	31.39	-61.89	-72.71	3.67		X	
CS-MW12-CC	1257.31	1089.87	1023.65	972.21	974.84	-5.91	-66.22	-51.44	2.63			X
CS-MW16-LGR	1244.60	1083.31	1019.20	981.61	978.07	-10.73	-64.11	-37.59	-3.54	X		
CS-MW16-CC*	1244.51	972.05	1010.71	969.46	908.68	-111.01	38.66	-41.25	-60.78			X
B3-EXW01*	1245.26	934.75	1012.66	971.60	971.81	-8.04	77.91	-41.06	0.21	X		
B3-EXW02*	1249.66	971.08	1022.06	979.89	974.45	-121.35	50.98	-42.17	-5.44	X		
B3-EXW03	1235.11	1085.71	1024.4	991.5	974.83	-17.60	-61.31	-32.90	-16.67	X		
B3-EXW04*	1228.46	951.12	1027.46	981.71	977.31	-145.84	76.34	-45.75	-4.40	X		
B3-EXW05*	1279.46	1076.23	967.06	978.64	941.72	-11.30	-109.17	11.58	-36.92	X		
CS-MW17-LGR	1257.01	1090.51	1028.75	952.86	943.78	-9.46	-61.76	-75.89	-9.08	X		
CS-MW18-LGR	1283.61	1094.03	1023.74	962.51	945.32	-15.45	-70.29	-61.23	-17.19	X		
CS-MW19-LGR	1255.53	1105.22	1039.09	975.18	960.10	-13.76	-66.13	-63.91	-15.08	X		
CS-MW20-LGR	1209.42	1110.42	1044.69	NA	963.17	-12.44	-65.73	NA	NA	X		
CS-MW21-LGR	1184.53	1085.43	1030.41	954.16	942.48	-14.60	-55.02	-76.25	-11.68	X		
CS-MW22-LGR	1280.49	1089.97	1024.17	945.63	926.49	-10.96	-65.80	-78.54	-19.14	X		
CS-MW23-LGR	1258.20	1085.81	1021.32	969.35	936.95	-13.87	-64.49	-51.97	-32.40	X		
CS-MW24-LGR	1253.90	1086.46	1019.42	984.23	980.84	-16.57	-67.04	-35.19	-3.39	X		
CS-MW25-LGR	1293.01	1089.59	1026.31	988.33	986.88	-9.99	-63.28	-37.98	-1.45	X		
CS-MW35-LGR	1186.97	1085.12	1016.29	996.78	925.65	-13.13	-68.83	-19.51	-71.13	X		
CS-MW36-LGR	1218.74	1096.55	1030.86	983.23	961.01	-13.30	-65.69	-47.63	-22.22	X		
CS-MW37-LGR	1205.83	1089.92	1021.46	975.73	931.43	NA	-68.46	-45.73	-44.30	X		
FO-20	**1327.00**	**1107.63**	**1044.07**	**1026.73**	**1037.96**	**-6.72**	**-63.56**	**-17.34**	**11.23**	**ALL**		
		Average groundwater elevation change (all wells minus pumpers):				**-8.57**	**-62.72**	**-48.78**	**-14.91**			
		Net change in average groundwater elevation since December 2016:				**-134.98**						

Notes:

Bold wells: CS-2, CS-9, CS-10, CS-12, CS-13, and FO-20 are open boreholes across more than one formational unit.

? = Exact screening information unknown for this well.

Shaded wells are routinely pumped for either domestic, livestock, or environmental remediation purposes, and therefore are not used in calculating statistics.

CS-1, CS-9, CS-10, CS-12, and CS-13 are current, inactive, or future drinking water wells.

CS-MW16-LGR, CS-MW16-CC, B3-EXW01 through B3-EXW05 pumps are cycling continuously to feed the B-3 Bioreactor.

* = submersible pump running at time of water level measurement.

Formational average groundwater elevation is calculated from non-pumping wells screened in only one formation.

All measurements given in feet.

NA = Data not available

Table 2.2
Summary of Groundwater Elevation by Formation, 2017

		2017 Groundwater Elevations				Formations Screened		
Well ID	**TOC elevation**	**March**	**June**	**September**	**December**	**LGR**	**BS**	**CC**
CS-1*	**1169.27**	**1044.97**	**1017.67**	**954.88**	**889.62**	**ALL**		
CS-2	**1237.59**	**1085.93**	**1018.43**	**991.57**	**980.19**	X	?	
CS-3	1240.17	1086.24	1022.00	980.76	979.29	X		
CS-4	**1229.28**	**1083.11**	**1022.61**	**981.31**	**977.53**	X		
CS-10*	**1331.51**	**1217.90**	**1022.31**	**956.03**	**953.36**	**ALL**		
CS-12	**1274.09**	**1088.99**	**1015.09**	**985.40**	**986.91**	**ALL**		
CS-13	**1193.26**	**1076.39**	**1023.43**	**942.85**	**929.46**	**ALL**		
CS-D	1236.03	1082.65	1019.71	983.06	979.17	X		
CS-MWG-LGR	1328.14	1107.03	1041.59	1012.88	1013.34	X		
CS-MWH-LGR*	1319.19	1103.37	1024.14	1003.54	967.24	X		
CS-I	1315.20	1101.25	1039.90	1008.72	1009.73	X		
CS-MW1-LGR	1220.73	1081.55	1031.77	979.62	977.73	X		
CS-MW1-BS	1221.09	1085.15	1039.62	979.19	976.26		X	
CS-MW1-CC	1221.39	1077.84	1023.12	971.69	967.99			X
CS-MW2-LGR	1237.08	1083.57	1035.90	978.97	975.88	X		
CS-MW2-CC	1240.11	1075.66	1030.12	978.12	966.36			X
CS-MW3-LGR	1334.14	1088.99	1028.56	982.92	980.81	X		
CS-MW4-LGR	1209.71	1146.56	1078.22	1037.45	1002.50	X		
CS-MW5-LGR	1340.24	1087.04	1033.26	974.74	971.57	X		
CS-MW6-LGR	1232.25	1097.49	1031.09	982.50	961.74	X		
CS-MW6-BS	1232.67	1104.44	1075.96	1018.23	982.27		X	
CS-MW6-CC	1233.21	1098.01	1030.19	948.51	942.51			X
CS-MW7-LGR	1202.27	1090.77	1025.55	978.67	946.00	X		
CS-MW7-CC	1201.84	1094.04	1025.02	947.25	936.50			X
CS-MW8-LGR	1208.35	1095.42	1029.55	980.85	957.71	X		
CS-MW8-CC	1206.13	1095.08	1026.20	946.50	938.33			X
CS-MW9-LGR	1257.27	1091.27	1020.72	987.99	987.77	X		
CS-MW9-BS	1256.73	1104.42	1032.70	989.10	988.27		X	
CS-MW9-CC	1255.95	1091.13	1021.54	973.07	979.24			X
CS-MW10-LGR	1189.53	1086.63	1009.77	989.76	926.60	X		
CS-MW10-CC	1190.04	1083.04	1014.86	969.09	917.42			X
CS-MW11A-LGR	1204.03	1075.45	1015.10	984.47	924.03	X		
CS-MW11B-LGR	1203.52	1073.05	1012.41	1003.17	999.26	X		
CS-MW12-LGR	1259.07	1092.49	1025.65	976.46	974.87	X		
CS-MW12-BS	1258.37	1108.31	1046.42	973.71	977.38		X	
CS-MW12-CC	1257.31	1089.87	1023.65	972.21	974.84			X
CS-MW16-LGR	1244.60	1083.31	1019.20	981.61	978.07	X		
CS-MW16-CC*	1244.51	972.05	1010.71	969.46	908.68			X
B3-EXW01*	1245.26	934.75	1012.66	971.6	971.81	X		
B3-EXW02*	1249.66	971.08	1022.06	979.89	974.45	X		
B3-EXW03	1235.11	1085.71	1024.4	991.5	974.83	X		
B3-EXW04*	1228.46	951.12	1027.46	981.71	977.31	X		
B3-EXW05*	1279.46	1076.23	967.06	978.64	941.72	X		
CS-MW17-LGR	1257.01	1090.51	1028.75	952.86	943.78	X		
CS-MW18-LGR	1283.61	1094.03	1023.74	962.51	945.32	X		
CS-MW19-LGR	1255.53	1105.22	1039.09	975.18	960.10	X		
CS-MW20-LGR	1209.42	1110.42	1044.69	NA	963.17	X		
CS-MW21-LGR	1184.53	1085.43	1030.41	954.16	942.48	X		
CS-MW22-LGR	1280.49	1089.97	1024.17	945.63	926.49	X		
CS-MW23-LGR	1258.20	1085.81	1021.32	969.35	936.95	X		
CS-MW24-LGR	1253.90	1086.46	1019.42	984.23	980.84	X		
CS-MW25-LGR	1293.01	1089.59	1026.31	988.33	986.88	X		
CS-MW35-LGR	1186.97	1085.12	1016.29	996.78	925.65	X		
CS-MW36-LGR	1218.74	1096.55	1030.86	983.23	961.01	X		
CS-MW37-LGR	1205.83	1089.92	1021.46	975.73	931.43	X		
FO-20	**1327.00**	**1107.63**	**1044.07**	**1026.73**	**1037.96**	**ALL**		
Average groundwater elevation by formation, each event:	**LGR:**	**1091.92**	**1027.70**	**982.86**	**964.68**	**Average groundwater elevation by formation all of 2017:**		**1016.79**
	BS:	**1100.58**	**1048.68**	**990.06**	**981.05**			**1030.09**
	CC:	**1088.08**	**1024.34**	**963.31**	**952.90**			**1007.16**

Notes:

Bold wells: CS-2, CS-10, CS-12, CS-13, and FO-20 are open boreholes across more than one formational unit.

? = Exact screening information unknown for this well.

Shaded wells are routinely pumped for either domestic, livestock, or environmental remediation purposes, and therefore are not used in calculating statistics.

CS-1, CS-10, CS-12, and CS-13 are current or future drinking water wells.

CS-MW16-LGR, CS-MW16-CC, B3-EXW01 through B3-EXW05 pumps are cycling continuously to feed the B-3 Bioreactor.

* = submersible pump running at time of water level measurement.

Formational average groundwater elevation is calculated from non-pumping wells screened in only one formation.

All measurements given in feet.

NA = Data not available

Through all the hydrologic cycles of 2017, the overall groundwater levels in the Middle Trinity aquifer decreased 134.98 feet from January through December 2017, as shown in **Table 2.1**. **Figure 2.1** presents a 15-year history of the quarterly groundwater elevation measurements in the LGR segment of the aquifer in relation to quarterly and annual precipitation measured at the KSAT weather station.

Based on 2017 quarterly aquifer level measurements, **Figure 2.2** shows the relationships of the water level in each portion of the aquifer at CSSA cluster wells (CS-MW1, CS-MW2, CS-MW6, CS-MW7, CS-MW8, CS-MW9, CS-MW10, and CS-MW12). The general trend in **Figure 2.2** shows that at an individual location, the head in the LGR well is typically greater than in the CC well. This was more prominent in September and December when the water table fell below 1000 ft. MSL. The amount of dissimilarity between water levels within a cluster is a good indicator of the degree of hydraulic separation between the formational units. Theoretically, intervals that are well connected hydraulically will have the same or very similar groundwater elevation. In prior years, the well clusters in the southern portion of the post (CS-MW6, CS-MW7, CS-MW8, and CS-MW10) show less hydraulic head separation between the LGR and CC production zones than cluster wells to the north (CS-MW1, CS-MW2, CS-MW9, and CS-MW12). In 2017, September showed the most hydraulic head separation throughout the post with the southern wells showing the most significant separation.

Under more favorable hydrologic conditions, the groundwater elevation in the BS typically falls between the LGR and CC elevations; this was not evident in 2017. As seen in **Figure 2.2**, when water levels decrease as they did all throughout 2017, the BS groundwater elevation is generally higher than both of its counterparts. This phenomenon has been observed before in the cluster wells, and is attributed to the low draining potential of the less permeable BS matrix during continual aquifer declines. Conversely, during recharge events, the groundwater in the BS wells will lag behind the LGR and CC wells. This was not depicted in 2017 due to below average rainfall throughout the year.

2.1.2 Weather Station and Transducer Data

Of the 56 wells listed on **Table 2.1**, 16 are equipped with transducers to continuously log groundwater levels and 11 are providing telemetry directly to the Supervisory Control and Data Acquisition (SCADA) system. As previously noted, two weather stations are in place at CSSA, B-3 WS is located next to the B3-EXW01 well in the north-central region of CSSA, and AOC-65 WS in the southwest corner of CSSA at AOC-65. Both weather stations record meteorological data, including precipitation, wind speed, wind direction, temperature, etc. The data are recorded to evaluate whether trends in rainfall and groundwater recharge. However, for the purposes of this report the data from the B-3 WS is used because it has the highest degree of accuracy and reliability.

Figure 2.1 - Average LGR Groundwater Elevations and Quarterly/Annual Precipitation

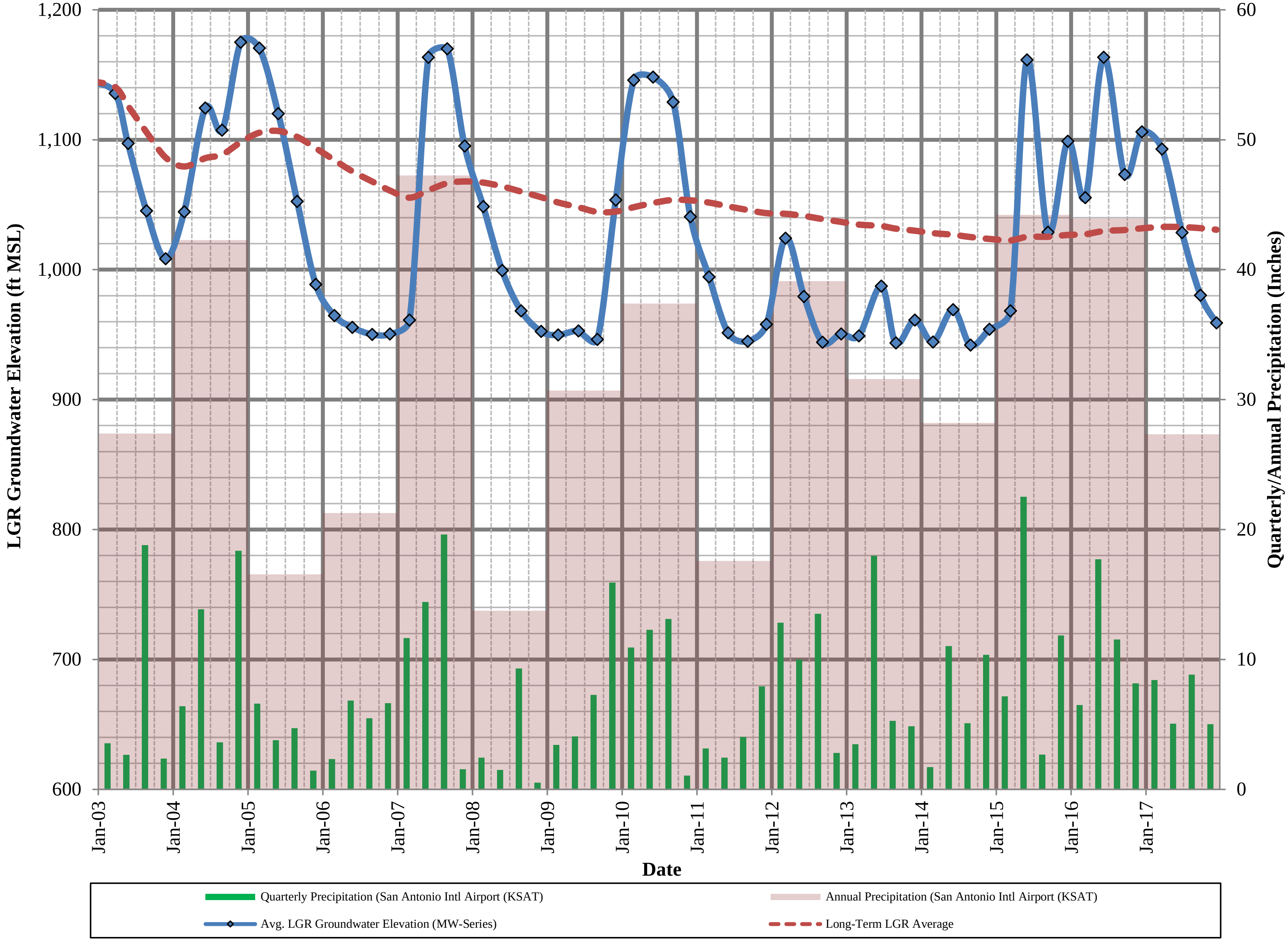
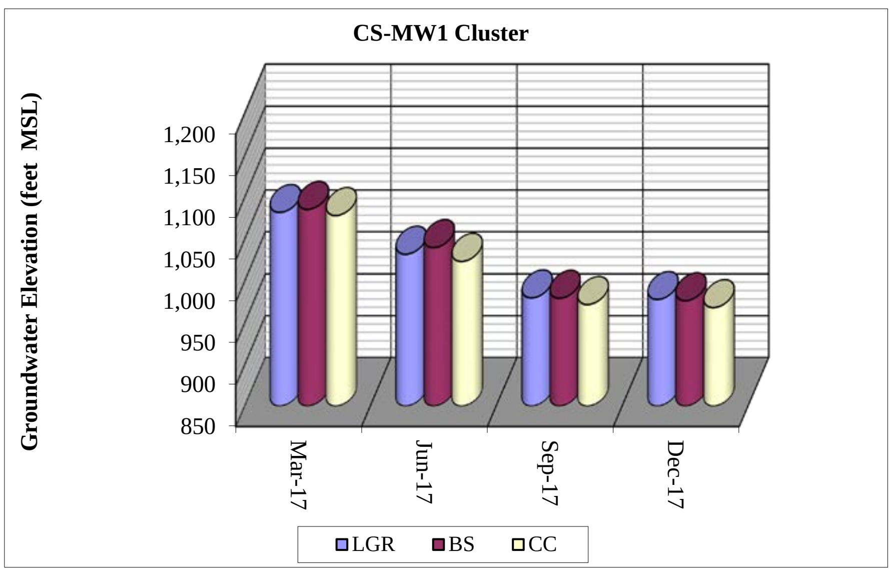
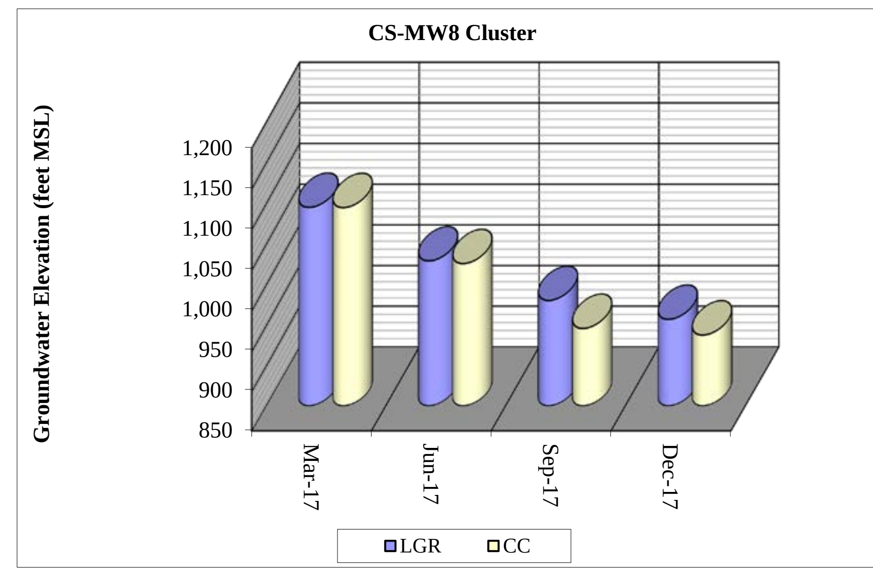
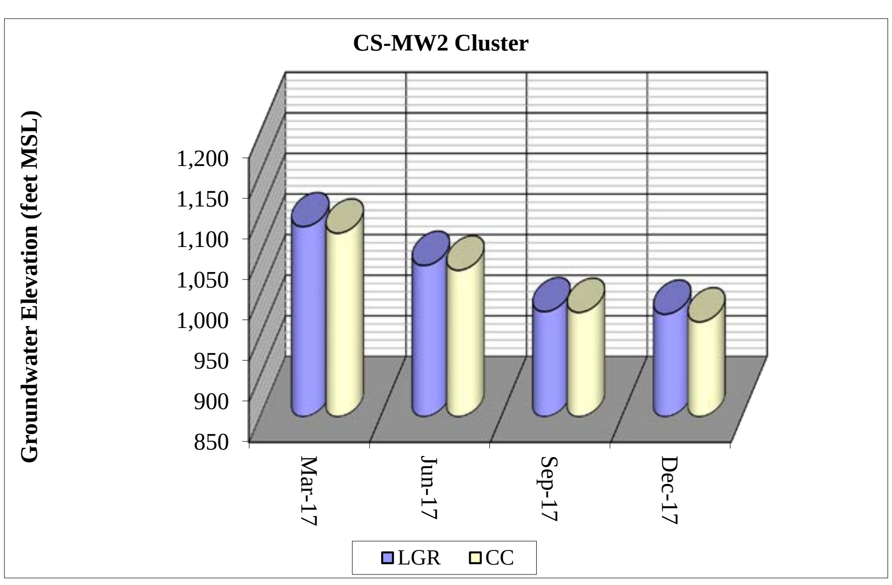
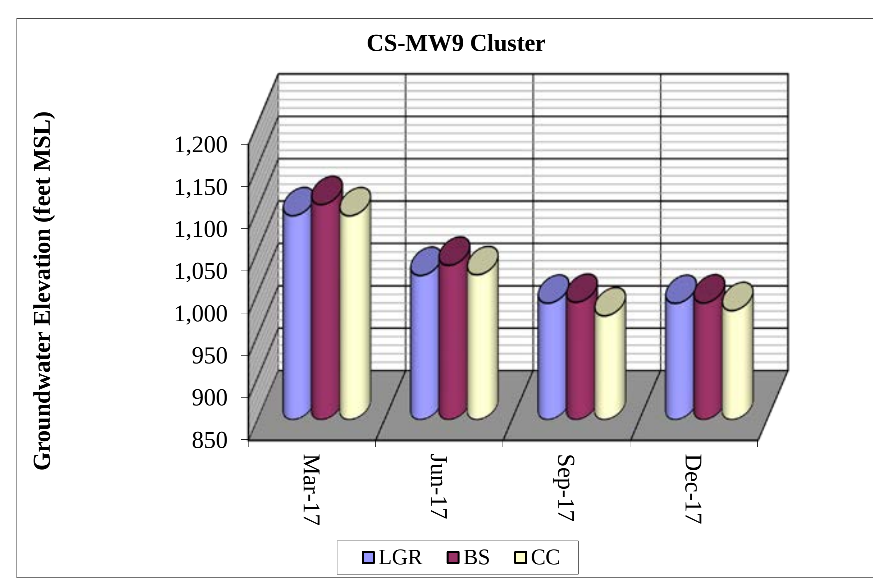


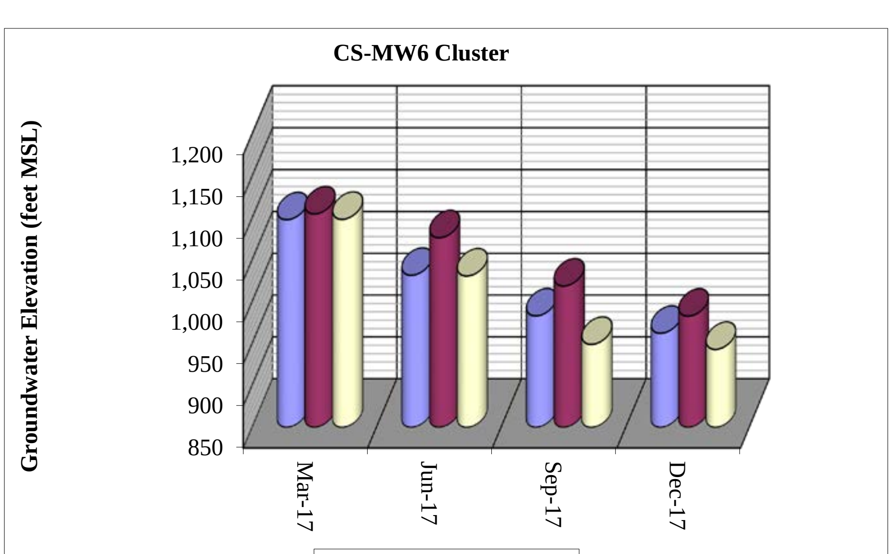
Figure 2.2
Comparison of Groundwater Elevations within Well Clusters

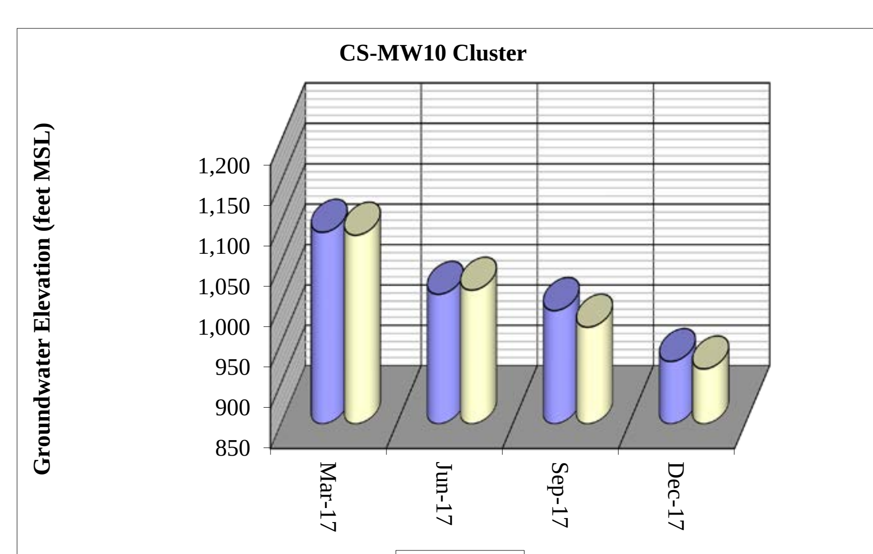


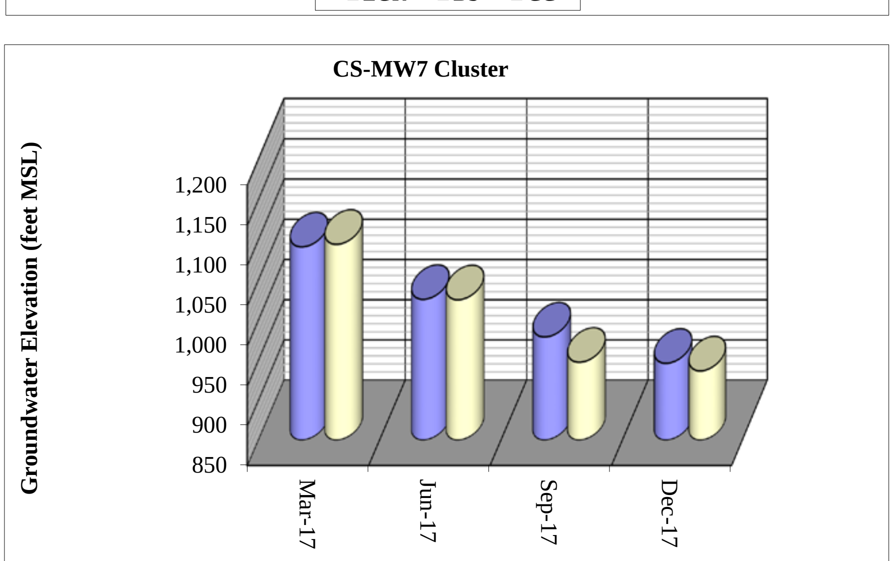


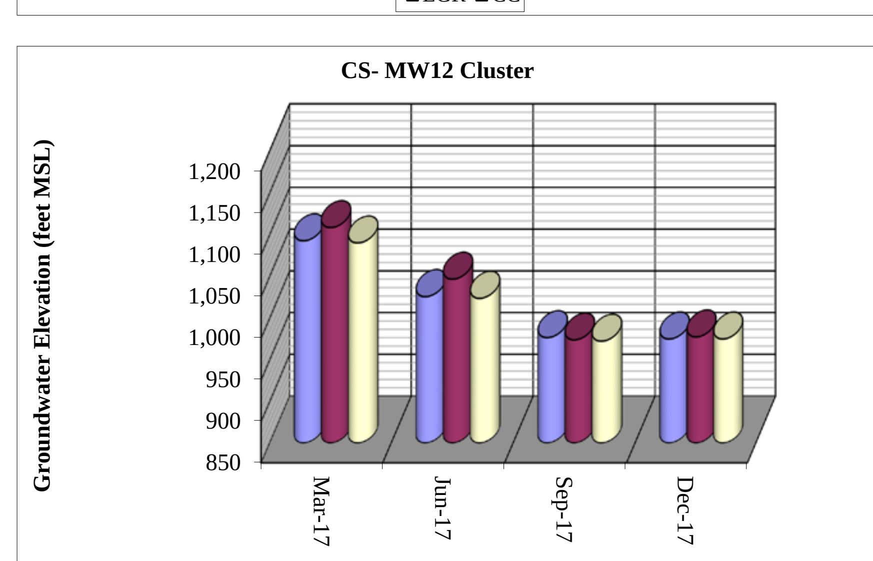












Continuous aquifer level data (January 1st through December 31st, 2017) collected from three wells screened within the LGR, and two wells screened within the CC are presented on **Figure 2.3** as well as the corresponding daily precipitation values. The wells presented in this figure are equipped with transducers set to record continuous water level measurements. The data from CS-MW10-CC is incomplete due to transducer malfunction. Both CS-MW16-LGR and CS-MW16-CC are omitted from this graphic since they are actively pumping wells for the Bioreactor system, and therefore do not reflect static aquifer conditions. The active drinking water wells and the B3-EXW extraction wells were also omitted for the same reason. As in the past, the groundwater elevations indicate recharge of the LGR formation immediately after precipitation.

CSSA B-3 WS reported 85 rainfall events with a total precipitation of 28.31 inches. The rainfall in 2017 started off above average in January and February then dropped off in March. The rainfall picked back up in April with 3.12 inches of rainfall, slightly above the 2.42 monthly average. The month of May had a rainfall total of 2.91 inches. The rain tapered off in June and July with a total rainfall recorded for those 2 months of 0.95 inches. August and September recorded average rainfall of 4.98 and 4.38 inches respectively. A trace amount of rainfall was recorded during the month of October (0.18 inches) at the B-3 WS. November recorded below average rainfall and December reported above average rain with 3.56 inches. August and September reported the highest monthly rainfall amounts and July had the lowest rainfall total recorded. During the same timeframe, 27.33 inches of rainfall was measured at the San Antonio International Airport, and 28.84 inches of rainfall was measured in Boerne, TX.

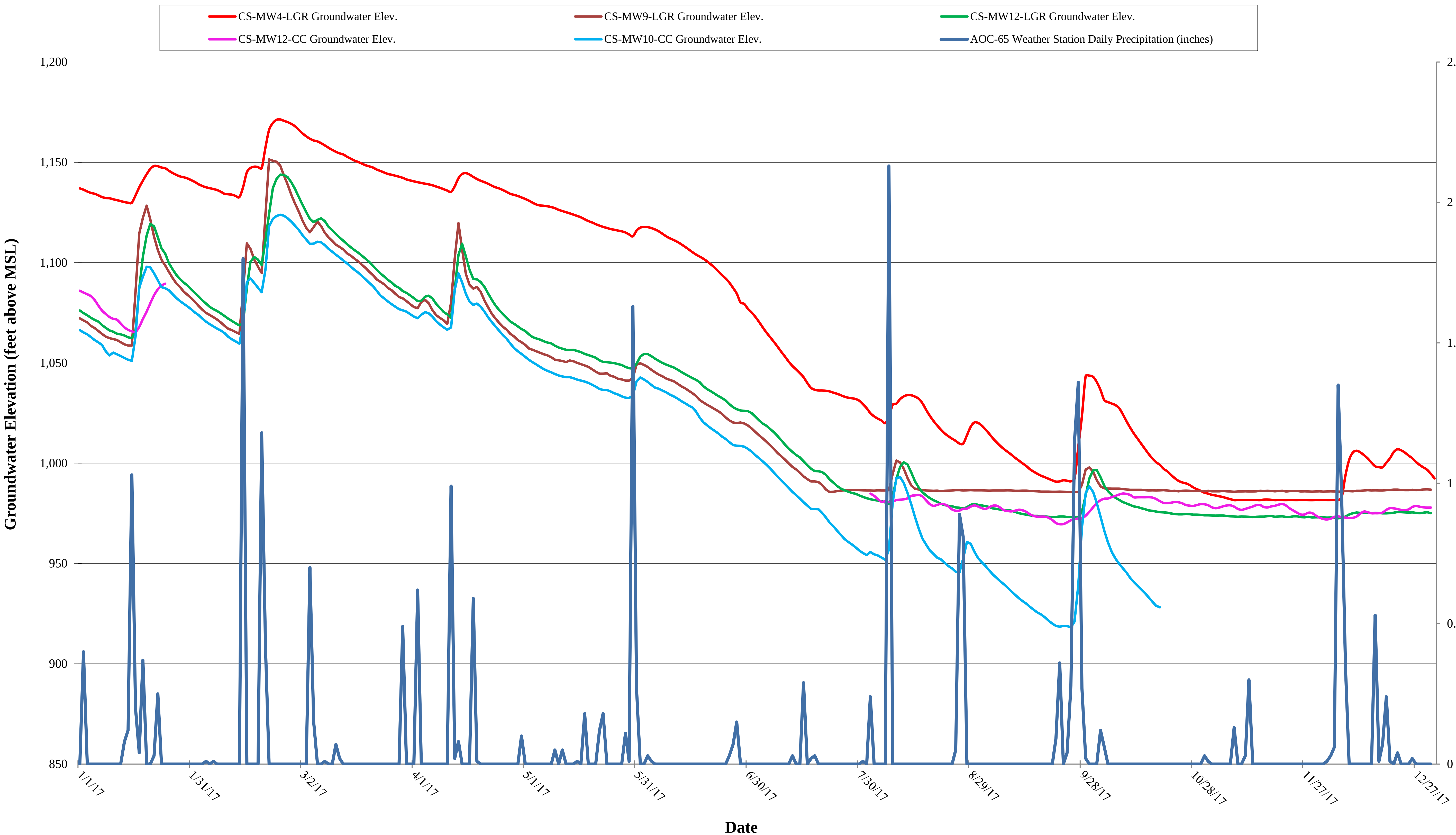
Based upon 30-year precipitation data (1988-2017), 2017 rainfall totals at CSSA ended about 8.07 inches below the Boerne NWS weather station average of 36.26 inches. For the same timeframe, the San Antonio NWS weather station reports a 30-year average of 32.23, which was 3.92 inches below the CSSA B-3 WS. Currently the San Antonio Water System (SAWS) is in the ‘year-round conservation’ stage and the Trinity Glen Rose Groundwater Conservation District (TGRGCD) is in ‘Stage 1’ water restrictions.

Table 2.3 shows the total precipitation received each quarter, average groundwater elevations in each formation, the average groundwater elevation change in each formation, the approximate gradient, and approximate gradient flow direction for all monitoring events.

Referring back to **Figure 2.1**, the latter half of 2009 marked the end of a drought cycle that had begun at the end of 2006. Major precipitation events in August and September 2009 recharged the aquifer and began a trend that continued through May 2010. The aquifer surge experienced in the first five months was negated by a summer dry period through August 2010. Rainfall amounts declined September 2010 through September 2011, resulting in regional aquifer level decline of approximately 195 feet. There was an increase in rainfall late in 2011 but due to the already depressed aquifer the drought conditions persisted into 2012. Although an average amount of rain fell in 2012 and 2013, the aquifer rebound was minimal. The below average rainfall in 2014 allowed the aquifer to drop an additional 5 feet over the 12-month period. In 2015 above average rainfall allowed the aquifer to recover 140 feet, bringing the San Antonio area out of the severe drought that began in late 2010. With above average rainfall recorded again in 2016 the aquifer level continued to climb an additional 4.5

feet. The below average rainfall recorded in 2017 has negated the gains experienced in 2015 and 2016 and the aquifer has dropped 147 feet over the 12-month period to levels similar to those experienced in last quarter of 2014 during the last drought cycle.

Figure 2.3, Selected Wells Groundwater Elevations vs Precipitation Data



J:\CSSA Program\Restoration\Groundwater\GW Monitoring Reports\2017\Annual Report\Figure 2-3 Transducer-WS Data.xlsx

Table 2.3
Precipitation, Groundwater Elevation and Gradient

Quarterly Report (Month, year)	Total Quarterly precipitation (inches) B-3 WS	Total Quarterly precipitation (inches) AOC-65 WS	Average GW elevation Change (feet)	CS-MW18-LGR GW Elevation Change (feet)	Average GW Elevation			Approximate gradient (ft/ft)	Approximate gradient flow direction
					Lower Glen Rose	Bexar Shale	Cow Creek		
September-99	7.52	--	-188.4	--	979.80	--	--	0.007	Southwest
December-99	2.84	--	-4.9	--	973.10	--	--	0.004	Southwest
March-00	3.58	--	-9.3	--	970.94	--	--	0.009	South-southeast
June-00	11.1	--	11.77	--	976.27	--	--	0.006	Southeast
September-00	1.96	--	-6.34	--	967.03	--	--	0.006	Southeast
December-00	14.48	--	122.99	--	1118.59	--	--	0.005	South-southeast
March-01	10.13	--	53.19	--	1157.20	--	--	0.0125	Southeast
June-01	6.58	--	-47.5	--	1104.00	1106.85	1093.89	0.007	Southeast
September-01	14.73	--	23.96	--	1140.55	1098.18	1095.75	0.0067	Southeast
December-01	10.16	--	15.46	--	1149.68	1131.36	1125.63	0.0092	Southeast
March-02	2.25	--	-70.97	--	1077.91	1064.46	1059.27	0.0086	Southeast
June-02	4.46	--	-48.29	--	1030.51	1022.51	994.02	0.0137	South-southeast
September-02	30.98	--	104.5	--	1130.87	1129.21	1098.34	0.017	South-southeast
December-02	12.91	--	19.48	-2.84	1143.98	1148.26	1133.11	0.0061	South-southeast
March-03	6.22	6.68	-8.47	-1.99	1135.18	1140.52	1122.95	0.012	South-southeast
June-03	4.67	4.64	-41.08	-40.06	1097.87	1095.36	1069.02	0.0022	South-southwest
September-03	8.05	10.28	-52.85	-54.54	1046.77	1060.39	1025.61	0.0045	South-southwest
December-03	2.79	2.92	-32.85	-40.46	1011.38	1029.39	1002.07	0.0095	South-southwest
March-04	6.35	5.93	22.89	36.7	1043.68	1026.20	1017.98	0.0046	South-southwest
June-04	12.95	12.33	71.91	88.99	1121.80	1101.85	1074.56	0.0012	South-southwest
September-04	14.3	14.57	-8.05	-21.66	1106.43	1110.17	1074.96	0.003	South-southeast
December-04	21.04	23.12	63.07	76.62	1173.98	1159.46	1135.16	0.004	South-southeast
March-05	7.38	6.48	-6.47	-7.11	1168.46	1151.60	1127.58	0.00436	South-southeast
June-05	NA	5.29	-45.93	-61.3	1119.19	1125.27	1082.40	0.0041	South-southeast
September-05	NA	5.93	-61.24	-64.87	1054.88	1077.87	1033.65	0.0068	South-southwest
December-05	NA	2.41	-57.9	-69.24	994.23	1023.45	980.25	0.0054	South-southwest
March-06	2.52	1.11	-24.81	-33.89	974.10	990.23	948.80	0.0084	South-southwest
June-06	7.65	11.18	-9.46	-1.4	966.16	983.47	933.59	0.0104	South-southwest
September-06	3.42	3.12	-6.66	-4.81	961.07	979.78	922.34	0.0099	South
December-06	4.68	5.9	2.48	3.02	958.87	979.73	933.37	0.0099	South
March-07	9.83		14.53	-1.27	969.87	992.53	958.06	0.0079	South
June-07	11.99		182.09	234.13	1162.17	1119.36	1128.32	0.0016	Southeast
September-07	29.4		15.56	0.54	1168.77	1168.14	1154.47	0.0019	South
December-07	1.95		-70.45	-87.12	1095.68	1101.19	1088.93	0.0052	South-southeast
March-08	2.17	2.31	-42.45	-43.22	1050.23	1053.76	1047.78	0.0072	South
June-08	1.9	2.69	-51.71	-52.47	1002.44	1015.93	966.67	0.0047	South
September-08	6.06	6.95	-27.49	-45.80	976.18	991.62	953.41	0.0058	South
December-08	1.69	1.74	-15.48	-5.06	961.10	981.76	934.26	0.0080	South-southeast
March-09	2.58	3.16	-4.25	-2.15	957.48	973.36	916.24	0.0073	South-southeast
June-09	3.77	4.41	1.25	1.53	959.75	971.67	914.68	0.0059	South-southeast
September-09	NA	7.41	-7.76	-5.48	953.49	967.07	903.39	0.0054	South-southeast
December-09	NA	14.63	101.24	114.02	1051.77	1040.48	1026.64	0.00002	South
March-10	9.23	NA	91.51	100.05	1144.36	1128.84	1131.78	0.00052	South-southeast
June-10	NA	10.66	3.97	3.40	1147.52	1145.30	1114.38	0.00078	South-southeast
September-10	NA	10.91	-37.77	-15.95	1126.83	1070.13	1059.82	0.00085	South-southeast
December-10	NA	4.45	-63.93	-97.99	1045.26	1060.79	1011.76	0.00029	South-southeast
March-11	NA	2.57	-41.89	-52.73	997.07	1020.56	994.18	0.00314	South-southeast
June-11	0.91	0.83	-41.80	-46.77	957.42	983.63	917.00	0.00532	South-southeast
September-11	2.29	2.13	-8.81	-3.15	952.98	970.34	900.90	0.00533	South-southeast
December-11	9.85	11.71	14.73	8.05	963.15	972.51	922.89	0.00536	South-southeast
March-12	NA	8.58	57.04	75.20	1021.21	992.83	975.99	0.00066	South-southeast
June-12	NA	5.83	-30.83	-54.76	981.01	1012.98	964.88	0.00326	South-southeast
September-12	NA	9.95	-36.51	-26.02	952.92	975.91	909.63	0.00455	South-southeast
December-12	NA	7.12	8.92	4.15	957.47	984.75	930.15	0.00550	South-southeast
March-13	4.88	4.79	-2.93	-2.05	954.43	977.59	933.99	0.00605	South-southeast
June-13	12.26	9.57	34.90	24.00	989.52	999.66	974.67	0.00350	South-southeast
September-13	5.03	3.92	-43.40	-26.95	947.00	974.20	918.61	0.00541	South-southeast
December-13	11.84	10.92	16.28	7.70	964.12	974.92	939.82	0.00506	South-southeast
March-14	0.96	1.10	-12.81	-6.03	950.62	970.44	926.47	0.00620	South-southeast
June-14	8.73	8.03	22.53	11.46	972.10	984.11	960.81	0.00513	South-southeast
September-14	6.25	5.09	-26.88	-13.86	947.85	970.50	916.54	0.00550	South-southeast
December-14	9.34	7.38	11.64	7.35	958.45	974.38	935.08	0.00544	South-southeast
March-15	7.95	5.52	14.41	4.62	971.61	986.23	955.73	0.00550	South-southeast
June-15	18.62	15.44	176.73	222.23	1162.97	1108.95	1115.04	0.00052*	South-southeast
September-15	6.76	3.66	-119.17	-147.45	1027.92	1055.29	1011.95	0.0053*	South-southeast
December-15	20.18	13.87	68.26	80.93	1100.39	1087.93	1083.84	0.00131	South-southeast

Table 2.3
Precipitation, Groundwater Elevation and Gradient

Quarterly Report (Month, year)	Total Quarterly precipitation (inches) B-3 WS	Total Quarterly precipitation (inches) AOC-65 WS	Average GW elevation Change (feet)	CS-MW18-LGR GW Elevation Change (feet)	Average GW Elevation			Approximate gradient (ft/ft)	Approximate gradient flow direction
					Lower Glen Rose	Bexar Shale	Cow Creek		
March-16	5.66	3.57	-43.11	-47.05	1054.01	1055.45	1045.55	0.00012*	South-southeast
June-16	NA	19.70	106.82	112.86	1165.70	1147.18	1143.07	0.00012	South-southeast
September-16	15.88	15.57	-85.26	-97.17	1073.18	1093.95	1070.35	0.00012	South-southeast
December-16	7.01	6.92	26.04	38.09	1105.84	1080.99	1091.31	0.00094	South-southeast
March-17	7.61	NA	-8.57	-15.45	1091.92	1100.58	1088.08	0.00131	South-southeast
June-17	6.86	5.31	-62.72	-70.29	1027.70	1048.68	1024.34	0.00106*	South-southeast
September-17	9.48	8.07	-48.78	-61.23	982.86	990.06	963.31	0.00362	South-southeast
December-17	4.36	4.33	-14.91	-17.19	964.68	981.05	952.90	0.00157	South-southeast

GW = groundwater, ft MSL = feet above mean sea level, ft/ft = feet per foot, WS = weather station
NA = Data not available due to weather station outage.
2007 precipitation data was combined to fill in data gaps due to multiple weather station outages during SCADA installation.
* alternate wells were used in calculating gradient to generally describe the regional gradient

2.1.3 Potentiometric Data

The groundwater gradient/potentiometric surface figures presented in **Appendix E** incorporate measured groundwater elevations from the LGR, BS, and CC screened wells. Drought conditions, which began in 2010 and continued through 2014, were eased in 2015 following above-average precipitation, allowing the aquifer to return to normal conditions. The above-average precipitation trend continued through 2016 resulting in above-average aquifer water levels. Below average precipitation in 2017 resulted in aquifer water level declines throughout the year. By the end of 2017, aquifer water levels returned to those typically experienced during drought conditions. As shown in **Appendix E**, water levels at CSSA can vary greatly. This variability is associated with several factors:

- A low storage capacity for groundwater within the primary porosity (interstitial voids between grains) of the limestone matrix, which is inherent to carbonate mudstone aquifers. These aquifers with lower storage capacities are more susceptible to widely fluctuating groundwater levels (as compared to a well-sorted sand matrix). Within the Middle Trinity aquifer and other regional carbonate aquifers, their groundwater yield is mostly derived from secondary porosity features resulting from faults, fractures, and chemical dissolution of the bedrock (karst).
- Differences in well completion depths and formations screened;
- Differences in recharge rates due to increased secondary porosity associated with the Salado Creek area;
- Differences in recharge rates due to increased secondary porosity associated with local fault zones;
- Pumping from on- and off-post public and private water supply wells; and
- Locations of major faults or fractures.

