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Our ref: HEM-18-11
Date: March 13, 2018

Subject: Westinghouse Hematite Decommissioning Project – Request for NRC Review of Final Status Survey Final Report Volume 6, Chapter 7, Post-remediation Groundwater Monitoring Summary, Revision 1 (License No. SNM-00033, Docket No. 070-00036)

The purpose of this letter is to provide to the U.S. Nuclear Regulatory Commission (NRC) for review Final Status Survey Final Report (FSSFR) Volume 6, Chapter 7, Post-remediation Groundwater Monitoring Summary, Revision 1.

Via email on February 12, 2018, the NRC provided to Westinghouse the NRC Staff's Preliminary Comments on the Post-remediation Groundwater Monitoring Summary. Via email on February 19, 2018, Westinghouse provided to the NRC a response to the NRC comments and a proposed path forward.

During the February 22, 2018, publicly noticed teleconference the NRC and Westinghouse concurred on the path forward for resolution to the NRC comments regarding Volume 6, Chapter 7, Post-remediation Groundwater Monitoring Summary.

Attachment 1 contains revised FSSFR Volume 6, Chapter 7, Revision 1 without a CD containing the Appendices. The Appendices are unchanged and therefore are not included. For Appendices refer to ML17250A376. Attachment 2 contains the revised FSSFR Volume 6, Chapter 7, Revision 1 in track change for ease of review. Attachment 3 contains a revision matrix for ease of review. Attachment 4 contains the February 19, 2018 Westinghouse response and path forward for FSSFR Volume 6, Chapter 7, Revision 1.

Please contact me at 314-810-3353, should you have questions or need additional information.

Sincerely,

Kenneth E. Pallagi
Licensing Manager,
Hematite Decommissioning Project

NMSS20

Attachment: 1) Final Status Survey Final Report Volume 6, Chapter 7, Post-remediation Groundwater Monitoring Summary, Revision 1 (HDP-RPT-FSS-507, Revision 1)

2) Final Status Survey Final Report Volume 6, Chapter 7, Post-remediation Groundwater Monitoring Summary, Revision 1, Track Change Version

3) Revision Matrix for FSSFR Volume 6, Chapter 7, Revision 1

4) Westinghouse Response and Path Forward for FSSFR Volume 6, Chapter 7, Revision 1, dated February 19, 2018

cc: V. J. Kelmeckis, Westinghouse
S. S. Koenick, NRC/DUWP/MDB
J. A. Smith, NRC/DUWP/MDB

Attachment 1

Final Status Survey Final Report Volume 6, Chapter 7, Revision 1

Post-remediation Groundwater Monitoring Summary

Westinghouse Electric Company LLC, Hematite Decommissioning Project

Docket No. 070-00036

Westinghouse

Final Status Survey Report

Hematite Decommissioning Project

Final Status Survey Final Report Volume 6, Chapter 7

TITLE: **Post-remediation Groundwater Monitoring Summary**

REVISION: **1**

EFFECTIVE DATE: MAR 1 3 2018

Approvals:

Author:	Kenneth E. Pallagi.	03-13-2018 Date
Reviewed By:	Kevin M. Harris, P.E.	03-13-2018 Date
Owner/Manager:	W. Clark Evers, CHP	3/13/18 Date

HDP-RPT-FSS-507
Revision 1

REVISION LOG

Revision No. Effect. Date	Revision
0 08/09/2017	Revision 0 is the initial issuance of the FSSFR Volume 6, Chapter 7, Post-remediation Groundwater Monitoring Summary.
1 See Cover Page	The NRC provided feedback during a recurring weekly publicly noticed teleconference with a subsequent written follow-up in regards to comments on FSSFR Volume 6, Chapter 7, Post-remediation Groundwater monitoring Summary. During a subsequent publicly noticed teleconference Westinghouse and the NRC discussed the path forward and resolution of the NRC comments. This revision to FSSFR Volume 6, Chapter 7, implements the resolution discussed during the weekly publicly noticed teleconference. This revision also contains minor editorial corrections.

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LIST OF ACRONYMS AND SYMBOLS

AOC	Area of Concern
DP	Hematite Decommissioning Plan
FSSFR	Final Status Survey Final Report
HDP	Hematite Decommissioning Project
HSU	Hydrostratigraphic Unit
MCL	Maximum Contaminant Level
NRC	United States Nuclear Regulatory Commission
msl	mean sea level
pCi/L	picocuries per liter
RAI	Request for Additional Information
ROC	Radionuclides of Concern
SOF	Sum Of Fractions
Tc	Technetium
U	Uranium

1.0 INTRODUCTION

The purpose of this document, Final Status Survey Final Report (FSSFR) Volume 6, Chapter 7, *Post-remediation Groundwater Monitoring Summary,* is to provide the radiological groundwater sampling results summary and analysis from the monitoring that was conducted for the Hematite Decommissioning Project (HDP) for the post-remediation groundwater monitoring period which commenced at the completion of radiological remediation and site restoration. Individual quarter results and trends have been presented in FSSFR Volume 6, Chapter 3 {ML16287A528}, Chapter 4 {ML16342B552}, Chapter 5 {ML17018A105}, and Chapter 6 {ML17142A356}. This Chapter will summarize the post-remediation groundwater monitoring period results, present the trending over the monitoring period, calculate an average concentration of for each of the radionuclides of concern (ROCs), calculate an annual dose contribution for the radionuclides in groundwater, and demonstrate that the residual dose attributed to groundwater does not exceed 4 mrem/year.

2.0 BACKGROUND

During the approval process for the Hematite Decommissioning Plan (DP), the NRC issued a Request for Additional Information (RAI) in letters dated October 14, 2010, NRC letter to Westinghouse, "Hematite Decommissioning Plan Review Requests for Additional Information for Decommissioning Plan Chapters 1, 4, 6 and 7," {ML102810455} and February 9, 2011, NRC letter to Westinghouse, "NRC Request for Additional Information from Westinghouse on Hematite Decommission Plan Chapter 3" {ML110210533}.

In response to the NRC's RAIs, Westinghouse committed to make modifications to its groundwater monitoring program regarding well placements and post-remediation sampling to protect the groundwater from future radioactive contamination. These commitments were captured by the NRC in the Safety Evaluation Report {ML112101630} that was issued in conjunction with the approval of the DP and associated documents. These commitments included:

1. Remove the 'leachate" impacted with radionuclides in the overburden clay. During soil excavation the contaminated "leachate" entering the excavation pit will be pumped to and treated for radionuclides by the Water Treatment System prior to its release in accordance with the effluent discharge requirements.
2. Abandon selected wells that contain screens that cross both the silty clay overburden and the sand/gravel unit below. The cross communication resulted in the transport of contaminated water from the silty clay overburden to the sand/gravel unit. New monitoring wells will be installed in the sand/gravel unit in close proximity to the abandoned wells which will monitor for groundwater during and after site remediation.
3. Conduct borings in the close proximity to four specified wells and collect soil samples to the top of sand/gravel layer for radionuclide analysis. Further soil excavation will be conducted if spent limestone and soil above the release criteria are found below the initially proposed excavation depth.
4. Monitor groundwater post-remediation.

In Westinghouse letter HEM-16-15, dated February 10, 2016, Westinghouse submitted to the NRC FSSFR Volume 6, Chapter 1, *Groundwater Overview* {ML16041A340}, which described the groundwater monitoring program regarding well placements and post-remediation sampling to support that Westinghouse has met its commitments to the NRC in supporting the unrestricted release of the site at license termination in regard to groundwater and the commitments as provided in the SER.

FSSFR Volume 6, Chapter 1 provided the basis for post-remediation groundwater monitoring, the objectives of post-remediation groundwater monitoring, and the summary of data collected prior to and during the radiological remediation of the Site. Westinghouse indicated in FSSFR Volume 6, Chapter 1 that that "*monitoring would be discontinued when it could be determined that the radioactivity concentrations did not pose an unacceptable potential for dose.*" and "*at the completion of the fourth quarter of post-remediation monitoring, an evaluation of the groundwater sample data will be performed to determine if the concentrations are stable, or are showing an increasing or decreasing trend as compared to historical data (2009 – 2015).*"

FSSFR Volume 6, Chapter 1 also provided that "*As there are no previous sample analysis results with indication of radionuclide contamination in the groundwater (Jefferson City-Cotter HSU, and the Roubidoux HSUs) exceeding MCLs or a dose limit of 4 mrem/year, the purpose of post-remediation sampling is to verify that remediation of the source area had not contributed radionuclide contamination to the groundwater.*"

Having completed a review of FSSFR Volume 6, Chapter 1 the NRC provided via email the Pre-Audit Submittal Table for FSSFR Volume 6, Chapter 1 which contained comments generated by the review. During a subsequent recurring weekly publicly noticed teleconference Westinghouse and the NRC discussed the path forward and resolution of the NRC comments for FSSFR Volume 6, Chapter 1.

In Westinghouse letter HEM-16-70, dated October 10, 2016, Westinghouse submitted to the NRC FSSFR Volume 6, Chapter 1, Revision 1 {ML16287A528} which contained the Westinghouse response to the comments provided in the Pre-Audit Submittal Table for FSSFR Volume 6, Chapter 1.

As discussed in FSSFR Volume 6, Chapter 1, the data provided in this chapter is intended to support the conclusion that remediation activities at HDP did not impact groundwater (Jefferson City-Cotter Hydrostratigraphic Unit (HSU), and the Roubidoux HSUs), and that the annual dose contribution due to radionuclides in groundwater is less than 4 mrem/year.

3.0 POST-REMEDIATION GROUNDWATER MONITORING WELL NETWORK

The post-remediation groundwater monitoring well network is composed of 18 monitoring wells screened in the sand/gravel HSU, eight wells screened in the Jefferson City-Cotter HSU, and five wells screened in the Roubidoux HSU. New monitoring wells were installed after site restoration and prior to the initiation of the post-remediation groundwater sampling. The new monitoring wells included installation of seven in the sand/gravel HSU and seven in the

Jefferson City-Cotter HSU. Figure 3-1, *Post-remediation Groundwater Monitoring Well Network,* provides the locations of all monitoring wells that are monitored for radiological purposes post-remediation. Table 3-1 below lists the wells included in the sampling network.

Post-remediation monitoring well locations were selected at locations down gradient from the former potential source areas. The radiologically impacted soil from these potential source areas was removed during the remediation process. The description of the remediation process of a specific are is provided in the FSSFR Volume 3 Chapter in which the area is located. Nevertheless, to demonstrate that the soil remediation did not have a deleterious effect on the groundwater, monitoring wells down gradient from each of the areas have been sampled as part of this program.

Monitoring well locations were selected based on the proximity to the potential source area and the predominate direction of groundwater flow. In addition, the groundwater flow rates, taken from the groundwater modeling effort presented in the Remedial Investigation, were used for each HSU to determine the likely movement of groundwater over the course of the annual monitoring. Table 3-2, Post-remediation Groundwater Monitoring Well Locations, indicates the monitoring well, the HSU being monitored, the area of concern (AOC) being monitored, the distance from the well to the center of the AOC, the distance from the well to the leading edge of the AOC, and the expected yearly flow for groundwater within that HSU. This indicates that radiological contamination, if contained within the groundwater, would be intercepted by the wells within the one year timeframe. Therefore, if contamination was present due to remedial activities, it would be present and detectable in the groundwater samples collected from the post-remediation monitoring wells.

Monitoring wells GW-BB, GW-EE, GW-FF, GW-GG, GW-W, NB-71, and NB-10 are positioned down gradient (northeast, east, and southeast) of the former burial pits to assess ground water quality following removal of contaminated soil/materials from this area.

Monitoring wells GW-DD, GW-II, GW-JJ, and GW-V are positioned down gradient (southeast) of the Process Building to assess groundwater quality following building demolition and removal of contaminated soil from this area.

Monitoring wells GW-CC, GW-X, GW-Y, NB-34, NB-35 and PZ-02 are positioned down gradient (southeast) of the Evaporation Ponds and former Leach Field to assess groundwater quality following removal of contaminated soil from these areas.

Monitoring well GW-HH is positioned down gradient (southeast) of the Red Room Roof Burial Area and Cistern/Burn Pit to assess groundwater quality following removal of contaminated soil and materials from these areas.

Three new monitoring wells (BR-14-JC, BR-15-JC, and BR-18-JC) have been installed in the Jefferson City-Cotter HSU down gradient of the Burial Pit and Tc-99 source areas. The wells are placed at locations to the south and east of the Documented Burial Pit Area. These wells are located closer to the central tract than the previously sampled wells and are located in areas that,

if contaminant migration is occurring, will identify the degradation of the water within the post-remediation monitoring timeframe.

Post-remediation monitoring of the Jefferson City-Cotter HSU in the vicinity of the former Process Building is accomplished by monitoring three newly installed monitoring wells (BR-13-JC, BR-16-JC, and BR-17-JC) within the source and down gradient of the areas beneath the former Process Buildings where the highest levels of contamination were removed. These wells are being used to evaluate the potential for contaminant migration from the overburden into the shallow bedrock.

Post-remediation monitoring of the Jefferson City-Cotter HSU in the vicinity of the former Evaporation Ponds is accomplished by monitoring of a newly installed monitoring well (BR-19-JC) at a location down gradient of the primary (deep) Evaporation Pond.

Post-remediation monitoring of the Roubidoux HSU is being or will be conducted using the sentry wells designated as BR-03-RB, BR-04-RB, BR-08-RB, and BR-10-RB. In addition, a background well (WS-04), which is located off-site at the Hematite Post Office, is being monitored.