2.1.4 Post-wide Flow Direction and Gradient

An overall average 2017 calculated LGR groundwater gradient is to the south-southeast at 0.00200 ft/ft. Depending which quadrant of the post the measurement is taken, the groundwater gradient varied from 0.00131 ft/ft and 0.00106 ft/ft in March and June, respectively, to 0.00362 ft/ft in September and 0.00157 ft/ft in December. General groundwater flow directions and average gradients calculated during past monitoring events are provided in **Table 2.3** for comparison.

<u>Lower Glen Rose</u>

The 2017 potentiometric surface maps for LGR-screened wells **(Appendices E.1, E.4, E.7** and **E.10)** exhibited a wide range of groundwater elevations. To illustrate, the average groundwater elevation in the LGR segment of the aquifer varied by more than 140 feet over the course of the year. Groundwater elevations are generally higher in the northern and central portions of CSSA and decrease to the south. This is consistent with the natural dip of the formations and the greater fault displacement in the southern portion of CSSA. The removal of well CS-G from the gridding process negates a mounding effect due to perched groundwater that is present at that well, and misleadingly disrupts the normal southerly and easterly components of the North Pasture. This well, along with open borehole completions in wells CS-D, CS-2, and CS-4 are not fully penetrating into the LGR, and therefore are not considered within these maps.

Between the December 2016 and March 2017 monitoring events, the LGR groundwater regionally decreased 8.57 feet as water levels receded following a moderate fourth quarter in 2016 with a wet December. As shown in **Table 2.1**, LGR groundwater levels continued to decline through the year, with the greatest declines stemming from unusually dry second and third quarters. The effect to the aquifer elevation can be seen by comparing the March 2017 (**Appendix E.1)** and June 2017 (**Appendix E.4)**. By September 2017 (**Appendix E.7**), the LGR segment had returned to the near drought conditions observed in the latter part of 2014, and by December 2017 (**Appendix E.10**) the aquifer receded an additional ~15 feet due to the sparse rainfall experienced during the latter part of the year. Overall, the LGR segment lost approximately 141 feet of aquifer elevation over the 12-month period between December 2016 and December 2017.

A typical feature as seen in **Appendix E.1, E.4**, **F.7**, and **E.10** is the groundwater mounding effect centered on CS-MW4-LGR in the central portion of the base. This is a typical feature during non-drought conditions when the surrounding groundwater elevation is above approximately 970 feet mean sea level (MSL). Unlike the general trend at CSSA, groundwater flow appears to radiate outward from CS-MW4-LGR. Presumably this region has a strong hydraulic connection to significant perched water either associated with Salado Creek or the hillsides to the east. Throughout 2017 this feature is observed; however, the mounding is less significant in December as the surrounding water level approaches the 970 feet MSL mark.

Historical data has shown that this mounding effect can either be muted or completely removed under distressed aquifer levels. Although this was not the case in 2017, more recent occurrences did happen in March and September 2014 (**2014 Annual Groundwater Report - Appendices E.1 and E.7**); this mounding effect subsides as the average groundwater elevation approaches the elevation of the basal production zone of the aquifer. Groundwater mounding is also depicted at CS-10 in March (**Appendix E.1**), however, the mounding at CS-10 is likely the product erroneous data obtained by CSSAs SCADA system rather than a record of actual groundwater elevation at this well. Supply well CS-10 typically exhibits slightly depressed groundwater elevations rather than mounding, which is contradictory during pumping.

The groundwater drawdown due to the cyclic pumping of CS-MW16-LGR, B3-EXW01-LGR, B3-EXW02-LGR, B3-EXW03-LGR, B3-EXW04-LGR, B3-EXW05-LGR (Bioreactor System) is a recurring feature in the central portion of the post (**Appendices E.1, E.4, E.7,** and **E.10**). As seen in these figures, the resultant groundwater "cone of depression" can vary due to combination of extraction wells actively pumping during the water level gauging effort. But as a collective system, they are effective in maintaining a zone of capture around the remediation system and re-injecting groundwater into the Bioreactor. During the year the cone of depression is most pronounced in March (**Appendix E.1**), and in September (**AppendixE.7**) is only slightly observed as a depressed area near one extraction well (B3-EXW-03).

Depending on the current pumping rates at the time of measurement, groundwater in the vicinity of the Bioreactor may be depressed by as much as 50 to 150 feet, as measured between a currently active extraction well (EXW) and other surrounding wells (**Appendix E.1)**. Groundwater in the inner cantonment also shows a drawdown effect from the pumping of water supply well CS-12 and is most notable in March 2017 (**Appendix E.1**).

Bexar Shale

Currently, groundwater head information is limited to four data points (CS-MW1-BS, CS-MW6-BS, CS-MW9-BS, and CS-MW12-BS). Given the paucity of well control, at best, the BS groundwater maps should be considered qualitative. The BS appears to have very limited groundwater that is likely associated with fracturing. Fractured bedrock such as this often results in discordant water levels between neighboring points and may not be a true indicator of flow direction. The appropriateness of preparing potentiometric surface maps for the BS is debatable, but these maps have been generated for completeness. Potentiometric maps for the Bexar Shale in 2017 are presented in **Appendices E.2, E.5, E.8** and **E.11**.

Compared to the LGR and CC segments, the BS aquitard fluctuates significantly less in response to both recharge and drought. After the 12-month period between December 2016 and December 2017, the BS segment had a net loss of 99.94 feet, whereas the LGR experienced a net loss of 141 feet. Historical data has shown for a given precipitation event, the BS water level will “peak” anywhere between 15 and 30 days after the LGR and CC has already crested for the same rain event.

From a historical perspective, the potentiometric surface maps for BS-screened wells often exhibit groundwater flow in multiple directions (**Appendix E.11**). Historically, these flow directions are to the south, east, and occasionally to the north. In 2017, the gradient of the BS potentiometric exhibit some of this variability in flow direction with mostly northerly and easterly flow directions observed during various quarterly events. As water levels in the BS segment began to drop from March 2017 to June 2017, flow was predominantly to the north northeast. As water levels continued to fall through the remainder of the year, flow in the northern portion of the post transitioned to the south.

Cow Creek

As with the BS, the post wide monitoring of the CC groundwater is limited due to the small number of wells completed only in the CC. Four of the nine CC wells are concentrated in the vicinity of AOC-65. In March, during its highest groundwater elevation of the year, the CC groundwater exhibited an east-southeast gradient (**Appendix E.3**) in the southern portion of the post. When groundwater was at its lowest elevations, in September and December 2017 (**Appendices E.6** and **F.12**), the predominant gradient was more strongly to the south with a slight western component.

The effects of continuous pumping of CS-MW16-CC influence groundwater gradients significantly in the CC interval near the Bioreactor. The March and December 2017 potentiometric maps show the most significant induced gradients created as a result of routine pumping action at well CS-MW16-CC (**Appendix E.3 and E.12**), however, the cone of depression was observed throughout the year. Prior studies have shown measurable pumping influence within the CC at distances of more than 2,000 feet from a CC pumping well, as measured at CS-MW1-CC.

The CC responds almost as quickly as the LGR to a recharge event, presumably because of direct infiltration on the outcrop areas to the north of CSSA. However, the recharge rate in the CC is somewhat slower than the LGR, and the crest of a precipitation response may come 15 days later than what is observed in the LGR. Typically, the CC aquifer elevation response to recharge or discharge is less than the LGR segment. After the 12-month period between December 2016 and December 2017, the net loss of the CC segment was 138.45 feet.

2.2 Chemical Characteristics

2.2.1 On-Post Analytical Results

The LTMO study implemented in December 2005, updated in 2010 and 2015, determines the frequency that on-post wells are sampled. An overview of sampling frequencies for on-post wells is given in **Table 2.4**. Fifty-seven on-post samples from 43 wells were scheduled to be collected in 2017 (4 in March, 43 in June, 5 in September, and 5 in December). All 57 samples were collected.

The wells were sampled using either dedicated low-flow pumps, high capacity submersible pumps, or dedicated solar-powered submersible pump (well CS-I). Samples were collected after field parameters (pH, temperature, conductivity) stabilized during well purging. Field parameters were recorded in the field logbook for each sampling event.

Groundwater samples were submitted to Agriculture & Priority Pollutants Laboratories, Inc. (APPL) of Clovis, California for analysis. The analytical program for on-post monitoring wells includes short-list VOC analysis and metals. The short list of VOC analytes included: *cis*-1.2-Dichloroethene (*cis*-1,2-DCE), PCE, TCE, and vinyl chloride. Drinking water wells were also sampled for the following metals: arsenic, barium, copper, chromium, cadmium, mercury, lead, and zinc.

Each sample is evaluated against either being qualitatively detected in trace amounts above the MDL [F-flagged data], quantitatively detected above the laboratory reporting limit (RL), or in exceedance of regulatory maximum contaminant level (MCL), action level (AL), or secondary standard (SS) comparison criteria. It is important to note that the RL value is significantly less than the promulgated groundwater standard criteria, and therefore the occurrence of a constituent above the RL does not necessarily indicate that there is an immediate concern, especially with the naturally occurring inorganics (metals) in groundwater. The only exception to this generalization is lead, where the RL (0.025 mg/L) is greater than the AL (0.015 mg/L).

2.2.1.2 On-Post Monitoring Wells with COC Detections above the MCL

Some wells sampled had concentrations detected that exceeded MCLs. The MCLs for some COCs were exceeded in wells CS-D, CS-MW1-LGR, CS-MW5-LGR, and CS-MW36-LGR in 2017. The respective comparison criteria (MCLs, SS, or AL) for each compound are included in **Table 2.5**. The detected concentrations are summarized as follows:

Table 2.4
Overview of On-Post Sampling for 2017

Count	Well ID	*Analytes*	*Last Sample Date*	*Mar-17*	*Jun-17 (30 month)*	*Sep-17*	*Dec-17*	*LTMO Sampling Frequency (as of Sept. 2016)*
1	CS-MW1-LGR	VOCs & metals (Cr, Cd, Hg, Pb)	Jun-17	NS	S	NS	NS	15 months
2	CS-MW1-BS	VOCs & metals (Cr, Cd, Hg, Pb)	Dec-12	NS	NS	NS	NS	as needed
3	CS-MW1-CC	VOCs & metals (Cr, Cd, Hg, Pb)	Jun-17	NS	S	NS	NS	30 months
4	CS-MW2-LGR	VOCs & metals (Cr, Cd, Hg, Pb)	Jun-17	NS	S	NS	NS	30 months
5	CS-MW2-CC	VOCs & metals (Cr, Cd, Hg, Pb)	Jun-17	NS	S	NS	NS	30 months
6	CS-MW3-LGR	VOCs & metals (Cr, Cd, Hg, Pb)	Jun-17	NS	S	NS	NS	30 months
7	CS-MW4-LGR	VOCs & metals (Cr, Cd, Hg, Pb)	Jun-17	NS	S	NS	NS	30 months
8	CS-MW5-LGR	VOCs & metals (Cr, Cd, Hg, Pb)	Jun-17	NS	S	NS	NS	15 months
9	CS-MW6-LGR	VOCs & metals (Cr, Cd, Hg, Pb)	Jun-17	NS	S	NS	NS	15 months
10	CS-MW6-BS	VOCs & metals (Cr, Cd, Hg, Pb)	Dec-12	NS	NS	NS	NS	as needed
11	CS-MW6-CC	VOCs & metals (Cr, Cd, Hg, Pb)	Jun-17	NS	S	NS	NS	30 months
12	CS-MW7-LGR	VOCs & metals (Cr, Cd, Hg, Pb)	Jun-17	NS	S	NS	NS	15 months
13	CS-MW7-CC	VOCs & metals (Cr, Cd, Hg, Pb)	Jun-17	NS	S	NS	NS	30 months
14	CS-MW8-LGR	VOCs & metals (Cr, Cd, Hg, Pb)	Jun-17	NS	S	NS	NS	15 months
15	CS-MW8-CC	VOCs & metals (Cr, Cd, Hg, Pb)	Jun-17	NS	S	NS	NS	15 months
16	CS-MW9-LGR	VOCs & metals (Cr, Cd, Hg, Pb)	Jun-17	NS	S	NS	NS	30 months
17	CS-MW9-BS	VOCs & metals (Cr, Cd, Hg, Pb)	Dec-12	NS	NS	NS	NS	as needed
18	CS-MW9-CC	VOCs & metals (Cr, Cd, Hg, Pb)	Jun-17	NS	S	NS	NS	30 months
19	CS-MW10-LGR	VOCs & metals (Cr, Cd, Hg, Pb)	Jun-17	NS	S	NS	NS	15 months
20	CS-MW10-CC	VOCs & metals (Cr, Cd, Hg, Pb)	Jun-17	NS	S	NS	NS	30 months
21	CS-MW11A-LGR	VOCs & metals (Cr, Cd, Hg, Pb)	Jun-17	NS	S	NS	NS	15 months
22	CS-MW11B-LGR	VOCs & metals (Cr, Cd, Hg, Pb)	Jun-17	NS	S	NS	NS	15 months
23	CS-MW12-LGR	VOCs & metals (Cr, Cd, Hg, Pb)	Jun-17	NS	S	NS	NS	15 months
24	CS-MW12-BS	VOCs & metals (Cr, Cd, Hg, Pb)	Dec-12	NS	NS	NS	NS	as needed
25	CS-MW12-CC	VOCs & metals (Cr, Cd, Hg, Pb)	Jun-17	NS	S	NS	NS	30 months
26	CW-MW17-LGR	VOCs & metals (Cr, Cd, Hg, Pb)	Jun-17	NS	S	NS	NS	15 months
27	CS-MW18-LGR	VOCs & metals (Cr, Cd, Hg, Pb)	Jun-17	NS	S	NS	NS	30 months
28	CS-MW19-LGR	VOCs & metals (Cr, Cd, Hg, Pb)	Jun-17	NS	S	NS	NS	30 months
29	CS-1	VOCs & metals (As,Ba,Cr, Cu,Cd,Hg,Pb,Zn)	Dec-17	S	S	S	S	Quarterly
30	CS-2	VOCs & metals (Cr, Cd, Hg, Pb)	Jun-17	NS	S	NS	NS	30 months
31	CS-4	VOCs & metals (Cr, Cd, Hg, Pb)	Jun-17	NS	S	NS	NS	15 months
32	CS-10	VOCs & metals (As,Ba,Cr, Cu,Cd,Hg,Pb,Zn)	Dec-17	S	S	S	S	Quarterly
33	CS-12	VOCs & metals (As,Ba,Cr, Cu,Cd,Hg,Pb,Zn)	Dec-17	S	S	S	S	Quarterly
34	CS-13	VOCs & metals (As,Ba,Cr, Cu,Cd,Hg,Pb,Zn)	Dec-17	S	S	S	S	Quarterly
35	CS-D	VOCs & metals (Cr, Cd, Hg, Pb)	Jun-17	NS	S	NS	NS	15 months
36	CS-MWG-LGR	VOCs & metals (Cr, Cd, Hg, Pb)	Jun-17	NS	S	NS	NS	30 months
37	CS-MWH-LGR	VOCs & metals (Cr, Cd, Hg, Pb)	Jun-17	NS	S	NS	NS	30 months
38	CS-I	VOCs & metals (Cr, Cd, Hg, Pb)	Jun-17	NS	S	NS	NS	30 months
39	CS-MW20-LGR	VOCs & metals (Cr, Cd, Hg, Pb)	Jun-17	NS	S	NS	NS	30 months
40	CS-MW21-LGR	VOCs & metals (Cr, Cd, Hg, Pb)	Jun-17	NS	S	NS	NS	30 months
41	CS-MW22-LGR	VOCs & metals (Cr, Cd, Hg, Pb)	Jun-17	NS	S	NS	NS	30 months
42	CS-MW23-LGR	VOCs & metals (Cr, Cd, Hg, Pb)	Jun-17	NS	S	NS	NS	30 months
43	CS-MW24-LGR	VOCs & metals (Cr, Cd, Hg, Pb)	Jun-17	NS	S	NS	NS	30 months
44	CS-MW25-LGR	VOCs & metals (Cr, Cd, Hg, Pb)	Jun-17	NS	S	NS	NS	30 months
45	CS-MW35-LGR	VOCs & metals (Cr, Cd, Hg, Pb)	Jun-17	NS	S	NS	NS	30 months
46	CS-MW36-LGR	VOCs & metals (Cr, Cd, Hg, Pb)	Jun-17	NS	S	NS	NS	15 months
47	CS-MW37-LGR	VOCs & metals (Cr, Cd, Hg, Pb)	Dec-17	NS	S	S	S	Quarterly for 1 yr

Notes/Abrreviations:
* New LTMO sampling frequency implemented September 2016. Metals analysis removed from monitoring wells and drinking water wells metals analysis remains the same.
S = Sample
NS = No Sample

Table 2.5
2017 On-post Groundwater COCs and Metals Analytical Results

Well ID		Sample Date	*cis* -1,2 DCE	PCE	TCE	Vinyl chloride
CS-1		4/4/2017	--	--	--	--
		6/27/2017	--	--	**0.16F**	--
	Duplicate	6/27/2017	--	--	**0.19F**	--
		9/26/2017	--	--	--	--
		12/6/2017	--	--	--	--
CS-2		6/16/2017	--	--	--	--
CS-4		6/16/2017	--	**0.61F**	**0.22F**	--
	Duplicate	6/16/2017	--	**0.59F**	**0.25F**	--
CS-10		3/30/2017	--	**0.18F**	--	--
		6/27/2017	--	--	--	--
		9/26/2017	--	--	--	--
		12/6/2017	--	--	--	--
	Duplicate	12/6/2017	--	--	--	--
CS-12		3/30/2017	--	**0.28F**	--	--
	Duplicate	3/30/2017	--	**0.19F**	--	--
		6/27/2017	--	--	--	--
		9/26/2017	--	--	--	--
	Duplicate	9/26/2017	--	--	--	--
		12/6/2017	--	--	--	--
CS-13		6/28/2017	--	--	--	--
		9/25/2017	--	--	--	--
		12/6/2017	--	--	--	--
CS-D		6/19/2017	**4.47**	**5.32**	**6.56**	--
CS-MWG-LGR		6/26/2017	--	--	--	--
CS-MWH-LGR		6/20/2017	--	--	--	--
CS-I		6/20/2017	--	--	--	--
CS-MW1-LGR		6/19/2017	**20.49**	**13.98**	**24.73**	--
CS-MW1-CC		6/28/2017	--	--	--	--
CS-MW2-LGR		6/19/2017	**0.36F**	--	--	--
CS-MW2-CC		6/28/2017	--	--	--	--
CS-MW3-LGR		6/19/2017	--	--	--	--
CS-MW4-LGR		6/28/2017	--	--	--	--
CS-MW5-LGR		6/16/2017	**11.65**	**5.87**	**13.16**	--
CS-MW6-LGR		6/8/2017	--	--	--	--
CS-MW6-CC		6/8/2017	--	--	--	--
CS-MW7-LGR		6/20/2017	--	**0.88F**	--	--
CS-MW7-CC		6/26/2017	--	--	--	--
	Duplicate	6/26/2017	--	--	--	--
CS-MW8-LGR		6/8/2017	--	**2.62**	--	--
CS-MW8-CC		6/8/2017	--	--	--	--
CS-MW9-LGR		6/19/2017	--	--	--	--
	Duplicate	6/19/2017	--	--	--	--
CS-MW9-CC		6/19/2017	--	--	--	--
CS-MW10-LGR		6/26/2017	--	**1.89**	--	--
CS-MW10-CC		6/26/2017	--	--	--	--
CS-MW11A-LGR		6/26/2017	--	**0.89F**	--	--
CS-MW11B-LGR		6/26/2017	--	**0.98F**	--	--
CS-MW12-LGR		6/16/2017	--	--	--	--
CS-MW12-CC		6/16/2017	--	--	--	--

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Table 2.5
2017 On-post Groundwater COCs and Metals Analytical Results

Well ID	Sample Date	*cis* -1,2 DCE	PCE	TCE	Vinyl chloride
CS-MW17-LGR	6/28/2017	--	**0.67F**	--	--
Duplicate	6/28/2017	--	**0.76F**	--	--
CS-MW18-LGR	6/16/2017	--	--	--	--
CS-MW19-LGR	6/16/2017	--	**0.68F**	--	--
CS-MW20-LGR	6/26/2017	--	**1.23F**	--	--
CS-MW21-LGR	6/28/2017	--	--	--	--
CS-MW22-LGR	6/26/2017	--	--	--	--
CS-MW23-LGR	6/26/2017	--	--	--	--
CS-MW24-LGR	6/19/2017	--	--	--	--
CS-MW25-LGR	6/27/2017	--	--	--	--
CS-MW35-LGR	6/26/2017	--	**0.66F**	--	--
CS-MW36-LGR	6/8/2017	--	**5.43**	**4.2**	--
CS-MW37-LGR	7/12/2017	--	--	--	--
	9/22/2017	--	--	--	--
	12/6/2017	--	--	--	--
Comparison Criteria					
Maximum Contaminant Level (MCL)		**70**	**5.0**	**5.0**	**2.0**
Reporting Limit (RL)		**1.2**	**1.4**	**1.0**	**1.1**
Method Detection Limit (MDL)		**0.07**	**0.06**	**0.05**	**0.08**

BOLD (red)	≥ MCL
BOLD (blue)	≥ RL
BOLD	≥ MDL

All samples were analyzed by APPL, Inc. using method SW8260B.
VOC data reported in ug/L & metals data reported in mg/L.

Abbreviations/Notes:

Duplicate	Field Duplicate
TCE	Trichloroethene
PCE	Tetrachloroethene
DCE	Dichloroethene

Data Qualifiers

-- = The analyte was analyzed for, but not detected. The associated numerical value is at or below the MDL.
F = The analyte was positively identified but the associated numerical value is below the RL.

Table 2.5
2017 On-post Groundwater COCs and Metals Analytical Results

Well ID:	CS-MW37-LGR			
Sample Date:	7/12/2017			
Analyte	MDL	RL	MCL	Concentration
Organics (µg/L)				
1,1,1,2-TETRACHLOROETHANE	0.09	0.5	NA	--
1,1,1-TCA	0.03	0.8	200	--
1,1,2,2-TETRACHLOROETHANE	0.07	0.4	NA	--
1,1,2-TCA	0.06	1	5	--
1,1-DCA	0.07	0.4	NA	--
1,1-DCE	0.12	1.2	7	--
1,1-DICHLOROPROPENE	0.1	1	NA	--
1,2,3-TRICHLOROBENZENE	0.24	0.3	NA	--
1,2,3-TRICHLOROPROPANE	0.17	3.2	NA	--
1,2,4-TRICHLOROBENZENE	0.16	0.4	70	--
1,2,4-TRIMETHYLBENZENE	0.04	1.3	NA	--
1,2-DCA	0.05	0.6	5	--
1,2-DCB	0.02	0.3	NA	--
1,2-DIBROM0-3-CHLOROPROPANE	0.76	2.6	0.2	--
1,2-DICHLOROPROPANE	0.06	0.4	5	--
1,2-EDB	0.06	0.6	NA	--
1,3,5-TRIMETHYLBENZENE	0.04	0.5	NA	--
1,3-DCB	0.03	1.2	NA	--
1,3-DICHLOROPROPANE	0.05	0.4	NA	--
1,4-DCB	0.07	0.3	NA	--
1-CHLOROHEXANE	0.04	0.5	NA	--
2,2-DICHLOROPROPANE	0.1	3.5	NA	--
2-CHLOROTOLUENE	0.04	0.4	NA	--
4-CHLOROTOLUENE	0.04	0.6	NA	--
BENZENE	0.07	0.4	NA	--
BROMOBENZENE	0.06	0.3	NA	--
BROMOCHLOROMETHANE	0.11	0.4	NA	--
BROMODICHLOROMETHANE	0.06	0.8	*80	--
BROMOFORM	0.13	1.2	*80	--
BROMOMETHANE	0.08	1.1	NA	--
CARBON TETRACHLORIDE	0.06	2.1	5	--
CHLOROBENZENE	0.04	0.4	0.1	--
CHLOROETHANE	0.07	1	NA	--
CHLOROFORM	0.06	0.3	*80	--
CHLOROMETHANE	0.16	1.3	NA	--
CIS-1,2-DCE	0.07	1.2	70	--
CIS-1,3-DICHLOROPROPENE	0.03	1	NA	--
DIBROMOCHLOROMETHANE	0.06	0.5	*80	--
DIBROMOMETHANE	0.06	2.4	NA	--
DICHLORODIFLUOROMETHANE	0.11	1	NA	--
ETHYLBENZENE	0.05	0.6	700	--
HEXACHLOROBUTADIENE	0.17	1.1	NA	--
ISOPROPYLBENZENE	0.04	0.5	NA	--
M&P-XYLENE	0.07	0.5	NA	--
METHYLENE CHLORIDE	0.35	1	NA	--
N-BUTYLBENZENE	0.17	1.1	NA	--

Table 2.5
2017 On-post Groundwater COCs and Metals Analytical Results

Well ID:	**CS-MW37-LGR**			
Sample Date:	**7/12/2017**			
Analyte	**MDL**	**RL**	**MCL**	**Concentration**
N-PROPYLBENZENE	0.03	0.4	NA	--
NAPHTHALENE	0.07	0.4	NA	--
O-XYLENE	0.06	1.1	NA	--
P-ISOPROPYLTOLUENE	0.05	1.2	NA	--
SEC-BUTYLBENZENE	0.05	1.3	NA	--
STYRENE	0.08	0.4	100	--
TCE	0.05	1	5	--
TERT-BUTYLBENZENE	0.04	1.4	NA	--
TETRACHLOROETHENE	0.06	1.4	5	--
TOLUENE	0.06	1.1	1000	--
TRANS-1,2-DCE	0.08	0.6	100	--
TRANS-1,3-DICHLOROPROPENE	0.04	1	NA	--
TRICHLOROFLUOROMETHANE	0.07	0.8	NA	--
VINYL CHLORIDE	0.08	1.1	2	--
Metals (mg/L)				
ARSENIC	0.00022	0.03	0.01	**0.00076F**
BARIUM	0.0003	0.005	2	**0.0442**
CADMIUM	0.0005	0.007	0.005	--
CHROMIUM	0.001	0.01	0.1	**0.0076F**
COPPER	0.003	0.01	AL = 1.3	--
LEAD	0.0019	0.025	AL = 0.015	--
ZINC	0.008	0.05	SS = 5	**0.588**
MERCURY	0.0001	0.001	0.002	--
Inorganics (mg/L)				
TOTAL DISSOLVED SOILIDS	4.4	10	SS = 500	**321**
BROMIDE	0.07	0.5	NA	**0.2F**
CHLORIDE	0.08	1	SS = 250	**11.96**
FLUORIDE	0.1	0.1	4	**0.42**
NITRATE	0.03	0.5	10	**4.6**
NITRITE	0.04	0.3	1	**0.12F**
SULFATE	0.26	1	SS = 250	**20.74**
BICARBONATE AS CACO3	0.3	2	NA	**264**

BOLD	≥ MDL
BOLD (blue)	≥ RL
BOLD (red)	≥ MCL

Data Qualifiers:
U-The analyte was analyzed for, but not detected. The associated numerical value is at or below the
F-The analyte was positively identified but the associated numerical value is below the RL.
Abbreviations/Notes:
* Total Trihalomethanes (TTHMs) - maximum allowable annual average level
NA = no applicable standard
SS = secondary standard
AL = action level
MDL = method detection limit
RL = reporting limit
MCL = maximum contaminant level

Table 2.5
2017 On-post Groundwater COCs and Metals Analytical Results

Well ID		Sample Date	Arsenic (mg/L)	Barium (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Copper (mg/L)	Lead (mg/L)	Mercury (mg/L)	Zinc (mg/L)
CS-1		4/4/2017	**0.0066F**	**0.0366**	--	--	**0.005F**	--	--	**0.191**
		6/27/2017	--	**0.0331**	--	--	**0.014**	**0.0057F**	--	**0.175**
	Duplicate	6/27/2017	**0.00101F**	**0.0357**	--	--	**0.015**	**0.0043F**	--	**0.145**
		9/26/2017	--	**0.0342**	--	--	--	--	--	**0.115J**
		12/6/2017	--	**0.0343**	--	--	**0.017**	--	--	**0.212**
CS-10		3/30/2017	**0.0054F**	**0.0396**	--	**0.0013F**	**0.011**	--	--	**0.227**
		6/27/2017	**0.00121F**	**0.0376**	--	**0.0012F**	--	**0.0027F**	--	**0.387**
		9/26/2017	--	**0.0351**	--	--	--	--	--	**0.353J**
		12/6/2017	--	**0.0372**	--	--	--	--	--	**0.458**
	Duplicate	12/7/2017	--	**0.0375**	--	--	--	--	--	**0.445**
CS-12		3/30/2017	**0.0023F**	**0.0291**	--	**0.0012F**	--	--	--	**0.028F**
	Duplicate	3/30/2017	**0.0013F**	**0.0284**	--	--	--	--	--	**0.025F**
		6/27/2017	**0.00125F**	**0.03**	--	**0.0746**	--	**0.0031F**	--	**0.033F**
		9/26/2017	--	**0.0298**	--	--	**0.008F**	--	--	**0.059J**
	Duplicate	9/26/2017	--	**0.0297**	--	--	**0.006F**	--	--	**0.083J**
		12/6/2017	--	**0.0298**	--	--	**0.007F**	--	--	**0.038F**
CS-13		6/28/2017	**0.00418F**	**0.0319**	--	**0.0016F**	--	**0.0034F**	--	**0.435**
		9/25/2017	--	**0.0287**	--	--	--	--	--	**0.378**
		12/6/2017	**0.01617F**	--	--	--	--	**0.0032F**	--	**0.054M**
Comparison Criteria										
Maximum Contaminant Level (MCL)			**0.01**	**2.0**	**0.005**	**0.1**	**1.3**	**0.015 (AL)**	**0.002**	**5.0 (SS)**
Report Limit (RL)			**0.03**	**0.005**	**0.007**	**0.01**	**0.01**	**0.025**	**0.001**	**0.05**
Method Detection Limit (MDL)			**0.00022**	**0.0003**	**0.0005**	**0.001**	**0.003**	**0.0019**	**0.0001**	**0.008**

BOLD (red)	≥ MCL
BOLD (blue)	≥ RL
BOLD	≥ MDL

All samples were analyzed by APPL, Inc. using laboratory method SW8260B.
VOC data reported in µg/L & metals data reported in mg/L.

Abbreviations/Notes:

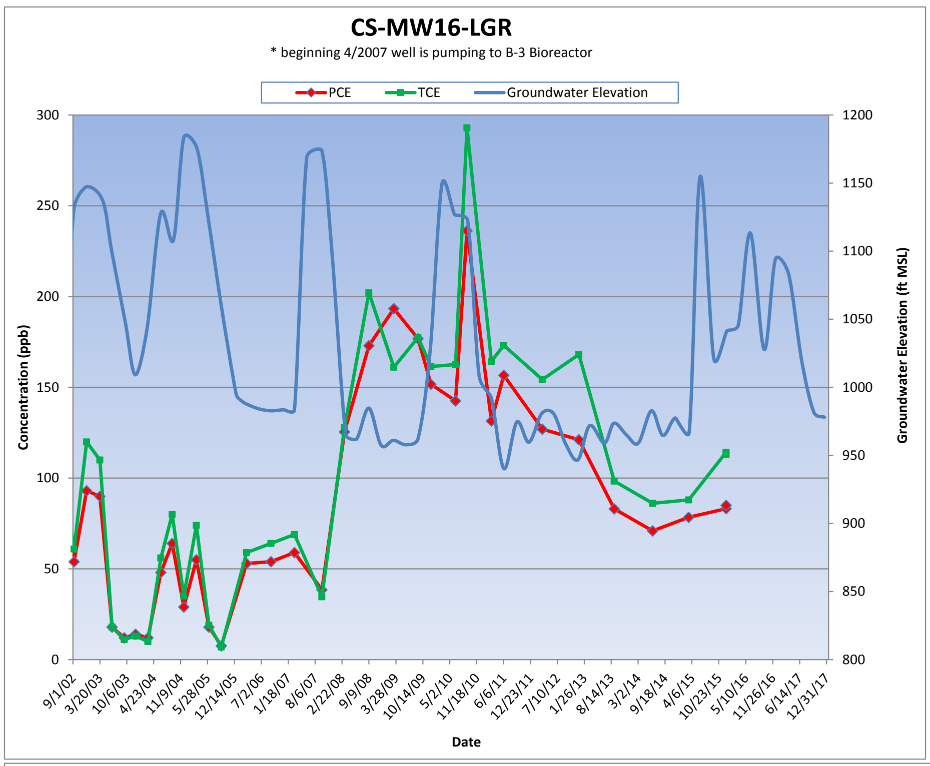
µg/L	micrograms per liter
mg/L	milligrams per liter
Duplicate	Field Duplicate
AL	Action Level
SS	Secondary Standard

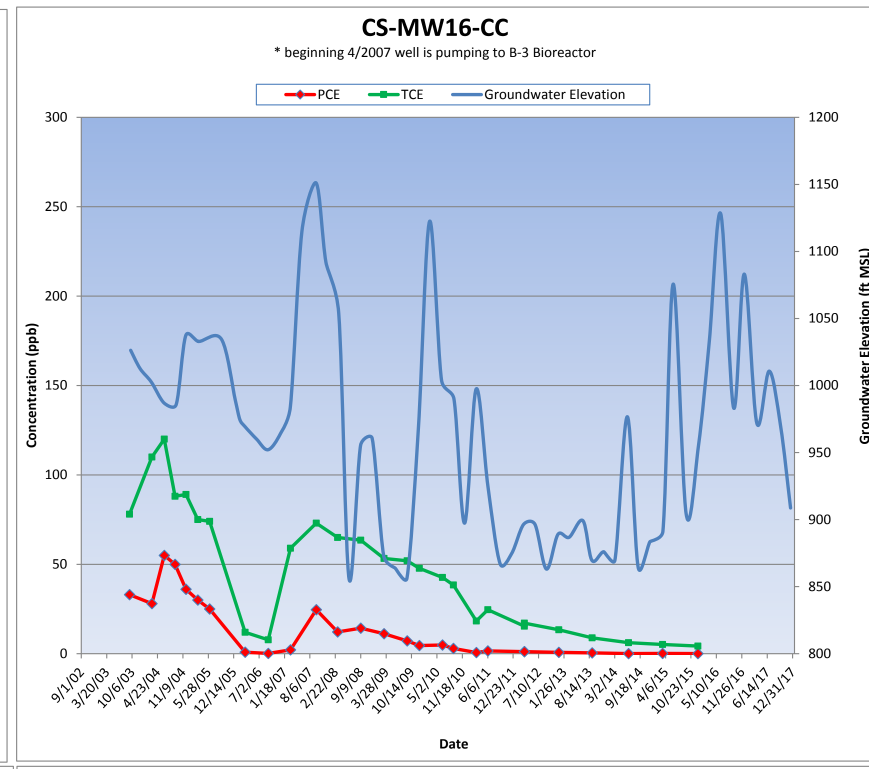
Data Qualifiers:
NA = Analyte not analyzed
F-The analyte was positively identified but the associated numerical value is below the RL.
J - Analyte detected, concentration estimated.
M - Matrix effect present
U-The analyte was analyzed for, but not detected. The associated numerical value is at or below the MDL.

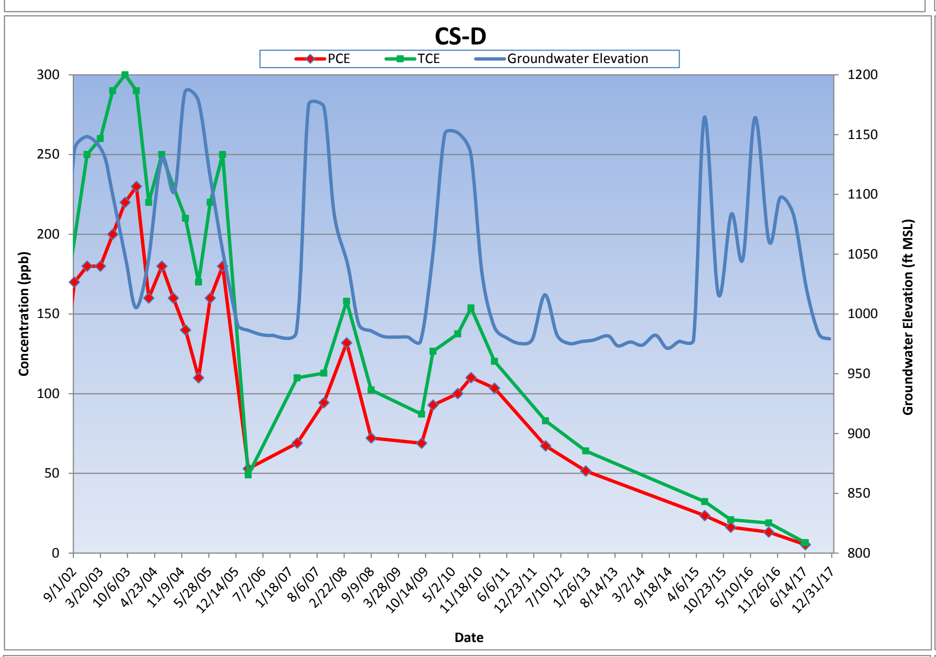
- **CS-D –** This well was sampled in June 2017. PCE and TCE concentrations were above their MCLs. Cis-1,2-DCE was also detected below the MCL in June 2017. Although the PCE and TCE levels remain above the MCL, the 2017 concentrations are the lowest seen in this well since sampling began in 1991.
- **CS-MW1-LGR –** This well was sampled once in 2017. PCE and TCE concentrations were above their MCLs in June 2017. *Cis*-1,2-DCE was also detected below the MCL.
- **CS-MW5-LGR** – This well was also sampled once in 2017. PCE and TCE concentrations were above their MCLs in June 2017. *Cis*-1,2-DCE was also detected below the MCL. PCE and TCE concentrations were first reported above the MCL in February 2016, this well has been monitored since June 2001.
- **CS-MW36-LGR –** This well was sampled during June event in 2017. PCE was above the MCL and TCE was below the MCL.

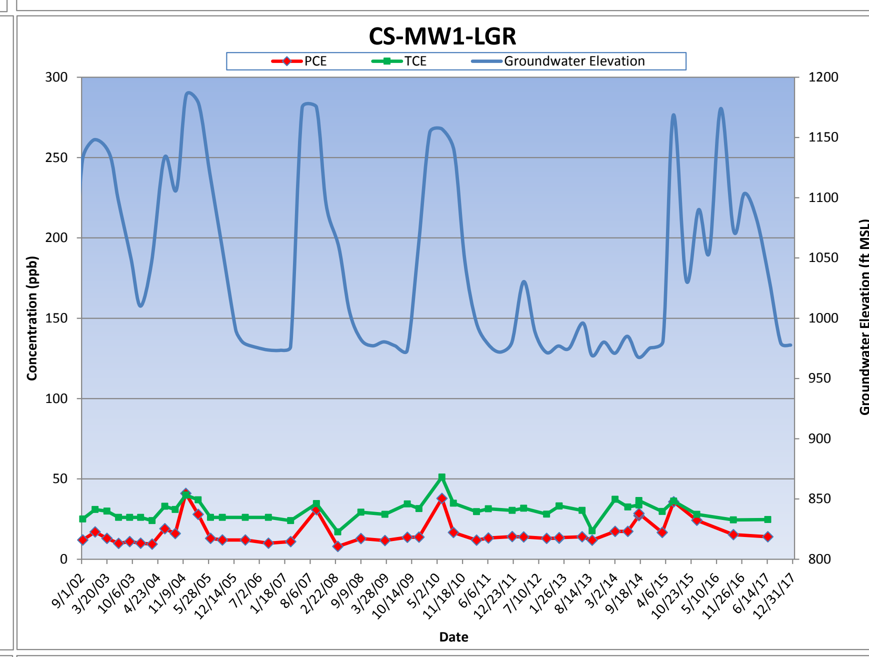
Concentration trends are illustrated on **Figure 2.4** for wells CS-MW16-LGR, CS-MW16-CC, CS-D, CS-MW1-LGR, CS-MW5-LGR, CS-MW36-LGR, and CS-4. These wells were selected because they have historical detections of PCE and TCE that approach and/or exceed MCLs. **Figure 2.4** also includes groundwater elevation data from each respective well to determine if there are correlations between VOC concentrations and water level. This figure suggests that CS-MW1-LGR has the most direct correlation between PCE/TCE concentration and groundwater recharge events. After that, discernible trends are less evident. Quarterly monitoring of CS-MW16-LGR and CS-D seems to indicate that increases in VOC concentrations lag recharge events by roughly six to nine months. CS-MW16-LGR and CS-MW16-CC have been removed from the groundwater monitoring program per the updated LTMO study and DQO's.

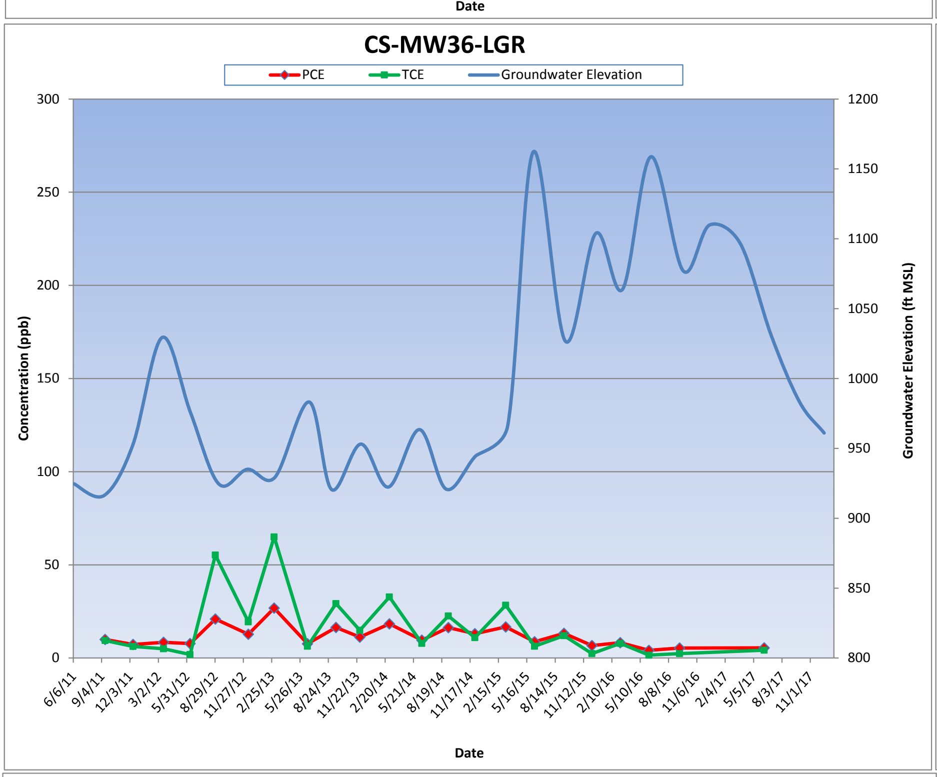
Figure 2.4
On-Post Cumulative Analytical vs. Groundwater Elevation

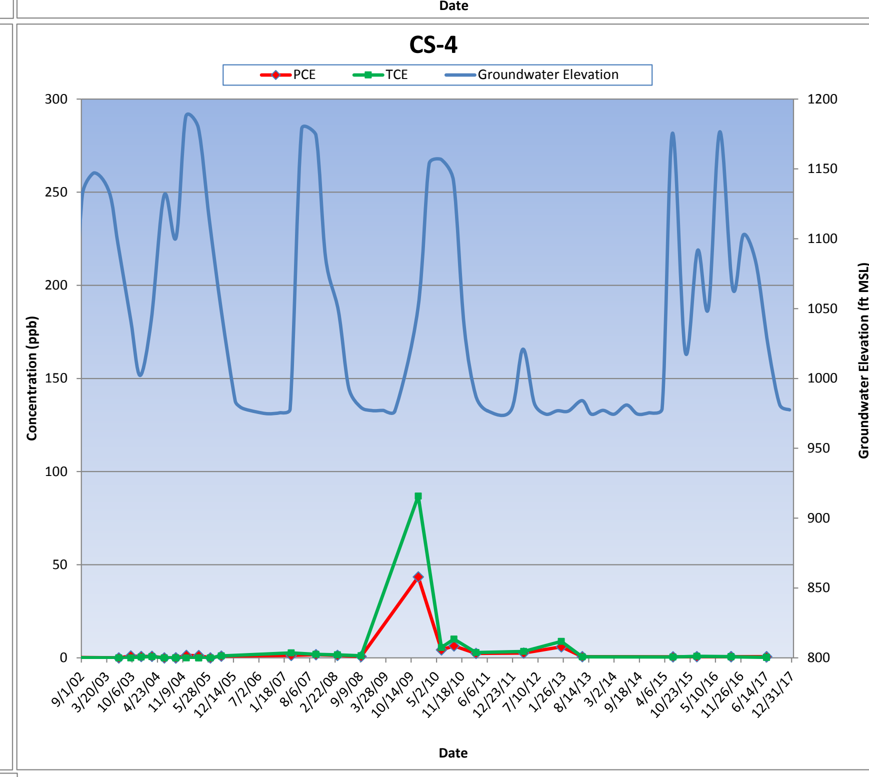


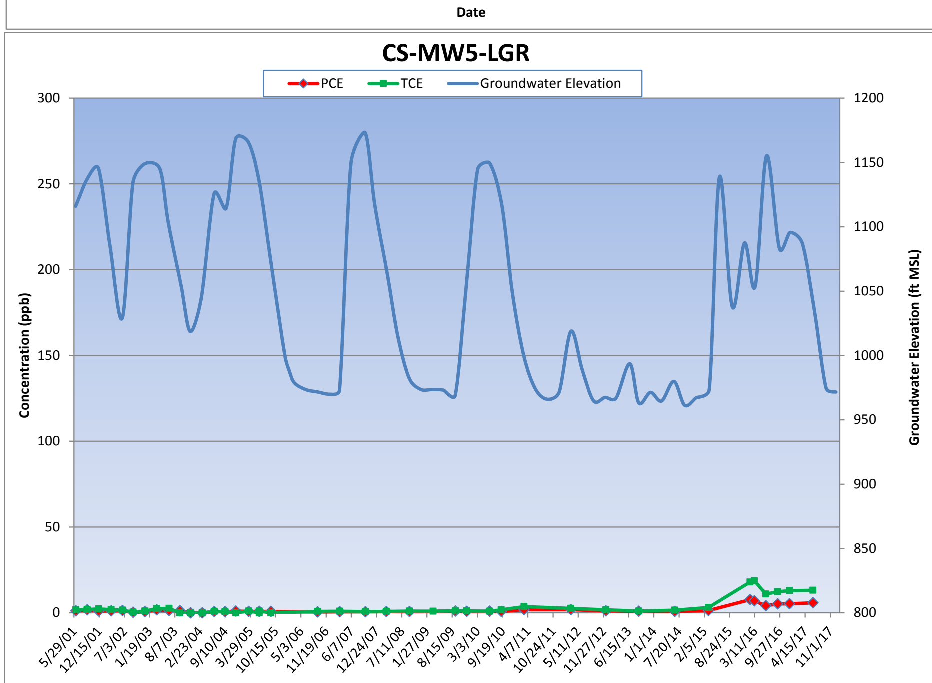












NOTE: Sampling dates are indicated by the squares on the trend line.

Notable trends in other wells appear to be related more to remedial activities than precipitation/recharge events. Concentrations at CS-MW16-CC decreased between March 2004 and June 2005 during a 15-month pump test of that well. Then concentrations increased in early 2007 during a time that roughly corresponds to the start-up of SWMU B-3 Bioreactor operations. Since that time, groundwater has been continually pumped from CS-MW16-CC and applied to the bioreactor as a remedial alternative. During that timeframe, VOC concentrations have steadily decreased, with little fluctuation attributable to precipitation. It is debatable whether the CS-MW36-LGR concentrations have responded to the in-situ chemical oxidation (ISCO) injections at AOC-65 in August 2012, May-June 2013, September-October 2014, and August-November 2015. The singular PCE/TCE peak at CS-4 has been attributed to the SWMU B-3 flood test in September 2009.

The VOC concentrations at CS-MW5-LGR have historically been below the MCLs since the well's inception in 2001. However, PCE, TCE, and *cis*-1,2-DCE all increased five-fold in 2015 and remained at these levels in 2016 and 2017. The recent significant increase in contamination in well CS-MW5-LGR could be a result of the above average rainfall in 2015 and 2016. This area has not seen above average rainfall since before the historical drought of 2011. This, coupled with remedial activities at the SWMU B-3 bioreactor to the west of this well, may have contributed to this increase.

2.2.1.3 On-Post Monitoring Wells with COC Detections below the MCL

Groundwater monitoring results included wells where COCs were detected at levels below the applicable MCLs, SS, or ALs but above RLs. These included wells CS-MW8-LGR and CS-MW10-LGR. The detections below the MCLs/ALs but above RLs are summarized as follows:

- **CS-MW8-LGR** - PCE was detected in June 2017; above the RL but below the MCL.
- **CS-MW10-LGR –** PCE (above RL) concentrations were detected below the MCL in June 2017. TCE was not detected in this well for the first time since sampling of this well began in 2001.

2.2.1.4 On-Post Monitoring Wells with COC Detections below the Reporting Limits

The on-post results include detections in wells for which the analyte is identified, but at a concentration below the RL. These results are assigned an "F" flag under the CSSA Quality Assurance Project Plan (QAPP). In 2017, this included wells CS-4, CS-MW2-LGR, CS-MW7-LGR, CS-MW11A-LGR, CS-MW11B-LGR, CS-MW17-LGR, CS-MW19-LGR, CS-MW20-LGR, and CS-MW35-LGR. Metals analysis was dropped from the schedule in September 2016 in accordance with the 2015 update to the LTMO study and DQO's. The detections below the reporting limit are summarized as follows:

- **CS-4 –** This well was sampled once in June 2017. PCE and TCE were detected below the RL in both the normal and field duplicate samples.
- **CS-MW2-LGR –** This well was sampled once in 2017. *Cis*-1,2-DCE was detected below the RL in June 2017. This is the lowest concentration of *cis*-1,2-DCE reported in this well since sampling began in 1997.

- **CS-MW7-LGR –** PCE was detected below the RL in June 2017. This was the highest concentration of PCE reported in this well to date.
- **CS-MW11A-LGR –** PCE was detected below the RL in June 2017.
- **CS-MW11B-LGR –** PCE was also detected below the RL in June 2017.
- **CS-MW17-LGR –** PCE was detected below the RL in June 2017. With concentrations of 0.76 µg/L in the field duplicate, this is the highest concentration reported in this well since sampling of the well began in 2002.
- **CS-MW19-LGR –** PCE was detected below the RL in June 2017.
- **CS-MW20-LGR –** PCE was also detected below the RL in June 2017.
- **CS-MW35-LGR –** PCE was detected below the RL in June 2017.

2.2.1.5 On-Post Monitoring Wells with No COC Detections

Of the 39 monitoring wells sampled in 2017, 15 wells reported COC detections. A total of 24 wells (CS-2, CS-MWG-LGR, CS-MWH-LGR, CS-I, CS-MW1-CC, CS-MW2-CC, CS-MW3-LGR, CS-MW4-LGR, CS-MW6-LGR, CS-MW6-CC, CS-MW7-CC, CS-MW8-CC, CS-MW9-LGR, CS-MW9-CC, CS-MW10-CC, CS-MW12-LGR, CS-MW12-CC, CS-MW18-LGR, CS-MW21-LGR, CS-MW22-LGR, CS-MW23-LGR, CS-MW24-LGR, CS-MW25-LGR, and CS-MW37-LGR) reported no VOC detections. In 2017 all scheduled samples were collected (**Table 2.4**). Details on the RL, MDLs, field duplicates, MCLs, etc., are described in the tables of detections (**Table 2.5**) and in **Appendix B**.

2.2.1.6 Drinking Water Supply Well Results

Four active CSSA drinking water supply wells (CS-1, CS-10, CS-12, and CS-13) were analyzed for VOCs and the 8 metals (arsenic, barium, cadmium, chromium, copper, lead, mercury, and zinc) in 2017. Under the LTMO study, the drinking water supply wells are scheduled to be sampled quarterly (**Table 2.4 & Appendix B**). The detections are summarized as follows:

- **CS-1 –** PCE was detected in June during the 4 sampling events in 2017. Barium and zinc were above their applicable RLs in all four quarters in 2017. Copper was also above the RL in June and December 2017. Arsenic and lead were also detected below the RL in 2017.
- **CS-10 –** Trace amounts of PCE were detected in March 2017. Barium, copper, and zinc were detected above the RLs in 2017. Arsenic, chromium, and lead were also detected below their applicable RLs in 2017.
- **CS-12 –** PCE was detected in March during the 4 sampling events in 2017. Barium and chromium were detected above their applicable RLs in 2017. Arsenic, copper, lead, and zinc were also detected below their applicable RLs in 2017.
- **CS-13 –** No VOCs were detected in this well in 2017. Samples were not collected from this well in March due to well house construction. Arsenic was detected above the MCL in December 2017. Barium and zinc were detected above their applicable RLs in 2017. Chromium and lead were detected below their applicable RL's. Additional analytes were collected in June 2017 in accordance with the project DQO's for newly installed wells.

2.2.1.7 Westbay®-equipped Well Results

Eight wells equipped with the Westbay multi-port interval sampling equipment have been installed at CSSA. Four wells (CS-WB05, CS-WB06, CS-WB07, and CS-WB08) are sampled as part of the SWMU B-3 bioreactor treatability study and are not addressed in this report. The remaining four wells (CS-WB01, CS-WB02, CS-WB03, and CS-WB04) are part of the postwide groundwater monitoring program and are included in this report. Under the provisions of the groundwater monitoring DQOs and the 2015 updated LTMO study, the schedule for sampling CS-WB01, CS-WB02, CS-WB03, and CS-WB04 is every 15 months for the UGR and LGR zones and every 30 months for the BS and CC zones. An overview of sampling frequencies for Westbay wells is given in **Table 2.6**.

Samples were collected from zones included in the 30-month schedule in June 2017. No samples were scheduled for collection in March, September, and December 2017. Samples were analyzed for PCE, TCE, *cis*-1,2-DCE, and vinyl chloride in June. All samples were analyzed by APPL. Per the DQOs, the Westbay data are used for screening purposes only, and therefore no quality assurance/quality control samples are collected with the Westbay samples. All intervals with detections of COCs are presented in **Table 2.7**. Full analytical results are presented in **Appendix C**. **Appendix D** illustrates the historical contaminant concentrations and groundwater elevations for each Westbay zone.

Additional samples were collected from the Westbay wells in conjunction with the normal quarterly groundwater monitoring in 2017. An ongoing ISCO treatability study is currently being conducted at AOC-65. The results of this effort are currently being tabulated and will be reported in a separate treatability study document.

Due to low groundwater elevations, certain zones (CS-WB01-UGR-01, CS-WB02-LGR-01, CS-WB02-LGR-02, CS-WB03-LGR-02, CS-WB04-UGR-01, and CS-WB04-LGR-02) could not be sampled in June because they were dry. CS-WB02-UGR-01 was not sampled due to a clogged sampling port and CS-WB04-LGR-05 was not sampled due to a non-operational sampling port. The remaining 39 zones scheduled for sampling contained water and were sampled. The Westbay-equipped wells are sampled using Westbay Instruments, Inc., equipment and sampling methods.

Table 2.6
Overview of Westbay Sampling for 2017

Westbay Interval	Last Sample Date	Mar-17	Jun-17 (30 month)	Sep-17	Dec-17	LTMO Sampling Frequency (as of Sept. 2016)
CS-WB01-UGR-01	Jun-16	NS	NSWL	NS	NS	15 months
CS-WB01-LGR-01	Jun-17	NS	S	NS	NS	15 months
CS-WB01-LGR-02	Jun-17	NS	S	NS	NS	15 months
CS-WB01-LGR-03	Jun-17	NS	S	NS	NS	15 months
CS-WB01-LGR-04	Jun-17	NS	S	NS	NS	15 months
CS-WB01-LGR-05	Jun-17	NS	S	NS	NS	15 months
CS-WB01-LGR-06	Jun-17	NS	S	NS	NS	15 months
CS-WB01-LGR-07	Jun-17	NS	S	NS	NS	15 months
CS-WB01-LGR-08	Jun-17	NS	S	NS	NS	15 months
CS-WB01-LGR-09	Jun-17	NS	S	NS	NS	15 months
CS-WB02-UGR-01	Dec-04	NS	clogged	NS	NS	15 months
CS-WB02-LGR-01	Jun-16	NS	NSWL	NS	NS	15 months
CS-WB02-LGR-02	Jun-16	NS	NSWL	NS	NS	15 months
CS-WB02-LGR-03	Jun-17	NS	S	NS	NS	15 months
CS-WB02-LGR-04	Jun-17	NS	S	NS	NS	15 months
CS-WB02-LGR-05	Jun-17	NS	S	NS	NS	15 months
CS-WB02-LGR-06	Jun-17	NS	S	NS	NS	15 months
CS-WB02-LGR-07	Jun-17	NS	S	NS	NS	15 months
CS-WB02-LGR-08	Jun-17	NS	S	NS	NS	15 months
CS-WB02-LGR-09	Jun-17	NS	S	NS	NS	15 months
CS-WB03-UGR-01	Jun-17	NS	S	NS	NS	15 months
CS-WB03-LGR-01	Jun-17	NS	S	NS	NS	15 months
CS-WB03-LGR-02	Oct-07	NS	NSWL	NS	NS	15 months
CS-WB03-LGR-03	Jun-17	NS	S	NS	NS	15 months
CS-WB03-LGR-04	Jun-17	NS	S	NS	NS	15 months
CS-WB03-LGR-05	Jun-17	NS	S	NS	NS	15 months
CS-WB03-LGR-06	Jun-17	NS	S	NS	NS	15 months
CS-WB03-LGR-07	Jun-17	NS	S	NS	NS	15 months
CS-WB03-LGR-08	Jun-17	NS	S	NS	NS	15 months
CS-WB03-LGR-09	Jun-17	NS	S	NS	NS	15 months
CS-WB04-UGR-01	Mar-04	NS	NSWL	NS	NS	15 months
CS-WB04-LGR-01	Jun-17	NS	S	NS	NS	15 months
CS-WB04-LGR-02	Mar-14	NS	NSWL	NS	NS	15 months
CS-WB04-LGR-03	Jun-17	NS	S	NS	NS	15 months
CS-WB04-LGR-04	Jun-17	NS	S	NS	NS	15 months
CS-WB04-LGR-06	Jun-17	NS	S	NS	NS	15 months
CS-WB04-LGR-07	Jun-17	NS	S	NS	NS	15 months
CS-WB04-LGR-08	Jun-17	NS	S	NS	NS	15 months
CS-WB04-LGR-09	Jun-17	NS	S	NS	NS	15 months
CS-WB04-LGR-10	Jun-17	NS	S	NS	NS	15 months
CS-WB04-LGR-11	Jun-17	NS	S	NS	NS	15 months
CS-WB04-BS-01	Jun-17	NS	S	NS	NS	30 months
CS-WB04-BS-02	Jun-17	NS	S	NS	NS	30 months
CS-WB04-CC-01	Jun-17	NS	S	NS	NS	30 months
CS-WB04-CC-02	Jun-17	NS	S	NS	NS	30 months
CS-WB04-CC-03	Jun-17	NS	S	NS	NS	30 months

Profiling performed quarterly, in conjunction with post wide water levels.
S = sample
NS = no sample
NSWL = no sample due to low water level

Table 2.7
2017 Westbay Groundwater COC Analytical Results, Detected Analytes

Well ID	Date Sampled	cis-1,2-DCE (cis-1,2-dichloroethene)	TCE (trichloroethene)	PCE (tetrachloroethene)	Vinyl Chloride
CS-WB01-UGR-01	6/21/2017	Dry			
CS-WB01-LGR-01	6/21/2017	--	**0.43F**	**1.20F**	--
CS-WB01-LGR-02	6/21/2017	--	**2.34**	**11.08**	--
CS-WB01-LGR-03	6/21/2017	--	**10.45**	**4.02**	--
CS-WB01-LGR-04	6/21/2017	--	--	--	--
CS-WB01-LGR-05	6/21/2017	**1.48**	--	--	--
CS-WB01-LGR-06	6/21/2017	**1.60**	**4.37**	--	--
CS-WB01-LGR-07	6/21/2017	--	**14.11**	**14.07**	--
CS-WB01-LGR-08	6/21/2017	**19.78**	**1.23**	--	--
CS-WB01-LGR-09	6/21/2017	**0.49F**	--	--	**1.94**
CS-WB02-UGR-01	6/22/2017	port clogged			
CS-WB02-LGR-01	6/22/2017	Dry			
CS-WB02-LGR-02	6/22/2017	Dry			
CS-WB02-LGR-03	6/22/2017	--	**0.47F**	**2.93**	--
CS-WB02-LGR-04	6/22/2017	--	**4.65**	**2.6**	--
CS-WB02-LGR-05	6/22/2017	**0.61F**	**1.66**	--	--
CS-WB02-LGR-06	6/22/2017	**0.72F**	**2.33**	**4.24**	--
CS-WB02-LGR-07	6/22/2017	**0.59F**	**1.14**	--	--
CS-WB02-LGR-08	6/22/2017	**3.08**	--	--	--
CS-WB02-LGR-09	6/22/2017	--	**6.82**	**7.14**	--
CS-WB03-UGR-01	6/22/2017	**9.56**	**103.64****	**9356.24*****	--
CS-WB03-LGR-01	6/22/2017	**0.54F**	**16.79**	**365.80***	--
CS-WB03-LGR-02	6/22/2017	Dry			
CS-WB03-LGR-03	6/22/2017	--	**0.52F**	**3.79**	--
CS-WB03-LGR-04	6/22/2017	--	**4.9**	**15.87**	--
CS-WB03-LGR-05	6/22/2017	--	**2.18**	**13.38**	--
CS-WB03-LGR-06	6/22/2017	**7.01**	--	--	--
CS-WB03-LGR-07	6/22/2017	**2.38**	**5.89**	**2.31**	--
CS-WB03-LGR-08	6/22/2017	**2.00**	--	--	**0.90F**
CS-WB03-LGR-09	6/22/2017	--	**2.29**	**2.57**	--
CS-WB04-UGR-01	7/10/2017	Dry			
CS-WB04-LGR-01	7/10/2017	--	--	**0.68F**	--
CS-WB04-LGR-02	7/10/2017	Dry			
CS-WB04-LGR-03	7/10/2017	--	--	--	--
CS-WB04-LGR-04	7/10/2017	**0.31F**	--	--	--
CS-WB04-LGR-06	7/10/2017	**3.74**	**12.69**	**16.87**	--
CS-WB04-LGR-07	7/10/2017	**32.58**	**4.71**	--	--
CS-WB04-LGR-08	7/10/2017	**0.53F**	**1.05**	**0.74F**	--
CS-WB04-LGR-09	7/10/2017	--	**6.93**	**8.75**	--
CS-WB04-LGR-10	7/10/2017	--	**0.46F**	**2.02**	--
CS-WB04-LGR-11	7/10/2017	--	--	**0.45F**	--
CS-WB04-BS-01	7/10/2017	--	--	--	--
CS-WB04-BS-02	7/10/2017	--	--	--	--
CS-WB04-CC-01	7/10/2017	**1.15F**	--	--	--
CS-WB04-CC-02	7/10/2017	--	--	**0.24F**	--
CS-WB04-CC-03	7/10/2017	--	--	**0.44F**	--
Comparison Criteria					
Method Detection Limit	**MDL**	**0.07**	**0.05**	**0.06**	**0.08**
Reporting Limit	**RL**	**1.2**	**1**	**1.4**	**1.1**
Max. Contaminant Level	**MCL**	**70**	**5**	**5**	**2**

Data Qualifiers
'--' indicates the result was non-detect.
F-The analyte was positively identified but the associated numerical value is below the RL.
* dilution of 5 run for this sample.
** dilution of 50 run for this sample.
*** dilution of 200 run for this sample
All values are reported in µg/L.

BOLD	≥ MDL
BOLD (blue)	≥ RL
BOLD (red)	≥ MCL

The following Westbay intervals (shown in their general stratigraphic position) reported detections of PCE and/or TCE above the MCL in 2017.

CS-WB01	**CS-WB02**	**CS-WB03**	**CS-WB04**
-	-	• UGR-01	-
-	-	• LGR-01	-
• LGR-02	-	-	-
• LGR-03	-	-	-
-	-	• LGR-04	-
-	-	• LGR-05	-
-	-	-	• LGR-06
• LGR-07	-	• LGR-07	-
-	-	-	-
-	• LGR-09	-	• LGR-09
			-
			-

Figures 2.5 and **2.6** present the June 2017 vertical distribution of the VOC plume within the multi-port wells for the most pervasive contaminants, PCE and TCE. The following discussion presents general observations that have been noted since the inception of Westbay monitoring at AOC-65.

In 2017, the VOC plume originating from AOC-65 is generally similar in concentration and distribution as in prior years. Near the source area (CS-WB03), the solvent contamination is persistent throughout the entire thickness of the LGR, with the greatest concentrations near the land surface; however non-detections of PCE within the LGR-08 zone in the source area (CS-WB03) and in CS-WB01 and CS-WB02 to the south of the source area and detections below the reporting limit in this zone at CS-WB04 to west of the source area result in two PCE plumes separated by the LGR-08 zone. As the plume disperses to the south and west, the contaminants seem to preferentially migrate in stratified lobes (LGR-01, -02, and -03), (LGR-06 and -07) and LGR-09.

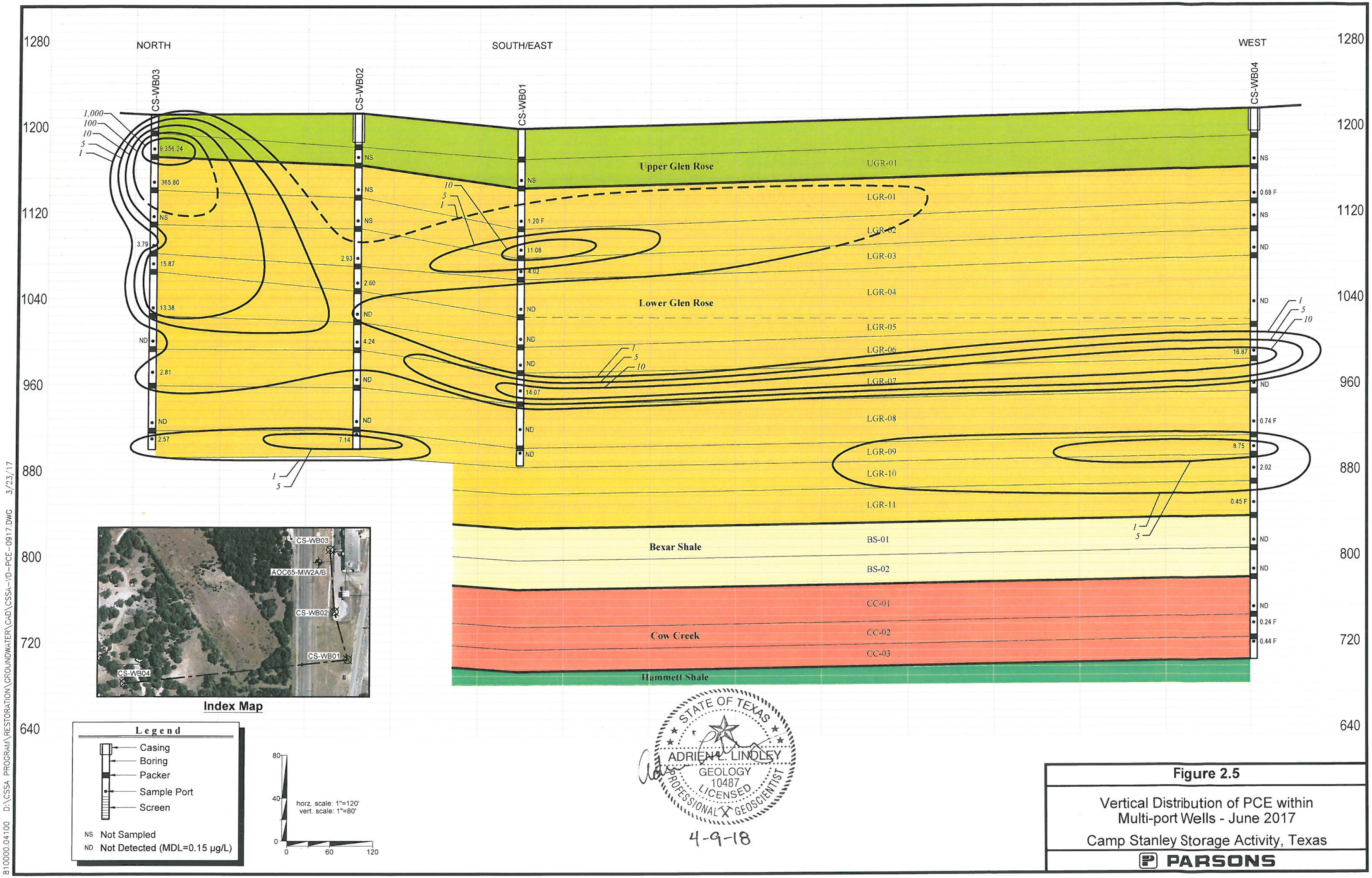


Figure 2.5

Vertical Distribution of PCE within Multi-port Wells - June 2017

Camp Stanley Storage Activity, Texas

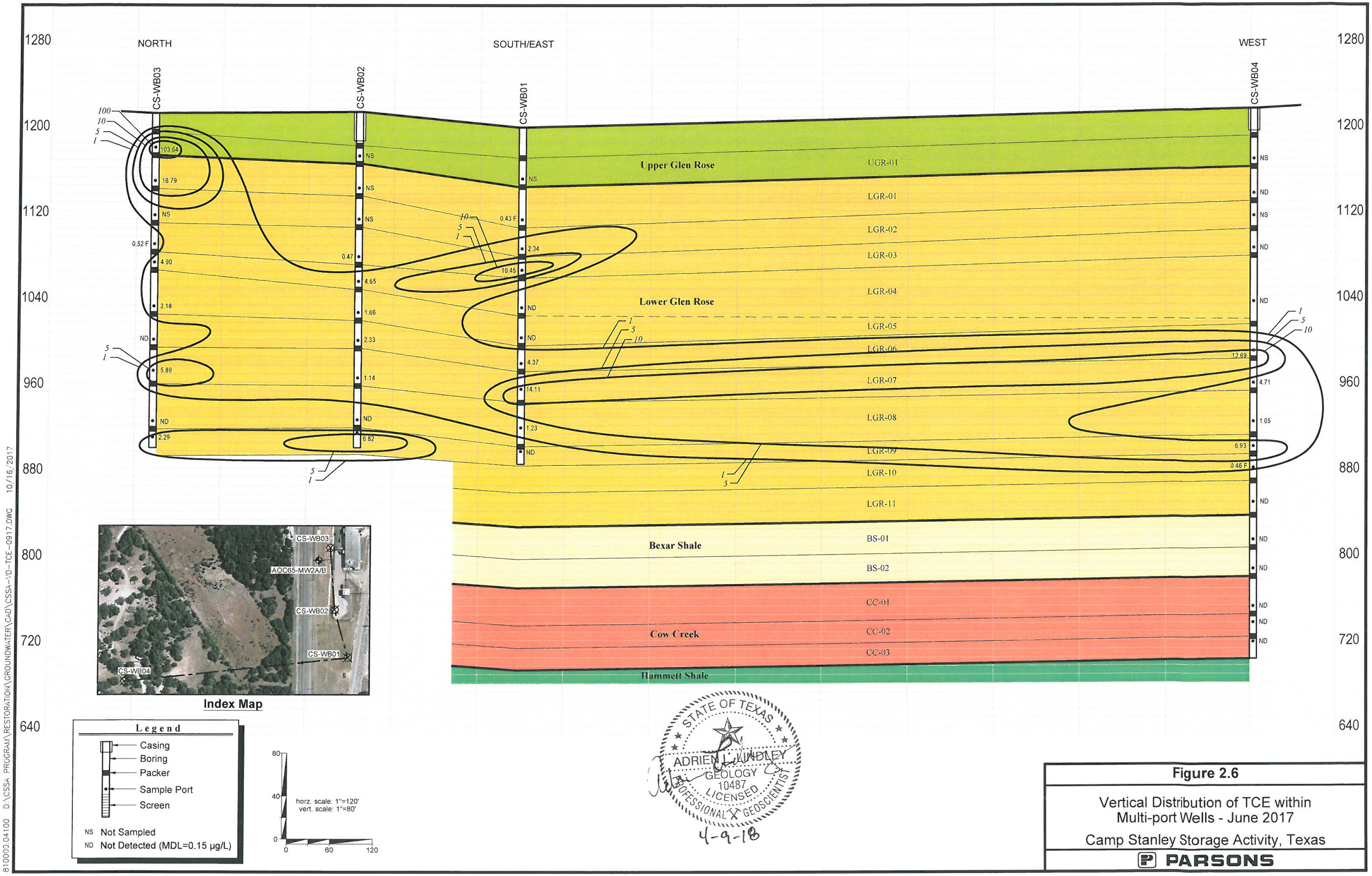


Figure 2.6

Vertical Distribution of TCE within Multi-port Wells - June 2017

Camp Stanley Storage Activity, Texas

PARSONS

CS-WB03 is located closest to the Building 90 source area, and consistently records the highest concentrations of contaminants (**Appendix D.3**). The upper zone (CS-WB03-LGR-02) is typically dry and has water only after significant rain. Because of frequent droughts and set sampling schedules, this zone has been sampled only a handful of times. In June 2017, the zone CS-WB03-LGR-02 was dry. Contamination is still present in the UGR zone with a slight decrease in concentration from September (9,817 µg/L) 2016 to June (9,356 µg/L) 2017. This level is well below the historical high concentration of 30,000 µg/L reported in March 2008. In June 2017, LGR-01 reported concentrations of PCE (365.8 µg/L) and TCE (16.79 µg/L) well above the MCLs. In December 2011, *cis*-1,2-DCE was detected in zone CS-WB03-LGR-06. Since then there have been nine consecutive detections increasing in concentration and levels have ranged from 0.25 to 8.87 µg/L. Zone -08 had no detection of PCE for the fifth consecutive time in the history of sampling this zone. Between February 2005 and September 2010, no *cis*-1,2-DCE had been reported in CS-WB03-LGR-09. Beginning in March 2011, a trace detection was reported in that zone, followed by thirteen consecutive sampling events that ranged in concentration between 0.20 µg/L and 45.73 µg/L. In 2016 and 2017 no detections of *cis*-1,2-DCE were reported in this zone. At the same time, PCE and TCE detections have fallen and stayed below the MCL. Since March 2012 PCE has dropped below the MCL and has showed a steady decline through 2013. In June 2017 PCE was 2.57 µg/L. The reason for these changes is likely a result of a biodegradation mechanism.

Historical results indicate that a persistent source of contamination still exists, and that periodic flushing by intense rainfall can mobilize these perched contaminants that are probably otherwise bound to the matrix during the rest of the year. Likewise, preliminary indications from the ISCO treatability study show that solvent contamination was mobilized/oxidized as a result of the study. Baseline samples in the WB03-UGR zone were less than 6 µg/L in July 2012. Thirty days after the initial injection, PCE concentrations were above 6,000 µg/L, and persisted through September 2016. In 2017 the PCE concentrations in this zone dropped slightly to 9,356 µg/L, down from 9,817 in September 2016.

CS-WB02 was installed nearly 300 feet south of CS-WB03 and the Building 90 source area. In general, most zones in 2017 showed PCE and TCE concentrations have remained constant since 2016 (**Appendix D.2**). Zones -LGR-01 and -LGR-02 remained dry in June 2017; these zones were dry in 2015. Zone -LGR-05 reported its first detection of *cis*-1,2-DCE in September 2015; it was still present in June 2017. Zone -LGR-04 has had consistent TCE detections above the MCL since March 2006, these levels have been slowly decreasing since and fell below the MCL in June 2017. Zone -LGR-09 was the only zone in this well with PCE and TCE above the MCL in June 2017. The changes over the last couple of years do not follow the historic pattern seen after the ISCO injections in August 2012 and May-June 2013 which showed a significant increase in PCE approximately 3-4 months after the ISCO injections. The result is interesting because it initially implicated that there is a vertical conduit between the shallower ISCO injection zones (trench gallery and injection wells) and the deeper strata of CS-WB02-LGR-09. In 2015 and 2016 this theory could be complicated by above average rainfall following a severe drought in the area.

Multi-port well CS-WB01 is located approximately 500 feet south of CS-WB03 and the Building 90 source area. Once again, for the zones that are normally saturated, historical PCE and TCE are present at concentrations less than 32 µg/L. Since mid-2005, there has been a general trend of increasing contaminant concentrations in zones CS-WB01-LGR-02 and -LGR-07. Initially, the –LGR-09 zone was following the same increasing trend beginning in 2005. In late 2009 the overall concentrations began decreasing until 2015 where they began an upward trend. In 2016, PCE and TCE concentrations began dropping again into 2017 which reported no detection of PCE or TCE in -LGR-09. This was the first sampling event with PCE and TCE below the MCL since sampling began at this well in 2003. These noted increases seem to correspond with increases observed in several upgradient CS-WB02 zones, and may be associated with a "flushing" event in which a slug of contaminated groundwater is moving downgradient away from the source zone (**Appendix D.1**). At CS-WB01, the trend has been that TCE concentrations generally exceed PCE for most zones. The zone with the relatively highest concentration is typically –LGR-09. Zones -05, -06, and -08 reported their highest detection of *cis*-1,2-DCE to date, with zone –LGR-08 showing the most significant increase. The results of CS-WB01 indicate that the contamination becomes preferentially stratified such that greater contamination is found above and below zones LGR-04, -05, and -06, to the south and west. No discernible effect from the ISCO treatability study has been ascertained at CS-WB01.

Off-post at CS-WB04, trace detections of less than 1 µg/L PCE are generally reported in the LGR-02, LGR-03, LGR-04, and LGR-08 zones. WB04-LGR-05 has never been sampled due to an erroneous sample port installation. Since September 2006, TCE has been reported above the MCL in zones LGR-06 and LGR-07 at concentrations less than 21 µg/L and PCE has been above the MCL since 2008. In 2009, the concentration of PCE in both LGR-06 and LGR-07 more than doubled compared to September 2008. PCE in zone LGR-07 did fall back below the MCL in September 2015 and has remained below the MCL in 2017 (**Appendix D.4**). In 2010, PCE in LGR-06 decreased from 33 µg/L to 11 µg/L while the LGR-07 PCE concentration decreased from 19 µg/L to 1.7 µg/L. But in 2011, the PCE concentration in LGR-06 increased to 28.76 µg/L, and zone LGR-07 also increased its PCE concentration to 24.41 µg/L. In June 2013, the increasing trend continued with PCE reaching a historical high of 39.18 µg/L in LGR-06. The levels in LGR-07 dropped slightly in 2013 and the levels remained similar in June and September 2013. In 2014, the increasing PCE trend reappeared in LGR-06 reaching another historic high in December 2014 (44.92 µg/L). Zone LGR-07 mimicked the LGR-06 zone but reaching its PCE historic high in June 2014 (32.86 µg/L). In March 2015, both of these zones reached another historic high concentration (55.08 µg/L in the -06 zone and 35.6 µg/L in the -07 zone) for PCE. In 2016, cis-1,2-DCE reached a historic high in zone -LGR-07 (40.9 µg/L). These trends in LGR-06 and -07 are evident on the graphs presented in **Appendix D.4**. These two zones have been the most dynamic of all the multiport zones monitored in this program, and are an indication that contaminant mass is migrating westward in these intervals.

Historically, the off-post zone with the most persistent contamination is CS-WB04-LGR-09. Nearly equivalent levels of PCE and TCE are found at concentrations that generally range above the MCL between 8 µg/L and 16 µg/L. In June 2017, LGR-09 fell back to the low end of this range. Zones LGR-10 (PCE = 7.47 µg/L) and LGR-11 (PCE = 444.82 µg/L) reported their first detection above the MCL in March 2015. In 2016 these concentrations had dropped back below the MCL and remained there in 2017. Prior to September 2006, essentially no chlorinated solvents were detected in the CS-WB04-LGR-11 zone. Below this depth, any solvent contamination in the remainder of the BS and CC are at concentrations less than 2.0 µg/L. The only exception to this is zone CC-03 which reported PCE at 6.66 µg/L in September 2015.

The BS and CC zones at CS-WB04 are sampled every 30 months and were sampled in June 2017. In prior years the BS and CC zones at CS-WB04 generally had little to no contamination present. In 2011, only trace detections of *cis*-1,2-DCE were reported in CS-WB04-BS-02 and –CC-01 intervals. But in 2012, the trace detections also included PCE in all five BS (2) and CC (3) zones. In March 2014 one zone showed a trace detection of *cis*-1,2-DCE (0.69F µg/L) in the –CC-01 interval. In September 2015, PCE was again detected in all five –BS and –CC zones. Zone CC-03 reported its highest detection of PCE to date (6.66 µg/L), with levels now above the MCL. *Cis*-1,2-DCE was also detected in all 3 –CC zones in September 2015. The BS and CC zones were not scheduled for sampling in 2016 but were sampled again in June 2017. PCE in the CC zones was back below the MCL and both BS zones reported no detections. The contention is that the trace contamination in the BS and CC at CS-WB04 is the result of the vertical mixing of contaminated LGR water within the nearby RFR-10 wellbore under a naturally downward vertical gradient. The last time VOCs have been seen distributed across most of the BS and CC zones was March 2009 and September 2012 when the aquifer was in a depressed condition.

2.2.2 Off-Post Analytical Results

The frequencies for sampling off-post wells in 2017 were determined by the updated *Three-Tiered Long Term Monitoring Network Optimization Evaluation* (Parsons 2015), in compliance with *The Plan*, and *DQOs for the Groundwater Monitoring Program* (Parsons 2015). These plans were updated in 2015 and new sampling frequencies were implemented in September 2016 after receiving TCEQ and EPA approval. An overview of sampling frequencies for off-post wells is given in **Table 2.8**. Fifty off-post samples were collected from 16 wells during the 2017 quarterly monitoring events, and their locations are illustrated on **Figure 1.1**. One well (I10-2) was not sampled in June 2017 due to pump outage. In September 2016 the 2015 updated LTMO study was implemented to sampling frequencies off-post. The TCEQ and EPA approval for implementing the LTMO off-post was received in April and May 2016 (see **Appendix I)**.

Off-post wells sampled during the quarterly monitoring events were selected based on previous sampling results and proximity to both the CSSA boundary and wells with detections of PCE and TCE. Public and private supply wells located west and south of CSSA were selected for these events. Samples were also collected from the off-post well GAC filtration systems after treatment during the March and September events.

Off-post wells sampled in 2017 included (see **Figure 1.1** for well locations):

- One public well on Boerne Stage Road (BSR-04);
- One public supply well for the Fair Oaks water system (FO-J1);
- One public well in the Hidden Springs Estates subdivision (HS-1);
- Two wells used by the general public along Interstate Highway 10 (I10-8 and I10-10);
- Three privately-owned wells in the Jackson Woods subdivision (JW-7, JW-8, and JW-20);

- Three privately-owned wells in the Leon Springs Villa area (LS-5, LS-6, and LS-7);
- One privately-owned well on Old Fredericksburg Road (OFR-3);
- Four privately-owned wells in the Ralph Fair Road area (RFR-10, RFR-11, RFR-12, and RFR-14).

All wells were sampled from a tap located as close to the wellhead as possible. Most taps were installed by CSSA to obtain a representative groundwater sample before pressurization, storage, or the water supply distribution system. Water was purged to engage the well pump prior to sample collection. Conductivity, pH, and temperature readings were recorded to confirm adequate purging while the well was pumping. Purging measurements were recorded in the field logbook for each sampling event.

All groundwater samples were submitted to APPL for analysis. Groundwater samples were analyzed for the short list of VOCs (*cis*-1,2-DCE, PCE, TCE, and vinyl chloride) using SW-846 Method 8260B. Off-post wells are not analyzed for metals as part of the groundwater monitoring program.

The data packages containing the analytical results for the 2017 sampling events were reviewed and verified according to the guidelines outlined in the CSSA QAPP. After the data packages were received by Parsons, quarterly DVRs were submitted to CSSA as an attachment in the Quarterly Groundwater Reports. The December 2017 DVRs are included in **Appendix H.**

Based on historical detections, the lateral extent of VOC contamination above the MDL extends approximately 2.7 miles beyond the west boundary of CSSA (well SLD-01) and 0.4 miles to the south of CSSA (well LS-4). Information such as well depth, pump depth, and other pertinent data necessary to characterize the vertical extent of migration is not readily available for most off-post wells. However, the typical well construction for the area is open borehole completions that penetrate the full thickness of the Middle Trinity aquifer (LGR, BS, and CC).

Concentrations of VOCs detected in 2017 are presented in **Table 2.9**. Full analytical results from the 2017 sampling events are presented in **Appendix F**. Concentration trends are illustrated on **Figures 2.7 and 2.8** for wells LS-5, LS-6, LS-7, OFR-3, RFR-10, and RFR-11 for PCE and TCE. These wells were selected because they have had detections of PCE and TCE that approach and/or exceed MCLs. **Figure 2.7** includes precipitation data from the weather stations located at CSSA, AOC-65 WS and B-3 WS. This figure suggests VOC concentrations in OFR-3 and RFR-10 are very sensitive to significant rain events and that VOC concentrations in LS-5, LS-6, and LS-7 are less sensitive to rainfall.

Data from RFR-11 presents a mixed picture. From October 2001 through December 2007, RFR-11 VOC concentration peaks showed a good correlation to significant rainfall events, but after 2007, this correlation is less pronounced. It may be coincidental, but the changes in rainfall/VOC concentration correlations in RFR-11 happened when the San Antonio Water System (SAWS) abandoned pumping of the Bexar Met public supply wells in Leon Springs Villas (LS-1, LS-2, LS-3, LS-4). **Figure 2.8** shows PCE and TCE concentrations with monthly water usage at each off-post well. The off-post GAC systems are equipped with flowmeters that track the gallons of water treated by the units. Data in this figure suggests little correlation between VOC concentrations and well pumping volumes.

Table 2.8
2017 Off-Post Groundwater Sampling Rationale

Well ID	2017 Mar	June	Sept	Dec	LTMO Sampling Frequency (as of Sept. 2016)
BSR-03	NS	NS	NS	NS	exclude
BSR-04	NS			NS	exclude after Sept. 2017
FO-8	NS	NS	NS	NS	exclude
FO-17	NS	NS	NS	NS	exclude
FO-22	NS	NS	NS	NS	exclude
FO-J1	NS		NS	NS	30 month
HS-1	NS			NS	exclude after Sept. 2017
HS-2	NS	NS	NS	NS	exclude
HS-3	NS	NS	NS	NS	exclude
I10-2	NS	NA	NS	NS	exclude after June 2018
I10-4	NA	NA	NA	NA	P&A
I10-5	NS	NS	NS	NS	exclude
I10-7	NS	NS	NS	NS	exclude
I10-8	NS		NS	NS	30 month
I10-10	NS		NS	NS	added to replace LS-1
JW-5	NS	NS	NS	NS	exclude after March 2016
JW-6	NS	NS	NS	NS	exclude
JW-7	NS		NS	NS	30 month
JW-8	NS		NS	NS	30 month
JW-9	NS	NS	NS	NS	exclude
JW-12	NS	NS	NS	NS	exclude
JW-13	NS	NS	NS	NS	exclude
JW-14	NS	NS	NS	NS	exclude
JW-15	NS	NS	NS	NS	exclude
JW-20	NS		NS	NS	exclude after Sept. 2018
JW-26	NS	NS	NS	NS	exclude
JW-27	NS	NS	NS	NS	exclude
JW-28	NS	NS	NS	NS	exclude
JW-29	NS	NS	NS	NS	exclude
JW-30	NS	NS	NS	NS	exclude
JW-31	NS	NS	NS	NS	exclude
LS-1	NS	NA	NA	NA	scheduled to be P&A
LS-4	NS	NA	NA	NA	scheduled to be P&A
LS-5					Quarterly
LS-5-A2		NS		NS	Biannually (Mar & Sept)
LS-6					Quarterly
LS-6-A2		NS		NS	Biannually (Mar & Sept)
LS-7					Quarterly
LS-7-A2		NS		NS	Biannually (Mar & Sept)
OFR-1	NA	NA	NA	NA	P&A
OFR-3					Quarterly
OFR-3-A2		NS		NS	Biannually (Mar & Sept)
OFR-4	NA	NA	NA	NA	P&A
OW-HH1	NS	NS	NS	NS	exclude
OW-HH2	NS	NS	NS	NS	exclude after March 2016
OW-CE1	NS	NS	NS	NS	exclude
OW-CE2	NS	NS	NS	NS	exclude
OW-MT2	NS	NS	NS	NS	exclude
OW-BARNOWL	NS	NS	NS	NS	exclude after March 2016
OW-DAIRYWELL	NS	NS	NS	NS	exclude
OW-HH3	NS	NS	NS	NS	exclude
RFR-3	NS	NS	NS	NS	exclude
RFR-4	NS	NS	NS	NS	exclude
RFR-5	NS	NS	NS	NS	exclude
RFR-8	NS	NS	NS	NS	exclude
RFR-9	NS	NS	NS	NS	exclude
RFR-10					Quarterly
RFR-10-A2		NS		NS	Biannually (Mar & Sept)
RFR-10-B2		NS		NS	Biannually (Mar & Sept)
RFR-11					Quarterly
RFR-11-A2		NS		NS	Biannually (Mar & Sept)
RFR-12	NS		NS	NS	15 months
RFR-13	NA	NA	NA	NA	exclude
RFR-14	NS		NS	NS	30 month
SLD-01	NS	NS	NS	NS	exclude
SLD-02	NS	NS	NS	NS	exclude

(red)	VOCs detected are greater than 90% of the MCL. Sample monthly; quarterly after GAC installation.
(orange)	VOCs detected are greater than 80% of the MCL. The well will be placed on a monthly sampling schedule until GAC installation then quarterly sampling after GAC installation.
(yellow)	VOCs detected are less than 80% of the MCL (<4.0 ppb and >0.06 ppb for PCE & <4.0 ppb >0.05 ppb for TCE). After four quarters of stable results the well can be removed from quarterly sampling.
(green)	No VOCs detected. Sample on an as needed basis.
(lavender)	This well has a GAC filtration unit installed by CSSA. A1 - after GAC canister #1 A2 - after GAC canister #2
NS	Not sampled for that event.
NA	Not applicable, sample could not be collected.