Figure 3-1
Post-remediation Groundwater Monitoring Well Network

Table 3-1
Post-remediation Groundwater Monitoring Wells

Well ID No.	HSU	Post-remediation Protocol			Existing or New*
		Purpose	Parameters	Sample Frequency	
GW-BB	Sand/Gravel	Burial Pit	Tc-99, Isotopic U	Quarterly	Existing
GW-EE	Sand/Gravel	Burial Pit	Tc-99, Isotopic U	Quarterly	New
GW-FF	Sand/Gravel	Burial Pit	Tc-99, Isotopic U	Quarterly	New
GW-GG	Sand/Gravel	Burial Pit	Tc-99, Isotopic U	Quarterly	New
GW-W	Sand/Gravel	Burial Pit	Tc-99, Isotopic U	Quarterly	Existing
NB-71	Sand/Gravel	Burial Pit	Tc-99, Isotopic U	Quarterly	Existing
NB-80	Sand/Gravel	Burial Pit	Tc-99, Isotopic U	Quarterly	Existing
GW-V	Sand/Gravel	Former Building Slabs	Tc-99, Isotopic U	Quarterly	Existing
GW-DD	Sand/Gravel	Former Building Slabs	Tc-99, Isotopic U	Quarterly	New
GW-II	Sand/Gravel	Former Building Slabs	Tc-99, Isotopic U	Quarterly	New
GW-JJ	Sand/Gravel	Former Building Slabs	Tc-99, Isotopic U	Quarterly	Existing
GW-CC	Sand/Gravel	Evaporation Pond	Tc-99, Isotopic U	Quarterly	New
GW-X	Sand/Gravel	Evaporation Pond	Tc-99, Isotopic U	Quarterly	Existing
GW-Y	Sand/Gravel	Evaporation Pond	Tc-99, Isotopic U	Quarterly	Existing
NB-34	Sand/Gravel	Evaporation Pond	Tc-99, Isotopic U	Quarterly	Existing
NB-35	Sand/Gravel	Evaporation Pond	Tc-99, Isotopic U	Quarterly	Existing
PZ-02	Sand/Gravel	Evaporation Pond	Tc-99, Isotopic U	Quarterly	Existing
GW-HH	Sand/Gravel	Red Room Rood Burial Area	Tc-99, Isotopic U	Quarterly	New
BR-04-JC	Jefferson City Cotter	Burial Pit	Tc-99, Isotopic U	Quarterly	Existing
BR-13-JC	Jefferson City Cotter	Former Building Slabs	Tc-99, Isotopic U	Quarterly	New
BR-14-JC	Jefferson City Cotter	Burial Pit	Tc-99, Isotopic U	Quarterly	New
BR-15-JC	Jefferson City Cotter	Burial Pit	Tc-99, Isotopic U	Quarterly	New
BR-16-JC	Jefferson City Cotter	Former Building Slabs	Tc-99, Isotopic U	Quarterly	New
BR-17-JC	Jefferson City Cotter	Former Building Slabs	Tc-99, Isotopic U	Quarterly	New
BR-18-JC	Jefferson City Cotter	Burial Pit	Tc-99, Isotopic U	Quarterly	New

Well ID No.	HSU	Post-remediation Protocol			Existing or New*
		Purpose	Parameters	Sample Frequency	
BR-19-JC	Jefferson City Cotter	Evaporation Pond	Tc-99, Isotopic U	Quarterly	New
BR-04-RB	Roubidoux	Deep Bedrock	Tc-99, Isotopic U	Quarterly	Existing
BR-08-RB	Roubidoux	Deep Bedrock	Tc-99, Isotopic U	Quarterly	Existing
BR-10-RB	Roubidoux	Deep Bedrock	Tc-99, Isotopic U	Quarterly	Existing
BR-03R-RB	Roubidoux	Deep Bedrock	Tc-99, Isotopic U	Quarterly	Existing
WS-04	Roubidoux	Deep Bedrock	Tc-99, Isotopic U	Quarterly	Existing

* Indicates if the well was an existing well or a new well installed for post-remediation monitoring.

Table 3-2
Post-remediation Groundwater Monitoring Well Locations

Well ID #	Horizon[1]	Area of Concern	Distance to Center of AOC (feet)	Distance to Down Gradient Edge of AOC (feet)	Average Annual Groundwater Flow Distance (feet)
BR-03R-RB	BR	Evaporation Ponds	945.81	929.53	3,600
BR-04-JC	BR	Burial Pits	772.54	720.74	1,000
BR-04-RB	BR	Burial Pits	859.08	807.31	3,600
BR-08-RB	BR	Burial Pits	1106.7	701.15	3,600
BR-10-RB	BR	Burial Pits	1370.86	1048.59	3,600
BR-13-JC	BR	Process Buildings	412.31	306.7	1,000
BR-14-JC	BR	Burial Pits	487.95	151.41	1,000
BR-15-JC	BR	Burial Pits	366.15	NA	1,000
BR-16-JC	BR	Process Buildings	92.14	NA	1,000
BR-17-JC	BR	Process Buildings	293.36	83.8	1,000
BR-18-JC	BR	Burial Pits	87.21	33.65	1,000
BR-19-JC	BR	Evaporation Ponds	136.84	152.19	1,000
GW-BB	OB	Burial Pits	421.65	62.32	6,208
GW-CC	OB	Evaporation Ponds	41.01	22.7	6,208
GW-DD	OB	Process Buildings	313.22	107.13	6,208
GW-EE	OB	Burial Pits	245.76	NA	6,208
GW-FF	OB	Burial Pits	85.54	33.55	6,208
GW-GG	OB	Burial Pits	226.44	NA	6,208
GW-HH	OB	Cistern Burn Pits/Red Room Roof	29.76	16.47	6,208

Well ID #	Horizon[1]	Area of Concern	Distance to Center of AOC (feet)	Distance to Down Gradient Edge of AOC (feet)	Average Annual Groundwater Flow Distance (feet)
GW-II	OB	Process Buildings	81.25	NA	6,208
GW-JJ	OB	Process Buildings	347.24	249.95	6,208
GW-V	OB	Process Buildings	419.03	312.93	6,208
GW-W	OB	Burial Pits	493.61	157.87	6,208
GW-X	OB	Process Buildings	476.54	374.83	6,208
GW-Y	OB	Evaporation Ponds	166.79	150.45	6,208
NB-34	OB	Evaporation Ponds	239.28	222.68	6,208
NB-35	OB	Evaporation Ponds	277.54	259.23	6,208
NB-71	OB	Burial Pits	442.96	380.47	6,208
NB-80	OB	Burial Pits	161.45	97.21	6,208
PZ-02	OB	Evaporation Ponds	170.39	155.32	6,208
WS-04	BR	Background			

[1] **BR**- Indicates the monitoring well is installed in the bedrock (Jefferson City-Cotter or Roubidoux HSU).
OB- Indicates the monitoring well is installed in the overburden (sand/gravel HSU).

4.0 POST-REMEDIAITION GROUNDWATER MONITORING SUMMARY REPORT

The post-remediation groundwater monitoring program was initiated after the completion of remediation of the site. The NRC was notified of completion of remediation in Westinghouse letter HEM-16-6 (Fussell) to NRC (Document Control Desk), dated January 18, 2016. The four quarters of sampling were conducted as follows:

1st Quarter – May 26 through June 11, 2016;
2nd Quarter – August 11 through September 29, 2016;
3rd Quarter – November 3 through November 21, 2016; and
4th Quarter - February 9 and February 28, 2017.

The post-remediation monitoring for radiological constituents was conducted simultaneous with the Interim Groundwater Monitoring Program with the exception of the first quarter, in which the IGMP monitoring was conducted after the radiological sampling was completed. The IGMP program focuses on the chemical contamination, primarily chlorinated volatile organics, present in the groundwater at the site, and utilizes many of the same monitoring wells as the post-remediation monitoring.

Results of each quarterly monitoring event were presented in previous chapters of FSSFR Volume 6, Chapters 2 and 3 (1st Quarter){ML16287A528}, Chapter 4 (2nd Quarter) {ML16342B552}, Chapter 5 (3rd Quarter){ML17018A105}, and Chapter 6 (4th quarter){ML17142A356}. These chapters did not include the original laboratory data packages, from the contracted analytical laboratory, Test America. These packages are included within this chapter as Appendix A through D. It should be noted that data for chemical results are included with the packages for Quarter 2 through Quarter 4, due to the radiological and chemical samples being collected and submitted concurrently.