Table 2.9
2017 Off-Post Groundwater COCs Analytical Results

Well ID	Analytical Method	Sample Date	*cis*-1,2-Dichloro-ethene (ug/L)	Tetra-chloroethene (ug/L)	Trichloro-ethene (ug/L)	Vinyl chloride (ug/L)
BSR-04	SW8260B	6/7/2017	--	--	--	--
	SW8260B	9/20/2017	--	--	--	--
FO-J1	SW8260B	6/27/2017	--	--	--	--
HS-1	SW8260B	6/7/2017	--	--	--	--
	SW8260B	9/20/2017	--	--	--	--
I10-8	SW8260B	6/7/2017	--	--	--	--
I10-10	SW8260B	6/7/2017	--	--	--	--
Duplicate	SW8260B	6/7/2017	--	--	--	--
JW-7	SW8260B	6/7/2017	--	--	--	--
JW-8	SW8260B	7/12/2017	--	--	--	--
JW-20	SW8260B	6/8/2017	--	--	--	--
LS-5	SW8260B	3/28/2017	--	**1.18F**	**2.24**	--
	SW8260B	6/5/2017	--	**1.07F**	**2.40**	--
	SW8260B	9/21/2017	--	**0.99F**	**2.85**	--
	SW8260B	12/4/2017	--	--	**2.84**	--
LS-5-A2	SW8260B	3/28/2017	--	--	--	--
	SW8260B	9/21/2017	--	--	--	--
LS-6	SW8260B	3/28/2017	--	**0.84F**	--	--
	SW8260B	6/5/2017	--	**0.80F**	**0.52F**	--
	SW8260B	9/21/2017	--	--	**1.65**	--
	SW8260B	12/4/2017	--	--	**1.39**	--
LS-6-A2	SW8260B	3/28/2017	--	--	--	--
	SW8260B	9/21/2017	--	--	--	--
LS-7	SW8260B	3/28/2017	--	**1.11F**	**0.25F**	--
	SW8260B	6/5/2017	--	**1.14F**	--	--
	SW8260B	9/21/2017	--	**1.60**	**0.50F**	--
Duplicate	SW8260B	9/21/2017	--	**1.79**	--	--
	SW8260B	12/4/2017	--	**1.06F**	**0.20F**	--
LS-7-A2	SW8260B	3/28/2017	--	--	--	--
	SW8260B	9/21/2017	--	--	--	--
OFR-3	SW8260B	3/28/2017	--	**6.98**	**3.58**	--
	SW8260B	6/5/2017	--	**6.29**	**3.62**	--
	SW8260B	9/27/2017	--	**3.69**	**2.06**	--
	SW8260B	12/4/2017	--	--	**0.75F**	--
OFR-3-A2	SW8260B	3/28/2017	--	--	--	--
	SW8260B	9/27/2017	--	--	--	--
RFR-10	SW8260B	3/28/2017	**0.37F**	**9.49**	**4.55**	--
Duplicate	SW8260B	3/28/2017	**0.37F**	**8.46**	**4.14**	--
	SW8260B	6/5/2017	--	**9.67**	**5.30**	--
	SW8260B	9/21/2017	**0.35F**	**17.63**	**11.03**	--
	SW8260B	12/4/2017	--	**7.47**	**5.03**	--
RFR-10-A2	SW8260B	3/28/2017	--	--	--	--
	SW8260B	9/21/2017	--	--	--	--
RFR-10-B2	SW8260B	3/28/2017	--	--	--	--
	SW8260B	9/21/2017	--	--	--	--
RFR-11	SW8260B	3/28/2017	--	**1.10F**	**1.82**	--
	SW8260B	6/5/2017	--	**0.87F**	**1.63**	--
	SW8260B	9/21/2017	--	**0.68F**	**2.12**	--
	SW8260B	12/4/2017	--	--	**1.87**	--
RFR-10-A2	SW8260B	3/28/2017	--	--	--	--

Table 2.9
2017 Off-Post Groundwater COCs Analytical Results

Well ID	Analytical Method	Sample Date	*cis*-1,2-Dichloro-ethene (ug/L)	Tetra-chloroethene (ug/L)	Trichloro-ethene (ug/L)	Vinyl chloride (ug/L)
	SW8260B	9/21/2017	--	--	--	--
RFR-12	SW8260B	6/7/2017	--	--	**0.69F**	--
RFR-14	SW8260B	6/7/2017	--	--	--	--
Comparison Criteria						
		Method Detection Limit (MDL)	**0.07**	**0.06**	**0.05**	**0.08**
		Reporing Limit (RL)	**1.2**	**1.4**	**1**	**1.1**
		Maximum Contaminant Level (MCL)	**70**	**5**	**5**	**2**

BOLD	≥ MDL
BOLD	≥ RL
BOLD	≥ MCL

All samples were analyzed by APPL, Inc.
VOC data reported in ug/L.
Abbreviations/Notes:

Duplicate	Field Duplicate
TCE	Trichloroethene
PCE	Tetrachloroethene
DCE	Dichloroethene

Data Qualifiers
U-The analyte was analyzed for, but not detected. The associated numerical value is at or below the MDL.
F-The analyte was positively identified but the associated numerical value is below the RL.

Figure 2.7
PCE and TCE Concentration Trends and Precipitation

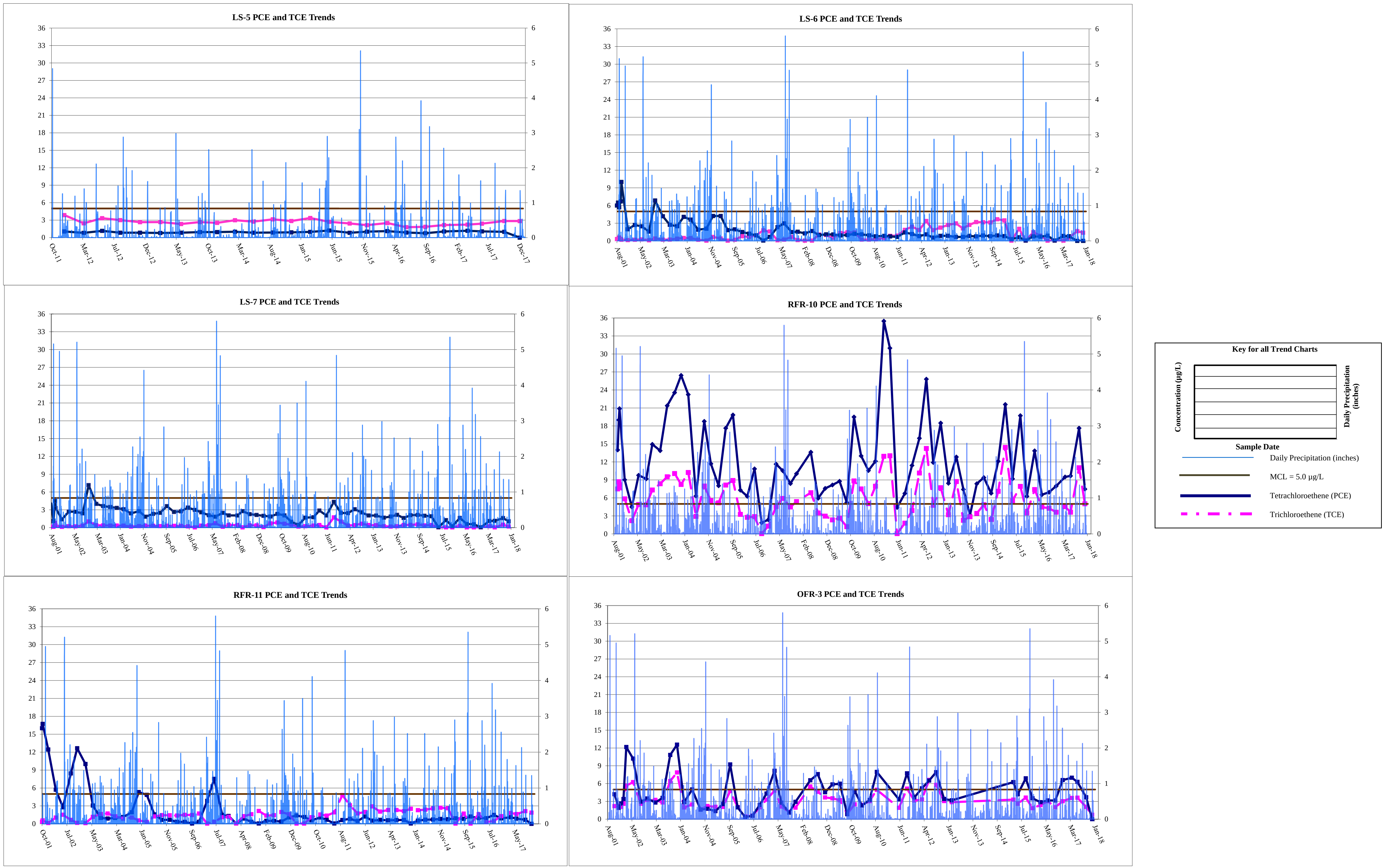
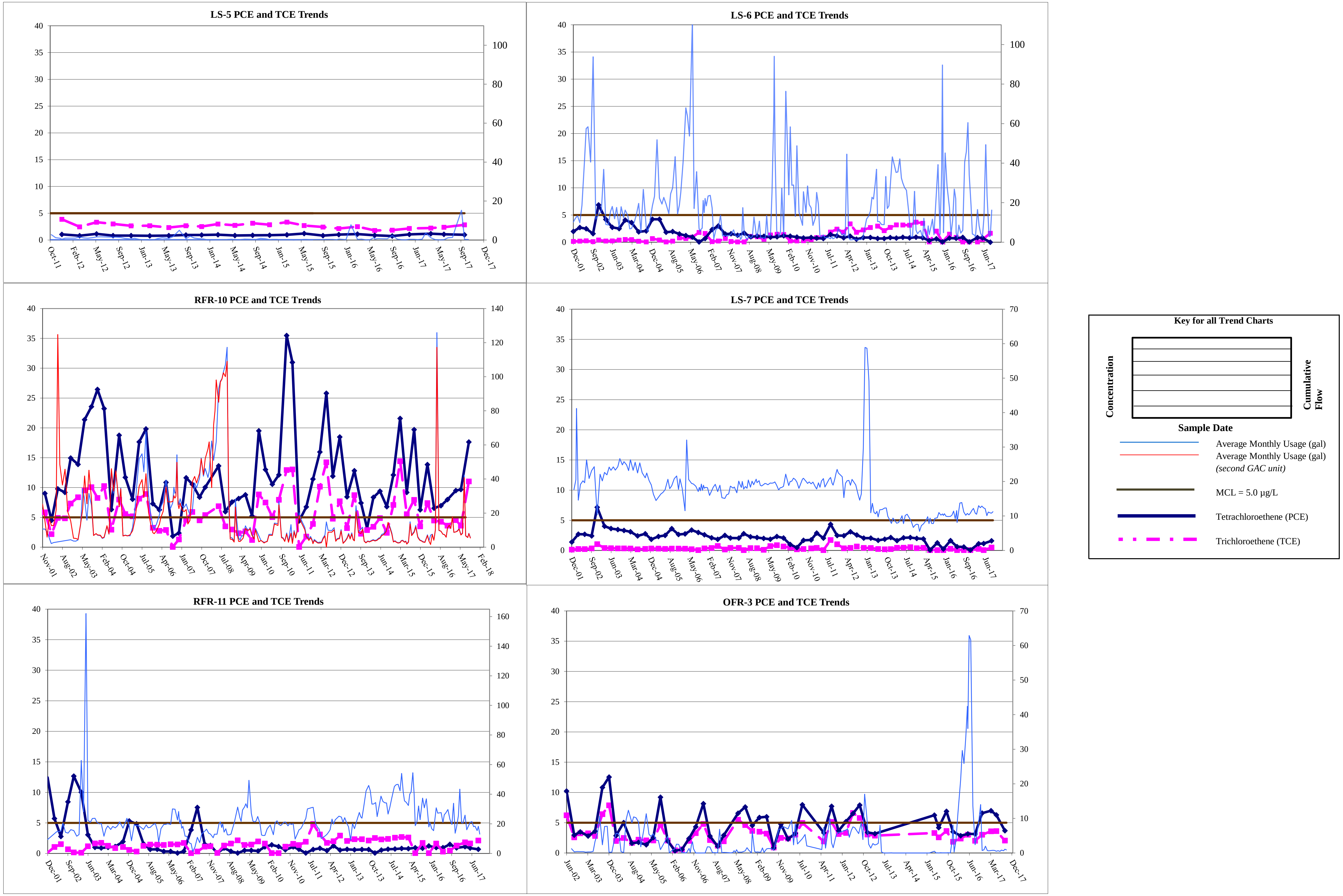


Figure 2.8
PCE and TCE Concentration Trends and Monthly Water Usage



2.2.2.1 Off-Post Wells with COC Detections above the MCL

During 2017, off-post wells RFR-10 and OFR-3 had raw water (pre-GAC) concentrations exceeding the MCL. Well RFR-10 concentrations exceeded the MCL for PCE during all 2017 sampling events and TCE also exceeded the MCL during the June, September, and December. Well OFR-3 exceeded the MCL for PCE during the March and June events. An evaluation of concentration trends through 2017 are included in **Figures 2.7 and 2.8**.

2.2.2.2 GAC Filtration Systems

All off-post drinking water wells that historically exceeded or approached MCLs have already been equipped with GAC filtration systems. These wells, and the date the filtration system was installed, are listed in **Table 2.10**. CSSA maintains and operates these GAC filtration systems at no cost or inconvenience to the well owners.

Table 2.10 GAC Filtration Systems Installed

Well	Date Installed
LS-6	August 2001
LS-7	August 2001
OFR-3	April 2002
RFR-10	October 2001
RFR-11	October 2001
LS-5	October 2011

Semi-annual post-GAC confirmation samples are collected from all wells equipped with GAC filtration systems (**Appendix G**). The samples confirm that the GAC filtration systems are working effectively and that VOCs are reduced to concentrations below the applicable drinking water MCLs.

Regular GAC maintenance/inspection occurs every 3 weeks. This task includes changing pre-filters and troubleshooting problems occurring with the systems. On March 28, 2017 and September 20, 2017, the carbon in the GAC filtration systems (LS-5, LS-6, LS-7, RFR-10, OFR-3, and RFR-11) was changed out.

2.2.2.3 Off-Post Wells with COC Detections below the MCL

Detections from all wells sampled off-post are presented in **Table 2.9** and complete 2017 results are included in **Appendix G**. The groundwater monitoring results include wells where COCs were detected at levels below applicable MCLs. These detections occurred in wells LS-5, LS-6, LS-7, and RFR-11. The detections below the MCL and above the RL are summarized as follows:

- **LS-5 –** Concentration of TCE exceeded the RL in March, June, September, and December 2017. PCE was also detected below the RL during the March, June, and September sampling events. This well is equipped with a GAC filtration system.

- **LS-6 –** Concentrations of TCE were non detect in March, below the RL in June, then exceeded the RL in September and December 2017. PCE was detected in March and June as well but below the RL. This well is equipped with a GAC filtration system.
- **LS-7 –** Concentrations of PCE exceeded the RL in September 2017 but was below the RL during the March, June, and December sampling events. Concentrations of TCE were also present in March, September, and December but below the RL. This well is equipped with a GAC filtration system.
- **RFR-11** - Concentration of TCE exceeded the RL in all 4 sampling events in 2017. PCE was also detected below the RL in March, June, and September but below the RL. This well is equipped with a GAC filtration system.

2.2.2.4 Off-Post Wells with COC Detections below the Reporting Limits

The off-post results include detections in wells for which the analyte is identified, but at a concentration below the RL. These results are assigned an "F" flag under the CSSA QAPP. In 2017, this included well RFR-12. The detections below the reporting limit are summarized as follows:

- **RFR-12 –** Concentrations of TCE detected below the RL in June 2017.

2.2.3 Isoconcentration Mapping

2.2.3.1 PCE, TCE, and cis-1,2-DCE

In annual reports prior to 2010, the maximum concentration detected during any quarterly event in the LGR wells (on-post and off-post) were contoured into isoconcentration contour maps for PCE, TCE, and *cis*-1,2-DCE. The reason for creating these "composite" maps resulted from the LTMO sampling frequency enacted in 2005. No single quarterly event included all of the wells in the sampling program. The LTMO program was updated in 2010 to include a "snapshot" sampling event in which all on- and off-post wells were sampled during the same event. These snapshot events began in September 2010, and occurred every 9 months. The 2015 update to the LTMO provides for a complete snapshot every 30 months with less inclusive events occurring every 15 months. The transition from the old to the new LTMO schedule began in late 2015 and was fully implemented in June of 2017 with the completion of the first 30-month snapshot event. Results from the June 2017 snapshot were utilized in generating plume isoconcentration contour maps. Annual reports now only include isoconcentration maps of contaminants collected during a single sampling event.

Another development in the representation of contamination in groundwater came in March 2012. At the direction of the USEPA (**Appendix J**), isoconcentration maps depicting groundwater contamination will no longer present isoconcentration contour lines below the laboratory RL, which is considered quantifiable data. Trace detections of contamination (F-flagged) data reported by the lab are considered qualitative results and therefore are not suitable for demonstrating the extent of contaminant plumes. Results below the RL are still presented on the maps, but are not contained within an isoconcentration contour line. For the compounds reported, the RL (and lowest isoconcentration line) are as follows: *cis*-1,2-DCE (1.2 µg/L), PCE (1.4 µg/L), and TCE (1.0 µg/L).

To better represent the plume source areas, data from the Westbay wells were composited into the isoconcentration maps. Previously, only data from the deepest LGR zone were included in the isoconcentration maps, though, these data do not reflect the range of VOC concentrations observed in all the zones within the LGR in each well. In Westbay wells CS-WB01 through CS-WB03 there are nine discrete sampling zones within the LGR and ten LGR zones in CS-WB04. Utilizing the highest concentration observed from any of the LGR zones in a single Westbay well is a more conservative approach to defining plume geometries. As an example, WB03 is located near the suspected source area at AOC-65. Typically, the PCE concentrations observed in the lowest zone (LGR-09) is less than 5 ppb (below the MCL), while zones LGR-05, -04, -02, and -01 all indicate the presence of PCE at or above the MCL. All zones of Westbay wells 01 through 04 have been incorporated in the groundwater monitoring program and are sampled according to the recommendations from the latest LTMO and all LGR zones scheduled were sampled in June and July of 2017 except for dry zones: LGR-01 zone in Westbay well -01 and LGR-02 zone in Westbay wells -02, -03, and -04. Data from all LGR zones from Westbay wells CS-WB01 through CS-WB04 sampled in June and July 2017 was reviewed, and the highest concentrations recorded for each well are included in the maps to help delineate Plume 2. The inclusion of data from zones other than LGR-09 does not appreciably affect the overall plume footprint, however, it does help define the core of the plume. The LGR-04 zone of Westbay wells CS-WB05 through CS-WB08 were sampled in June 2017 as part of the SWMU B-3 Bioreactor operations and assist in delineating the central portion of Plume 1. These isoconcentration maps are provided for June 2017 in **Figures 2.11, 2.12, and 2.13** to illustrate the extent of contamination as measured and inferred from analytical results.

The extent of COCs above the RL (approximately 1 µg/L) for each of PCE, TCE and *cis*-1,2-DCE can be determined by reviewing the set of figures generated for June 2017. 2017 PCE concentrations above 1.4 µg/L are detected on-post in wells CS-D, CS-MW1-LGR, CS-MW5-LGR, CS-MW8-LGR, CS-MW10-LGR, CS-MW36-LGR, B3-EXW01 and B3-EXW02. Additionally, in CS-WB01, zones -LGR-02, -LGR-03, and -07-LGR; in CS-WB02, zones -LGR-03, -LGR-04, -LGR-06, and -LGR-09; in CS-WB03, zones -LGR-01, -LGR-03, -LGR-04, -LGR-05, -LGR-07, and -LGR-09; in CS-WB04, zones -LGR-06, -LGR-09, and -LGR-10 PCE and the LGR-04 zones from CS-WB05 through CS-WB08 are all above the PCE RL of 1.4 µg/L (**Figure 2.11**). Off-post detections of PCE above 1.4 µg/L include OFR-3, RFR-10, and CS-WB04 zones -LGR-06, -LGR-09, and -LGR-10.

TCE follows a similar pattern in June 2017 and has been detected above 1.0 µg/L in Plume 1 wells CS-D, CS-MW1-LGR, CS-MW5-LGR, B3-EXW01, and B3-EXW-02, and the LGR-04 zones from CS-WB05 through CS-WB08 and in Plume 2 wells CS-MW8-LGR, and CS-WB01 zones -LGR-02, -LGR-03, -LGR-06, -LGR-07, and -LGR-08; CS-WB02 zones -LGR-04, -LGR-05, -LGR-06, -LGR-07, and -LGR-09; and CS-WB03 zones -LGR-01, -LGR-04, -LGR-05, -LGR-06, -LGR-07, and -LGR-09 (**Figure 2.12**). Off-post wells with a TCE concentration reported above 1.0 µg/L include wells LS-5, OFR-3, RFR-10, RFR-11 and CS-WB04 zones -LGR-06, -LGR-07, -LGR-08, and -LGR-09.

In June 2017, *cis*-1,2-DCE was reported at levels above 1.2 µg/L in on-post wells CS-D, CS-MW1-LGR, CS-MW5-LGR, CS-EXW01 through CS-EXW04 and the LGR-04 zones of CS-WB05 through CS-WB08, and in CS-WB01 zones -LGR-06, -LGR-07, and -LGR-08;

CS-WB02-LGR-08, and CS-WB03 zones -LGR-06, -LGR-07, and -LGR-08. Off-post wells with a *cis*-1,2-DCE concentration reported above 1.2 µg/L only included Westbay well CS-WB04 zones -LGR-06, and -LGR-07 (**Figure 2.13**).

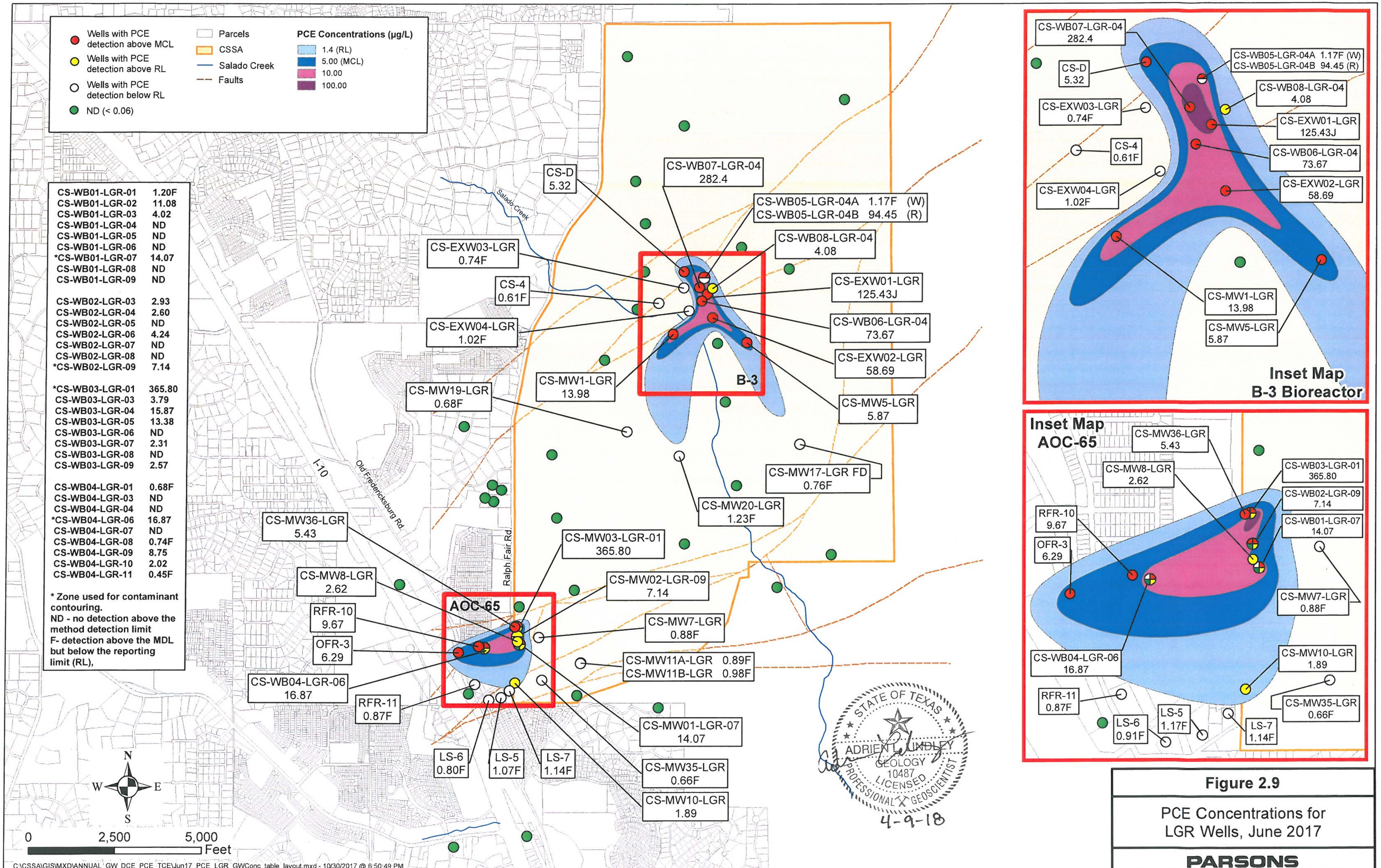


Figure 2.9

PCE Concentrations for LGR Wells, June 2017

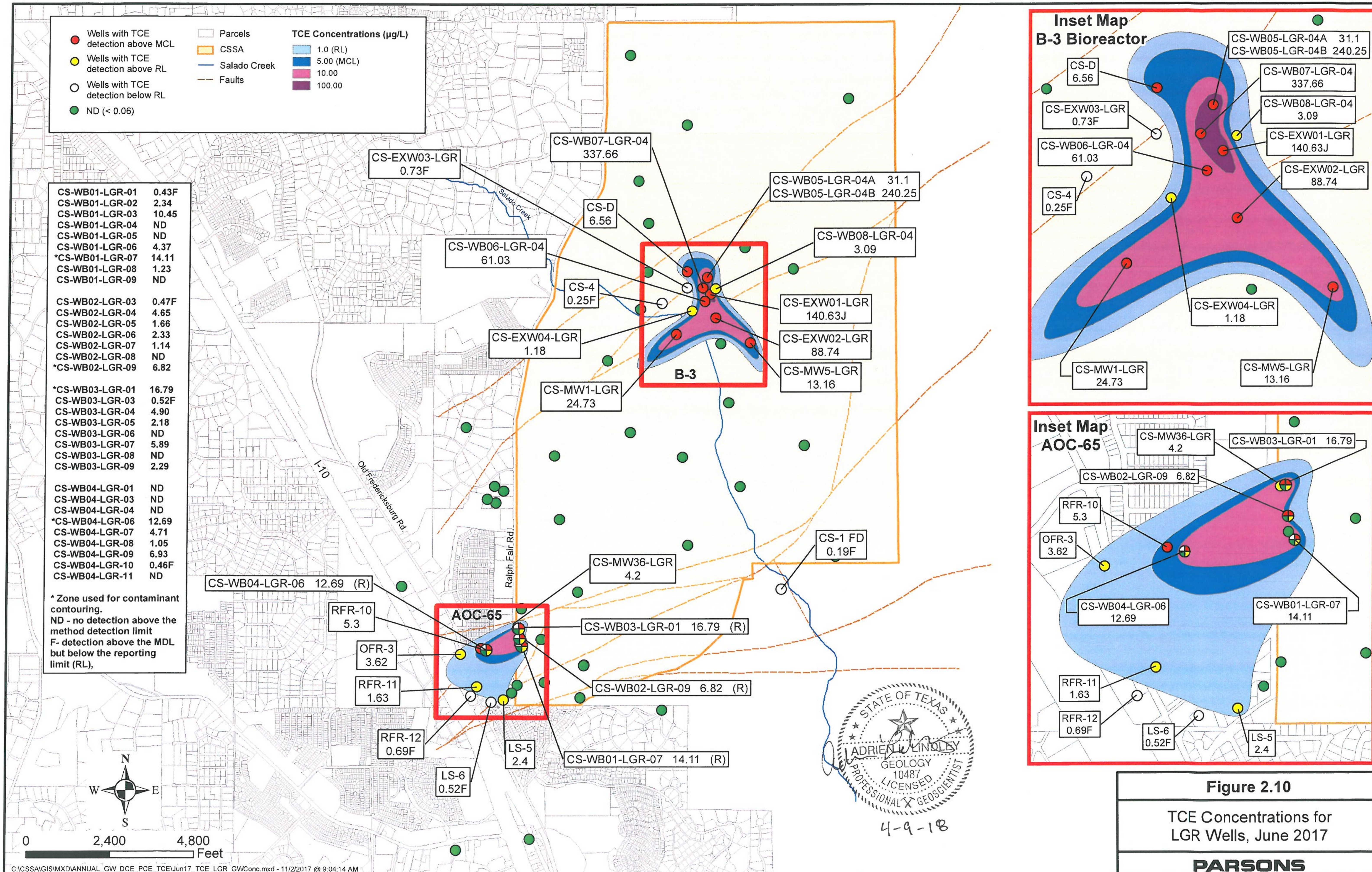


Figure 2.10

TCE Concentrations for LGR Wells, June 2017

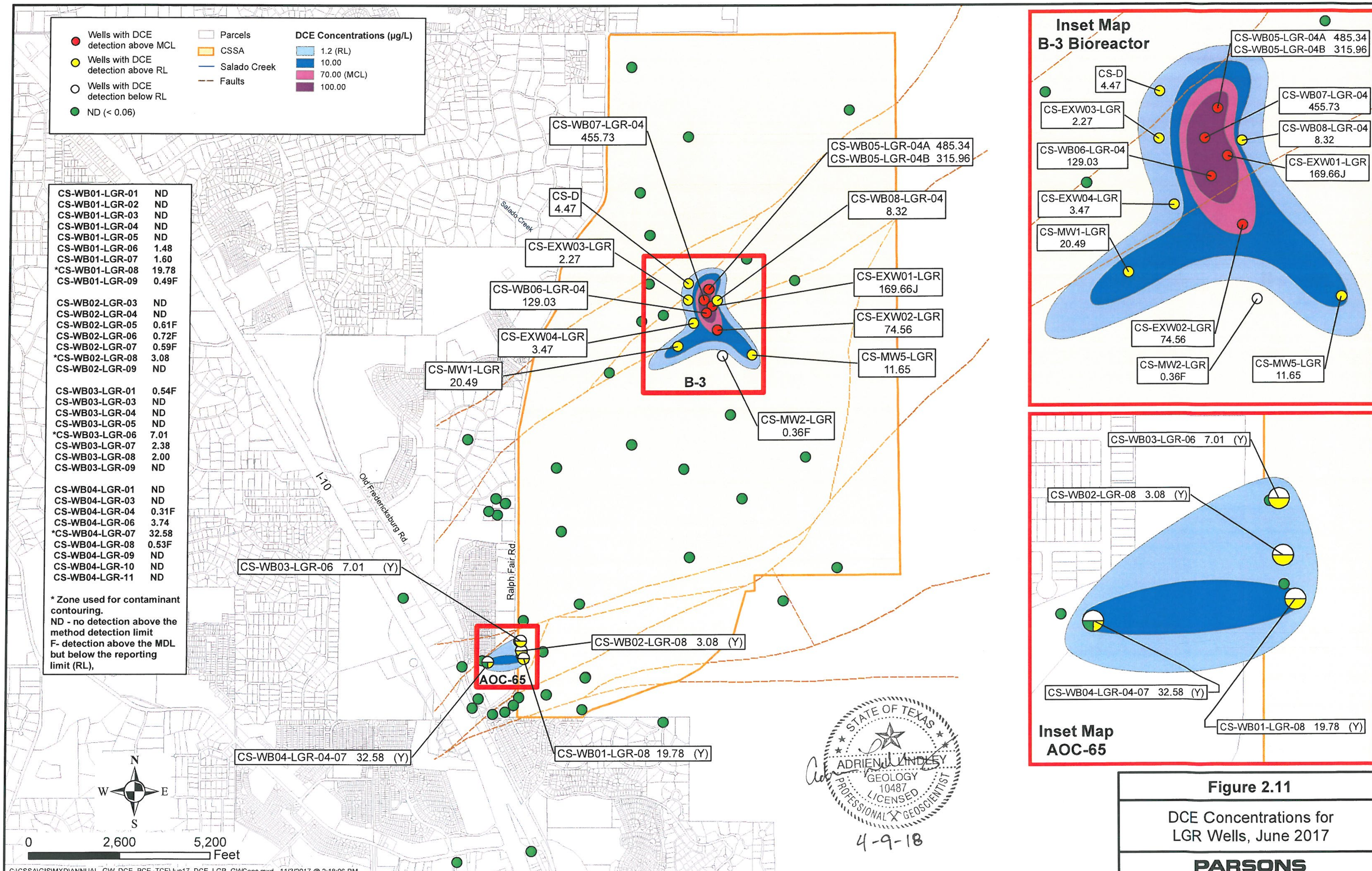


Figure 2.11

DCE Concentrations for LGR Wells, June 2017

Isoconcentration maps have also been prepared based on analytical data collected in 2006 through 2016. Those isoconcentration maps are available for review in the ***CSSA Environmental Encyclopedia, Volume 5 Groundwater***, in the *2006 through 2016 Annual Groundwater Reports*. In general, the 2017 plume extent is consistent with 2016 data and the geometry has changed slightly, accounting for the highest recorded concentrations in LGR zones.

Finally, the maximum annual concentrations detected near the LGR plume centers are generally stable in comparison to 2016. At Plume 1, VOC concentrations have slightly decreased at upgradient well CS-D and remained stable at upgradient and cross-gradient wells CS-EXW-03 and CS-EXW-04, and slightly decreased downgradient at CS-MW1-LGR and slightly increased at CS-MW5-LGR. Within Plume 2, the VOC concentrations have slightly increased in well RFR-10, OFR-3 (downgradient off-post) and decreased in CS-MW36-LGR (source area). Shallower source area monitoring points have noted increases in VOC concentrations at CS-WB03 and decreases in VOC concentrations at CS-WB02, presumably in response to the remedial efforts associated with the ISCO treatability study or other hydrogeologic conditions. The inclusion of shallower Westbay well LGR zone data has increased the extent and concentrations observed in the core of Plume 2. See **Table 2.11** for comparison of the 2016 and 2017 data near the plume centers.

Table 2.11 Comparison of 2016 & 2017 PCE, TCE, and cis-1,2-DCE Max. Levels

	PCE		TCE		*cis*-1,2-DCE	
	2016	*2017*	*2016*	*2017*	*2016*	*2017*
B-3 Plume 1						
CS-D	13.14	5.32	18.9	6.56	12.71	4.47
CS-MW1-LGR	15.1	13.98	24.26	24.73	24.14	20.49
CS-4	0.68	0.61	0.57	0.22	0.09	ND
AOC-65 Plume 2						
RFR-10	13.85	17.63	7.4	11.03	0.18	0.37
CS-MW36-LGR	8.26	5.43	7.86	4.20	0.28	ND
CS-WB02-LGR-09	7.31	7.14	7.42	6.82	ND	ND
CS-WB03-UGR-01	9,817.43	9,356.24	129.76	103.64	16.67	9.56

3.0 GROUNDWATER MONITORING PROGRAM CHANGES

3.1 Access Agreements Obtained in 2016

Access agreements are signed by off-post well owners to grant permission to CSSA to collect groundwater samples from each well. All wells retained after the 2015 update to the LTMO study and DQO's have current access agreements in place.

3.2 Wells Added to or Removed From Program

Based on the 2015 update to the LTMO study and DQO's for the groundwater monitoring program 2 wells were excluded from the program based on their history of non-detects. Wells BSR-04 and HS-1 were excluded after the September 2017 sampling event with a 5-year history of no detections.

Well I10-2 can be excluded from the program in June 2018 and well JW-20 will meet the 5 years of non-detect criteria in September 2018.

4.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the evaluation of the on- and off-post groundwater monitoring program data collected in 2017, the following conclusions and recommendations can be made:

- On-post wells CS-D, CS-MW1-LGR, CS-MW5-LGR, and CS-MW36-LGR all exceeded VOC MCLs in 2017 and should remain on the sampling schedule in the future.
- Well CS-MW5-LGR reported PCE and TCE above the applicable MCLs in June 2017. This well was first sampled in 2001 and reported its first detection above the MCL in December 2015. This well is currently on a 15 month sampling schedule. Due to its proximity to drinking water well CS-13 and the recent increase in contaminant concentrations, it is recommended that CS-MW5-LGR also be sampled as part of the SWMU B-3 study which samples monitoring wells semi-annually.
- The four current drinking water wells had no metals detections above the MCL, SS, or AL in 2017. Also, newly installed well CS-MW37-LGR reported no metals detections above the MCL, SS, or AL for its first sampling event in July 2017.
- Eleven Westbay intervals had detections above the MCL in 2017. These intervals should remain on the 15-month sampling schedule in the future as recommended in the LTMO study.
- The Westbay wells at AOC-65 continue to indicate the strong presence of contamination near the source area (CS-WB03). Significant contamination above the MCLs continues to exist near-surface and in the lower-yielding upper strata of aquifer. The concentrations in the upper WB03-UGR-01 zone increased significantly in September 2012, likely due to the ISCO injection into the AOC-65 trench performed in August 2012. In May-June 2013, a larger scale ISCO injection was performed and the levels in this upper zone remained elevated. In September-October 2014, an even larger ISCO injection was performed and the VOC concentrations showed a steep decline in some intervals of the aquifer by December 2014. From August-September 2015 a smaller injection was performed using permanganate and injecting into newly installed infiltration cells in the road west of Building 90. This in turn significantly increased concentration in the upper WB03-UGR-01 zone. In December 2016 permanganate paraffin wax cylinders were installed in 6 select wells at AOC-65. The cylinders are infused with solid permanganate crystals which allow the permanganate to be released passively. This method allows permanganate treatment of groundwater under various (flood or drought) conditions. Future sampling results will determine the effectiveness of the slow release treatment. In most cases throughout the post, VOC contamination in the main portion of aquifer remains at concentrations below the MCLs.
- Off-post wells OFR-3 and RFR-10 exceeded the MCL for PCE and/or TCE in 2017. Wells OFR-3, RFR-10, LS-5, LS-6, LS-7, and RFR-11, are equipped with a GAC filtration system and should remain on the quarterly sampling schedule in the future. The GAC filtration systems will continue to be maintained by CSSA.
- **Figure 2.7** shows VOC concentrations in RFR-10 and OFR-3 are very sensitive to rainfall events while VOC concentrations in LS-5, LS-6, LS-7; and RFR-11 show less

fluctuations after significant precipitation. This observation suggests RFR-10 and OFR-3 may be located along a fracture pattern that ties into the AOC-65 source area.

5.0 REFERENCES

CSSA 2002. *CSSA Quality Assurance Program Plan.*

CSSA 2002a. *Off-Post Monitoring Program and Response Plan.*

CSSA 2008. *CSSA Environmental Encyclopedia*, www.stanley.army.mil

Parsons 2001. *Offsite Well Survey Report*.

Parsons 2005. *Final Three-Tiered Long Term Monitoring Network Optimization Evaluation.*

Parsons 2006. *Final Data Quality Objectives for the Groundwater Monitoring Program.*

Parsons 2010. *Updated Off-Post Well Survey Report*.

Parsons 2016a. *Final Data Quality Objectives for the Groundwater Monitoring Program. Revised January 2016.*

Parsons 2016b. *2015 Update: Final Three-Tiered Long Term Monitoring Network Optimization Evaluation.*

NOAA, National Weather Service Forecast, Monthly/Annual/Average Precipitation Boerne and San Antonio (KSAT), Texas (1986 - 2015), http://nowdata.rcc-acis.org/ewx/

APPENDIX A

EVALUATION OF DATA QUALITY OBJECTIVES ATTAINMENT

ON-POST AND OFF-POST

Appendix A. On-Post Evaluation of Data Quality Objectives Attainment

Activity	Objectives	Action	Objective Attained?	Recommendations
Field Sampling	Conduct field sampling in accordance with procedures defined in the project work plan, SAP, QAPP, and HSP.	All sampling was conducted in accordance with the procedures described in the project plans.	Yes.	NA
Characterization of Environmental Setting (Hydrogeology)	Prepare water-level contour and/or potentiometric maps for each formation of the Middle Trinity Aquifer (3.5.3).	Potentiometric surface maps were prepared based on water levels measured in each of CSSA's wells screened in three formations in 2017.	To the extent possible with data available. Due to the limited data available and the fact that wells are completed across multiple water-bearing units, potentiometric maps should only be used for regional water flow direction, not local. Ongoing pumping in the CSSA area likely affects the natural groundwater flow direction.	As additional wells are installed screened in distinct formations, future evaluations will eliminate reliance on wells screened across multiple formations.
	Describe the flow system, including the vertical and horizontal components of flow (2.1.9).	Potentiometric maps were created using 2017 water level data, and horizontal flow direction was tentatively identified. Insufficient data are currently available to determine vertical component of flow.	As described above, due to the lack of aquifer-specific water level information, potentiometric surface maps should only be used as an estimate of regional flow direction.	Same as above.
	Define formation(s) in the Middle Trinity Aquifer are impacted by the VOC contaminants (2.1.3).	Quarterly groundwater monitoring provides information on Middle Trinity Aquifer impacts. Monitoring wells equipped with Westbay® - multi-port samplers are sampled by zone, the LGR zones are sampled every 15 months and the BS and CC zones are sampled every 30 months. Selected zones from these wells were sampled in 2017.	Yes.	Continue sampling.

Activity	Objectives	Action	Objective Attained?	Recommendations
	Identify any temporal changes in hydraulic gradients due to seasonal influences (2.1.5).	Downloaded data from continuous-reading transducer in wells: CS-1, CS-10, CS-12, CS-13, CS-MW4-LGR, CS-MW16-LGR, CS-MW16-CC, CS-MW9-LGR, CS-MW12-LGR, CS-MW12-CC, and CS-MW10-CC. Data was also downloaded from the northern and southern continuous-reading weather stations B-3 WS and AOC-65 WS. Water levels will be graphed from selected wells against precipitation through 2017 and will be included in this annual groundwater report.	Yes.	Continue collection of transducer data and possibly install transducers in other cluster wells.
Contamination Characterization (Groundwater Contamination)	Characterize the horizontal and vertical extent of any immiscible or dissolved plume(s) originating from the Facility (3.1.2).	Samples for laboratory analysis were collected from 43 of 47 CSSA wells. All 57 samples scheduled to be collected in 2017 were collected.	The horizontal and vertical extent of groundwater contamination is continuously monitored.	Continue groundwater monitoring and construct additional wells as necessary.
	Determine the horizontal and vertical concentration profiles of all constituents of concern (COCs) in the groundwater that are measured by USEPA-approved procedures (3.1.2). COCs are those chemicals that have been detected in groundwater in the past and their daughter (breakdown) products.	Samples were analyzed for the selected VOCs using USEPA method SW8260B. Drinking water wells were also sampled for metals (As, Ba, Cr, Cu, Cd, Hg, Pb, Zn). Analyses were conducted in accordance with the AFCEE QAPP and approved variances. All RLs were below MCLs, as listed below: **ANALYTE** / **RL (µg/L)** / **MCL (µg/L)** *cis*-1,2-DCE / 1.2 / 70 Vinyl Chloride / 1.1 / 2 PCE / 1.4 / 5 TCE / 1.0 / 5	Yes.	Continue sampling.

Activity	Objectives	Action	Objective Attained?	Recommendations
Contamination Characterization (Groundwater Contamination) (Continued)		**ANALYTE** / **RL (µg/L)** / **MCL (µg/L)** Arsenic / 30 / 10 Barium / 5 / 2000 Chromium / 10 / 100 Copper / 10 / 1300 (AL) Zinc / 50 / 5000 (SS) Cadmium / 7 / 5 Lead / 25 / 15 (AL) Mercury / 1 / 2		
	Meet AFCEE QAPP quality assurance requirements.	Samples were analyzed in accordance with the CSSA QAPP and approved variances. Parsons chemists verified all data and performed data validation according to the CSSA QAPP and approved variances.	Yes.	NA
		All data flagged with a "U", "J", "M", and "F" are usable for characterizing contamination. All "R" flagged data are considered unusable.	Yes.	NA
		An MDL study for arsenic, cadmium, and lead was not performed within a year of the analyses, as required by the AFCEE QAPP.	The laboratory performed new MDL studies in February 2001 for these metals and the new MDL values were found to be almost identical to the previous MDLs and all met the associated AFCEE QAPP requirements. MDLs for these three metals are well below MCLs. In addition, the laboratory performed daily calibrations and RL verifications for these metals, both of which demonstrate the laboratory's ability to detect and quantitate these metals at RL levels. These daily analyses also indicate that concentrations above the laboratory RL for these compounds were not affected by the expired MDL study.	Use results for groundwater characterization purposes.

Activity	Objectives	Action	Objective Attained?	Recommendations
Remediation	Determine goals and create cost-effective and technologically appropriate methods for remediation (2.2.1).	Continued data collection will provide analytical results for accomplishing this objective.	Ongoing.	Continue sampling and evaluation, including quarterly groundwater monitoring teleconferences to address remediation.
	Determine placement of new wells for monitoring (2.3.1, 3.6)	Sampling frequency and sample locations to be monitored (including any new wells) will be based on trend data from monitoring event(s) (3.1.5).	Ongoing.	Continue quarterly groundwater teleconferences to discuss sampling frequency and placement of new monitor wells.
Project schedule/ Reporting	Produce a quarterly monitoring project schedule as a road map for sampling, analysis, validation, verification, reviews, and reports.	Prepare schedules and sampling guidelines prior to each quarterly sampling event.	Yes.	Continue sampling schedule preparation each quarter.

Appendix A Off-Post Evaluation of Data Quality Objectives Attainment

Activity	Objectives	Action	Objective Attained?	Recommendations
Field Sampling	Conduct field sampling in accordance with procedures defined in the project work plan, SAP, QAPP, and HSP.	All sampling was conducted in accordance with the procedures described in the project plans.	Yes	NA
Contamination Characterization (Groundwater Contamination)	Determine the potential extent of off-post contamination (§2.3.1 of the DQOs for the Groundwater Contamination Investigation, revised 2015).	Samples for laboratory analysis were collected from selected off-post public and private wells, which are located within a ½ mile radius of CSSA. Also, selected wells outside the ½ mile radius were sampled at the request of the EPA.	Partially	Continue sampling wells in accordance with the LTMO study recommendations. If significant changes are seen in contaminant concentrations then consider adding wells in the vicinity back to the sampling schedule to track any plume movement.
	Meet CSSA QAPP quality assurance requirements.	Samples were analyzed in accordance with the CSSA QAPP and approved variances. Parsons chemists verified all data and performed data validation according to the CSSA QAPP and approved variances.	Yes	NA
		All data flagged with a "U", "M", and "J" are usable for characterizing contamination.	Yes	NA

Activity	Objectives	Action	Objective Attained?	Recommendations
	Evaluate CSSA monitoring program and expand as necessary (§2.3.1 of the DQOs for the Groundwater Contamination Investigation, revised 2015). Determine locations of future monitoring locations.	Evaluation of data collected is ongoing and is reported in this annual groundwater report and will be reported in future quarterly groundwater reports. Additional information covering the CSSA monitoring program is available in Volume 5, CSSA Environmental Encyclopedia.	Yes	Continue data evaluation and quarterly teleconferences for evaluation of the monitoring program. Each teleconference/planning session covers expansion of the quarterly monitoring program, if necessary.
Project schedule/ Reporting	The quarterly monitoring project schedule shall provide a schedule for sampling, analysis, validation, verification, reviews, and reports for monitoring events off-post.	A schedule for sampling, analysis, validation, verification, data review and reports is provided in this annual groundwater report and will be reported in future quarterly groundwater reports. Additional information covering the CSSA monitoring program is available in Volume 5, CSSA Environmental Encyclopedia.	Yes	Continue quarterly and annual reporting to include a schedule for sampling, analysis, validation, verification, data review and data reports.

Activity	Objectives	Action	Objective Attained?	Recommendations
Remediation	Evaluate the effectiveness of GACs (§3.2.3) and install as needed (§3.2.5 both of the DQOs for the Groundwater Contamination Investigation, revised 2015).	Perform maintenance as needed. Install new GACs as needed.	Yes	Maintenance to the off-post GAC systems to be continued by Parsons' personnel approximately every 3 weeks. Semi annual (or as needed) maintenance to the off-post GAC systems by additional subcontractors to continue. Evaluations of future sampling results for installation of new GAC systems will occur as needed.