Each of the Quarterly monitoring chapters within this volume included trending of the data, using Mann-Kendall analysis. The purpose of the Mann-Kendall analysis was to identify statistically significant increasing or decreasing concentration trends, if they exist, or to identify stable concentrations. The Mann-Kendall analysis was chosen based on its prior use at the U.S. Department of Energy Oak Ridge Reservation, as presented at the Waste Management Conference, Phoenix, Arizona, February 2013. Specifically, the abstract states:

"*This paper describes a spreadsheet-based approach for applying the Mann-Kendall (MK) Test to identify statistically significant increasing or decreasing concentration trends, stable concentration trends (not increasing or decreasing), and indeterminate concentration trends (no trend) defined by time-series groundwater monitoring data for inorganic, organic, or radiological contaminants. The approach has been applied in support of ongoing long-term monitoring (LTM) of groundwater contamination at the U.S. Department of Energy (DOE) Y-12 National Security Complex (Y-12) in Oak Ridge, Tennessee and elsewhere on the DOE Oak Ridge Reservation (ORR), and has proven effective at minimizing subjective bias in the evaluation and interpretation of contaminant concentration trend data. Application of the approach for the purposes of optimizing groundwater sampling frequency for LTM also is outlined*"

The abstract further states that "*contaminant concentration data from a minimum of four and no more than ten independent sampling events*" is to be used to perform the Mann-Kendall trending analysis.

Since the technical approach requires a minimum of four independent sampling events arranged in chronological order by sampling date and time, the Mann-Kendall trending analysis was not conducted for the newly installed wells during the first three quarters of monitoring, as four data points were not available. FSSFR Volume 6, Chapter 6 which summarized the fourth quarter sampling results was the first opportunity to present the results of the Mann-Kendall trending analysis with four quarters of data for the newly installed post-remediation groundwater monitoring wells. The data in the tables and graphs from that chapter are also included in this chapter, as they are inclusive of all four quarters of data.

4.1 Jefferson City-Cotter HSU Data Set

The data set for each radiological constituent [Tc-99, U-233/234, U-235/236, and U-238], including the MDC and Error, is provided in Attachment 1, *Post-Remediation Groundwater Monitoring Period Summary of Results*. In Attachment 2, *Mann-Kendall Analysis and Sample Results Graphs,* the data set for each radiological constituent has been graphed for each monitoring well versus the respective Maximum Contaminant Level (MCL), along with the Mann-Kendell trend graph, as described previously. The full laboratory data packages for each sampling event are contained in Appendix A through D.

For discussion purposes, summary tables for each radiological constituent showing the four quarterly results, the average concentration of the radiological constituent for each well, and the maximum detected concentration of the radiological constituent for each Jefferson City-Cotter HSU monitoring well are presented in Table 4-1 through Table 4-4 below.

Table 4-1
Jefferson City-Cotter HSU Monitoring Period Summary of Technetium - 99

JEFFERSON CITY – COTTER HSU Tc-99 pCi/L						
Well ID	**1st Quarter Result**	**2nd Quarter Result**	**3rd Quarter Result**	**4th Quarter Result**	**Average**	**Maximum**
BR-04-JC	-1.16	-0.266	0.528	0.306	0.2085	0.528
BR-13-JC	-0.695	-0.117	-0.657	0.162	0.0405	0.162
BR-14-JC	-1.24	-0.126	-0.927	1.19	0.2975	1.19
BR-15-JC	-0.33	-0.683	-0.471	0.919	0.22975	0.919
BR-16-JC	-0.767	-0.946	0.567	-1.09	0.14175	0.567
BR-17-JC	-0.402	-0.307	-0.901	-0.718	0	N/A
BR-18-JC	0.0809	-0.899	0.054	-0.358	0.033725	0.0809
BR-19-JC	0.276	-0.648	0.0273	0.0784	0.095425	0.276

Table 4-2
Jefferson City-Cotter HSU Monitoring Period Summary of Uranium - 233/234

JEFFERSON CITY – COTTER HSU U-233/234 pCi/L						
Well ID	**1st Quarter Result**	**2nd Quarter Result**	**3rd Quarter Result**	**4th Quarter Result**	**Average**	**Maximum**
BR-04-JC	2.81	3.32	2.89	2.68	2.925	3.32
BR-13-JC	4.02	4.16	4.34	4.05	4.1425	4.34
BR-14-JC	3.74	3.56	4.01	3.21	3.63	4.01
BR-15-JC	1.38	1.33	1.13	1.37	1.3025	1.38
BR-16-JC	1.72	4.59	5.4	4.18	3.9725	5.4
BR-17-JC	11.7	4.91	2.73	2.84	5.545	11.7
BR-18-JC	2.64	2.25	2.15	2.08	2.28	2.64
BR-19-JC	6.26	7.02	7.21	6.72	6.8025	7.21

Table 4-3
Jefferson City-Cotter HSU Monitoring Period Summary of Uranium - 235/236

JEFFERSON CITY – COTTER HSU U-235/236						
Well ID	**1st Quarter Result**	**2nd Quarter Result**	**3rd Quarter Result**	**4th Quarter Result**	**Average**	**Maximum**
BR-04-JC	0.0477	0.0705	-0.0253	0.0145	0.033175	0.0705
BR-13-JC	0.0168	0.0709	-0.0087	0.0537	0.03535	0.0709
BR-14-JC	0.0662	0.0474	0.112	0.0554	0.07025	0.112
BR-15-JC	0.0241	0.0139	-0.0183	0.0501	0.022025	0.0501
BR-16-JC	0.0204	0.0286	0.101	0.0394	0.04735	0.101
BR-17-JC	0.126	0.0221	0.0228	0.0267	0.0494	0.126
BR-18-JC	0.0187	0.0491	0.0243	0.0279	0.03	0.0491
BR-19-JC	0.149	0.0468	0.0668	0.104	0.09165	0.149

Table 4-4
Jefferson City-Cotter HSU Monitoring Period Summary of Uranium - 238

JEFFERSON CITY – COTTER HSU U-238 pCi/L						
Well ID	**1st Quarter Result**	**2nd Quarter Result**	**3rd Quarter Result**	**4th Quarter Result**	**Average**	**Maximum**
BR-04-JC	0.402	0.461	0.394	0.262	0.37975	0.461
BR-13-JC	0.59	0.299	0.29	0.361	0.385	0.59
BR-14-JC	0.435	0.678	0.568	0.604	0.57125	0.678
BR-15-JC	0.358	0.345	0.194	0.237	0.2835	0.358
BR-16-JC	0.655	0.888	0.822	0.77	0.78375	0.888
BR-17-JC	2.04	0.828	0.49	0.436	0.9485	2.04
BR-18-JC	0.433	0.216	0.239	0.118	0.2515	0.433
BR-19-JC	1.05	1.11	0.995	0.972	1.03175	1.11

The Jefferson City-Cotter HSU data sets were reviewed for the four quarters of sampling to determine the maximum concentration of each radiological constituent detected during the annual monitoring. Table 4-5 below indicates the maximum concentration detected for each radiological constituent, the monitoring well where the detection occurred, and the quarter in which the maximum detection occurred. In addition, the drinking water MCL and an indication of whether any of the analyses indicated contamination above the MCL. A review of the data set indicates that none of the monitoring well sampling results for any radiological constituent approached or was near the MCL.

Table 4-5
Jefferson City-Cotter HSU Maximum Concentrations of ROCs

Radiological Constituent	**Units**	**Maximum Detected Concentration**	**MCL**	**Number of Analyses > MCL**	**Maximum Location**	**Maximum Quarter**
Technetium-99	pCi/L	1.19 ± 1.02	900	0	BR-14-JC	4th Quarter
Uranium-234	pCi/L	11.7 ± 1.39	20*	0	BR-17-JC	1st Quarter
Uranium-235/236	pCi/L	0.149 ± 0.0804	20*	0	BR-19-JC	1st Quarter
Uranium-238	pCi/L	2.04 ± 0.44	20*	0	BR-17-JC	1st Quarter

* Isotopic Evaluation Level since MCL is 30 μg/L for total uranium.

The results of the Mann-Kendell trend analysis for the Jefferson City-Cotter HSU are provided in Table 4-6 below. The Mann-Kendall analysis showed a downward trend for Tc-99 in monitoring well BR-04-JC and a downward trend for Total Uranium in monitoring well BR-18-JC. No upward trends were indicated by the analysis, supporting the premise that there is not an expanding plume of radiological contamination within the Jefferson City-Cotter HSU.

Table 4-6
Mann-Kendell Trend Analysis Results – Jefferson City-Cotter HSU

Well ID	Tc-99	Total U
BR-04-JC	Downward Trend	No Trend
BR-13-JC	No Trend	No Trend
BR-14-JC	No Trend	No Trend
BR-15-JC	No Trend	No Trend
BR-16-JC	No Trend	No Trend
BR-17-JC	No Trend	No Trend
BR-18-JC	No Trend	Downward Trend
BR-19-JC	No Trend	No Trend

4.2 Roubidoux HSU Data Set

The data set for each radiological constituent [Tc-99, U-233/234, U-235/236, and U-238], including the MDC and Error, is provided in Attachment 1, *Post-remediation Groundwater Monitoring Period Summary of Results*. In Attachment 2, *Mann-Kendall Analysis and Sample Results Graphs*, the data set for each radiological constituent has been graphed for each well versus the respective MCL, along with the Mann-Kendell trend graph, as described previously. The full laboratory data packages for each sampling event are contained in Appendix A through Appendix D.

For discussion purposes, each radiological constituent showing the four quarterly results, the average concentration of the radiological constituent for each well, and the maximum detected concentration of the radiological constituent for each Roubidoux HSU monitoring well are presented in Tables 4-7 through Table 4-10 below.

Table 4-7
Roubidoux HSU Monitoring Period Summary of Technetium - 99

ROUBIDOUX HSU Tc-99 pCi/L						
Well ID	**1st Quarter Result**	**2nd Quarter Result**	**3rd Quarter Result**	**4th Quarter Result**	**Average**	**Maximum**
BR-03R-RB	-1.08	-1.09	-0.207	-0.0105	0	N/A
BR-04-RB	-0.478	0.394	-0.738	-0.962	0.0985	0.394
BR-08-RB	-0.937	-0.37	-0.369	-1.13	0	N/A
BR-10-RB	-1.13	-0.162	-1.13	0.969	0.24225	0.969
WS-04	-0.11	-0.37	-0.852	-1.77	0	N/A

Table 4-8
Roubidoux HSU Monitoring Period Summary of Uranium - 233/234

ROUBIDOUX HSU U-233/234 pCi/L						
Well ID	**1st Quarter Result**	**2nd Quarter Result**	**3rd Quarter Result**	**4th Quarter Result**	**Average**	**Maximum**
BR-03R-RB	1.9	2	2.01	1.69	1.9	2.01
BR-04-RB	2.41	2.45	2.58	2.43	2.4675	2.58
BR-08-RB	6.2	5.21	6.01	6.09	5.8775	6.2
BR-10-RB	2.91	3.21	2.82	3.26	3.05	3.26
WS-04	1.05	0.936	1.25	1.12	1.089	1.25

Table 4-9
Roubidoux HSU Monitoring Period Summary of Uranium - 235/236

ROUBIDOUX HSU U-235/236 pCi/L						
Well ID	**1st Quarter Result**	**2nd Quarter Result**	**3rd Quarter Result**	**4th Quarter Result**	**Average**	**Maximum**
BR-03R-RB	0.0392	0.0422	0.0134	0.000953	0.02393825	0.0422
BR-04-RB	0.00412	0	0.0473	0.0168	0.017055	0.0473
BR-08-RB	0.0757	0.0722	-0.0472	0.0237	0.0429	0.0757
BR-10-RB	0.0185	0.00867	0.0237	0	0.0127175	0.0237
WS-04	0.0216	0.0222	0.0395	0.0347	0.0295	0.0395

Table 4-10
Roubidoux HSU Monitoring Period Summary of Uranium - 238

ROUBIDOUX HSU U-238 pCi/L						
Well ID	**1st Quarter Result**	**2nd Quarter Result**	**3rd Quarter Result**	**4th Quarter Result**	**Average**	**Maximum**
BR-03R-RB	0.169	0.158	0.158	0.115	0.15	0.169
BR-04-RB	0.204	0.281	0.206	0.241	0.233	0.281
BR-08-RB	0.426	0.306	0.503	0.381	0.404	0.503
BR-10-RB	0.123	0.125	0.144	0.135	0.13175	0.144
WS-04	0.607	0.508	0.541	0.717	0.59325	0.717

The Roubidoux HSU data sets were reviewed for the four quarters of sampling to determine the maximum concentration of each radiological constituent detected during the annual monitoring. Table 4-11 below indicates the maximum concentration detected for each radiological constituent, the monitoring well where the detection occurred, and the quarter in which the maximum detection occurred. In addition, the drinking water MCL and an indication of whether any of the analyses indicated contamination above the MCL. A review of the data set indicates that none of the monitoring well sampling results for any radiological constituent approached or was near the MCL.

Table 4-11
Roubidoux HSU Maximum Concentrations of ROCs

Radiological Constituent	Units	Maximum Detected Concentration	MCL	Number of Analyses > MCL	Maximum Location	Maximum Quarter
Technetium-99	pCi/L	0.969 ± 0.97	900	0	BR-10-RB	4th Quarter
Uranium-234	pCi/L	6.2 ± 0.732	20*	0	BR-08-RB	1st Quarter
Uranium-235/236	pCi/L	0.0757 ± 0.737	20*	0	BR-08-RB	1st Quarter
Uranium-238	pCi/L	0.717 ± 0.152	20*	0	WS-04	4th Quarter

* Isotopic Evaluation Level since MCL is 30 μg/L for total uranium.

The results of the Mann-Kendell trend analysis for the Roubidoux HSU are provided in Table 4-12 below. The Mann-Kendall analysis showed a downward trend for Total Uranium in monitoring well BR-10-RB. No upward trends were indicated by the analysis, supporting the premise that there is not an expanding plume of radiological contamination within the Roubidoux HSU.

Table 4-12
Mann-Kendell Trend Analysis Results – Roubidoux HSU

Well ID	Tc-99	Total U
BR-03R-RB	No Trend	No Trend
BR-04-RB	No Trend	No Trend
BR-08-RB	No Trend	No Trend
BR-10-RB	No Trend	Downward Trend
WS-04	No Trend	No Trend

4.3 Sand/Gravel HSU Data Set

The data set for each radiological constituent [Tc-99, U-233/234, U-235/236, and U-238], including the MDC and Error, is provided in Attachment 1, *Post-remediation Groundwater Monitoring Period Summary of Results*. In Attachment 2, *Mann-Kendall Analysis and Sample Results Graphs*, the data set for each radiological constituent has been graphed for each well versus the respective MCL, along with the Mann-Kendell trend graph, as described previously. The full laboratory data packages for each sampling event are contained in Appendix A through D.

For discussion purposes, each radiological constituent is showing the four quarterly results, the average concentration of the radiological constituent for each monitoring well, and the maximum detected concentration of the radiological constituent for each Sand/Gravel HSU monitoring well are presented in Tables 4-13 through 4-16 below.