APPENDIX B

2017 QUARTERLY ON-POST GROUNDWATER ANALYTICAL RESULTS

Appendix B
2017 Quarterly On-Post Groundwater Monitoring Analytical Results

Well ID	Sample Date	*cis* -1,2 DCE (ug/L)	PCE (ug/L)	TCE (ug/L)	Vinyl chloride (ug/L)	pH	Temp. (deg. C)	Specific Conductivity (mS)
						Field Measurements		
CS-1	4/4/2017	0.07U	0.06U	0.05U	0.08U	7.32	22.16	0.578
	6/27/2017	0.07U	0.06U	**0.16F**	0.08U	6.83	21.91	0.545
Duplicate	6/27/2017	0.07U	0.06U	**0.19F**	0.08U	6.83	21.91	0.545
	9/26/2017	0.07U	0.06U	0.05U	0.08U	7.26	21.70	0.512
	12/6/2017	0.07U	0.06U	0.05U	0.08U	7.27	21.08	0.502
CS-2	6/16/2017	0.07U	0.06U	0.05U	0.08U	6.58	21.38	0.701
CS-4	6/16/2017	0.07U	**0.61F**	**0.22F**	0.08U	6.34	21.41	0.559
Duplicate	6/16/2017	0.07U	**0.59F**	**0.25F**	0.08U	6.34	21.41	0.559
CS-10	3/30/2017	0.07U	**0.18F**	0.05U	0.08U	7.25	22.31	0.579
	6/27/2017	0.07U	0.06U	0.05U	0.08U	7.10	22.96	0.625
	9/26/2017	0.07U	0.06U	0.05U	0.08U	7.22	22.95	0.586
	12/6/2017	0.07U	0.06U	0.05U	0.08U	7.18	21.53	0.556
Duplicate	12/6/2017	0.07U	0.06U	0.05U	0.08U	7.18	21.53	0.556
CS-12	3/30/2017	0.07U	**0.28F**	0.05U	0.08U	7.32	21.58	0.508
Duplicate	3/30/2017	0.07U	**0.19F**	0.05U	0.08U	7.32	21.58	0.508
	6/27/2017	0.07U	0.06U	0.05U	0.08U	6.89	22.26	0.528
	9/26/2017	0.07U	0.06U	0.05U	0.08U	7.21	22.20	0.491
Duplicate	9/26/2017	0.07U	0.06U	0.05U	0.08U	7.21	22.20	0.491
	12/6/2017	0.07U	0.06U	0.05U	0.08U	7.26	21.73	0.479
CS-13	6/28/2017	0.07U	0.06U	0.05U	0.08U	7.05	23.16	0.685
	9/25/2017	0.07U	0.06U	0.05U	0.08U	7.17	23.29	0.682
	12/6/2017	0.07U	0.06U	0.05U	0.08U	7.37	21.90	0.631
CS-D	6/19/2017	**4.47**	**5.32**	**6.56**	0.08U	7.00	22.93	0.528
CS-MWG-LGR	6/26/2017	0.07U	0.06U	0.05U	0.08U	6.34	21.51	0.470
CS-MWH-LGR	6/20/2017	0.07U	0.06U	0.05U	0.08U	6.12	22.12	0.508
CS-I	6/20/2017	0.07U	0.06U	0.05U	0.08U	6.99	22.50	0.576
CS-MW1-LGR	6/19/2017	**20.49**	**13.98**	**24.73**	0.08U	6.69	21.73	0.541
CS-MW1-CC	6/28/2017	0.07U	0.06U	0.05U	0.08U	6.95	22.03	0.745
CS-MW2-LGR	6/19/2017	**0.36F**	0.06U	0.05U	0.08U	7.02	21.87	0.539
CS-MW2-CC	6/28/2017	0.07U	0.06U	0.05U	0.08U	9.33	22.70	0.722
CS-MW3-LGR	6/19/2017	0.07U	0.06U	0.05U	0.08U	6.60	22.32	0.499
CS-MW4-LGR	6/28/2017	0.07U	0.06U	0.05U	0.08U	6.82	21.49	0.675
CS-MW5-LGR	6/16/2017	**11.65**	**5.87**	**13.16**	0.08U	7.04	26.45	0.546
CS-MW6-LGR	6/8/2017	0.07U	0.06U	0.05U	0.08U	6.97	22.80	0.567
CS-MW6-CC	6/8/2017	0.07U	0.06U	0.05U	0.08U	7.14	22.72	0.785
CS-MW7-LGR	6/20/2017	0.07U	**0.88F**	0.05U	0.08U	6.45	21.57	0.661

Appendix B
2017 Quarterly On-Post Groundwater Monitoring Analytical Results

Well ID	Sample Date	*cis* -1,2 DCE (ug/L)	PCE (ug/L)	TCE (ug/L)	Vinyl chloride (ug/L)	pH	Temp. (deg. C)	Specific Conductivity (mS)
						Field Measurements		
CS-MW7-CC	6/26/2017	0.07U	0.06U	0.05U	0.08U	6.69	21.70	0.807
Duplicate	6/26/2017	0.07U	0.06U	0.05U	0.08U	6.69	21.70	0.807
CS-MW8-LGR	6/8/2017	0.07U	**2.62**	0.05U	0.08U	6.36	22.73	0.649
CS-MW8-CC	6/8/2017	0.07U	0.06U	0.05U	0.08U	6.97	22.71	0.836
CS-MW9-LGR	6/19/2017	0.07U	0.06U	0.05U	0.08U	6.11	21.85	0.590
Duplicate	6/19/2017	0.07U	0.06U	0.05U	0.08U	6.11	21.85	0.590
CS-MW9-CC	6/19/2017	0.07U	0.06U	0.05U	0.08U	6.82	21.75	0.701
CS-MW10-LGR	6/26/2017	0.07U	**1.89**	0.05U	0.08U	6.68	22.54	0.652
CS-MW10-CC	6/26/2017	0.07U	0.06U	0.05U	0.08U	7.03	22.12	0.809
CS-MW11A-LGR	6/26/2017	0.07U	**0.89F**	0.05U	0.08U	6.69	22.16	0.579
CS-MW11B-LGR	6/26/2017	0.07U	**0.98F**	0.05U	0.08U	6.83	22.72	0.606
CS-MW12-LGR	6/16/2017	0.07U	0.06U	0.05U	0.08U	7.09	22.93	0.555
CS-MW12-CC	6/16/2017	0.07U	0.06U	0.05U	0.08U	7.30	22.48	0.692
CS-MW17-LGR	6/28/2017	0.07U	**0.67F**	0.05U	0.08U	6.68	21.59	0.627
Duplicate	6/28/2017	0.07U	**0.76F**	0.05U	0.08U	6.68	21.59	0.627
CS-MW18-LGR	6/16/2017	0.07U	0.06U	0.05U	0.08U	7.23	22.92	0.483
CS-MW19-LGR	6/16/2017	0.07U	**0.68F**	0.05U	0.08U	6.68	22.10	0.604
CS-MW20-LGR	6/26/2017	0.07U	**1.23F**	0.05U	0.08U	6.44	21.69	0.595
CS-MW21-LGR	6/28/2017	0.07U	0.06U	0.05U	0.08U	6.77	21.43	0.574
CS-MW22-LGR	6/26/2017	0.07U	0.06U	0.05U	0.08U	6.48	21.71	0.550
CS-MW23-LGR	6/26/2017	0.07U	0.06U	0.05U	0.08U	6.91	22.62	0.527
CS-MW24-LGR	6/19/2017	0.07U	0.06U	0.05U	0.08U	6.69	22.15	0.562
CS-MW25-LGR	6/27/2017	0.07U	0.06U	0.05U	0.08U	7.08	22.78	0.468
CS-MW35-LGR	6/26/2017	0.07U	**0.66F**	0.05U	0.08U	6.54	21.95	0.668
CS-MW36-LGR	6/8/2017	0.07U	**5.43**	**4.2**	0.08U	6.95	22.96	0.809
CS-MW37-LGR	7/12/2017	0.07U	0.06U	0.05U	0.08U	7.18	25.87	0.593
	9/22/2017	0.07U	0.06U	0.05U	0.08U	7.04	21.73	0.567
	12/6/2017	0.07U	0.06U	0.05U	0.08U	7.15	19.01	0.512

Comparison Criteria	*cis* -1,2 DCE	PCE	TCE	Vinyl chloride
Maximum Contaminant Level (MCL)	**70**	**5.0**	**5.0**	**2.0**
Reporting Limit (RL)	**1.2**	**1.4**	**1.0**	**1.1**
Method Detection Limit (MDL)	**0.07**	**0.06**	**0.05**	**0.08**

Legend	
BOLD (red)	≥ MCL
BOLD (blue)	≥ RL
BOLD	≥ MDL

Well ID	Sample Date	*cis* -1,2 DCE (ug/L)	PCE (ug/L)	TCE (ug/L)	Vinyl chloride (ug/L)	pH	Temp. (deg. C)	Specific Conductivity (mS)
						Field Measurements		

All samples were analyzed by APPL, Inc. using method SW8260B.
VOC data reported in ug/L & metals data reported in mg/L.

Abbreviations/Notes:

mS	millisiemans
µg/L	micrograms per liter
mg/L	milligrams per liter
deg. C	degrees Celsius
Duplicate	Field Duplicate
TCE	Trichloroethene
PCE	Tetrachloroethene
DCE	Dichloroethene

Data Qualifiers

NA = Analyte not analyzed
U-The analyte was analyzed for, but not detected. The associated numerical value is at or below the MDL.
F-The analyte was positively identified but the associated numerical value is below the RL.

Appendix B
2017 Quarterly On-Post Groundwater Monitoring Analytical Results

Well ID:	CS-MW37-LGR			
Sample Date:	7/12/2017			
Analyte	MDL	RL	MCL	Concentration
Organics (µg/L)				
1,1,1,2-TETRACHLOROETHANE	0.09	0.5	NA	0.09U
1,1,1-TCA	0.03	0.8	200	0.03U
1,1,2,2-TETRACHLOROETHANE	0.07	0.4	NA	0.07U
1,1,2-TCA	0.06	1	5	0.06U
1,1-DCA	0.07	0.4	NA	0.07U
1,1-DCE	0.12	1.2	7	0.12U
1,1-DICHLOROPROPENE	0.1	1	NA	0.1U
1,2,3-TRICHLOROBENZENE	0.24	0.3	NA	0.24U
1,2,3-TRICHLOROPROPANE	0.17	3.2	NA	0.17U
1,2,4-TRICHLOROBENZENE	0.16	0.4	70	0.16U
1,2,4-TRIMETHYLBENZENE	0.04	1.3	NA	0.04U
1,2-DCA	0.05	0.6	5	0.05U
1,2-DCB	0.02	0.3	NA	0.02U
1,2-DIBROM0-3-CHLOROPROPANE	0.76	2.6	0.2	0.76U
1,2-DICHLOROPROPANE	0.06	0.4	5	0.06U
1,2-EDB	0.06	0.6	NA	0.06U
1,3,5-TRIMETHYLBENZENE	0.04	0.5	NA	0.04U
1,3-DCB	0.03	1.2	NA	0.03U
1,3-DICHLOROPROPANE	0.05	0.4	NA	0.05U
1,4-DCB	0.07	0.3	NA	0.07U
1-CHLOROHEXANE	0.04	0.5	NA	0.04U
2,2-DICHLOROPROPANE	0.1	3.5	NA	0.1U
2-CHLOROTOLUENE	0.04	0.4	NA	0.04U
4-CHLOROTOLUENE	0.04	0.6	NA	0.04U
BENZENE	0.07	0.4	NA	0.07U
BROMOBENZENE	0.06	0.3	NA	0.06U
BROMOCHLOROMETHANE	0.11	0.4	NA	0.11U
BROMODICHLOROMETHANE	0.06	0.8	*80	0.06U
BROMOFORM	0.13	1.2	*80	0.13U
BROMOMETHANE	0.08	1.1	NA	0.08U
CARBON TETRACHLORIDE	0.06	2.1	5	0.06U
CHLOROBENZENE	0.04	0.4	0.1	0.04U
CHLOROETHANE	0.07	1	NA	0.07U
CHLOROFORM	0.06	0.3	*80	0.06U
CHLOROMETHANE	0.16	1.3	NA	0.16U
CIS-1,2-DCE	0.07	1.2	70	0.07U
CIS-1,3-DICHLOROPROPENE	0.03	1	NA	0.03U
DIBROMOCHLOROMETHANE	0.06	0.5	*80	0.06U
DIBROMOMETHANE	0.06	2.4	NA	0.06U
DICHLORODIFLUOROMETHANE	0.11	1	NA	0.11U
ETHYLBENZENE	0.05	0.6	700	0.05U
HEXACHLOROBUTADIENE	0.17	1.1	NA	0.17U
ISOPROPYLBENZENE	0.04	0.5	NA	0.04U
M&P-XYLENE	0.07	0.5	NA	0.07U
METHYLENE CHLORIDE	0.35	1	NA	0.35U
N-BUTYLBENZENE	0.17	1.1	NA	0.17U

Appendix B
2017 Quarterly On-Post Groundwater Monitoring Analytical Results

Well ID:	CS-MW37-LGR			
Sample Date:	**7/12/2017**			
Analyte	**MDL**	**RL**	**MCL**	**Concentration**
N-PROPYLBENZENE	0.03	0.4	NA	0.03U
NAPHTHALENE	0.07	0.4	NA	0.07U
O-XYLENE	0.06	1.1	NA	0.06U
P-ISOPROPYLTOLUENE	0.05	1.2	NA	0.05U
SEC-BUTYLBENZENE	0.05	1.3	NA	0.05U
STYRENE	0.08	0.4	100	0.08U
TCE	0.05	1	5	0.05U
TERT-BUTYLBENZENE	0.04	1.4	NA	0.04U
TETRACHLOROETHENE	0.06	1.4	5	0.06U
TOLUENE	0.06	1.1	1000	0.06U
TRANS-1,2-DCE	0.08	0.6	100	0.08U
TRANS-1,3-DICHLOROPROPENE	0.04	1	NA	0.04U
TRICHLOROFLUOROMETHANE	0.07	0.8	NA	0.07U
VINYL CHLORIDE	0.08	1.1	2	0.08U
Metals (mg/L)				
ARSENIC	0.00022	0.03	0.01	**0.00076F**
BARIUM	0.0003	0.005	2	**0.0442**
CADMIUM	0.0005	0.007	0.005	0.0005U
CHROMIUM	0.001	0.01	0.1	**0.0076F**
COPPER	0.003	0.01	AL = 1.3	0.003U
LEAD	0.0019	0.025	AL = 0.015	0.0019U
ZINC	0.008	0.05	SS = 5	**0.588**
MERCURY	0.0001	0.001	0.002	0.0001U
Inorganics (mg/L)				
TOTAL DISSOLVED SOILIDS	4.4	10	SS = 500	**321**
BROMIDE	0.07	0.5	NA	**0.2F**
CHLORIDE	0.08	1	SS = 250	**11.96**
FLUORIDE	0.1	0.1	4	**0.42**
NITRATE	0.03	0.5	10	**4.6**
NITRITE	0.04	0.3	1	**0.12F**
SULFATE	0.26	1	SS = 250	**20.74**
BICARBONATE AS CACO3	0.3	2	NA	**264**

BOLD	≥ MDL
BOLD	≥ RL
BOLD	≥ MCL

Data Qualifiers:
U-The analyte was analyzed for, but not detected. The associated numerical value is at or below the
F-The analyte was positively identified but the associated numerical value is below the RL.
Abbreviations/Notes:
* Total Trihalomethanes (TTHMs) - maximum allowable annual average level
NA = no applicable standard
SS = secondary standard
AL = action level
MDL = method detection limit
RL = reporting limit
MCL = maximum contaminant level

Appendix B
2017 Quarterly On-Post Groundwater Monitoring Analytical Results

Well ID		Sample Date	Arsenic (mg/L)	Barium (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Copper (mg/L)	Lead (mg/L)	Mercury (mg/L)	Zinc (mg/L)
CS-1		4/4/2017	**0.0066F**	**0.0366**	0.0005U	0.0010U	**0.005F**	0.0019U	0.0001U	**0.191**
		6/27/2017	0.00022U	**0.0331**	0.0005U	0.0001U	**0.014**	**0.0057F**	0.0001U	**0.175**
	Duplicate	6/27/2017	**0.00101F**	**0.0357**	0.0005U	0.0010U	**0.015**	**0.0043F**	0.0001U	**0.145**
		9/26/2017	0.00022U	**0.0342**	0.0005U	0.0010U	0.003U	0.0019U	0.0001U	**0.115J**
		12/6/2017	0.00022U	**0.0343**	0.0005U	0.0010U	**0.017**	0.0019U	0.0001U	**0.212**
CS-10		3/30/2017	**0.0054F**	**0.0396**	0.0005U	**0.0013F**	**0.011**	0.0019U	0.0001U	**0.227**
		6/27/2017	**0.00121F**	**0.0376**	0.0005U	**0.0012F**	0.003U	**0.0027F**	0.0001U	**0.387**
		9/26/2017	0.00022U	**0.0351**	0.0005U	0.0010U	0.003U	0.0019U	0.0001U	**0.353J**
		12/6/2017	0.00022U	**0.0372**	0.0005U	0.0010U	0.003U	0.0019U	0.0001U	**0.458**
	Duplicate	12/7/2017	0.00022U	**0.0375**	0.0005U	0.0010U	0.003U	0.0019U	0.0001U	**0.445**
CS-12		3/30/2017	**0.0023F**	**0.0291**	0.0005U	**0.0012F**	0.003U	0.0019U	0.0001U	**0.028F**
	Duplicate	3/30/2017	**0.0013F**	**0.0284**	0.0005U	0.0010U	0.003U	0.0019U	0.0001U	**0.025F**
		6/27/2017	**0.00125F**	**0.03**	0.0005U	**0.0746**	0.003U	**0.0031F**	0.0001U	**0.033F**
		9/26/2017	0.00022U	**0.0298**	0.0005U	0.0010U	**0.008F**	0.0019U	0.0001U	**0.059J**
	Duplicate	9/26/2017	0.00022U	**0.0297**	0.0005U	0.0010U	**0.006F**	0.0019U	0.0001U	**0.083J**
		12/6/2017	0.00022U	**0.0298**	0.0005U	0.0010U	**0.007F**	0.0019U	0.0001U	**0.038F**
CS-13		6/28/2017	**0.00418F**	**0.0319**	0.0005U	**0.0016F**	0.003U	**0.0034F**	0.0001U	**0.435**
		9/25/2017	0.00022U	**0.0287**	0.0005U	0.0010U	0.003U	0.0019U	0.0001U	**0.378**
		12/6/2017	**0.01617F**	0.0003U	0.0005U	0.0010U	0.003U	**0.0032F**	0.0001U	**0.054M**
Comparison Criteria										
Maximum Contaminant Level (MCL)			**0.01**	**2.0**	**0.005**	**0.1**	**1.3**	**0.015 (AL)**	**0.002**	**5.0 (SS)**
Report Limit (RL)			**0.03**	**0.005**	**0.007**	**0.01**	**0.01**	**0.025**	**0.001**	**0.05**
Method Detection Limit (MDL)			**0.00022**	**0.0003**	**0.0005**	**0.001**	**0.003**	**0.0019**	**0.0001**	**0.008**

Legend	
BOLD (red)	≥ MCL
BOLD (blue)	≥ RL
BOLD	≥ MDL

All samples were analyzed by APPL, Inc. using laboratory method SW8260B.
VOC data reported in µg/L & metals data reported in mg/L.

Abbreviations/Notes:

µg/L	micrograms per liter
mg/L	milligrams per liter
Duplicate	Field Duplicate
AL	Action Level
SS	Secondary Standard

Data Qualifiers:

NA = Analyte not analyzed
F-The analyte was positively identified but the associated numerical value is below the RL.
J - Analyte detected, concentration estimated.
M - Matrix effect present.
U-The analyte was analyzed for, but not detected. The associated numerical value is at or below the MDL.

APPENDIX C

2017 WESTBAY® ANALYTICAL RESULTS

Appendix C
2017 Westbay® Analytical Results

Well ID	Date Sampled	cis-1,2-DCE (cis-1,2-dichloroethene)	TCE (trichloroethene)	PCE (tetrachloroethene)	Vinyl Chloride
CS-WB01-UGR-01	6/21/2017	Dry			
CS-WB01-LGR-01	6/21/2017	<0.07	0.43F	1.20F	<0.08
CS-WB01-LGR-02	6/21/2017	<0.07	2.34	11.08	<0.08
CS-WB01-LGR-03	6/21/2017	<0.07	10.45	4.02	<0.08
CS-WB01-LGR-04	6/21/2017	<0.07	<0.05	<0.06	<0.08
CS-WB01-LGR-05	6/21/2017	1.48	<0.05	<0.06	<0.08
CS-WB01-LGR-06	6/21/2017	1.60	4.37	<0.06	<0.08
CS-WB01-LGR-07	6/21/2017	<0.07	14.11	14.07	<0.08
CS-WB01-LGR-08	6/21/2017	19.78	1.23	<0.06	<0.08
CS-WB01-LGR-09	6/21/2017	0.49F	<0.05	<0.06	1.94
CS-WB02-UGR-01	6/22/2017	port clogged			
CS-WB02-LGR-01	6/22/2017	Dry			
CS-WB02-LGR-02	6/22/2017	Dry			
CS-WB02-LGR-03	6/22/2017	<0.07	0.47F	2.93	<0.08
CS-WB02-LGR-04	6/22/2017	<0.07	4.65	2.6	<0.08
CS-WB02-LGR-05	6/22/2017	0.61F	1.66	<0.06	<0.08
CS-WB02-LGR-06	6/22/2017	0.72F	2.33	4.24	<0.08
CS-WB02-LGR-07	6/22/2017	0.59F	1.14	<0.06	<0.08
CS-WB02-LGR-08	6/22/2017	3.08	<0.05	<0.06	<0.08
CS-WB02-LGR-09	6/22/2017	<0.07	6.82	7.14	<0.08
CS-WB03-UGR-01	6/22/2017	9.56	103.64**	9356.24***	<0.08
CS-WB03-LGR-01	6/22/2017	0.54F	16.79	365.80*	<0.08
CS-WB03-LGR-02	6/22/2017	Dry			
CS-WB03-LGR-03	6/22/2017	<0.07	0.52F	3.79	<0.08
CS-WB03-LGR-04	6/22/2017	<0.07	4.9	15.87	<0.08
CS-WB03-LGR-05	6/22/2017	<0.07	2.18	13.38	<0.08
CS-WB03-LGR-06	6/22/2017	7.01	<0.05	<0.06	<0.08
CS-WB03-LGR-07	6/22/2017	2.38	5.89	2.31	<0.08
CS-WB03-LGR-08	6/22/2017	2.00	<0.05	<0.06	0.90F
CS-WB03-LGR-09	6/22/2017	<0.07	2.29	2.57	<0.08
CS-WB04-UGR-01	7/10/2017	Dry			
CS-WB04-LGR-01	7/10/2017	<0.07	<0.05	0.68F	<0.08
CS-WB04-LGR-02	7/10/2017	Dry			
CS-WB04-LGR-03	7/10/2017	<0.07	<0.05	<0.06	<0.08
CS-WB04-LGR-04	7/10/2017	0.31F	<0.05	<0.06	<0.08
CS-WB04-LGR-06	7/10/2017	3.74	12.69	16.87	<0.08
CS-WB04-LGR-07	7/10/2017	32.58	4.71	<0.06	<0.08
CS-WB04-LGR-08	7/10/2017	0.53F	1.05	0.74F	<0.08
CS-WB04-LGR-09	7/10/2017	<0.07	6.93	8.75	<0.08
CS-WB04-LGR-10	7/10/2017	<0.07	0.46F	2.02	<0.08
CS-WB04-LGR-11	7/10/2017	<0.07	<0.05	0.45F	<0.08
CS-WB04-BS-01	7/10/2017	<0.07	<0.05	<0.06	<0.08
CS-WB04-BS-02	7/10/2017	<0.07	<0.05	<0.06	<0.08
CS-WB04-CC-01	7/10/2017	1.15F	<0.05	<0.06	<0.08
CS-WB04-CC-02	7/10/2017	<0.07	<0.05	0.24F	<0.08
CS-WB04-CC-03	7/10/2017	<0.07	<0.05	0.44F	<0.08
Comparison Criteria					
Method Detection Limit	MDL	0.07	0.05	0.06	0.08
Reporting Limit	RL	1.2	1	1.4	1.1
Max. Contaminant Level	MCL	70	5	5	2

Data Qualifiers

Appendix C
2017 Westbay® Analytical Results

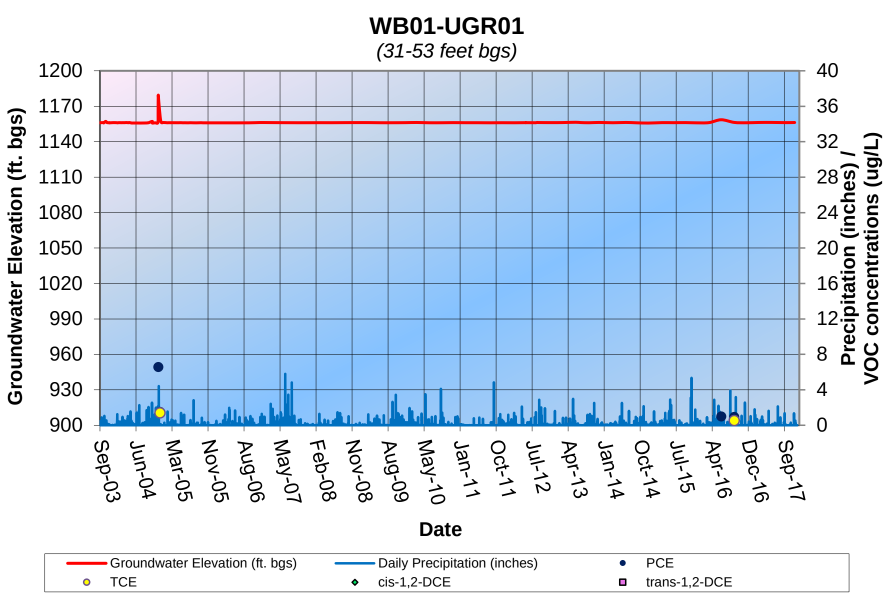
'--' indicates the result was non-detect.
F-The analyte was positively identified but the associated numerical value is below the RL.
* dilution of 5 run for this sample.
** dilution of 50 run for this sample.
*** dilution of 200 run for this sample
All values are reported in µg/L.

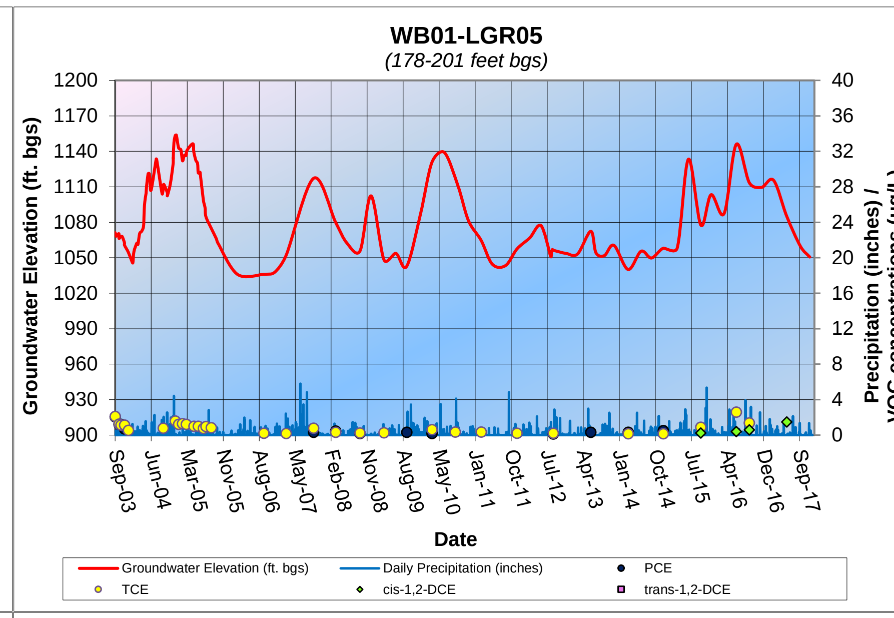
BOLD	≥ MDL
BOLD	≥ RL
BOLD	≥ MCL

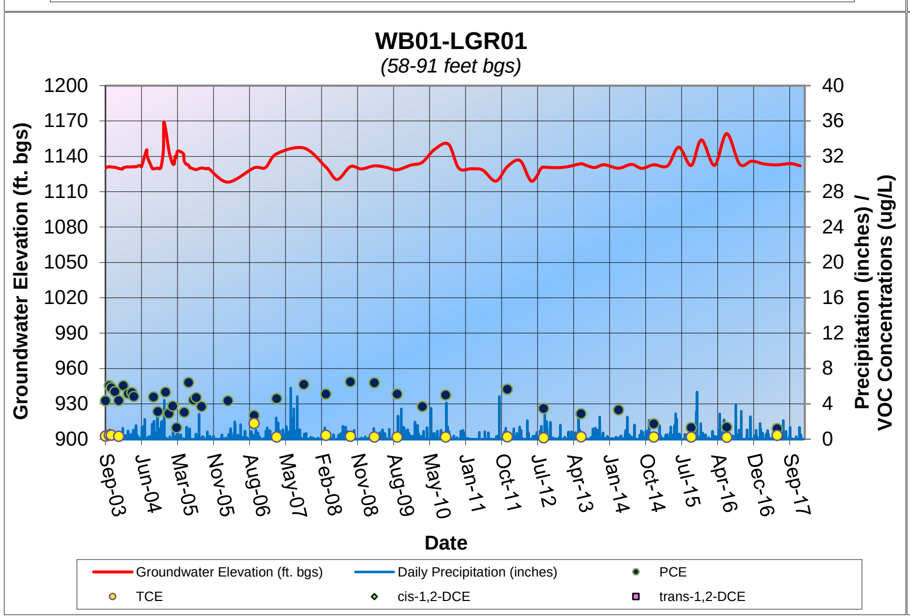
APPENDIX D

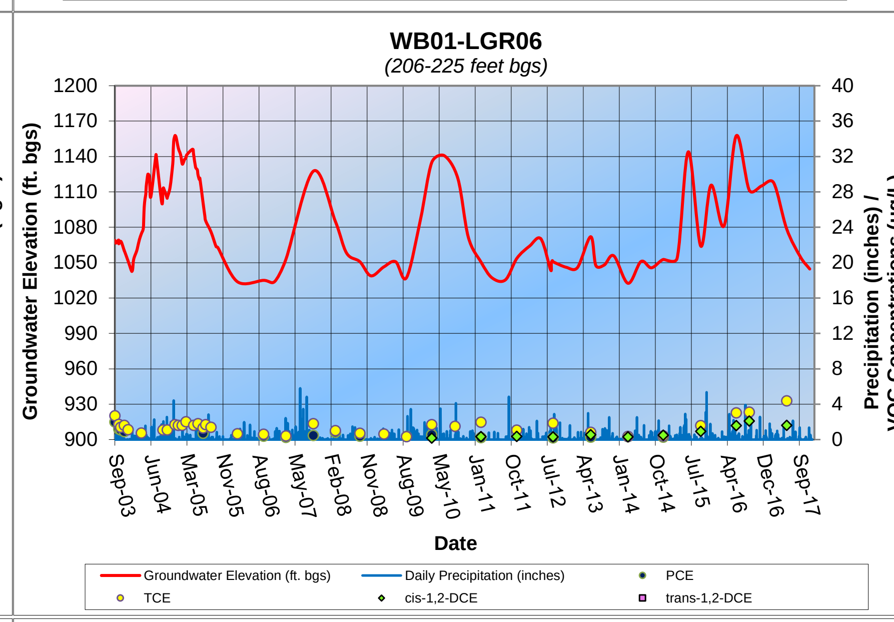
CUMULATIVE WESTBAY® ANALYTICAL GRAPHS

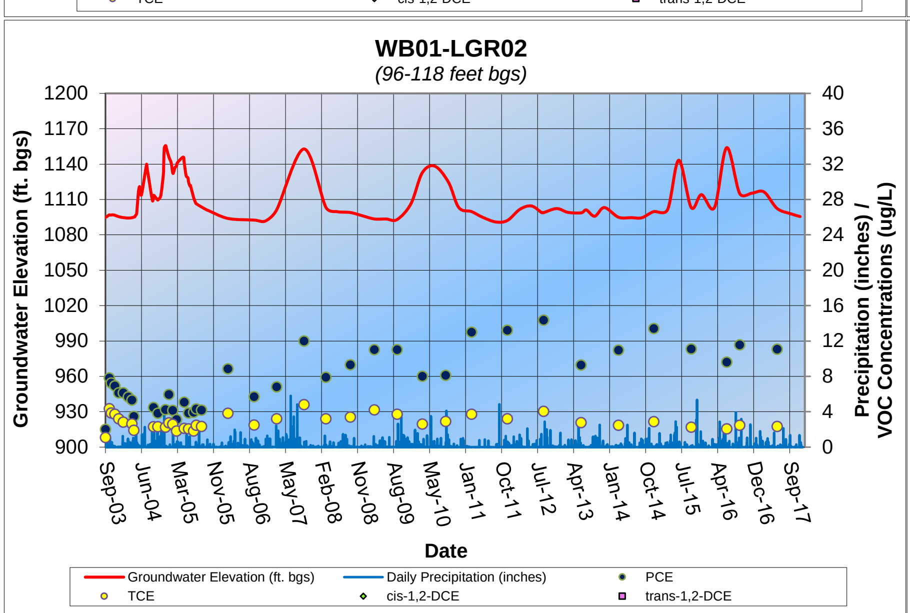
Appendix D.1 - CS-WB01 Culmulative VOC Concentrations, Groundwater Level, and Precipitation

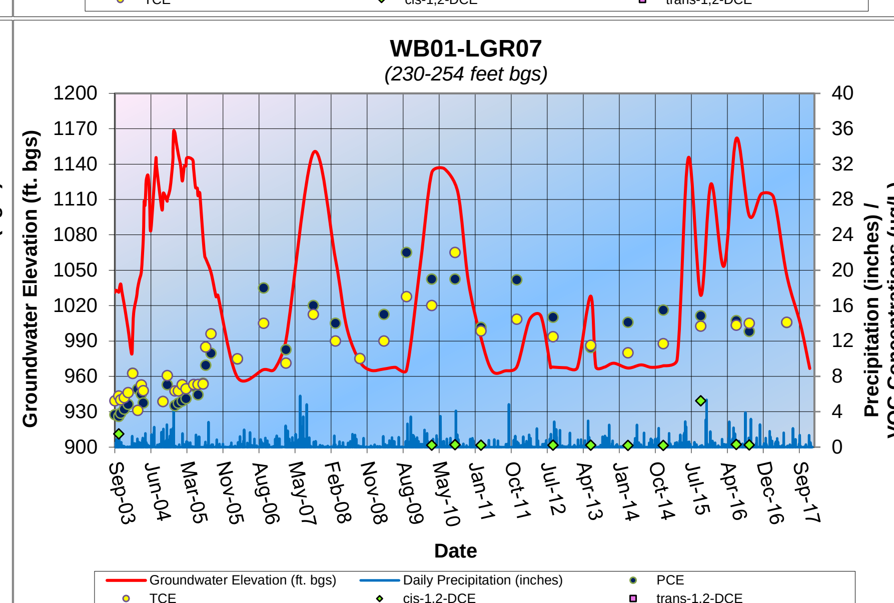


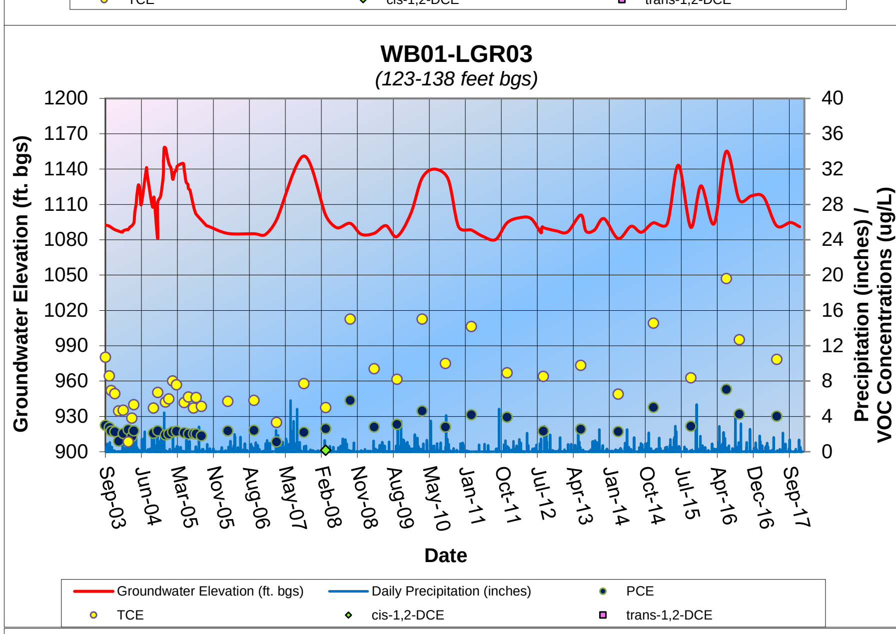


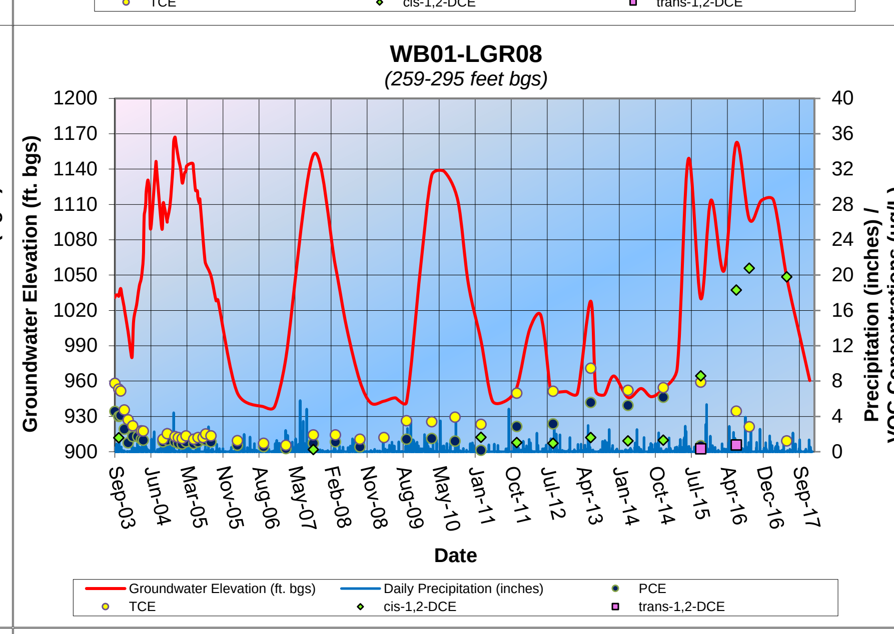


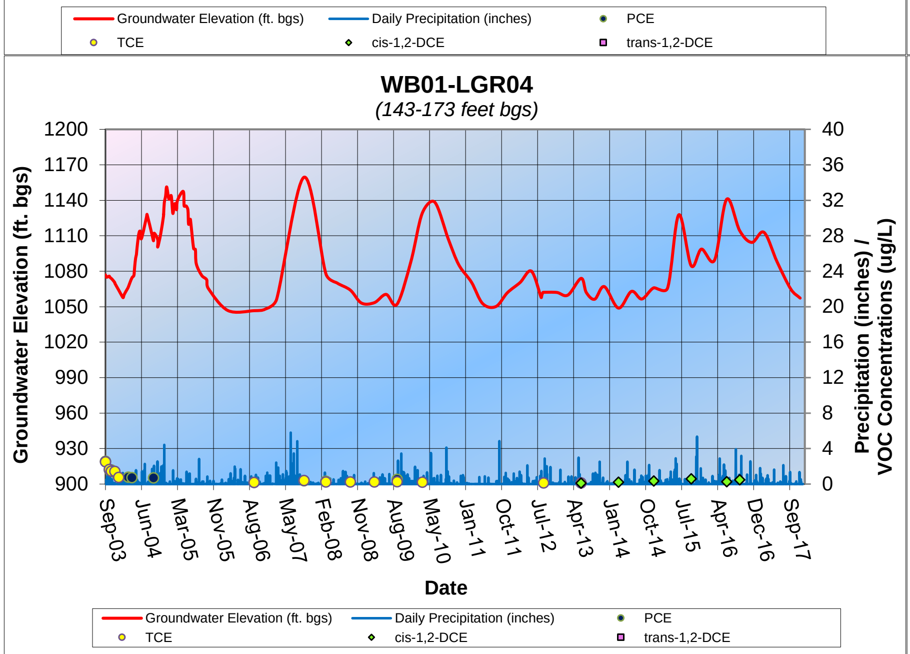


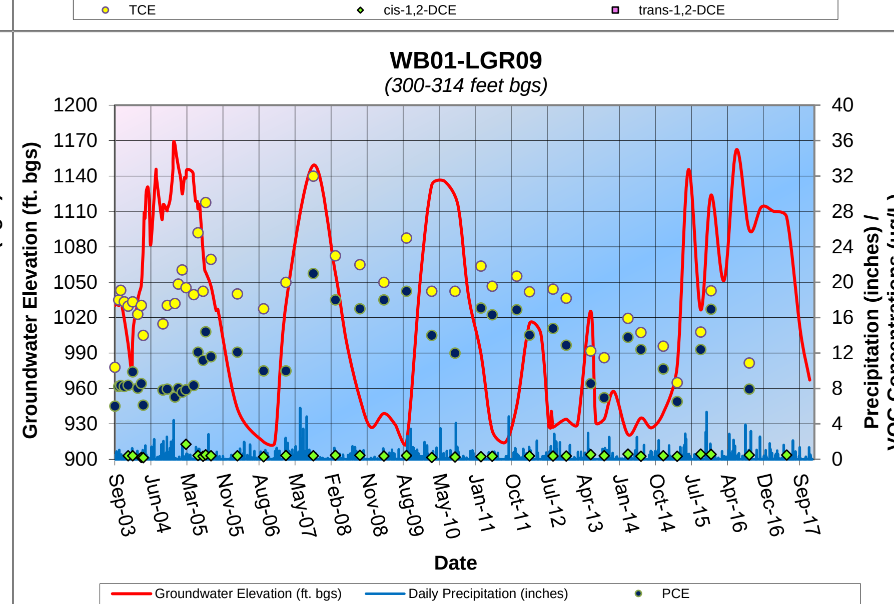




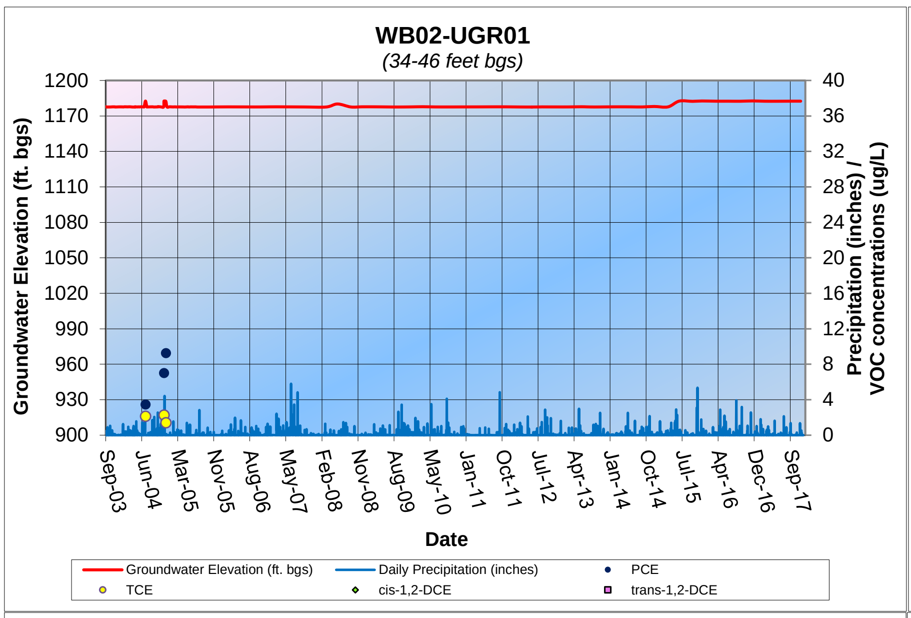


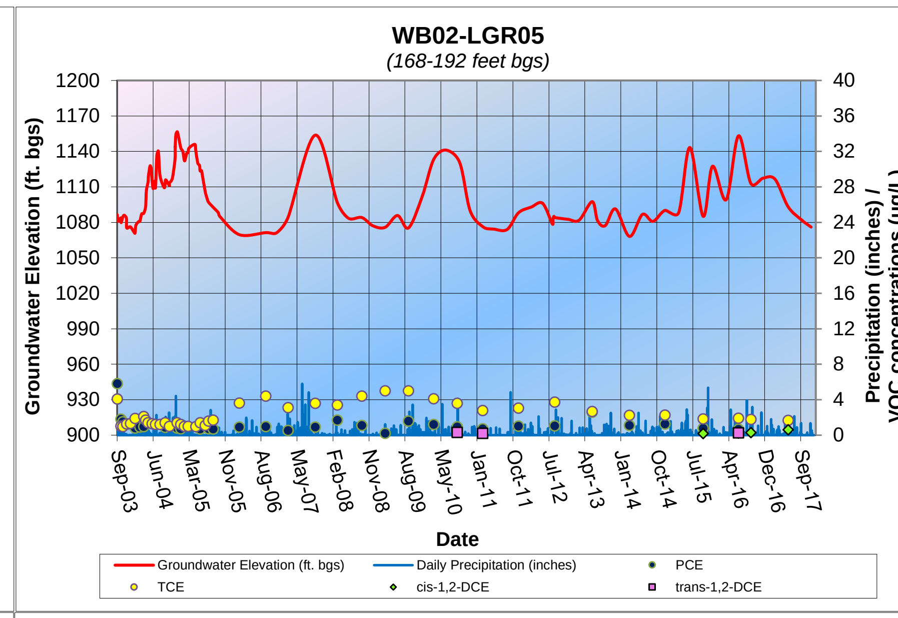


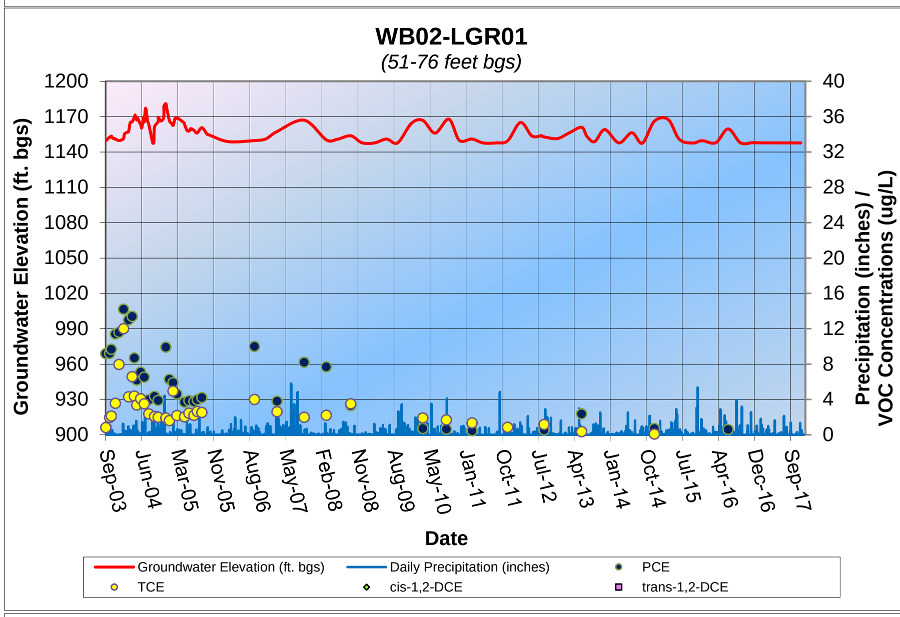


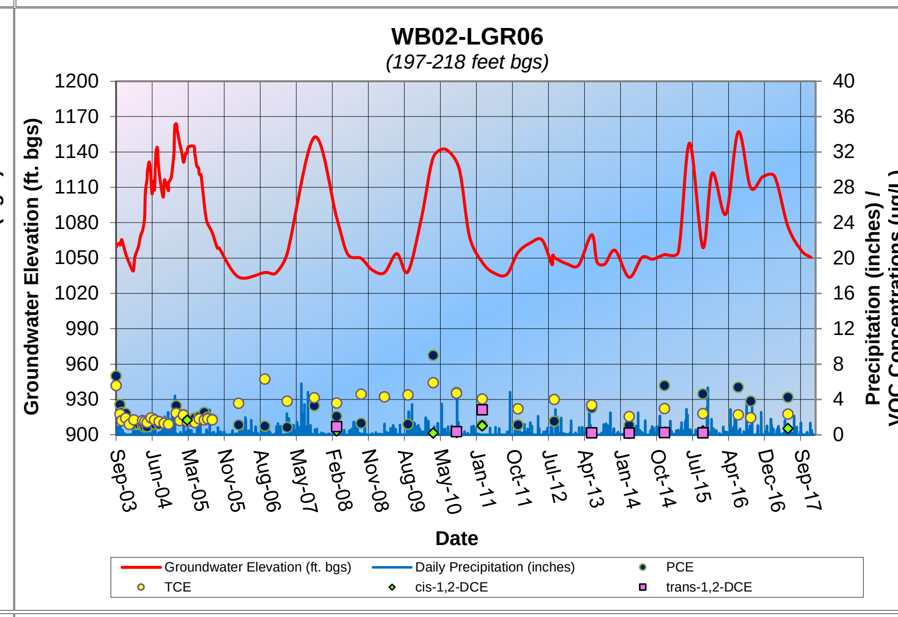


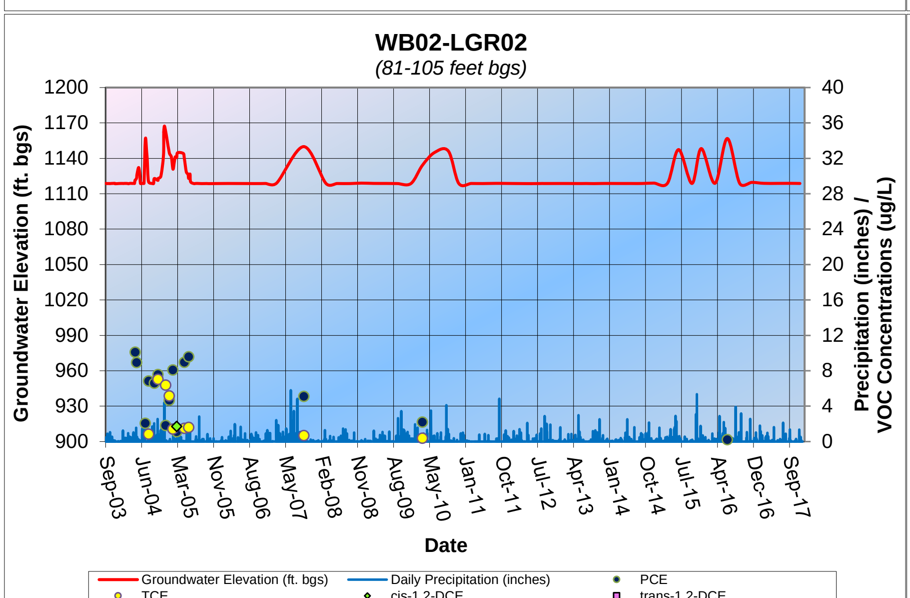
Appendix D.2 - CS-WB02 Culmulative VOC Concentrations, Groundwater Level, and Precipitation