Table 4-13
Sand/Gravel HSU Monitoring Period Summary of Technetium - 99

SAND/GRAVEL HSU Tc-99 pCi/L						
Well ID	**1st Quarter Result**	**2nd Quarter Result**	**3rd Quarter Result**	**4th Quarter Result**	**Average**	**Maximum**
GW-BB	-0.036	0.405	1.93	0.793	0.782	1.93
GW-CC	3.6	2.66	3.95	6.12	4.0825	6.12
GW-DD	4.82	5.06	3.91	4.23	4.505	5.06
GW-EE	1.72	1.51	1.95	1.51	1.6725	1.95
GW-FF	3.05	3.58	1.93	1.32	2.47	3.58
GW-GG	-0.563	-0.0554	-0.667	1	0.25	1
GW-HH	-0.513	-0.478	-0.234	-0.764	0	N/A
GW-II	-0.252	-1.27	0.0832	0.243	0.08155	0.243
GW-JJ	5.69	4.12	3.28	6.83	4.98	6.83
GW-V	5.12	4.88	4.68	2.65	4.3325	5.12
GW-W	1.17	0.322	0.373	0.486	0.58775	1.17
GW-X	61.4	71	80.3	75.7	72.1	80.3
GW-Y	3.29	3.68	3.35	2.65	3.2425	3.68
NB-34	2.27	4.5	3.46	2.17	3.1	4.5
NB-35	2.38	1.33	1.94	3.02	2.1675	3.02
NB-71	0.23	-1.03	-0.315	-0.989	0.0575	0.23
NB-80	0.522	-0.414	-0.153	-1.3	0.1305	0.522
PZ-02	2.5	4.73	3.86	2.29	3.345	4.73

Table 4-14
Sand/Gravel HSU Monitoring Period Summary of Uranium - 233/234

SAND/GRAVEL HSU U-233/234 pCi/L						
Well ID	**1st Quarter Result**	**2nd Quarter Result**	**3rd Quarter Result**	**4th Quarter Result**	**Average**	**Maximum**
GW-BB	0	0.0251	0.0306	0.0417	0.02435	0.0417
GW-CC	0.97	0.928	0.746	0.709	0.83825	0.97
GW-DD	0.148	0.0422	0.0378	0.00875	0.0591875	0.148
GW-EE	0.226	0.0392	0.0185	0.00657	0.0725675	0.226
GW-FF	0.723	0.366	0.284	0.649	0.5055	0.723
GW-GG	0.0868	0	0.235	0.00929	0.0827725	0.235
GW-HH	0.518	1.02	0.3	4.5	1.5845	4.5
GW-II	0.127	0.0406	0.00902	0.0602	0.059205	0.127
GW-JJ	0.0371	0.00882	-0.0221	-0.0152	0.01148	0.0371
GW-V	0.0833	0.0645	0.0458	-0.00312	0.0484	0.0833
GW-W	0.0691	0.0225	0.0482	-0.00632	0.03495	0.0691
GW-X	0.00503	0.0188	0.0496	0.0353	0.0271825	0.0496
GW-Y	0.33	0.287	0.374	0.279	0.3175	0.374
NB-34	0.058	0.0621	0.109	0.0777	0.0767	0.109
NB-35	-0.0461	0.0275	0.131	0.04	0.049625	0.131
NB-71	0.0831	0.0536	0.0343	0.0581	0.057275	0.0831
NB-80	-0.00721	0.118	-0.00471	0.0269	0.036225	0.118
PZ-02	0.0382	0.0247	0.0893	0.00724	0.03986	0.0893

Table 4-15
Sand/Gravel HSU Monitoring Period Summary of Uranium - 235/236

SAND/GRAVEL HSU U-235/236 pCi/L						
Well ID	**1st Quarter Result**	**2nd Quarter Result**	**3rd Quarter Result**	**4th Quarter Result**	**Average**	**Maximum**
GW-BB	0	0.0125	0	-0.00499	0.003125	0.0125
GW-CC	0.047	0.013	0.0245	0.0638	0.037075	0.0638
GW-DD	0.0276	0.00543	0.0358	0	0.0172075	0.0358
GW-EE	0	0	-0.0072	0.0368	0.0092	0.0368
GW-FF	0.0697	0.0398	-0.00527	0.0459	0.03885	0.0697
GW-GG	0.0193	-0.1	0	0.0116	0.007725	0.0193
GW-HH	0.0115	0	0.0134	0.121	0.036475	0.121
GW-II	0.0176	0.0126	-0.00935	-0.00506	0.00755	0.0176
GW-JJ	0	0	-0.0075	0.011	0.00275	0.011
GW-V	0	0.00211	-0.019	0	0.0005275	0.00211
GW-W	0	-0.007	0.015	0	0.00375	0.015
GW-X	0.0125	0.0134	0.00668	0.0305	0.01577	0.0305
GW-Y	0	0.0227	0.0412	0.0134	0.019325	0.0412
NB-34	0.0176	-0.00677	0.0102	-0.0191	0.00695	0.0176
NB-35	-0.0148	0.0054	-0.0322	0.0307	0.009025	0.0307
NB-71	0	-0.00814	0	0.00301	0.0007525	0.00301
NB-80	-0.018	-0.00688	-0.0195	0.00837	0.0020925	0.00837
PZ-02	0.0204	-0.00808	-0.00783	0	0.0051	0.0204

Table 4-16
Sand/Gravel HSU Monitoring Period Summary of Uranium - 238

SAND/GRAVEL HSU U-238 pCi/L						
Well ID	**1st Quarter Result**	**2nd Quarter Result**	**3rd Quarter Result**	**4th Quarter Result**	**Average**	**Maximum**
GW-BB	0.00915	0.0438	-0.00803	0.0561	0.0272625	0.0561
GW-CC	0.704	0.606	0.663	0.518	0.62275	0.704
GW-DD	0.103	0.0218	0.101	0.0214	0.0618	0.103
GW-EE	0.00901	0.00434	0.0358	0.041	0.0225375	0.041
GW-FF	0.494	0.128	0.156	0.287	0.26625	0.494
GW-GG	0.0465	-0.0111	0.261	0.0332	0.085175	0.261
GW-HH	0.203	0.185	0.0925	1.1	0.395125	1.1
GW-II	0.0989	0.0607	0.018	0.0114	0.04725	0.0989
GW-JJ	0.011	0.0692	-0.0321	0.0216	0.02545	0.0692
GW-V	0.0416	0.0203	-0.00457	0.00701	0.0172275	0.0416
GW-W	0.0138	0.0157	-0.0344	0.0394	0.017225	0.0394
GW-X	0.0314	0.043	0.0495	0.0145	0.0346	0.0495
GW-Y	0.277	0.233	0.164	0.169	0.21075	0.277
NB-34	0.0334	0.0728	0.14	0.0865	0.083175	0.14
NB-35	0.0289	0.0274	0.0361	0.0169	0.027325	0.0361
NB-71	0.0099	0.0313	0.00285	0.00644	0.0126225	0.0313
NB-80	0.0115	0.0773	0.011	0.0269	0.031675	0.0773
PZ-02	0.0286	0.0337	0.0565	0.00161	0.0301	0.0565

The Sand/Gravel HSU data sets were reviewed for the four quarters of sampling to determine the maximum concentration of each radiological constituent detected during the annual monitoring. Table 4-17 below indicates the maximum concentration detected for each radiological constituent, the monitoring well where the detection occurred, and the quarter in which the maximum detection occurred. In addition, the drinking water MCL and an indication of whether any of the analyses indicated contamination above the MCL. A review of the data set indicates that none of the monitoring well sampling results for any radiological constituent approached or was near the MCL.

Table 4-17
Sand/Gravel HSU Maximum Concentrations of ROCs

Radiological Constituent	Units	Maximum Detected Concentration	MCL	Number of Analyses > MCL	Maximum Location	Maximum Quarter
Technetium-99	pCi/L	80.3 ± 8.24	900	0	GW-X	3rd Quarter
Uranium-234	pCi/L	4.5 ± 0.518	20*	0	GW-HH	4th Quarter
Uranium-235/236	pCi/L	0.121 ± 0.0655	20*	0	GW-HH	4th Quarter
Uranium-238	pCi/L	1.1±0.198	20*	0	GW-HH	4th Quarter

* Isotopic Evaluation Level since MCL is 30 µg/L for total uranium.

The results of the Mann-Kendell trend analysis for the Sand/Gravel HSU are provided in the table below. The Mann-Kendall analysis showed a downward trend for Tc-99 in monitoring well GW-X, which is the sand/gravel well with the highest detected concentration of Tc-99. The Mann-Kendall analysis also indicated downward trends for Total Uranium in monitoring wells GW-CC, GW-JJ, NB-35, and NB-80. No upward trends were indicated by the analysis, supporting the premise that there is not an expanding plume of radiological contamination within the Sand/Gravel HSU.

The results of the Mann-Kendell trend analysis for the Jefferson City-Cotter HSU are provided in the Table 4-18 below. There were no upward trends indicated for either Technetium-99 or total Uranium during the 4th Quarter sampling. There were downward trends indicated in monitoring wells GW-CC, GW-JJ, NB-35, and NB-80 for total Uranium and in monitoring well GW-X for Technetium-99.

Table 4-18
Mann-Kendell Trend Analysis Results – Sand Gravel HSU

Well ID	Tc-99	Total U
GW-BB	No Trend	No Trend
GW-CC	No Trend	Downward Trend
GW-DD	No Trend	No Trend
GW-EE	No Trend	No Trend
GW-FF	No Trend	No Trend
GW-GG	No Trend	No Trend
GW-HH	No Trend	No Trend
GW-II	No Trend	No Trend
GW-JJ	No Trend	Downward Trend
GW-V	No Trend	No Trend
GW-W	No Trend	No Trend
GW-X	Downward Trend	No Trend
GW-Y	No Trend	No Trend
NB-34	No Trend	No Trend
NB-35	No Trend	Downward Trend
NB-71	No Trend	No Trend
NB-80	No Trend	Downward Trend
PZ-02	No Trend	No Trend

4.4 Calculated Groundwater Dose Contribution

FSSFR Volume 3 Chapter 1 in regards to Groundwater Dose states "*In summary, to support the NRC review of LSA survey area release records prior to the completion of the post remediation groundwater monitoring, the SOF for groundwater will be set at the conservative value of 0.16 in the survey area release records for each LSA. This value is based upon groundwater not exceeding the EPA drinking water standard of 4 millirem/year.*"

Having obtained the required post-remediation groundwater monitoring period sample data the dose contribution that will be assigned to all Land Survey Area survey units for the purpose of demonstrating compliance with the unrestricted release criteria can be calculated. The basis for the use of the average radionuclide concentration from the post-remediation monitoring period is considered to be the optimal reasonable and representative data to determine the groundwater dose contribution as it 1) the data is representative of conditions post remediation rather than pre-remediation, 2) the duration of the monitoring period includes effects of seasonal changes, 3) is consistent with the MARSSIM approach for determining dose contribution.

DP Chapter 5, Section 5.3.8 states "*Groundwater dose will be calculated by multiplying the groundwater concentration identified, if any, for a given ROC by the corresponding DSR_{GW} listed in Table 5-14.*"

The Safety Evaluation Report for the DP Section 4.5, Groundwater {ML112101630} states "*The chemical analyses of groundwater samples collected from the monitoring wells completed in various hydrostratigraphic units confirmed that only Uranium-234, Uranium-235, Uranium-238 and Technetium-99 are the primary radionuclides of concern in groundwater.*" As such, Table 4-19 provides the DSR_{GW} for the radionuclides specified as taken from Table 5-14 of the DP.

Table 4-19
Groundwater DSR_{GW}s for the ROCs (from Table 5-14 of DP)

Radionuclide of Concern	DSR_{GW} (mrem/yr per pCi/L)
Tc-99	9.374 E-04
U-234	0.1532
U-235 + D	0.1448
U-238 + D	0.1455

The average monitoring period concentration is used as the "groundwater concentration identified" as it best represents the ROC concentration within the aquifer and therefore is a reasonable representation of the impacts of drinking water on a person living on the property, and consuming drinking water from underground sources. The average monitoring period concentration is representative of the ROC concentration as it considers 1) the ROC concentration over the entirety of the monitoring period, 2) the monitoring period spans the full seasonal cycle impacts experienced over the course of a year, and 3) the Mann-Kendall trend analysis for all ROCs in all aquifers are demonstrated to be stable or showing a downward trend.

To determine the groundwater dose the average monitoring period concentration for each ROC in each aquifer was multiplied by the DSR_{GW} for the ROC. The calculated dose for each ROC within the aquifer was then summed to determine the calculate groundwater dose for the aquifer (Table 4-20).

Therefore, as can be seen in Table 4-20, the dose an individual is expected to receive as a result of groundwater is 0.68 mrem/year (assuming a drinking water well was installed in the Jefferson City-Cotter aquifer).

In FSSFR Volume 7, *Chapter 1, Final Status Summary Final Report – Summary*, which will be submitted with the request to terminate NRC License SNM-33 for the site, the default groundwater dose contribution to each LSA survey unit will be replaced with the determined groundwater dose contribution of 0.68 mrem/year.

4.4.1 Bounding Scenario – Maximum Quarterly Concentration per HSU

To confirm that a there is not a scenario in which the groundwater dose contribution could exceed the EPA drinking water standard of 4 millirem/year a theoretical ROC maximum concentration scenario was also evaluated for bounding purposes. This scenario assumed the maximum ROC concentration in an individual quarterly result in each aquifer was representative of the entire HSU. These results are shown in Table 4-21.

Under this extremely unlikely scenario, which assumes a person in the future will install a well within the Jefferson City-Cotter aquifer, and that the maximum observed ROC concentration was received consistently throughout the entire year, the maximum dose received from groundwater would be 2.11 mrem/year, which is 52.75 % of the EPA drinking water standard.

This evaluation bounds an intruder scenario which assumes a person in the future will install an illegal and unlicensed well within the sand/gravel layer (not a source of potable water), and that the maximum observed ROC concentrations were received consistently throughout the entire year. The maximum dose received would be 1.30 mrem/year.

This scenario is being presented to demonstrate that regardless of how any future members of the public are to use the land comprising the Hematite site, that the dose contribution from groundwater sources will never exceed the EPA drinking water standard of 4 mrem/year.

4.4.2 Bounding Scenario – Maximum Quarterly Concentration for all HSUs

An additional bounding scenario was also considered when assessing the groundwater dose contribution for compliance with the release criteria. The scenario assumed the maximum quarterly radionuclide result as the concentration in the groundwater, regardless of the HSU from which the result originated. Therefore, for this bounding scenario, the maximum hypothetical result for Tc-99 used originated from the Sand/Gravel HSU, while the maximum hypothetical results from the uranium isotopes originated from the Jefferson City-Cotter HSU.

While this scenario is considered by Westinghouse to be incredible due to 1) the limited extent and thickness of the Sand/Gravel HSU, 2) the State of Missouri regulations regarding placement

of potable water wells in formations like the Sand/Gravel HSU, and 3) the future monitoring and control of the facility to accomplish chemical groundwater remediation as approved by the State of Missouri Department of Natural Resources, the results of this scenario supports the conclusion that the dose contribution from groundwater sources, calculated to be 2.186 mrem/year, does not exceed the EPA drinking water standard of 4 mrem/year. The results of this scenario are shown in Table 4-22.