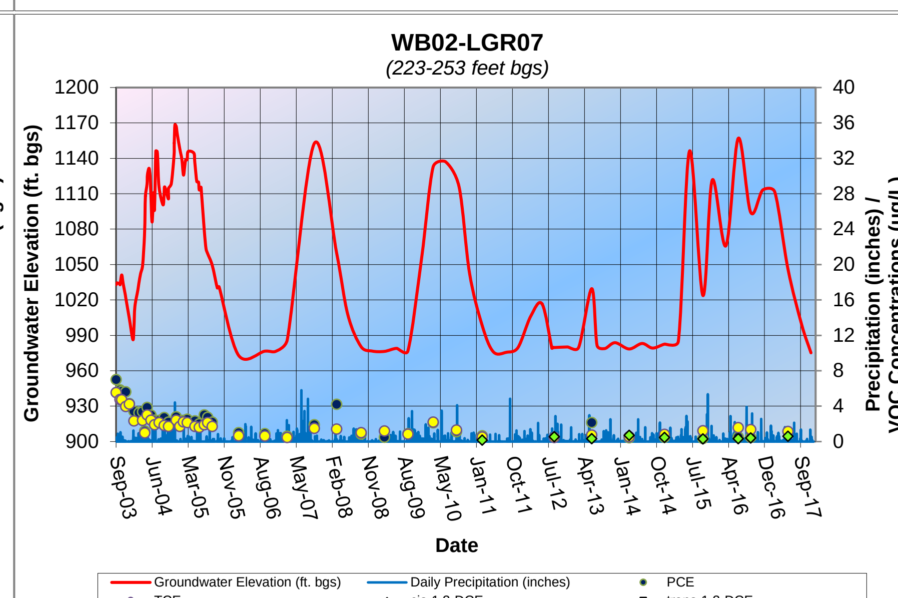


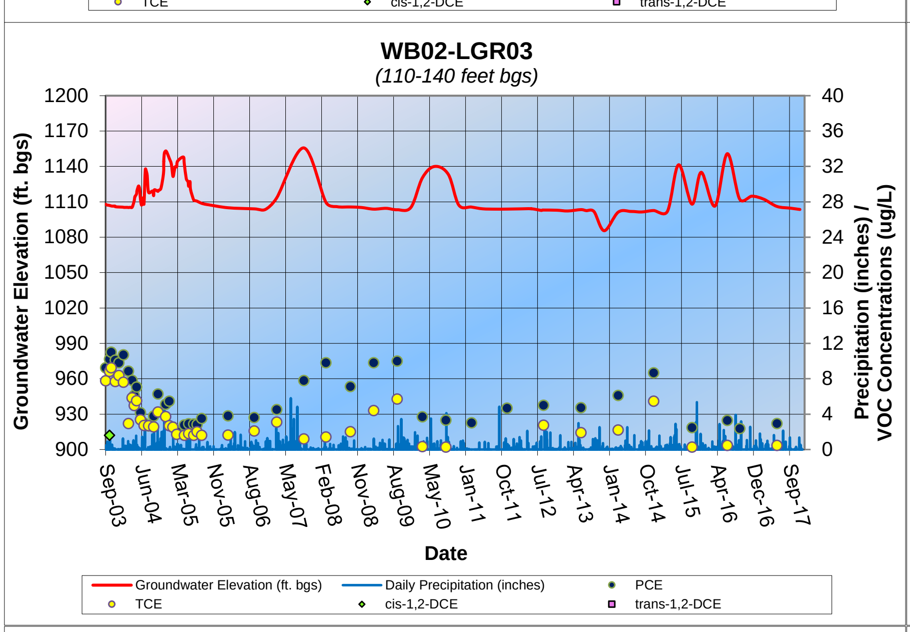


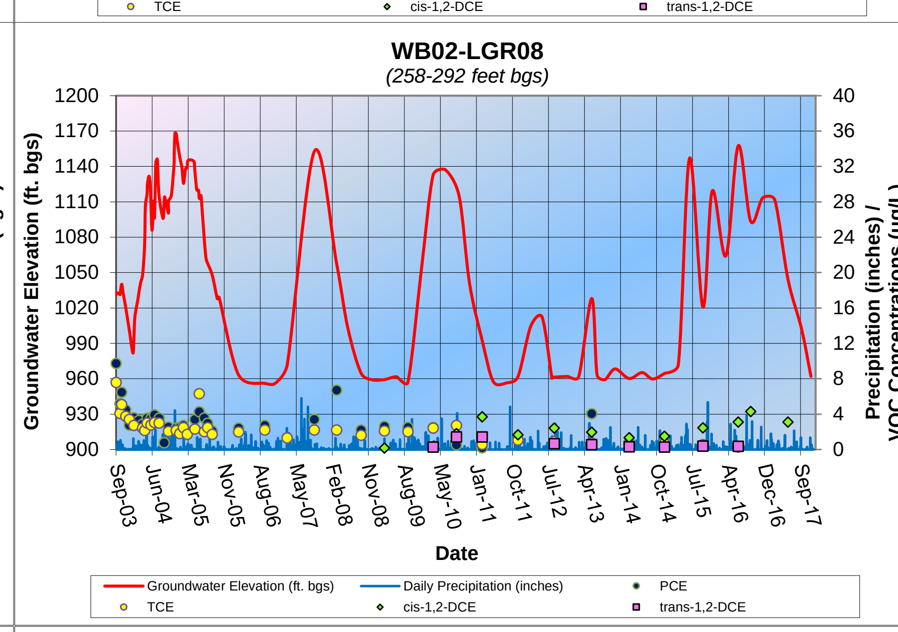


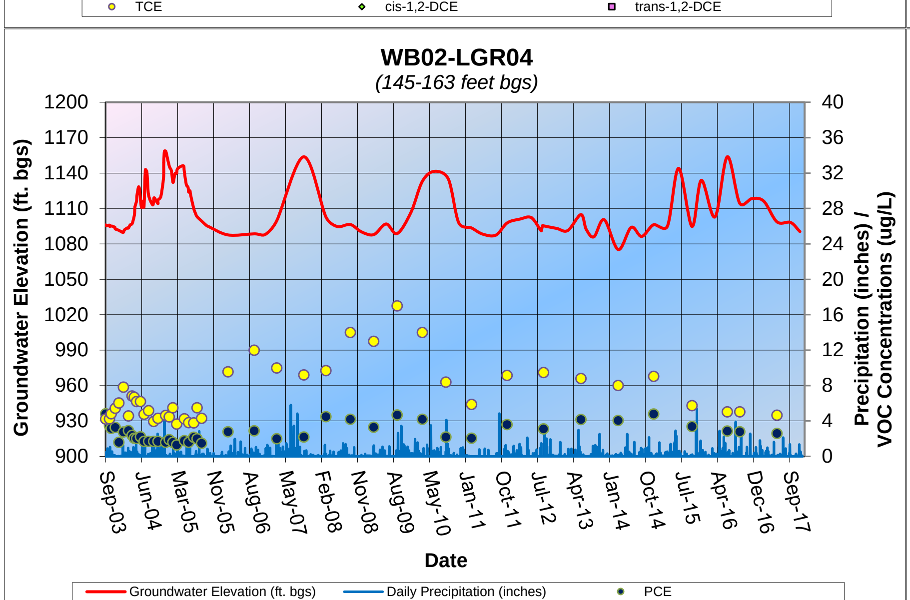


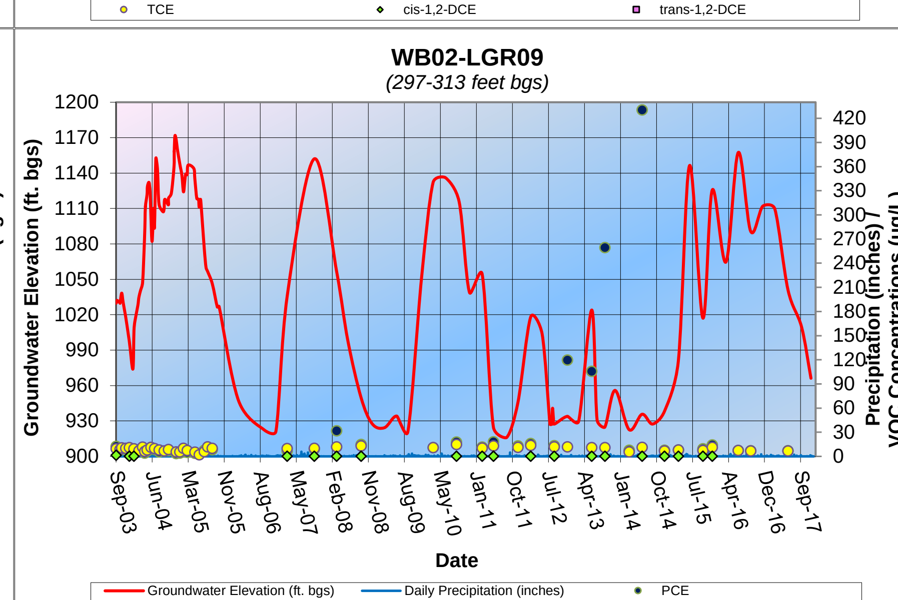












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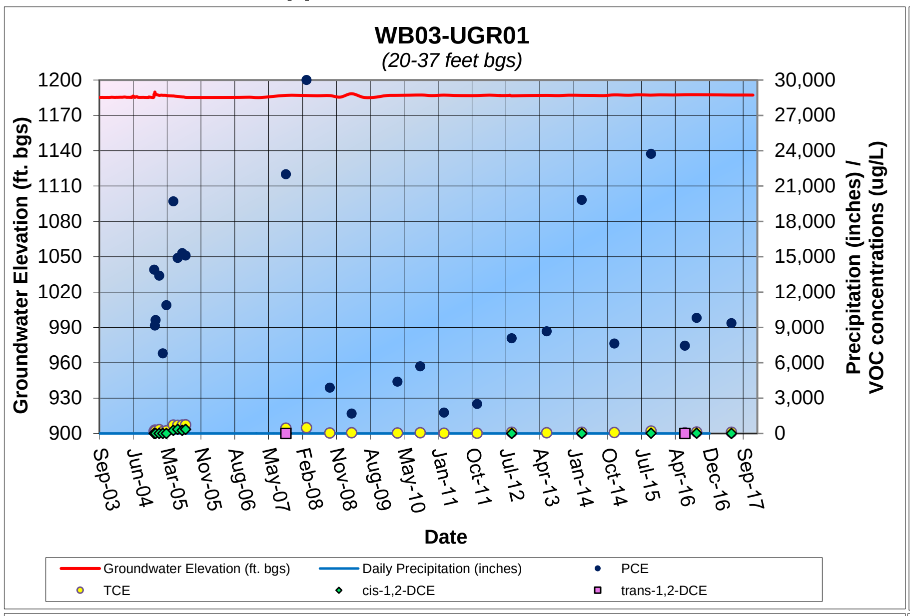
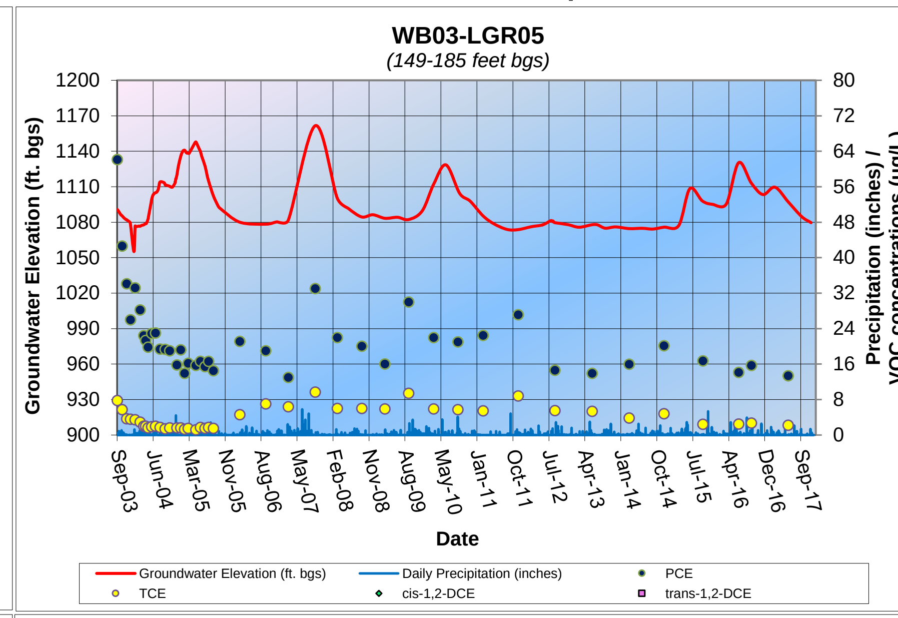
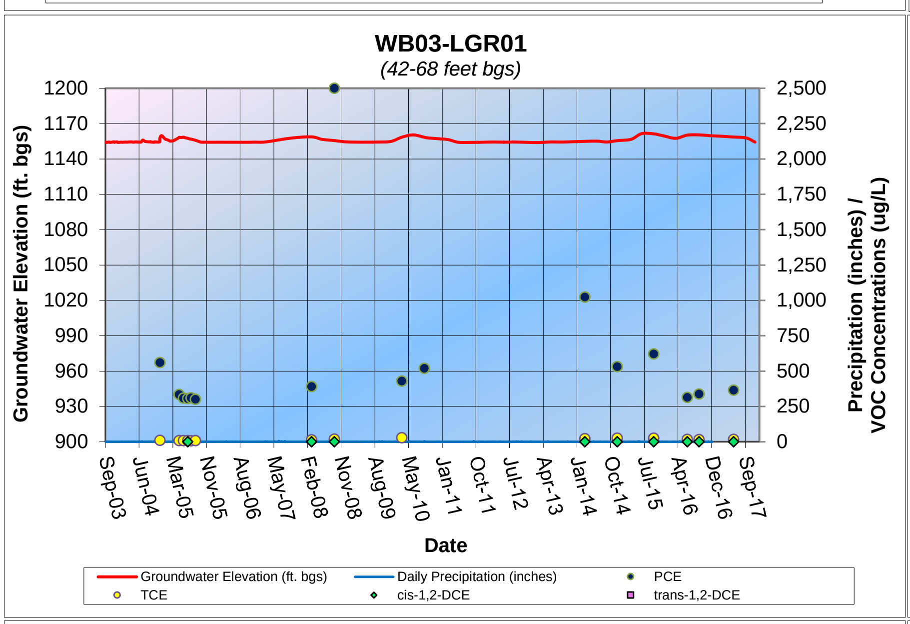
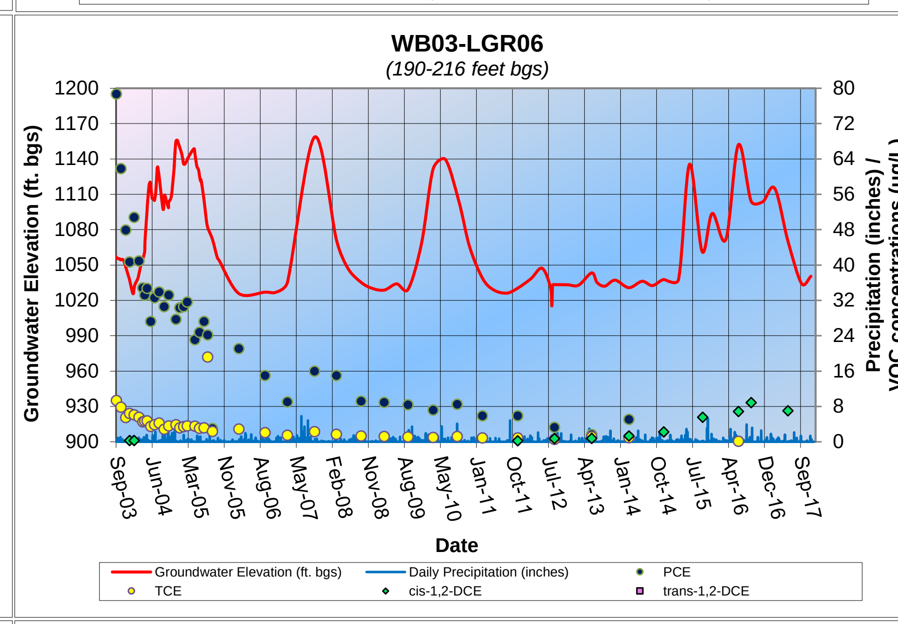
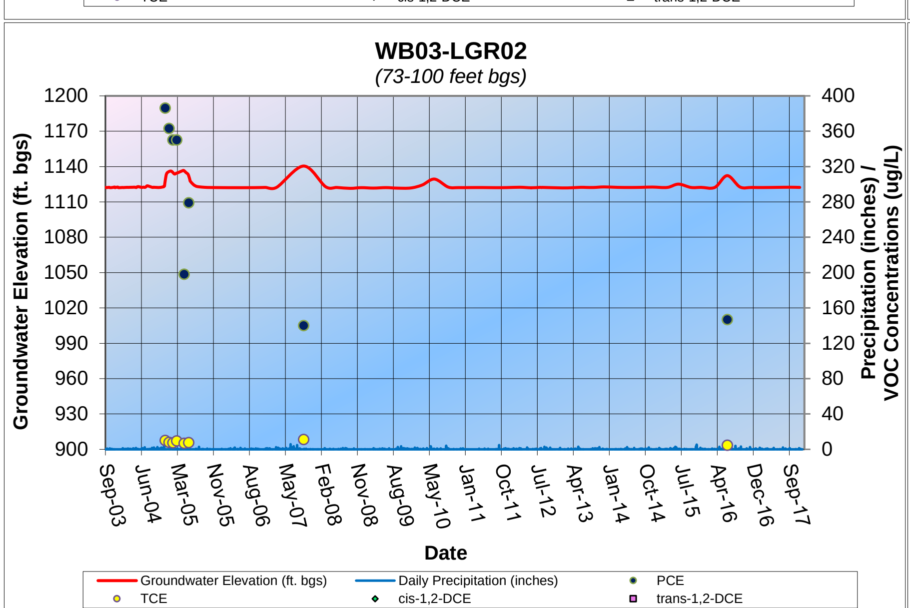
Appendix D.3 - CS-WB03 Culmulative VOC Concentrations, Groundwater Level, and Precipitation

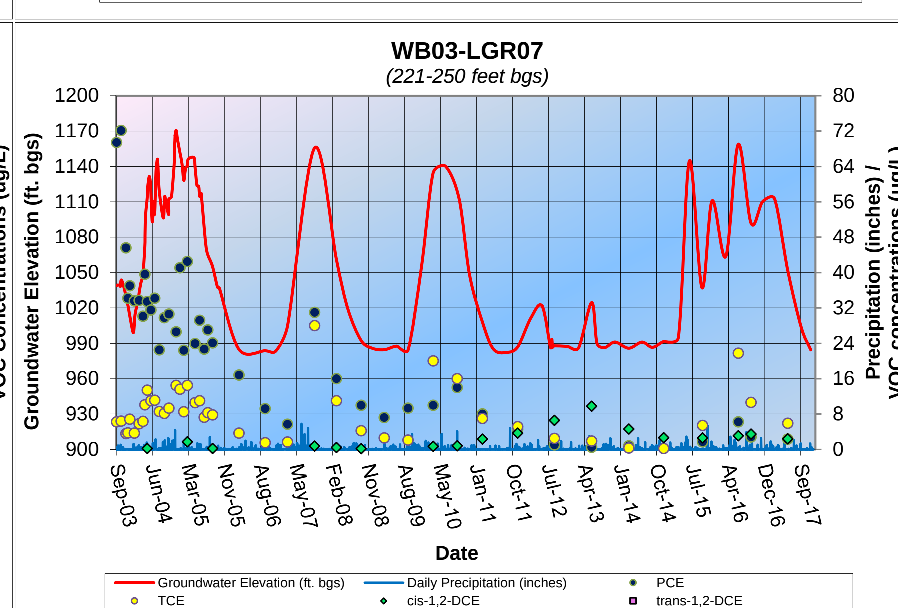


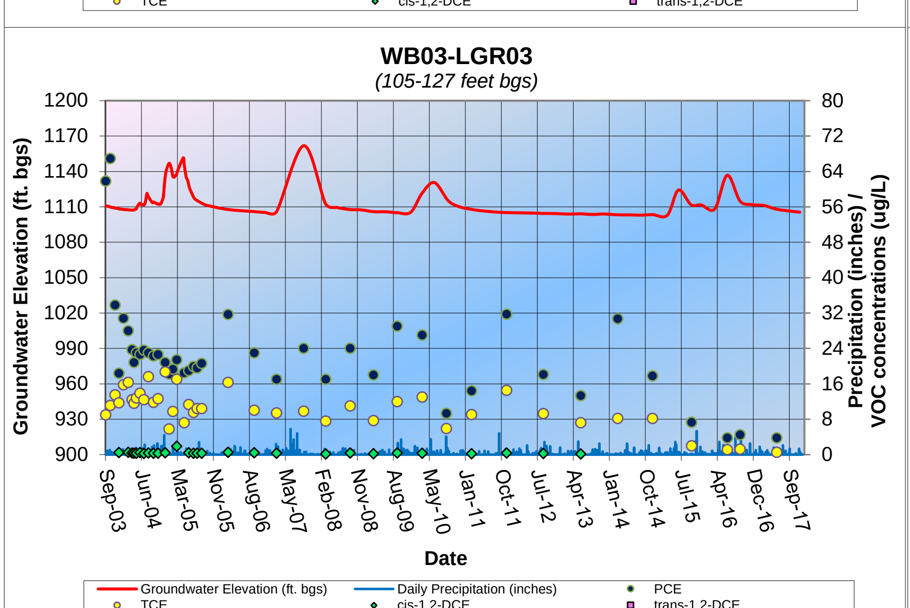


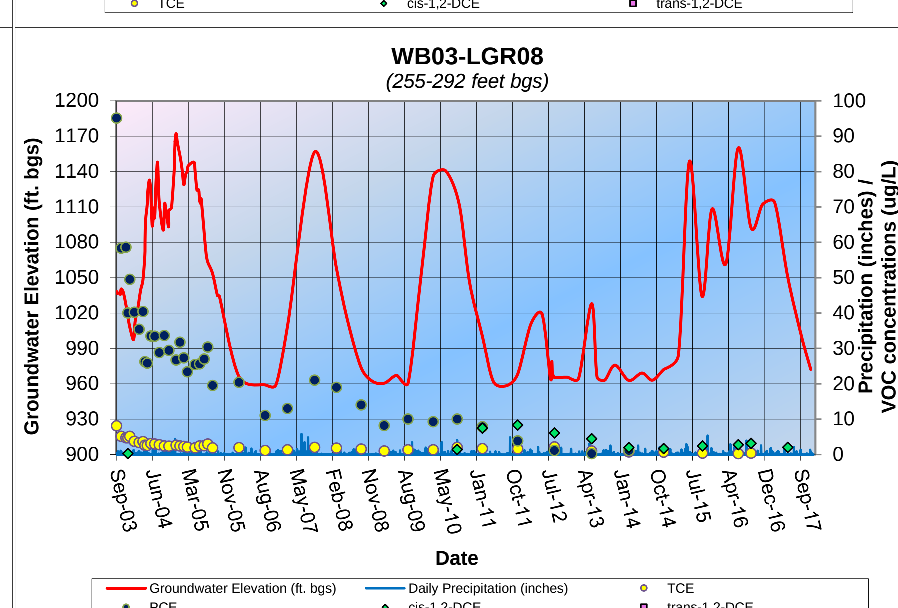


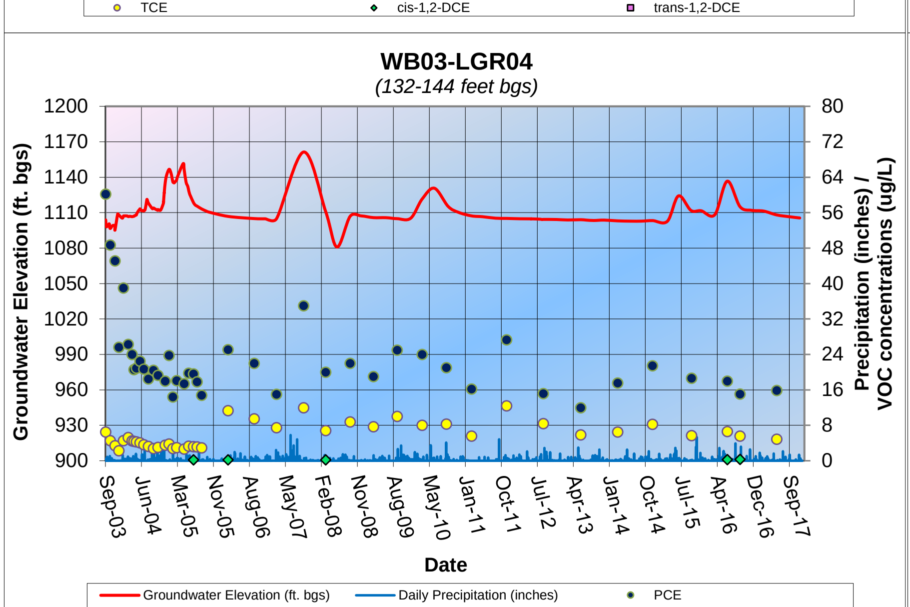


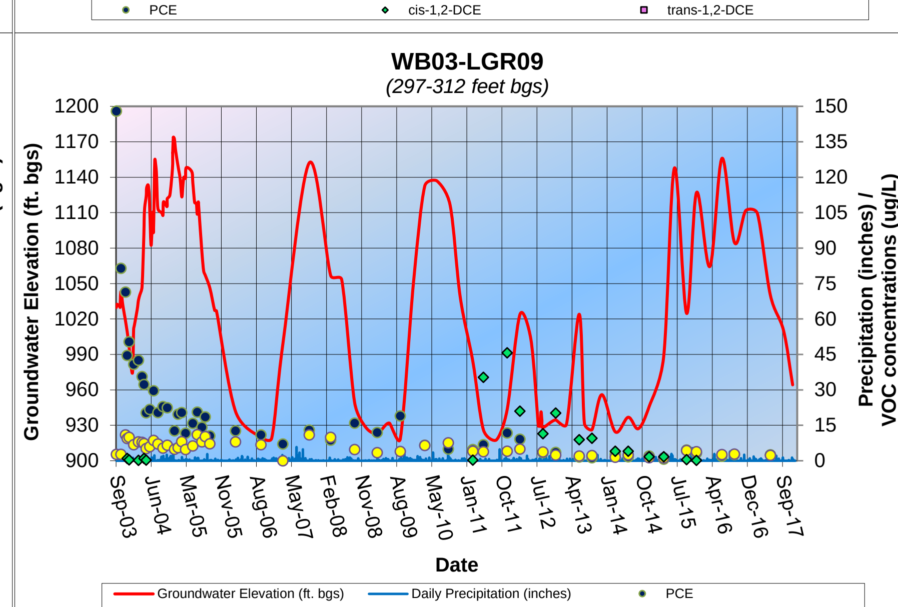




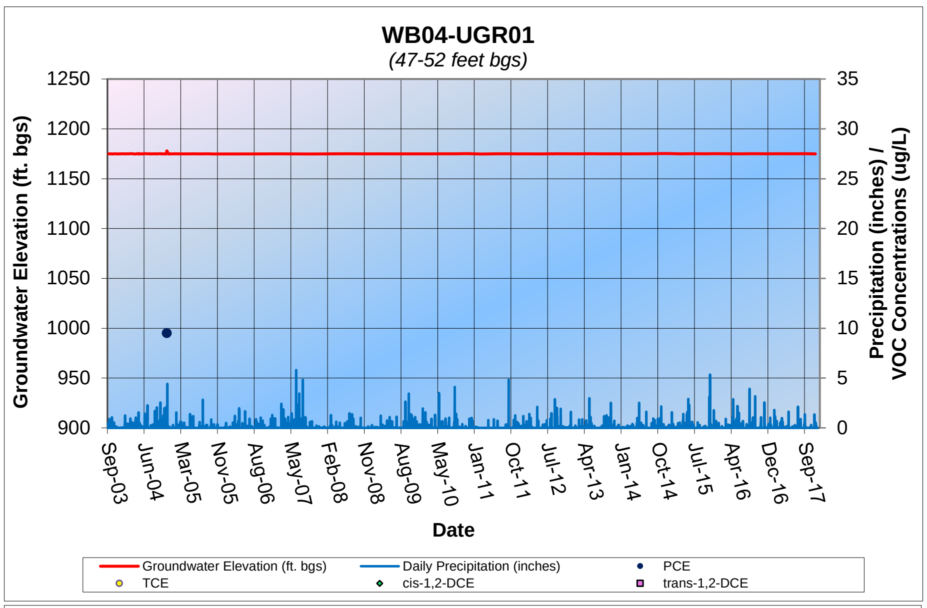


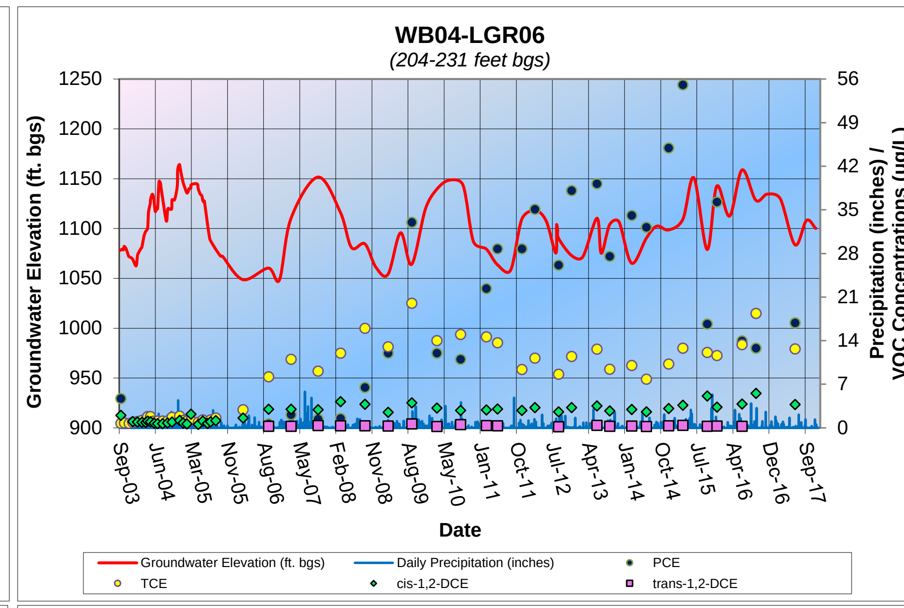


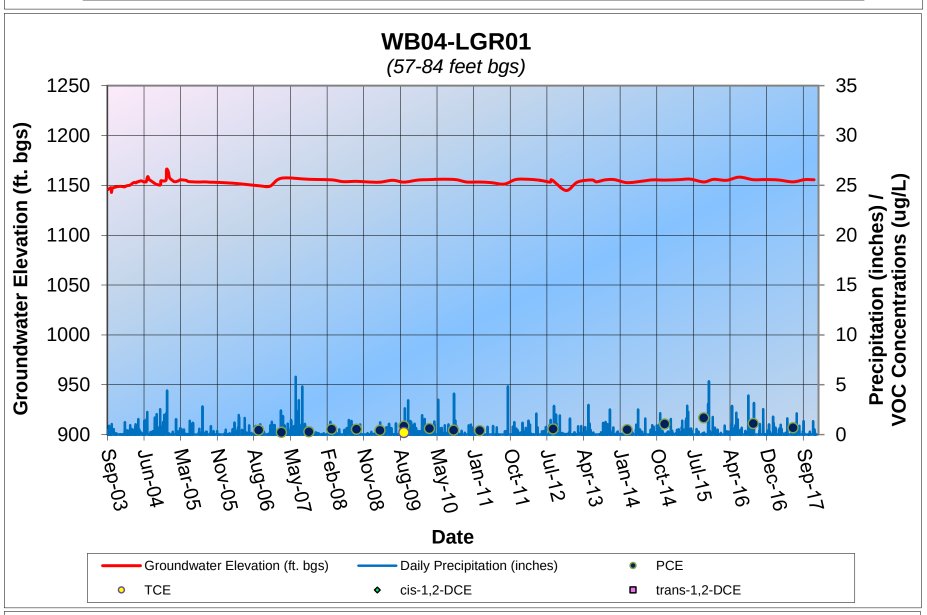


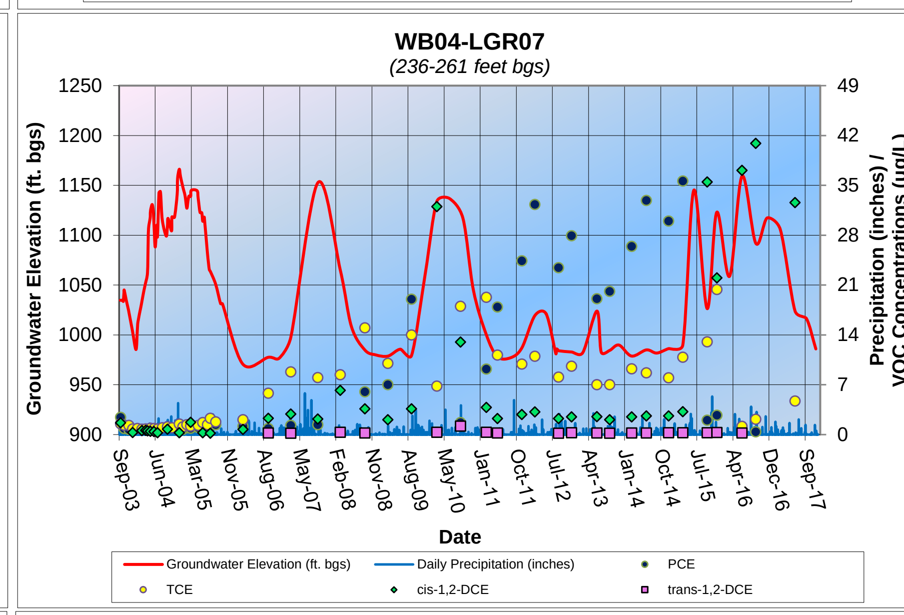


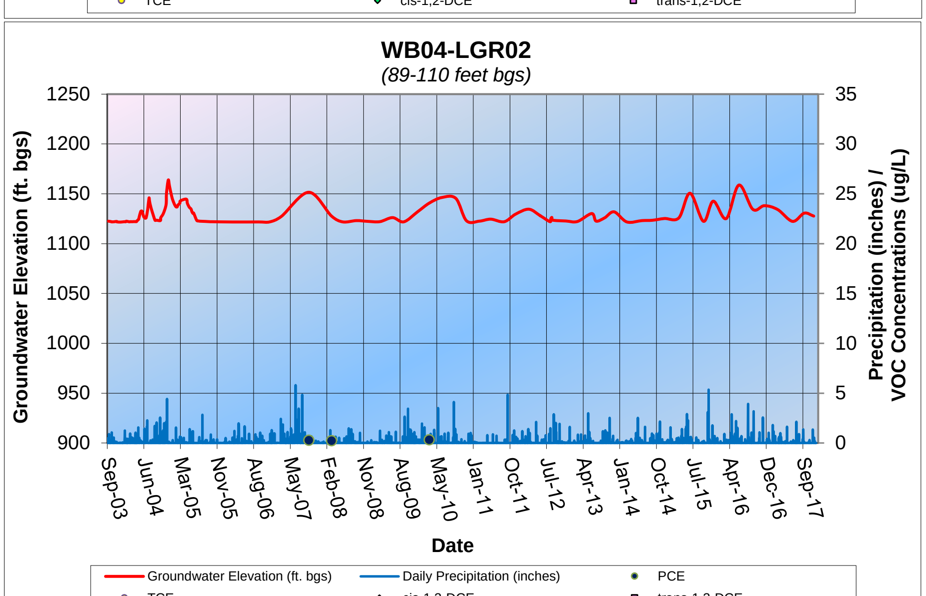
Appendix D.4 - CS-WB04 Culmulative VOC Concentrations, Groundwater Level, and Precipitation

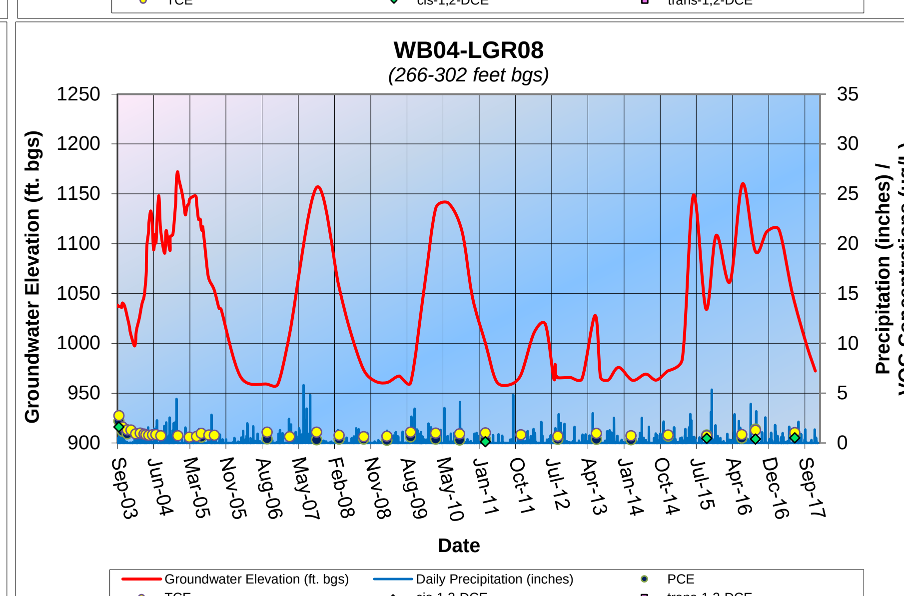


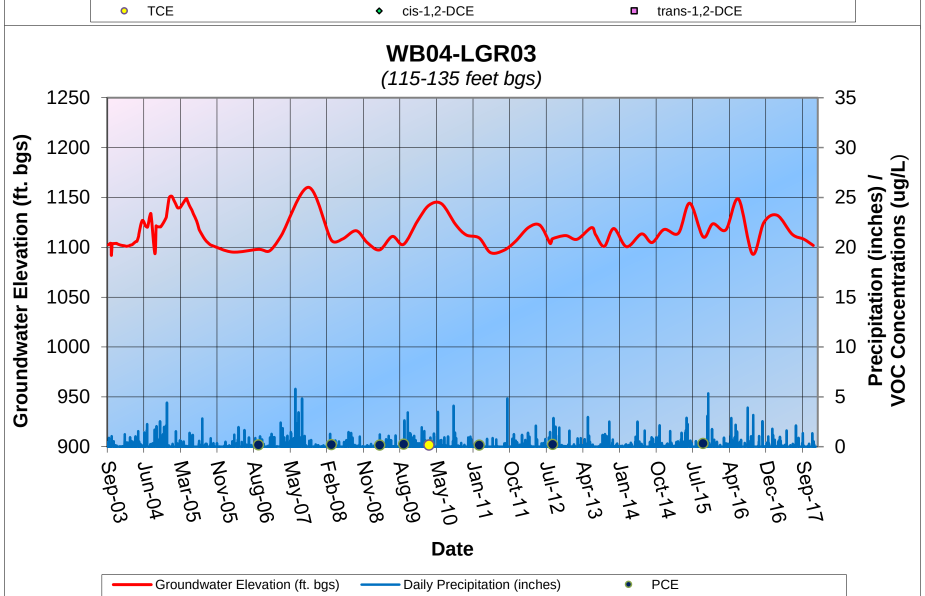


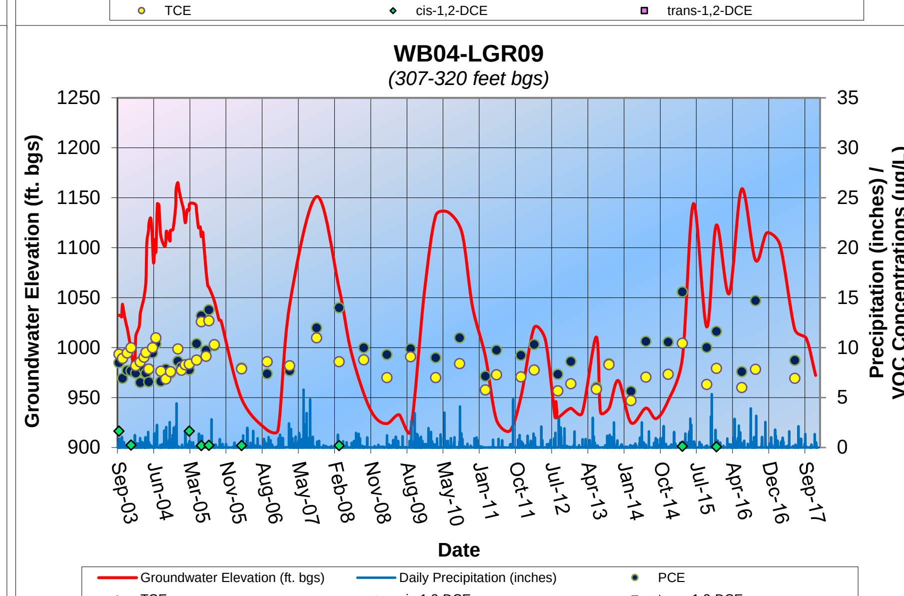


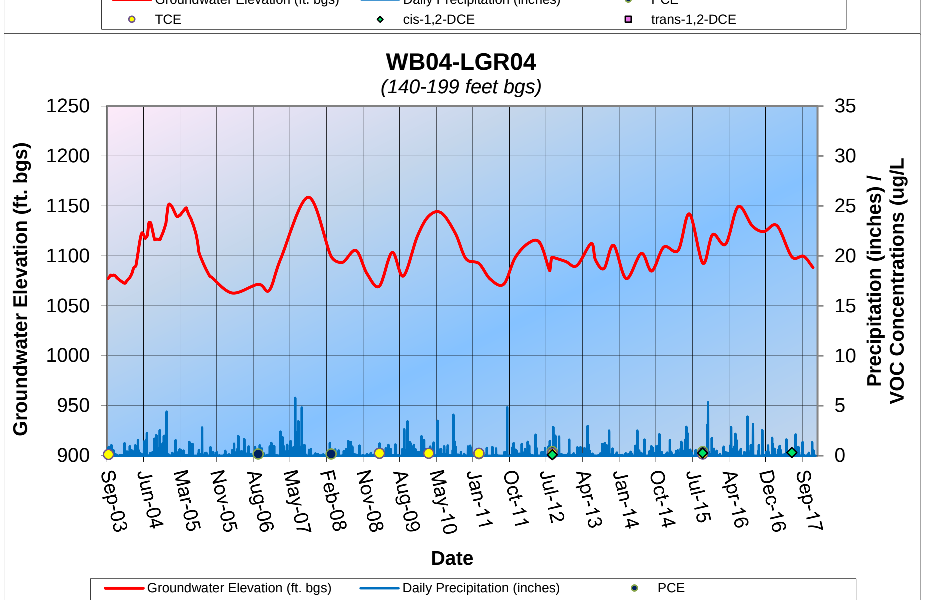


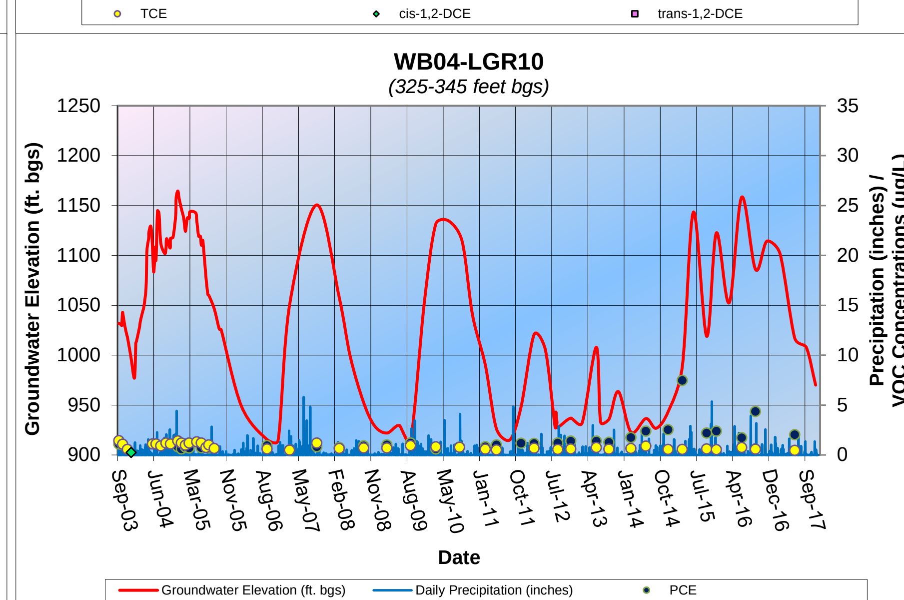




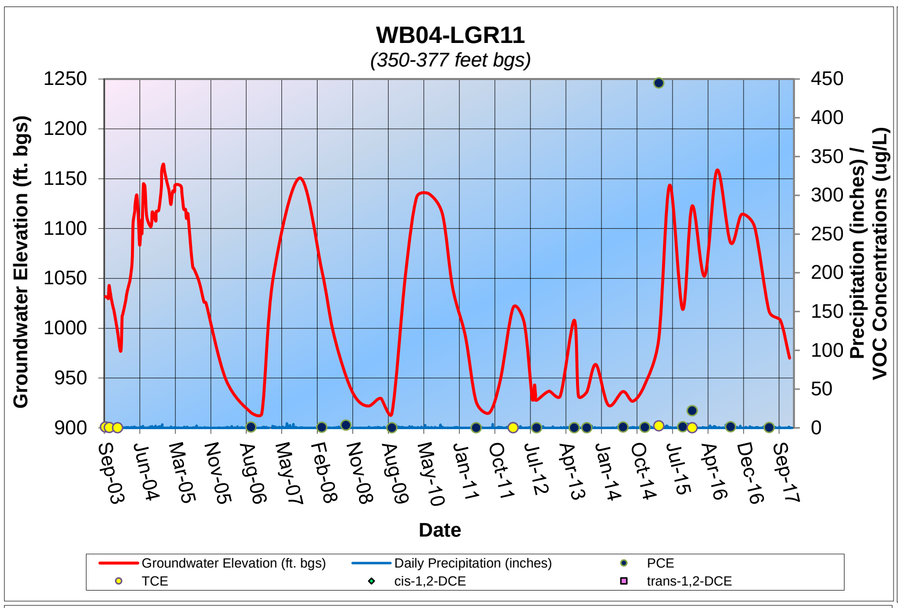


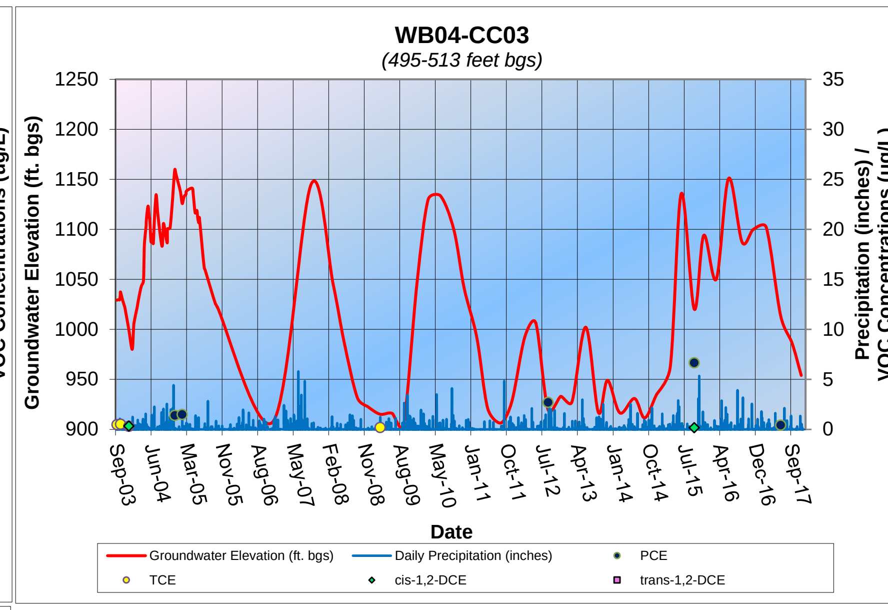


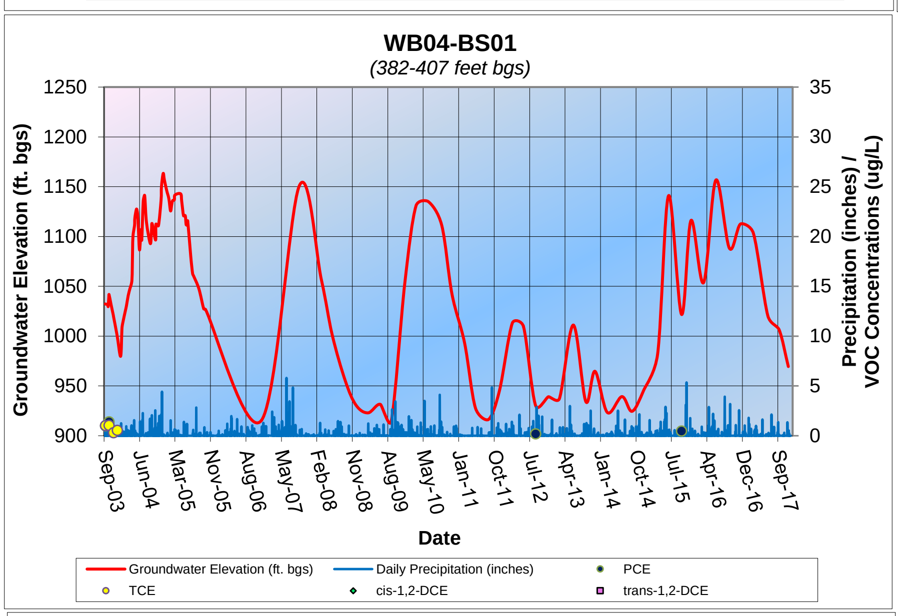


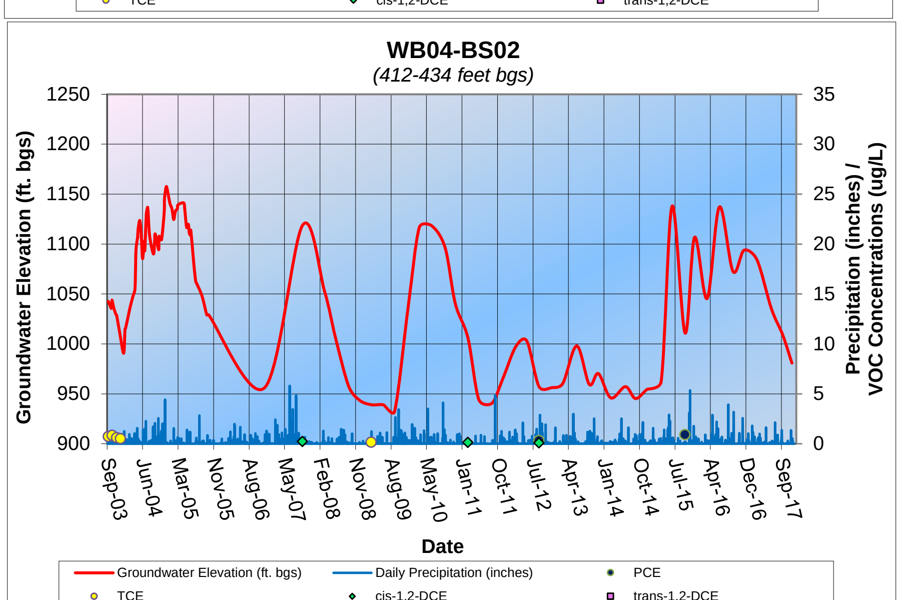


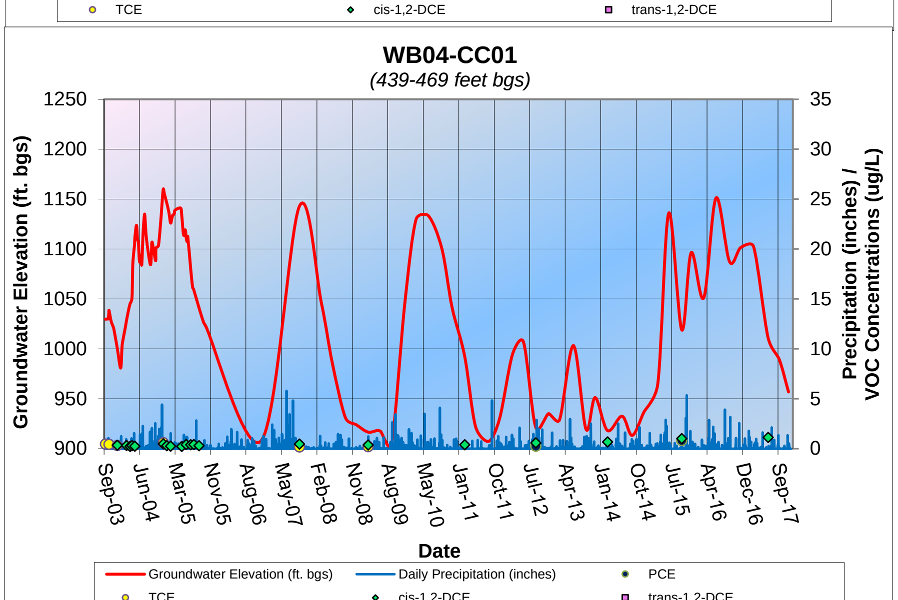
Appendix D.4 - CS-WB04 Culmulative VOC Concentrations, Groundwater Level, and Precipitation

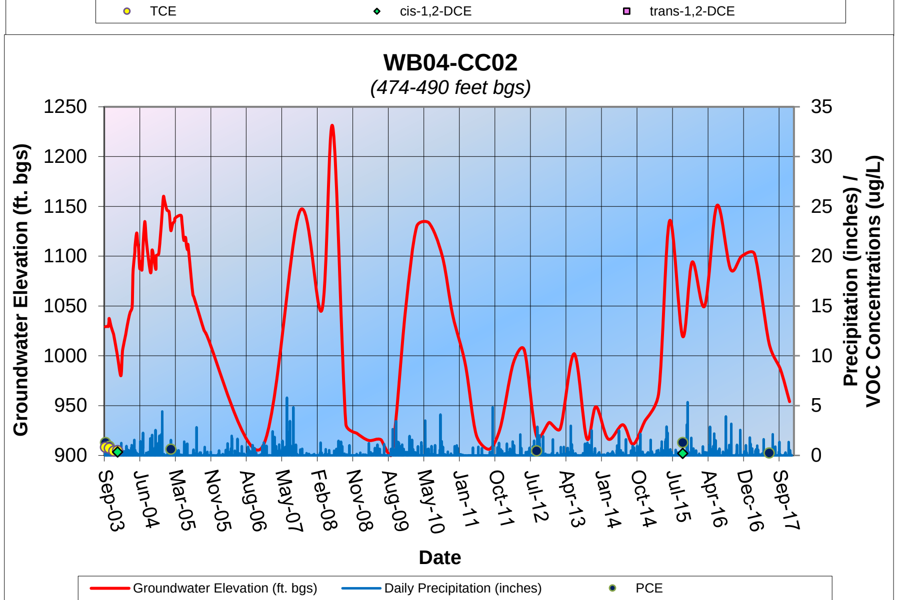






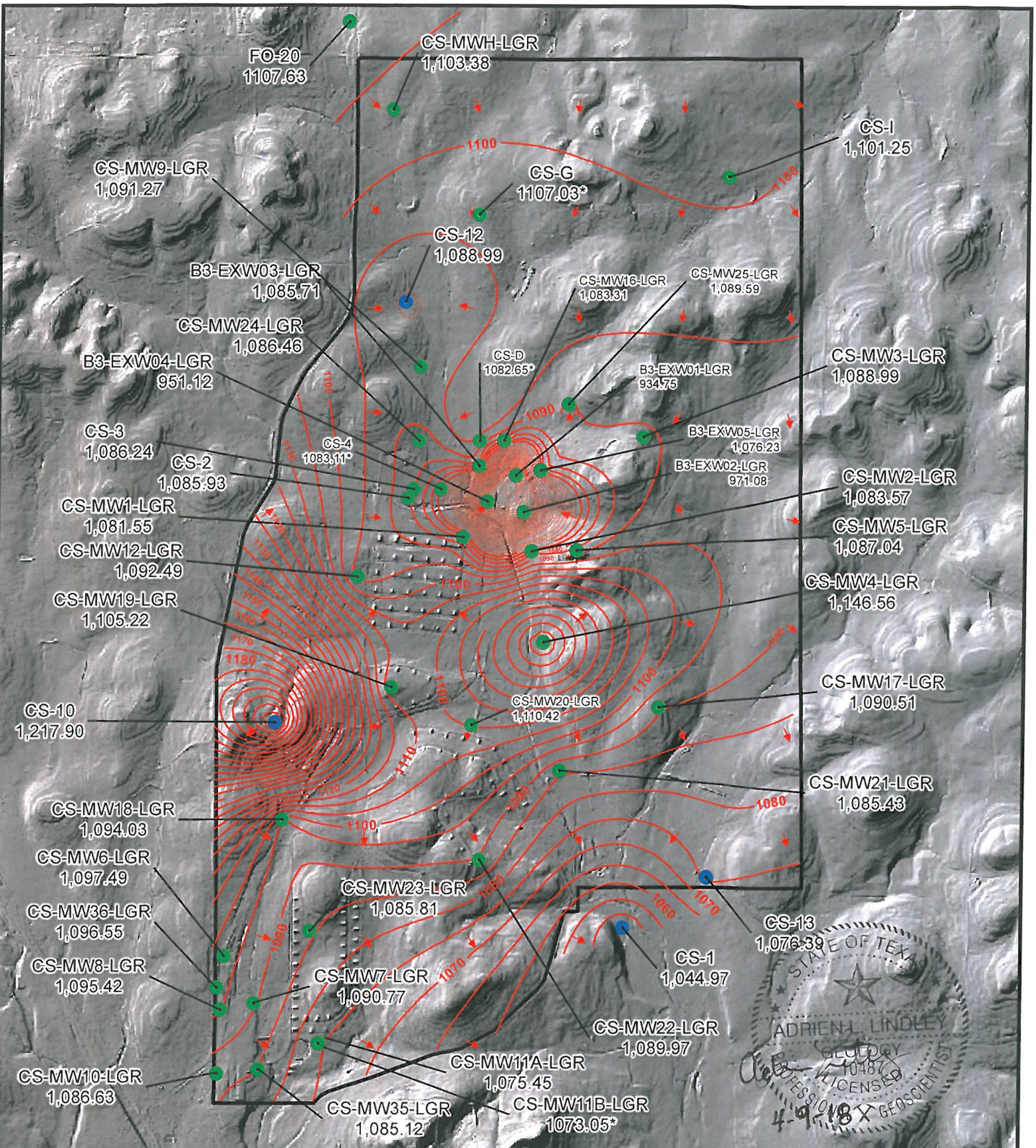






APPENDIX E

POTENTIOMETRIC MAPS FOR MARCH, JUNE, SEPTEMBER, DECEMBER 2017



N

0 — 0.5 Miles

Flow direction

Outer fence

LGR Groundwater Contours

LGR Wells and groundwater elevation (ft above msl)

Drinking water wells (may be completed in LGR, BS, and/or CC)

* Not a fully penetrating well into LGR. Groundwater elevation not used in contouring

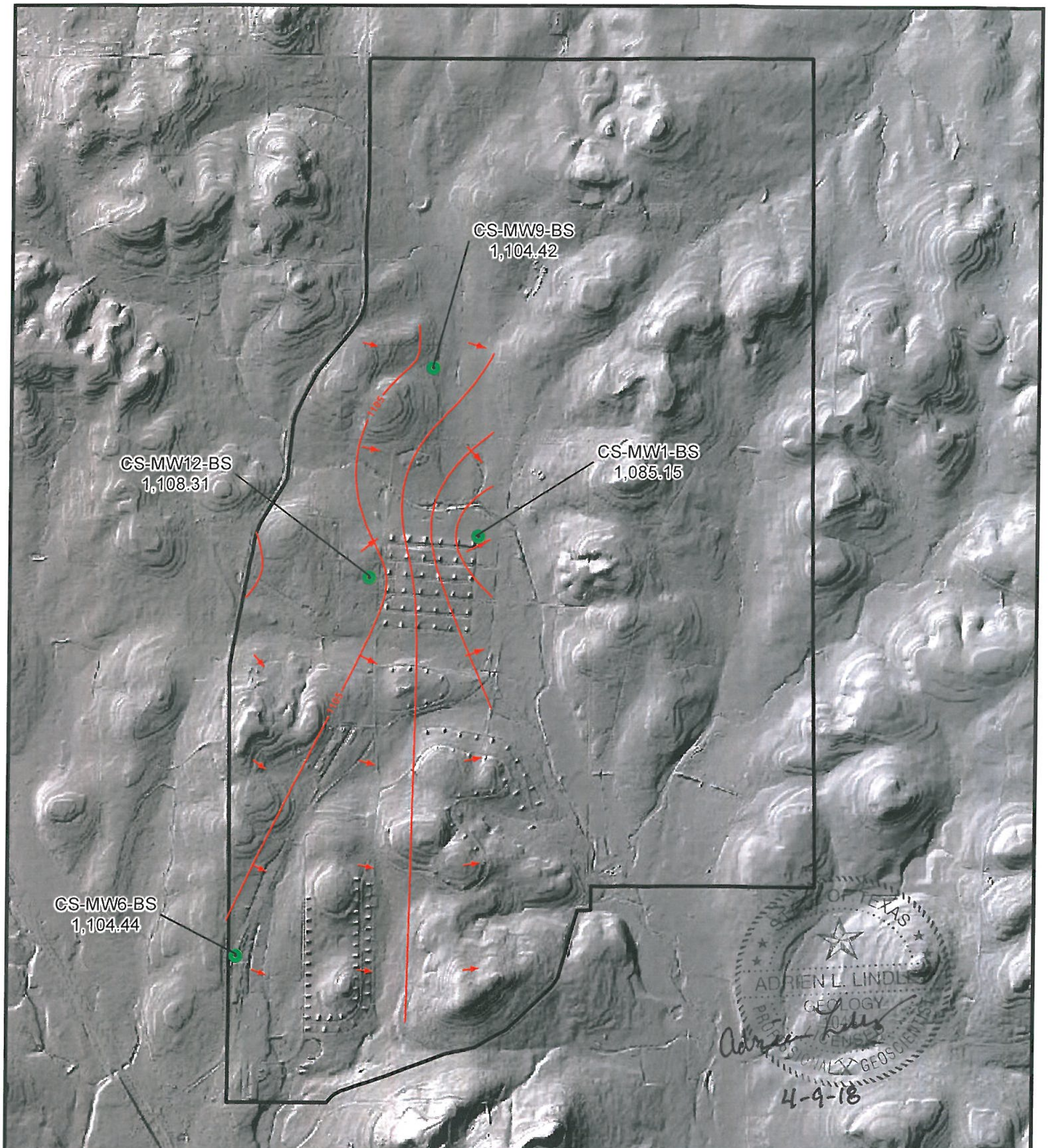
C:\CSSA\GIS\GW_POTENTIOMETRIC\MAR2017\Mar17_potentiometric_lgr.mxd - 8/15/2017 @ 9:50:33 AM

Figure E.1

March 2017 Potentiometric Surface Map, LGR Wells

Camp Stanley Storage Activity

PARSONS



N

0 0.5 Miles

- Flow direction
- Outer fence
- BS Groundwater Contours
- BS Wells and groundwater elevation (ft above msl)

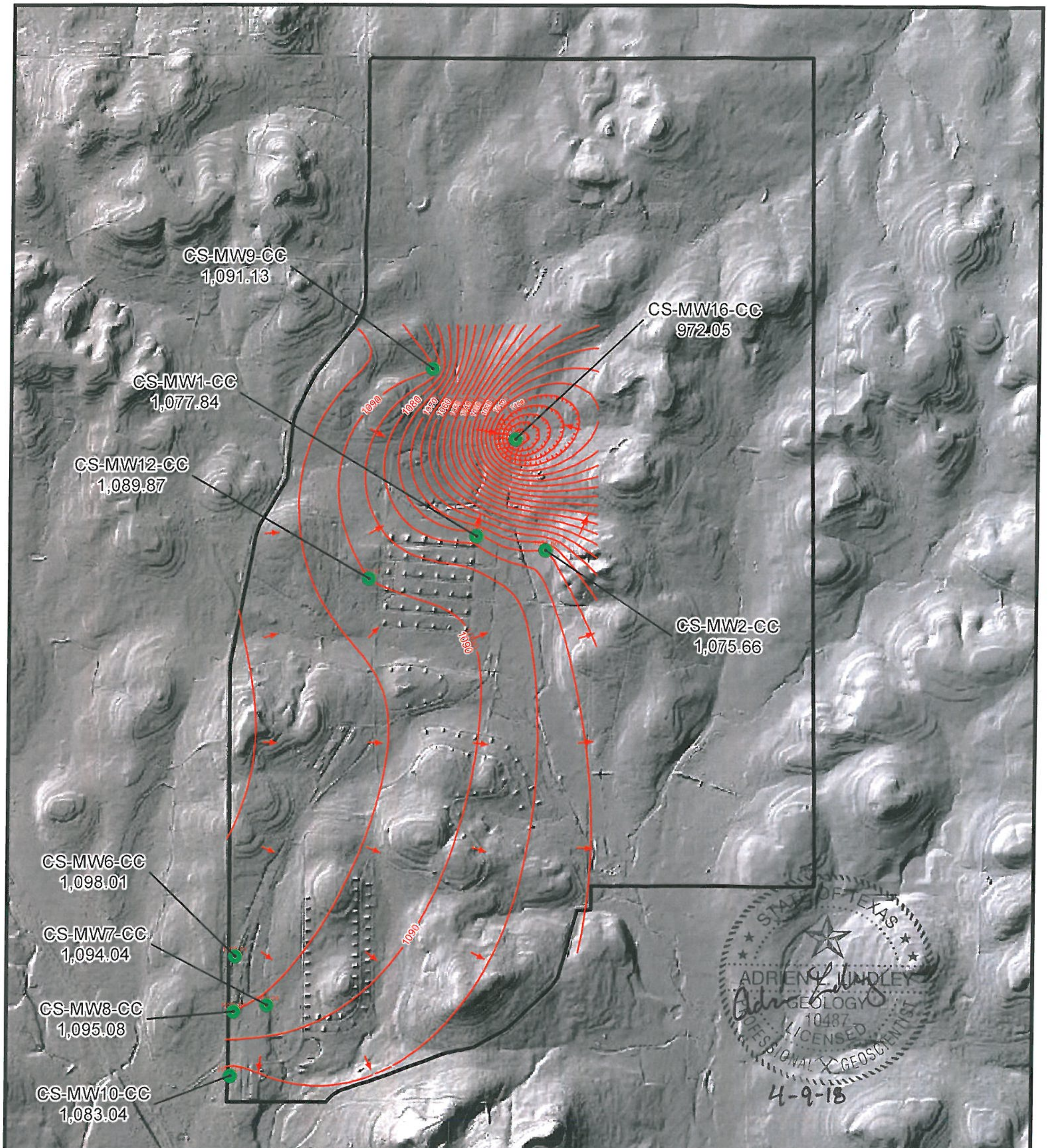
Figure E.2

March 2017 Potentiometric Surface Map, BS Wells

Camp Stanley Storage Activity

PARSONS

C:\CSSA\GIS\GW_POTENTIOMETRIC\MAR2017\Mar17_potentiometric_bs.mxd - 8/15/2017 @ 11:48:58 AM



N

0 — 0.5 Miles

Flow direction

Outer fence

CC Groundwater Contours

CC Wells and groundwater elevation (ft above msl)

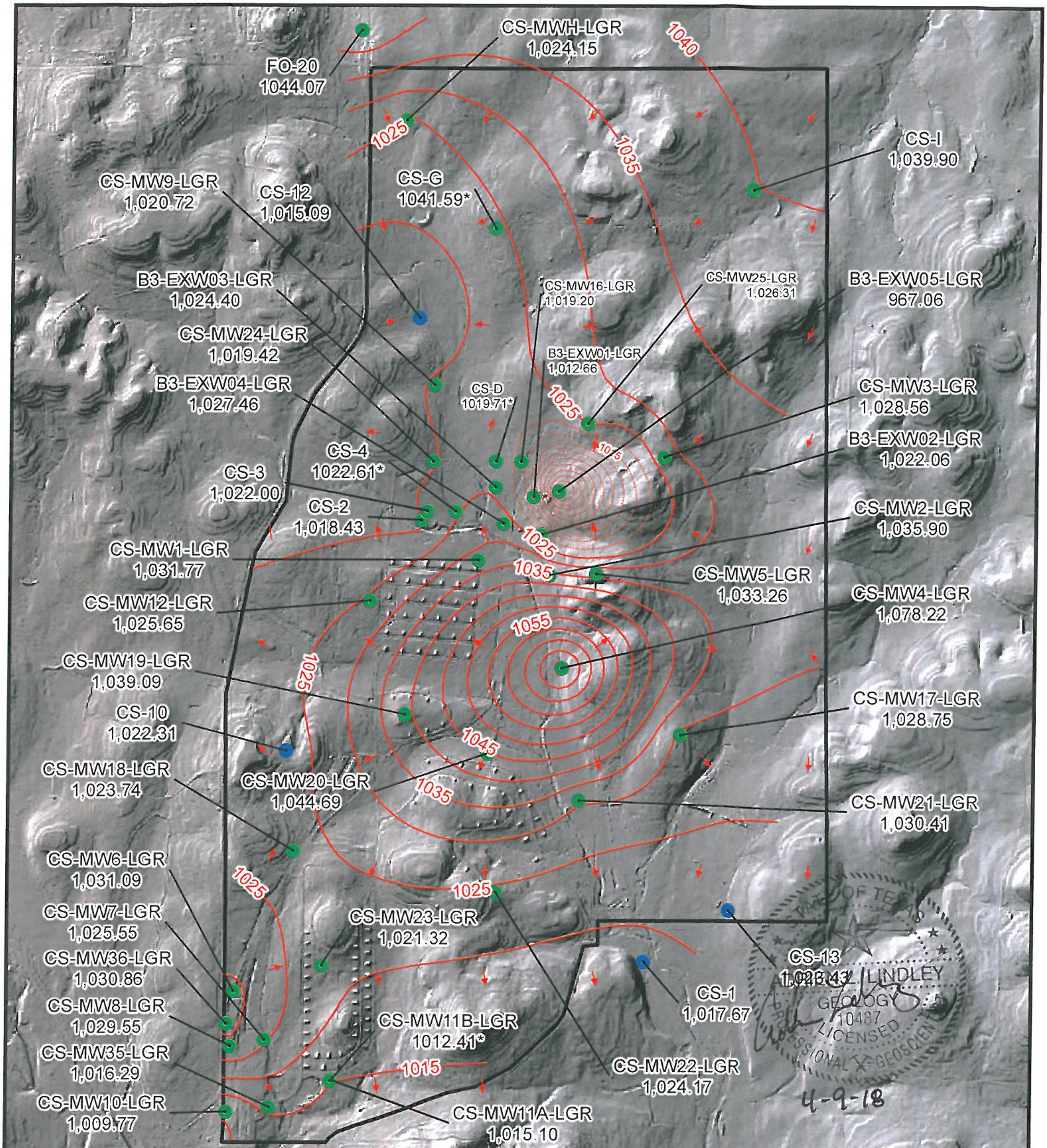
Figure E.3

March 2017 Potentiometric Surface Map, CC Wells

Camp Stanley Storage Activity

PARSONS

C:\CSSA\GIS\GW_POTENTIOMETRIC\MAR2017\Mar17_potentiometric_cc.mxd - 8/15/2017 @ 11:07:05 AM



N

0 0.5 Miles

Flow direction

Outer fence

LGR Groundwater Contours

LGR Wells and groundwater elevation (ft above msl)

Drinking water wells (may be completed in LGR, BS, and/or CC)

* Not a fully penetrating well into LGR. Groundwater elevation not used in contouring

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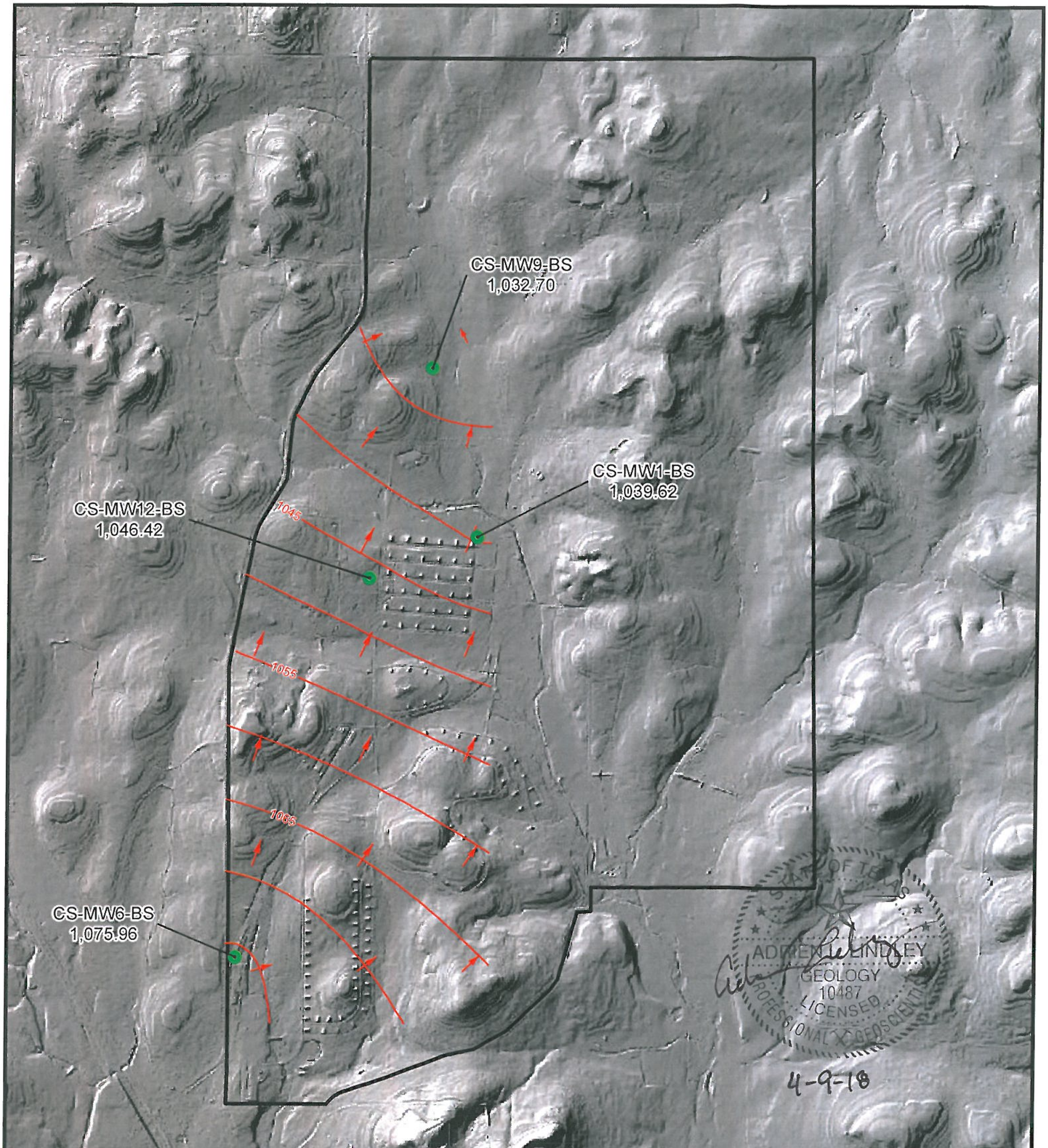
Figure E.4

June 2017 Potentiometric Surface Map, LGR Wells

Camp Stanley Storage Activity

PARSONS



N

0 0.5 Miles

Flow direction

Outer fence

BS Groundwater Contours

BS Wells and groundwater elevation (ft above msl)

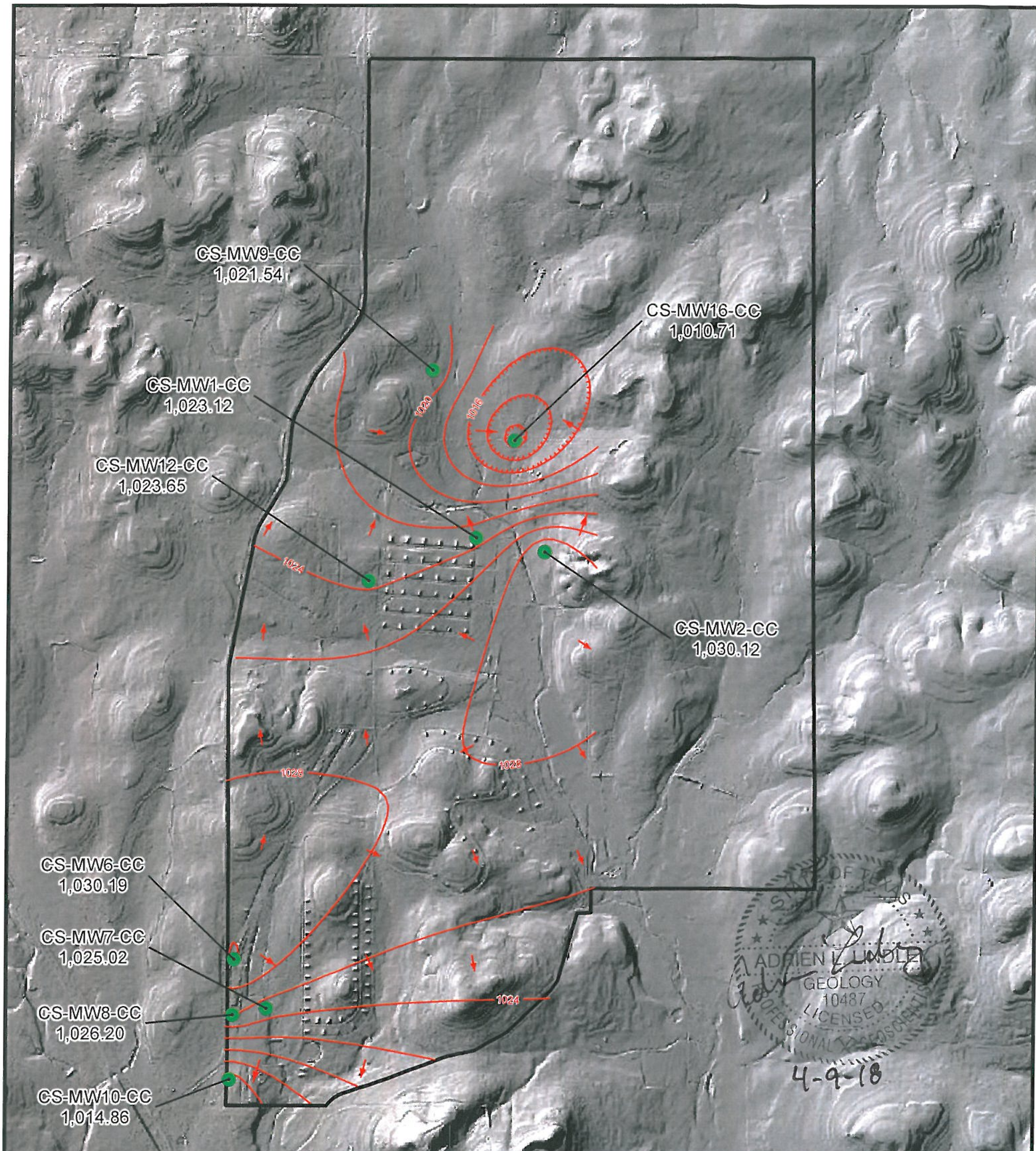
Figure E.5

June 2017 Potentiometric Surface Map, BS Wells

Camp Stanley Storage Activity

PARSONS

C:\CSSA\GIS\GW_POTENTIOMETRIC\JUN2017\Jun17_potentiometric_bs.mxd - 8/17/2017 @ 2:18:02 PM



N

0 0.5 Miles

Flow direction
Outer fence
CC Groundwater Contours
CC Wells and groundwater elevation (ft above msl)

Figure E.6

June 2017 Potentiometric Surface Map, CC Wells

Camp Stanley Storage Activity

PARSONS

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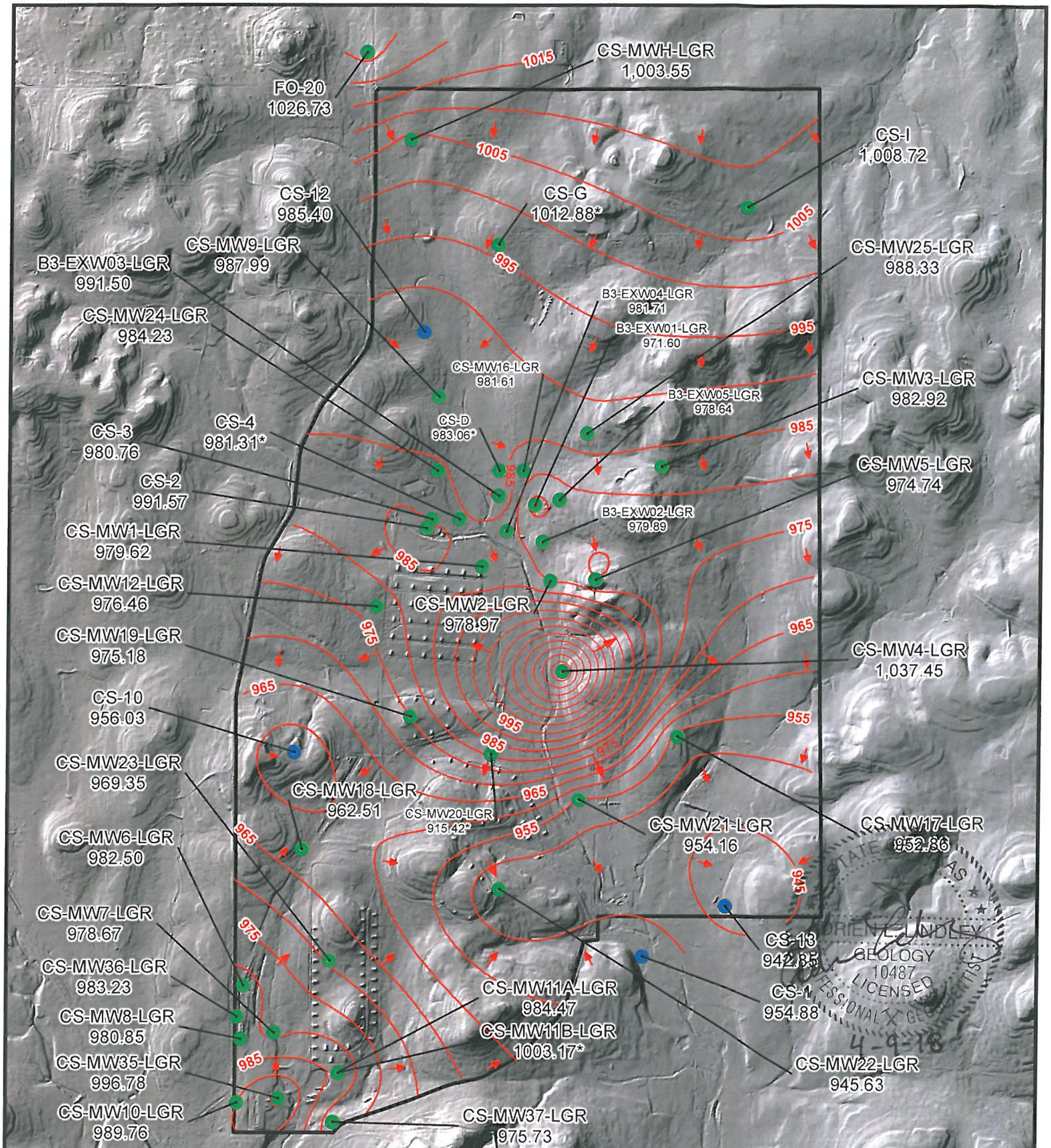

N

0 0.5 Miles

- Flow direction
- Outer fence
- LGR Groundwater Contours
- LGR Wells and groundwater elevation (ft above msl)
- Drinking water wells (may be completed in LGR, BS, and/or CC)

* Not a fully penetrating well into LGR. Groundwater elevation not used in contouring

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Figure E.7

September 2017 Potentiometric Surface Map, LGR Wells

Camp Stanley Storage Activity

PARSONS

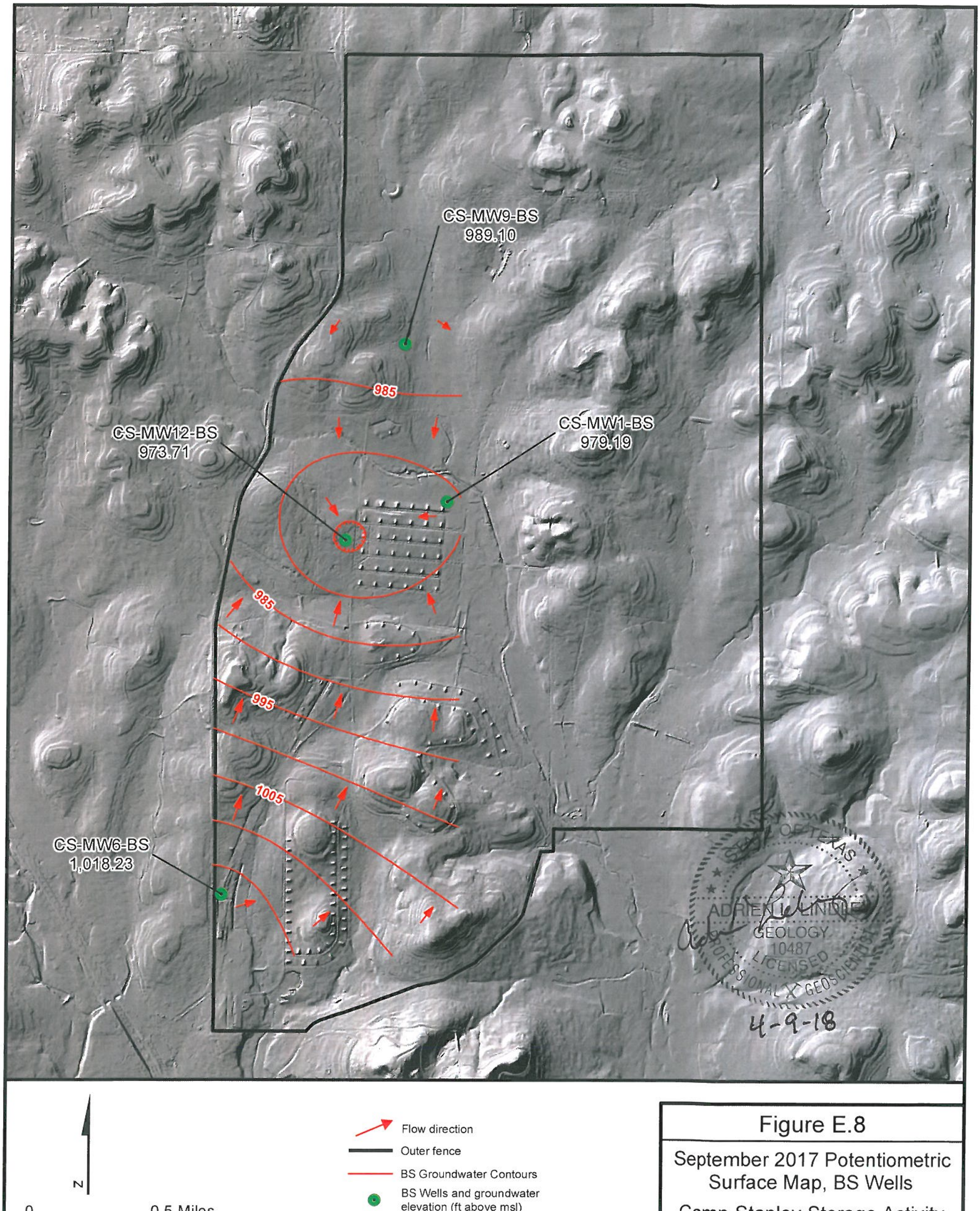

Figure E.8

September 2017 Potentiometric Surface Map, BS Wells

Camp Stanley Storage Activity

PARSONS

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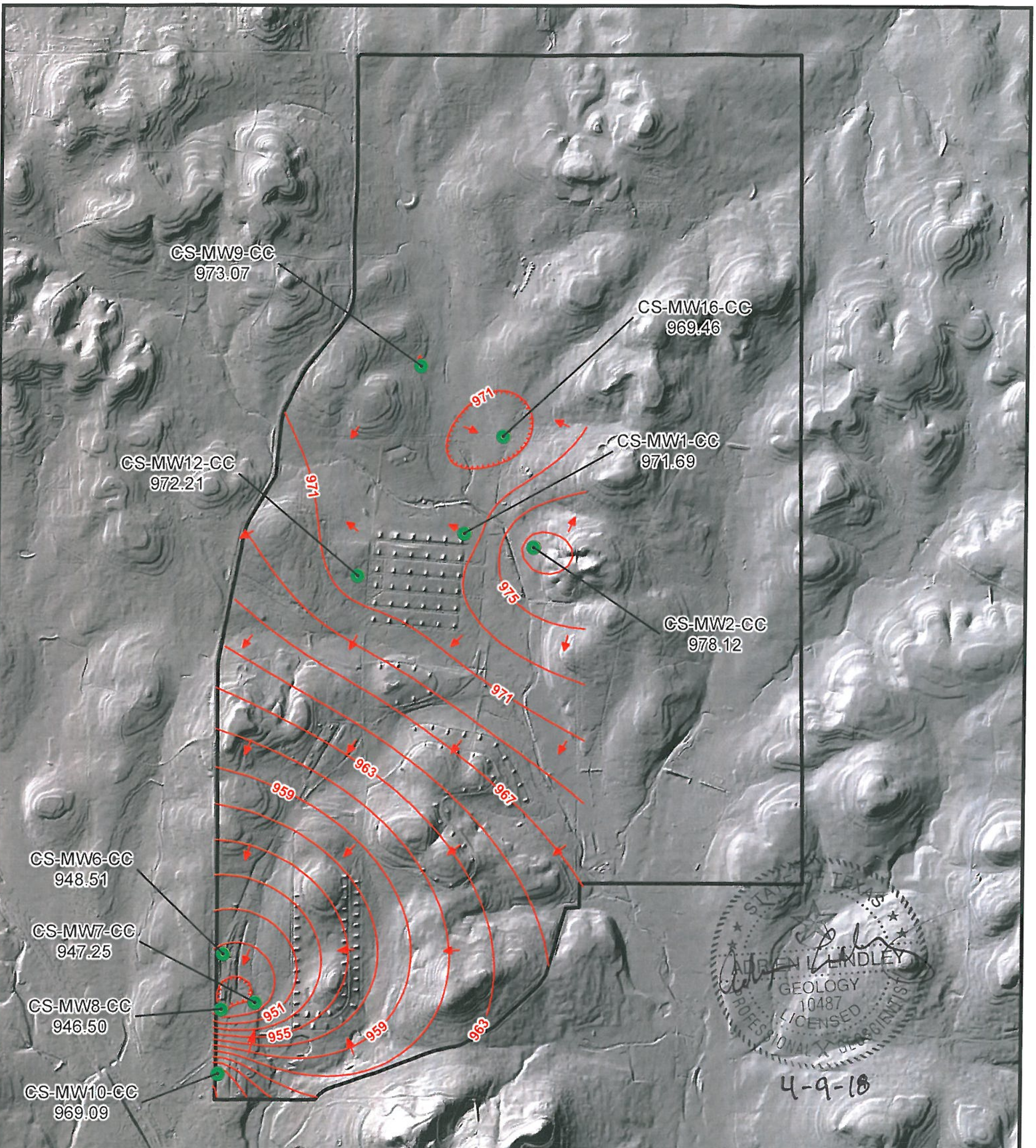


N

0 — 0.5 Miles

- Flow direction
- Outer fence
- CC Groundwater Contours
- CC Wells and groundwater elevation (ft above msl)

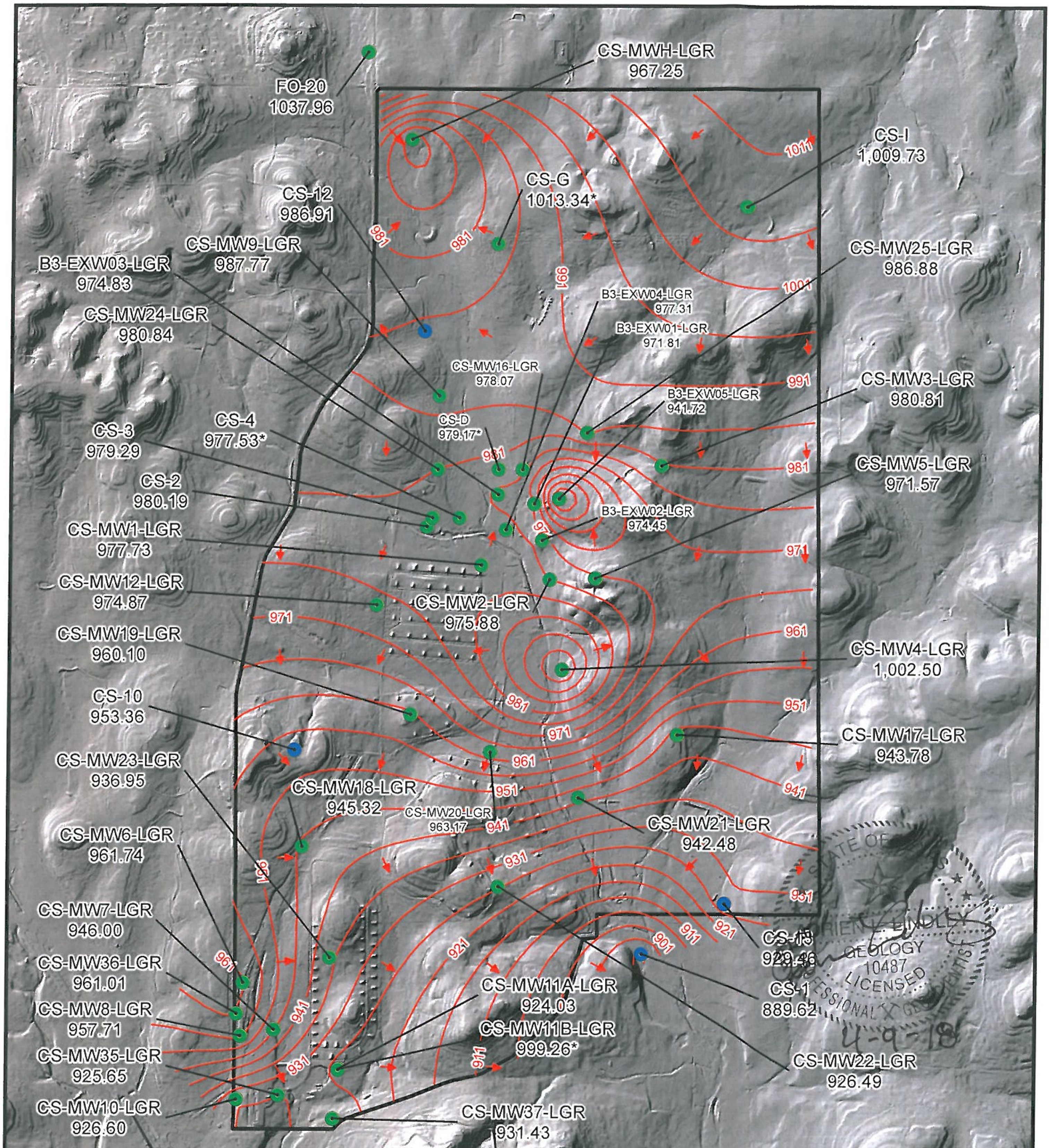
C:\CSSA\GIS\GW_POTENTIOMETRIC\SEP2017\Sep17_potentiometric_cc.mxd - 11/3/2017 @ 9:03:09 AM

Figure E.9

September 2017 Potentiometric Surface Map, CC Wells

Camp Stanley Storage Activity

PARSONS



Flow direction

Outer fence

LGR Groundwater Contours

LGR Wells and groundwater elevation (ft above msl)

Drinking water wells (may be completed in LGR, BS, and/or CC)

N

0 0.5 Miles

* Not a fully penetrating well into LGR. Groundwater elevation not used in contouring

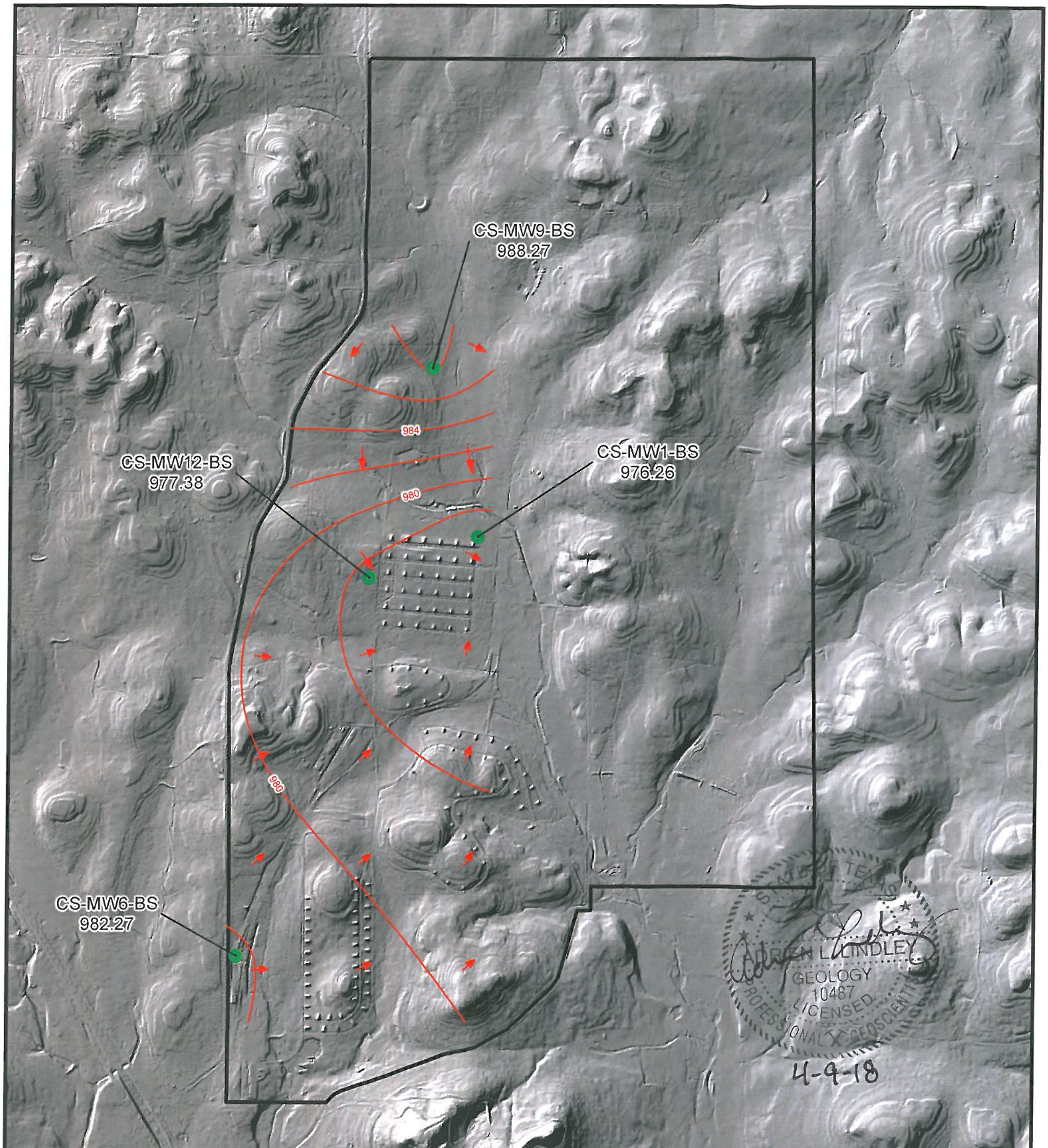
C:\CSSA\GIS\GW_POTENTIOMETRIC\DEC2017\Dec17_potentiometric_lgr.mxd - 1/9/2018 @ 8:23:56 AM

Figure E.10

December 2017 Potentiometric Surface Map, LGR Wells

Camp Stanley Storage Activity

PARSONS



N

0 0.5 Miles

Flow direction

Outer fence

BS Groundwater Contours

BS Wells and groundwater elevation (ft above msl)

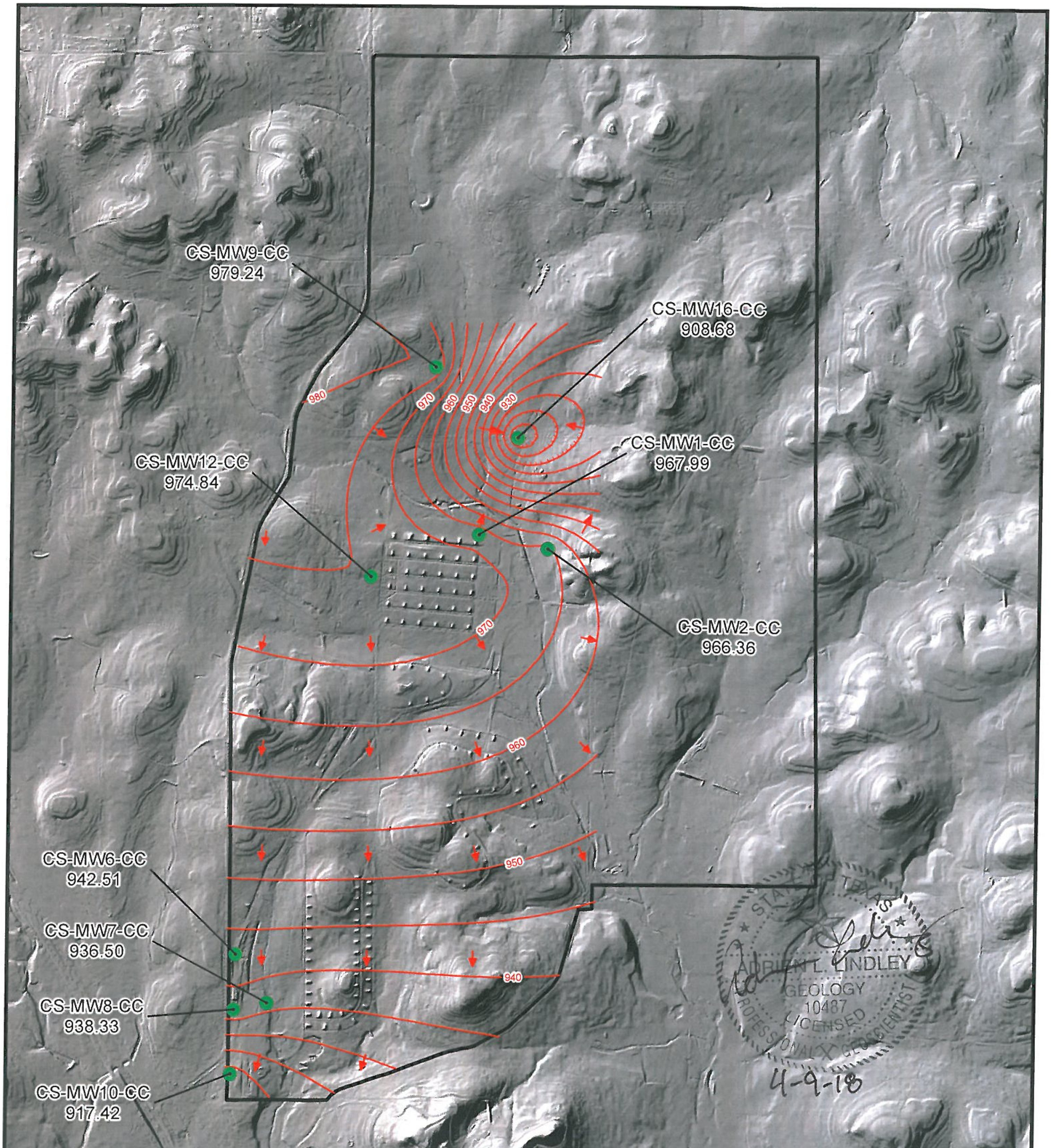
Figure E.11

December 2017 Potentiometric Surface Map, BS Wells

Camp Stanley Storage Activity

PARSONS

C:\CSSA\GIS\GW_POTENTIOMETRIC\DEC2017\Dec17_potentiometric_bs.mxd - 1/9/2018 @ 9:11:25 AM



N

0 0.5 Miles

Flow direction

Outer fence

CC Groundwater Contours

CC Wells and groundwater elevation (ft above msl)

Figure E.12

December 2017 Potentiometric Surface Map, CC Wells

Camp Stanley Storage Activity

PARSONS

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APPENDIX F

2017 QUARTERLY OFF-POST GROUNDWATER ANALYTICAL RESULTS

Appendix F
2017 Quarterly Off-Post Groundwater Monitoring Analytical Results

Well ID	Analytical Method	Sample Date	*cis*-1,2-Dichloro-ethene (ug/L)	Tetra-chloroethene (ug/L)	Trichloro-ethene (ug/L)	Vinyl chloride (ug/L)	pH	Temperature (°C)	Specific Conductivity (mS)
BSR-04	SW8260B	6/7/2017	0.07U	0.06U	0.05U	0.08U	6.88	21.96	0.812
	SW8260B	9/20/2017	0.07U	0.06U	0.05U	0.08U	6.77	21.96	0.808
FO-J1	SW8260B	6/27/2017	0.07U	0.06U	0.05U	0.08U	7.16	22.06	0.651
HS-1	SW8260B	6/7/2017	0.07U	0.06U	0.05U	0.08U	6.85	23.35	0.667
	SW8260B	9/20/2017	0.07U	0.06U	0.05U	0.08U	7.16	23.36	0.650
I10-8	SW8260B	6/7/2017	0.07U	0.06U	0.05U	0.08U	6.75	22.26	0.603
I10-10	SW8260B	6/7/2017	0.07U	0.06U	0.05U	0.08U	7.07	22.88	0.587
Duplicate	SW8260B	6/7/2017	0.07U	0.06U	0.05U	0.08U	7.07	22.88	0.587
JW-7	SW8260B	6/7/2017	0.07U	0.06U	0.05U	0.08U	6.75	21.24	0.588
JW-8	SW8260B	7/12/2017	0.07U	0.06U	0.05U	0.08U	6.94	22.56	0.576
JW-20	SW8260B	6/8/2017	0.07U	0.06U	0.05U	0.08U	7.15	21.29	0.660
LS-5	SW8260B	3/28/2017	0.07U	**1.18F**	**2.24**	0.08U	6.81	22.58	0.651
	SW8260B	6/5/2017	0.07U	**1.07F**	**2.40**	0.08U	6.86	22.56	0.657
	SW8260B	9/21/2017	0.07U	**0.99F**	**2.85**	0.08U	6.87	22.52	0.640
	SW8260B	12/4/2017	0.07U	0.06U	**2.84**	0.08U	6.89	22.54	0.650
LS-5-A2	SW8260B	3/28/2017	0.07U	0.06U	0.05U	0.08U			
	SW8260B	9/21/2017	0.07U	0.06U	0.05U	0.08U			
LS-6	SW8260B	3/28/2017	0.07U	**0.84F**	0.05U	0.08U	6.64	22.29	0.763
	SW8260B	6/5/2017	0.07U	**0.80F**	**0.52F**	0.08U	6.66	22.45	0.741
	SW8260B	9/21/2017	0.07U	0.06U	**1.65**	0.08U	6.79	21.85	0.685
	SW8260B	12/4/2017	0.07U	0.06U	**1.39**	0.08U	6.78	22.44	0.676
LS-6-A2	SW8260B	3/28/2017	0.07U	0.06U	0.05U	0.08U			
	SW8260B	9/21/2017	0.07U	0.06U	0.05U	0.08U			
LS-7	SW8260B	3/28/2017	0.07U	**1.11F**	**0.25F**	0.08U	6.68	22.45	0.712
	SW8260B	6/5/2017	0.07U	**1.14F**	0.05U	0.08U	6.74	22.74	0.687
	SW8260B	9/21/2017	0.07U	**1.60**	**0.50F**	0.08U	6.76	22.81	0.660
Duplicate	SW8260B	9/21/2017	0.07U	**1.79**	0.05U	0.08U	6.76	22.81	0.660
	SW8260B	12/4/2017	0.07U	**1.06F**	**0.20F**	0.08U	6.78	22.74	0.670
LS-7-A2	SW8260B	3/28/2017	0.07U	0.06U	0.05U	0.08U			
	SW8260B	9/21/2017	0.07U	0.06U	0.05U	0.08U			
OFR-3	SW8260B	3/28/2017	0.07U	**6.98**	**3.58**	0.08U	6.90	24.08	0.582
	SW8260B	6/5/2017	0.07U	**6.29**	**3.62**	0.08U	6.87	25.08	0.603
	SW8260B	9/27/2017	0.07U	**3.69**	**2.06**	0.08U	6.95	24.33	0.790
	SW8260B	12/4/2017	0.07U	0.06U	**0.75F**	0.08U	6.94	22.57	0.576
OFR-3-A2	SW8260B	3/28/2017	0.07U	0.06U	0.05U	0.08U			
	SW8260B	9/27/2017	0.07U	0.06U	0.05U	0.08U			
RFR-10	SW8260B	3/28/2017	**0.37F**	**9.49**	**4.55**	0.08U	7.10	22.88	0.678
Duplicate	SW8260B	3/28/2017	**0.37F**	**8.46**	**4.14**	0.08U	7.10	22.88	0.678
	SW8260B	6/5/2017	0.07U	**9.67**	**5.30**	0.08U	7.03	22.64	0.644
	SW8260B	9/21/2017	**0.35F**	**17.63**	**11.03**	0.08U	6.88	22.70	0.633
	SW8260B	12/4/2017	0.07U	**7.47**	**5.03**	0.08U	6.65	21.80	0.702
RFR-10-A2	SW8260B	3/28/2017	0.07U	0.06U	0.05U	0.08U			
	SW8260B	9/21/2017	0.07U	0.06U	0.05U	0.08U			
RFR-10-B2	SW8260B	3/28/2017	0.07U	0.06U	0.05U	0.08U			
	SW8260B	9/21/2017	0.07U	0.06U	0.05U	0.08U			
RFR-11	SW8260B	3/28/2017	0.07U	**1.10F**	**1.82**	0.08U	6.85	22.75	0.659
	SW8260B	6/5/2017	0.07U	**0.87F**	**1.63**	0.08U	6.84	22.77	0.678
	SW8260B	9/21/2017	0.07U	**0.68F**	**2.12**	0.08U	6.92	22.85	0.616
	SW8260B	12/4/2017	0.07U	0.06U	**1.87**	0.08U	6.94	22.79	0.597
RFR-10-A2	SW8260B	3/28/2017	0.07U	0.06U	0.05U	0.08U			
	SW8260B	9/21/2017	0.07U	0.06U	0.05U	0.08U			
RFR-12	SW8260B	6/7/2017	0.07U	0.06U	**0.69F**	0.80U	7.00	23.05	0.572
RFR-14	SW8260B	6/7/2017	0.07U	0.06U	0.05U	0.08U	6.98	23.59	0.559
Comparison Criteria									
Method Detection Limit (MDL)			**0.07**	**0.06**	**0.05**	**0.08**			
Reporing Limit (RL)			**1.2**	**1.4**	**1**	**1.1**			
Maximum Contaminant Level (MCL)			**70**	**5**	**5**	**2**			

BOLD	≥ MDL
BOLD	≥ RL
BOLD	≥ MCL

All samples were analyzed by APPL, Inc.
VOC data reported in ug/L.

Abbreviations/Notes:

Duplicate	Field Duplicate
TCE	Trichloroethene
PCE	Tetrachloroethene
DCE	Dichloroethene

APPENDIX G

PRE- AND POST-GAC SAMPLE COMPARISONS FOR WELLS LS-5, LS-6, LS-7, OFR-3, RFR-10, AND RFR-11

APPENDIX G

PRE- AND POST-GAC SAMPLE COMPARISONS FOR WELLS LS-5, LS-6, LS-7, RFR-10, RFR-11, AND OFR-3

LS-5					LS-6				
	PCE (μg/L)		TCE (μg/L)			PCE (μg/L)		TCE (μg/L)	
Date	Pre	Post	Pre	Post	Date	Pre	Post	Pre	Post
3/28/17	1.18F	ND	2.24	ND	3/28/17	0.84F	ND	ND	ND
6/5/17	1.07F	NA	2.40	NA	6/5/17	0.80F	NA	0.52F	NA
9/21/17	0.99F	ND	2.85	NA	9/21/17	ND	ND	1.65	ND
12/4/17	ND	NA	2.84	NA	12/4/17	ND	NA	1.39	NA

LS-7					RFR-10				
	PCE (μg/L)		TCE (μg/L)			PCE (μg/L)		TCE (μg/L)	
Date	Pre	Post	Pre	Post	Date	Pre	Post	Pre	Post
3/28/17	1.11F	ND	0.25F	ND	3/28/17	9.49	ND/ND	4.55	ND/ND
6/5/17	1.14F	NA	ND	NA	3/28/17 FD	8.46	NA	4.14	NA
9/21/17	1.60	ND	0.50F	ND	6/5/17	9.67	NA	5.30	NA
9/21/17 FD	1.79	NA	ND	NA	9/21/17	17.63	ND/ND	11.03	ND/ND
12/4/17	1.06F	NA	0.20F	NA	12/4/17	7.47	NA	5.03	NA

RFR-11					OFR-3				
	PCE (μg/L)		TCE (μg/L)			PCE (μg/L)		TCE (μg/L)	
Date	Pre	Post	Pre	Post	Date	Pre	Post	Pre	Post
3/28/17	1.10F	ND	1.82	ND	3/28/17	6.98	ND	3.58	ND
6/5/17	0.87F	NA	1.63	NA	6/5/17	6.29	NA	3.62	NA
9/21/17	0.68F	ND	2.12	ND	9/21/17	3.69	ND	2.06	ND
12/4/17	ND	NA	1.87	NA	12/4/17	ND	NA	0.75F	NA

NA – not applicable (post-GAC not sampled during this event)
ND – indicates analyte was not detected at or above the MDL.
FD – field duplicate.

APPENDIX H

DECEMBER 2017
DATA VERIFICATION REPORTS

SDG 84431
SDG 84469

DATA VERIFICATION SUMMARY REPORT

for off-post samples collected from

CAMP STANLEY STORAGE ACTIVITY

BOERNE, TEXAS

Data Verification by: Tammy Chang
Parsons - Austin

INTRODUCTION

The following data verification summary report covers six groundwater samples and the associated field quality control (QC) sample collected from off-post Camp Stanley Storage Activity (CSSA) on December 4, 2017. The samples were assigned to the following Sample Delivery Group (SDG). All samples were analyzed for volatile organic compounds (VOCs).

84431

The field QC sample associated with this SDG was one trip blank (TB) sample. No ambient blanks were collected. During the initiation of this project, it was determined that ambient blanks were not necessary due to the absence of a source at these sites.

All samples were collected by Parsons and analyzed by APPL, Inc. following the procedures outlined in the Statement of Work and CSSA QAPP, Version 1.0. Samples in this SDG were shipped to the laboratory in two coolers which were received by the laboratory at a temperature of 3.0ºC and 3.5ºC, respectively which were within the 2-6ºC range recommended by the CSSA QAPP.

EVALUATION CRITERIA

The data submitted by the laboratory has been reviewed and verified following the guidelines outlined in the CSSA QAPP, Version 1.0. Information reviewed in the data package included sample results; field and laboratory quality control samples; calibrations; case narratives; raw data; chain-of-custody (COC) forms and the sample receipt checklist. The findings presented in this report are based on the reviewed information, and whether the guidelines in the CSSA QAPP, Version 1.0, were met.

VOLATILES

General

The volatiles portion of this data package consisted of six (6) off-post groundwater samples and one (1) TB. All samples were collected on December 4, 2017 and analyzed for a reduced list of VOCs which included: *cis*-1,2-dichloroethene, tetrachloroethene, trichloroethene, and vinyl chloride.

The VOC analyses were performed using United States Environmental Protection Agency (USEPA) SW846 Method 8260B. The samples were analyzed in two analytical batches, #225302 and #225303, under one set of initial calibration (ICAL). All samples were analyzed following the procedures outlined in the CSSA QAPP and were prepared and analyzed within the holding time required by the method. All analyses were performed undiluted.

Accuracy

Accuracy was evaluated using the percent recovery (%R) obtained from the laboratory control spike (LCS) sample and the surrogate spikes.

All LCS and surrogate spike recoveries were within acceptance criteria.

Precision

Precision could not be evaluated due to the lack of duplicate analyses.

Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represents actual site conditions. Representativeness has been evaluated by:

- Comparing the COC procedures to those described in the CSSA QAPP;
- Comparing actual analytical procedures to those described in the CSSA QAPP;
- Evaluating holding times; and
- Examining laboratory blank for cross contamination of samples during analysis.

All samples in this data package were analyzed following the COC and the analytical procedures described in the CSSA QAPP, Version 1.0. All samples were prepared and analyzed within the holding time required by the method.

- All instrument performance check criteria were met.
- All initial calibration criteria were met.
- All initial calibration verification (ICV) criteria were met. The ICV was prepared using a secondary source standard. All second source verification criteria were met.
- All continuing calibration verification (CCV) criteria were met.

- All internal standard criteria were met.

There were two method blanks and one TB associated with the VOC analyses in this SDG and all blanks were non-detect for all target VOCs.

Completeness

Completeness has been evaluated in accordance with the CSSA QAPP. The number of usable results has been divided by the number of possible individual analyte results and expressed as a percentage to determine the completeness of the data set.

All VOC results for the samples in this SDG were considered usable. The completeness for this SDG is 100%, which meets the minimum acceptance criteria of 95%.

DATA VERIFICATION SUMMARY REPORT

for on-post samples collected from

CAMP STANLEY STORAGE ACTIVITY

BOERNE, TEXAS

Data Verification by: Tammy Chang
Parsons - Austin

INTRODUCTION

The following data verification summary report covers five groundwater samples and the associated field quality control (QC) samples collected from on-post Camp Stanley Storage Activity (CSSA) on December 6, 2017. The samples were assigned to the following Sample Delivery Group (SDG). All samples were analyzed for volatile organic compounds (VOCs) and metals including arsenic, barium, cadmium, chromium, copper, lead, zinc, and mercury.

84469

The field QC samples associated with this SDG were one field duplicate (FD), one set of matrix spike/matrix spike duplicate (MS/MSD), and one trip blank (TB) samples. No ambient blanks were collected. During the initiation of this project, it was determined that ambient blanks were not necessary due to the absence of a source at these sites.

All samples were collected by Parsons and analyzed by APPL, Inc. following the procedures outlined in the Statement of Work and CSSA QAPP, Version 1.0. Samples in this SDG were shipped to the laboratory in two coolers which were received by the laboratory at temperature of 1.5ºC and 3.0ºC. All samples in the cooler of 1.5ºC had no indication of frozen, therefore, it had no impact to the data quality.

EVALUATION CRITERIA

The data submitted by the laboratory has been reviewed and verified following the guidelines outlined in the CSSA QAPP, Version 1.0. Information reviewed in the data package included sample results; field and laboratory quality control samples; calibrations; case narratives; raw data; chain-of-custody (COC) forms and the sample receipt checklist. The findings presented in this report are based on the reviewed information, and whether the guidelines in the CSSA QAPP, Version 1.0, were met.

VOLATILES

General

The volatiles portion of this data package consisted of five (5) on-post groundwater samples, one FD, one set of MS/MSD, and one (1) TB. Samples were collected on December 6, 2017 and analyzed for a reduced list of VOCs which included: *cis*-1,2-dichloroethene, tetrachloroethene, trichloroethene, and vinyl chloride.

The VOC analyses were performed using United States Environmental Protection Agency (USEPA) SW846 Method 8260B. The samples were analyzed in two analytical batches, #225303 and #225307 under one set of initial calibration (ICAL). All samples were analyzed following the procedures outlined in the CSSA QAPP and were prepared and analyzed within the holding time required by the method. All analyses were performed undiluted.

Accuracy

Accuracy was evaluated using the percent recovery (%R) obtained from two laboratory control spike (LCS) samples, MS/MSD analyses, and the surrogate spikes. Sample CS-13 was designated as the parent sample for the MS/MSD analyses.

All LCS, MS, MSD, and surrogate spike recoveries were within acceptance criteria.

Precision

Precision was evaluated using the relative percent difference (%RPD) of the MS/MSD results and parent/FD results. Sample CS-10 was collected in duplicate.

None of the four target VOCs were detected in the parent and FD samples at or above the reporting limits, therefore, the %RPD calculations were not applicable.

All %RPDs of MS and MSD were compliant.

Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represents actual site conditions. Representativeness has been evaluated by:

- Comparing the COC procedures to those described in the CSSA QAPP;
- Comparing actual analytical procedures to those described in the CSSA QAPP;
- Evaluating holding times; and
- Examining trip blank and laboratory blank for cross contamination of samples during sample collection and analysis.

All samples in this data package were analyzed following the COC and the analytical procedures described in the CSSA QAPP, Version 1.0. All samples were prepared and analyzed within the holding time required by the method.

- All instrument performance check criteria were met for both instrument.
- All initial calibration criteria were met.

- All initial calibration verification (ICV) criteria were met. The ICV was prepared using secondary source standards. All second source verification criteria were met.
- All continuing calibration verification (CCV) criteria were met.
- All internal standard criteria were met.

There were two method blanks and one TB associated with the VOC analyses in this SDG and all were non-detect for all target VOCs.

Completeness

Completeness has been evaluated in accordance with the CSSA QAPP. The number of usable results has been divided by the number of possible individual analyte results and expressed as a percentage to determine the completeness of the data set.

All VOC results for the samples in this SDG were considered usable. The completeness for this SDG is 100%, which meets the minimum acceptance criteria of 95%.

ICP-AES METALS

General

The ICP-AES portion of this SDG consisted of four (4) on-post groundwater samples, one FD, and one set of MS/MSD. All samples were collected on December 6, 2017. All samples were analyzed for arsenic, barium, cadmium, chromium, copper, lead, and zinc.

The ICP-AES metals analyses were performed using USEPA SW846 Method 6010B. All samples were analyzed following the procedures outlined in the CSSA QAPP and were prepared and analyzed within the holding time required by the method.

The samples for ICP-AES metals were digested in batch #225047. All analyses were performed undiluted.

Accuracy

Accuracy was evaluated using the percent recovery obtained from the LCS, MS and MSD. CS-13 was designated as the parent sample for the MS/MSD analyses.

All LCS, MS, and MSD recoveries were within acceptance criteria except zinc had higher %R in both MS and MSD analyses due to matrix effect. “M” flag was correctly applied to the parent sample result by lab.

Precision

Precision was measured based on the %RPD of MS/MSD results and parent/FD sample results. Sample CS-10 was collected in duplicate.

All %RPDs were compliant for the MS/MSD.

Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represents actual site conditions. Representativeness has been evaluated by:

- Comparing the COC procedures to those described in the CSSA QAPP;
- Comparing actual analytical procedures to those described in the CSSA QAPP;
- Evaluating preservation and holding times; and
- Examining laboratory blank for cross contamination of samples during analysis.

All samples were analyzed following the COC and the analytical procedures described in the CSSA QAPP, Version 1.0, prepared and analyzed within the holding time required by the method.

- All initial calibration criteria were met.
- All second source verification criteria were met. The ICV was prepared using a secondary source.
- All CCV criteria were met.
- All interference check (ICSA/ICSAB) criteria were met.
- No dilution test was required, as per the CSSA QAPP.

One method blank and several calibration blanks were analyzed in association with the ICP-AES analyses in this SDG. All blanks were free of target metals at or above the RL.

Completeness

Completeness has been evaluated by comparing the total number of samples collected with the total number of samples with valid analytical data.

All ICP-AES metals results for the samples in this SDG were considered usable. The completeness for the ICP metals portion of this SDG is 100%, which meets the minimum acceptance criteria of 95%.

MERCURY

General

The mercury portion of this SDG consisted of four (4) on-post groundwater samples, one FD, and one (1) set of MS/MSD. All samples were collected on December 6, 2017 and were analyzed for mercury.

The mercury analyses were performed using USEPA SW846 Method 7470A. These samples were analyzed following the procedures outlined in the CSSA QAPP, prepared and analyzed within the holding time required by the method.

The mercury samples were prepared in batch #224978. The analyses were performed undiluted.

Accuracy

Accuracy was evaluated using the %R obtained from the LCS, MS, and MSD analyses. CS-13 was designated as the parent sample for the MS/MSD analyses.

The LCS, MS, and MSD recovery were within acceptance criteria.

Precision

Precision was measured based on the %RPD of MS/MSD results and parent/FD sample results. Sample CS-10 was collected in duplicate.

The %RPD of MS/MSD was compliant.

Mercury was not detected in the parent and FD sample.

Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represents actual site conditions. Representativeness has been evaluated by:

- Comparing the COC procedures to those described in the CSSA QAPP;
- Comparing actual analytical procedures to those described in the CSSA QAPP;
- Evaluating holding times; and
- Examining laboratory blanks for cross contamination of samples during analysis.

All samples were analyzed following the COC and the analytical procedures described in the CSSA QAPP, prepared and analyzed within the holding times required by the method.

- All initial calibration criteria were met.
- All second source verification criteria were met. The ICV was prepared using a secondary source.
- All calibration verification criteria were met.

There was one method blank and several calibration blanks associated with the mercury analyses in this SDG. All blanks were free of mercury at or above the RL.

Completeness

Completeness has been evaluated by comparing the total number of samples collected with the total number of samples with valid analytical data.

Mercury result for the samples in this SDG was considered usable. The completeness for the mercury portion of this SDG is 100%, which meets the minimum acceptance criteria of 90%.

APPENDIX I

LTMO AND DQO REGULATOR APPROVAL CORRESPONDENCE

March 22, 2011
April 22, 2016
April 29, 2016

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Protecting Texas by Reducing and Preventing Pollution

March 22, 2011

Camp Stanley Storage Activity
ATTN: Mr. Gabriel Moreno-Fergusson
25800 Ralph Fair Road
Boerne, TX 78015-4800

Re: Approval – "Three-Tiered Long Term Monitoring Network Optimization Evaluation and Data Quality Objectives for the Groundwater Monitoring Program", dated November 23, 2011
Camp Stanley Storage Activity (CSSA), Boerne, TX
TCEQ Solid Waste Registration (SWR) No. 69026
RN 100662840; CN 602728206; EPA ID No. TX2210020739

Dear Mr. Moreno-Fergusson:

The Texas Commission on Environmental Quality (TCEQ) has completed the review of the above mentioned report. In accordance with the final Resource Conservation and Recovery Act (RCRA) Section 3008(h) Administrative Order on Consent (Order) for CSSA, the Environmental Protection Agency (EPA) approved the entitled report on February 16, 2011, along with the recommendations. Based on the information provided, the TCEQ approves the LTMO evaluation recommendations and data quality objectives (DQOs).

Questions concerning this letter should be directed to my attention at 512.239.2572 or via email at kcoulter@tceq.state.tx.us. Thank you for your continued cooperation.

Sincerely,

Kirk Coulter, P.G., Project Manager
Corrective Action Team 1, VCP-CA Section
Remediation Division

KEC/jdm

cc: Mr. Greg Lyssy, U.S. EPA Region 6, 1445 Ross Ave (6SF-LT), Dallas, TX 75202-2733
Ms. Julie Burdey, Parsons Inc., 8000 Centre Park Drive, Suite 200, Austin, TX 78754
Mr. Joel Anderson, Waste Program Manager, TCEQ Region 13 Office, San Antonio, TX

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Protecting Texas by Reducing and Preventing Pollution

April 22, 2016

Mr. Jason Shirley
Installation Manager
Camp Stanley Storage Activity
25800 Ralph Fair Road
Boerne, TX 78015

Re: Approval
- *Three-Tiered Long Term Monitoring Network Optimization Evaluation*, dated January 11, 2016
- *Data Quality Objectives - Groundwater Monitoring Program*, dated February 2, 2016
- *Synopsis of Metals Detections in Camp Stanley Groundwater – Compendium Document to the 2015 Data Quality Objectives and Long-Term Monitoring Optimization Documents*, dated January 28, 2016

Camp Stanley Storage Activity, Boerne, Texas
TCEQ SWR No. 69026, CN602728206, RN100662840
EPA ID No. TX2210020739

Dear Mr. Shirley:

The Texas Commission on Environmental Quality (TCEQ) has reviewed the above-referenced submittals. The reports were submitted in accordance with the final Resource Conservation and Recovery Act (RCRA) §3008(h) Administrative Order on Consent (Order) for Camp Stanley Storage Activity, dated May 5, 1999. The reports provide adequate documentation and rationale to support the recommendations and revisions contained therein. The TCEQ approves the Three-Tiered Long Term Monitoring Network Optimization Evaluation, Data Quality Objectives (DQOs) – Groundwater Monitoring, and Synopsis of Metals Detections in Camp Stanley Groundwater as submitted with the following comment:

- The groundwater monitoring DQOs were revised such that the volatile organic compound (VOC) list was reduced from six compounds to four [dropping 1,1-dichloroethene (1-1-DCE) and *trans*-1,2-dichloroethene (trans-1,2-DCE) while retaining tetrachloroethene, trichloroethene, and *cis*-1,2-dichloroethene (*cis*-1,2-DCE)]. If future groundwater analytical results document significant increases in *cis*-1,2,-DCE, the TCEQ requests that CSSA consider evaluating whether 1,1-DCE and *trans*-1,2-DCE should again be added to VOC analyte list.

Questions concerning this letter should be directed to me at (512) 239-6526. Thank you for your continued cooperation.

Sincerely,

Amanda Pirani, P.G., Project Manager
Team 1, VCP-CA Section
Remediation Division
Texas Commission on Environmental Quality

AP/mdh

cc: Ms. Felicia Kraintz, Environmental Program Manager, Camp Stanley Storage Activity (PDF)
Mr. Greg Lyssy, Senior Project Manager, U.S. EPA, Region 6 (PDF)
Ms. Julie Burdey, P.G., Parsons (PDF)
Mr. Jorge Salazar, Federal Facilities Coordinator, TCEQ Region 13 Office (PDF)
Mr. Cameron Lopez, Waste Program Manager, TCEQ Region 13 Office (PDF)

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 6
1445 Ross Avenue, Suite 1200
Dallas, Texas 75202-2733

Transmitted via email

April 29, 2016

Mr. Jason D. Shirley
Installation Manager
Camp Stanley Storage Activity
25800 Ralph Fair Road
Boerne, TX 78015-4800

RE: *RCRA Three Tiered Long Term Monitoring Network Optimization Evaluation*
Camp Stanley Storage Activity, Boerne, Texas

Dear Mr. Shirley:

The Three Tiered Long Term Monitoring Network Optimization (LTMO) Evaluation, dated January 11, 2016, for Camp Stanley Storage Activity (CSSA), has been reviewed by the U.S. EPA (EPA) in accordance with the final Resource Conservation and Recovery Act (RCRA) § 3008(h) Administrative Order on Consent for CSSA, (Order) Docket No. RCRA-VI 002(h)99-H FY99, dated May 5, 1999.

The purpose of the LTMO Evaluation is to ensure that the groundwater monitoring program adequately addresses the monitoring requirements of the remedial actions at the Site, both temporally and spatially. CSSA has been collecting groundwater data since 1991, and has optimized the monitoring program several times to ensure that an adequate monitoring program is in place. The proposed sampling schedule in the LTMO Evaluation meets the temporal and spatial objectives of the CSSA groundwater monitoring program and is hereby approved.

If you have any questions, please feel to contact me at 214-665-8317 or via e-mail at lyssy.gregory@epa.gov.

Sincerely,

Greg J. Lyssy

Greg J. Lyssy
Senior Project Manager
RCRA Corrective Action Section (6MM-RC)

cc: Felicia Kraintz, CSSA
Amanda Pirani, TCEQ
Jorge Salazar, TCEQ
Laurie King, EPA
Julie Burdey, Parsons

APPENDIX J

USEPA CONSTITUENT CONCENTRATION MAPS LETTER

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 6
1445 Ross Avenue, Suite 1200
Dallas, Texas 75202-2733

Transmitted via e-mail

February 13, 2012

MEMORANDUM

FROM: *Greg J. Lyssy*
Senior Project Manager
Federal Facilities Section (6PD-F)

TO: Gabriel Moreno-Ferguson
CSSA

CC: Kirk Coulter
TCEQ

RE: **CSSA Constituent Concentration Maps**

This Memo is written pursuant to our meeting on January 24, 2012, and as a follow-up to the discussions on the graphical depiction of analytical data in groundwater plume maps, and in accordance with the final Resource Conservation and Recovery Act (RCRA), Section 3008(h) Administrative Order on Consent (Order) for Camp Stanley Storage Activity (CSSA), Docket No. RCRA-VI 002(h)99-H FY99, dated May 5, 1999.

Historically, CSSA has created groundwater plume delineation maps utilizing all analytical data, including historical data points as well as data points that are near or at the method detection limit of the constituents. Preparing plume maps utilizing data points that are in the part per trillion range (and several orders of magnitude below the Maximum Contaminant Levels (MCLs)) may create a misleading graphical representation of the actual plume size.

In order to have consistency on plume maps across different facilities, it is my recommendation that CSSA create a groundwater plume map at the MCL (or appropriate regulatory level if there is not an MCL) for the constituents of concern (COCs). In addition, CSSA should also create a groundwater plume map that depicts isoconcentrations at 20% of the MCL.

If desired, CSSA may create a ***base*** groundwater plume map using data near the method detection limit, but that map ***must*** contain qualifying information on the data that was used to create the map.

Groundwater monitoring of the plume at CSSA is required, and will continue to be required, as long as the Order is in place and there are COCs in the groundwater.

If CSSA, or your technical consultants, have any questions regarding this Memo, please do not hesitate to call me at 214.665.8317, or I may be contacted via e-mail at *lyssy.gregory@epa.gov*.