Table 4-20
Calculated Groundwater Dose

Groundwater Formation	Monitoring Period Average Tc-99 (pCi/L)	x	DSR_{GW} (mrem/yr per pCi/L)	=	Dose Contribution from Radionuclide	Monitoring Period Average U233/234 (pCi/L)	x	DSR_{GW} (mrem/yr per pCi/L)	=	Dose Contribution from Radionuclide	Monitoring Period Average U-235/236 (pCi/L)	x	DSR_{GW} (mrem/yr per pCi/L)	=	Dose Contribution from Radionuclide	Monitoring Period Average U-238 (pCi/L)	x	DSR_{GW} (mrem/yr per pCi/L)	=	Dose Contribution from Radionuclide	Calculated Groundwater Dose (mem/year)
Sand/Gravel HSU	5.994	x	9.374 E-04	=	0.0056	0.218	x	0.1532	=	0.0334	0.0124	x	0.1448	=	0.0018	0.165	x	0.1455	=	0.0240	**0.06**
Jefferson City-Cotter HSU	0.131	x	9.374 E-04	=	0.0001	3.825	x	0.1532	=	0.5860	0.0474	x	0.1448	=	0.0069	0.5794	x	0.1455	=	0.0843	**0.68**
Roubidoux HSU	0.0682	x	9.374 E-04	=	0.00006	2.8768	x	0.1532	=	0.4407	0.0252	x	0.1448	=	0.0036	0.3024	x	0.1455	=	0.0440	**0.49**

Table 4-21
Calculated Groundwater Dose – Maximum Quarterly Concentration Scenario per HSU

Groundwater Formation	Maximum Detected Tc-99 (pCi/L)	x	DSR_{GW} (mrem/yr per pCi/L)	=	Dose Contribution from Radionuclide	Maximum Detected U-233/234 (pCi/L))	x	DSR_{GW} (mrem/yr per pCi/L)	=	Dose Contribution from Radionuclide	Maximum Detected U-235/236 (pCi/L)	x	DSR_{GW} (mrem/yr per pCi/L)	=	Dose Contribution from Radionuclide	Maximum Detected U-238 (pCi/L)	x	DSR_{GW} (mrem/yr per pCi/L)	=	Dose Contribution from Radionuclide	Calculated Groundwater Dose Based on Maximum Concentration (mem/year)
Sand/Gravel HSU	80.3	x	9.374 E-04	=	0.0753	4.5	x	0.1532	=	0.6894	0.121	x	0.1448	=	0.0175	3.56	x	0.1455	=	0.5180	**1.30**
Jefferson City-Cotter HSU	1.19	x	9.374 E-04	=	0.0011	11.7	x	0.1532	=	1.7924	0.149	x	0.1449	=	0.0216	2.04	x	0.1455	=	0.2968	**2.11**
Roubidoux HSU	0.969	x	9.374 E-04	=	0.0009	6.2	x	0.9498	=	0.4407	0.0757	x	0.1448	=	0.0110	0.717	x	0.1455	=	0.1043	**0.56**

Table 4-22

Calculated Groundwater Dose – Maximum Quarterly Concentration Scenario for All HSUs

Radionuclide of Concern	HSU	Maximum Detected Activity (pCi/L)	DSR_{GW} (mrem/yr per pCi/L)	Dose Contribution from Radionuclide (mrem/year)
Tc-99	Sand/Gravel	80.3	9.374 E-04	0.075
U-233/234	Jefferson City-Cotter	11.7	0.1532	1.792
U-235/236	Jefferson City-Cotter	0.149	0.1448	0.022
U-238	Jefferson City-Cotter	2.04	0.1455	0.297
			Sum of Dose Contributions:	**2.186**

4.4.3 Uncertainty Analysis

To evaluate the potential impact of uncertainties associated with the ROC detections, Westinghouse used the data from the maximum quarterly concentration scenario groundwater dose (Table 4-22) and added the uncertainty to the detected value as shown in Table 4-23 below.

Table 4-23

Maximum Quarterly Concentration Scenario for All HSUs with Uncertainty

Radionuclide of Concern	HSU	Maximum Detected Activity (pCi/L)	Uncertainty (pCi/L)	Activity Maximum Detected + Uncertainty (pCi/L)	DSR_{GW} (mrem/yr per pCi/L)	Dose Contribution from Radionuclide (mrem/year)
Tc-99	Sand/Gravel	80.3	8.24	88.54	9.374 E-04	0.083
U-233/234	Jefferson City-Cotter	11.7	1.39	13.09	0.1532	2.005
U-235/236	Jefferson City-Cotter	0.149	0.0804	0.2294	0.1448	0.033
U-238	Jefferson City-Cotter	2.04	0.44	2.48	0.1455	0.361
					Sum of Dose Contributions:	**2.482**

Using this method, the calculated worst-case groundwater dose including sample uncertainty was 2.482 mrem/year, which is below the EPA standard of 4 mrem/year. Westinghouse used this calculation to determine that the effect of uncertainty on the dose calculation would not result in a false negative situation, where the groundwater dose would be incorrectly assumed to be below the EPA standard. Instead, this uncertainty analysis demonstrates that there was not a potential

for a false negative due to uncertainty, as the maximum concentrations plus the error did not result in exceedance of the EPA standard of 4 mrem/year.

4.5 HSU Groundwater Elevation Contour Maps

To evaluate the potential seasonal effects on the groundwater elevation and flow, groundwater elevations were collected from monitoring wells prior to the initiation of sampling. The water levels were collected within a 24 hour period to minimize the potential change in environmental parameters, such as precipitation, infiltration and barometric pressure, on the wells so an accurate temporal representation could be depicted.

The groundwater elevation contour maps for the Jefferson City-Cotter HSU, Roubidoux HSU and the Sand/Gravel HSU for the 4 Quarters of post-remediation groundwater monitoring period are provided in Attachment 3. There were no perceived changes in groundwater flow throughout the annual monitoring.

5.0 Tc– 99 EVALUATION IN SOIL ADJACENT TO HYBRID WELLS

In a response to a Request for Additional Information (RAI) on DP Chapter 3 (HDP-3-Q9), Westinghouse responded in Westinghouse letter HEM-11-56 {ML111260624} that an investigation protocol (Former Process Buildings Investigation Area and Hybrid Well Investigation) would be applied to the abandonment of hybrid wells. This commitment was intended to verify that hybrid wells were not introducing or creating a pathway from the leachate zone (silty/clay aquitard) to the underlying sand/gravel layer.

Westinghouse Technical Report, HDP-RPT-FSS-302, Summary Report of Investigations of Hybrid Wells and Former Process Buildings Investigation Area (Appendix E), describes the actions taken which included conducting borings in the close proximity to four specified wells and collect soil samples to the top of sand/gravel layer for radionuclide analysis to complete the investigations and the analytical results obtained.

The analytical results were used in the planning of remediation of the site and also for determination of the appropriate Conceptual Site Model DCGLs (uniform or Three Stratum) to be used to demonstrate compliance with the unrestricted release criteria.

6.0 ABANDONMENT OF GROUNDWATER MONITORING WELLS

As captured by the NRC in the Safety Evaluation Report {ML112101630}, Westinghouse committed to the abandonment of selected wells.

The first group of monitoring wells to be abandoned were selected hybrid wells identified with leachate impacted with radionuclides. These wells included PL-06, NB-33, EP-20, BD-14, WS-13, NB-31, NB-81, WS-17B, and DM-02. Prior to removal of these wells, a paired well, installed with a well screen solely in the sand/grave was placed adjacent to each well. This paired well analysis is discussed in FSSFR Volume 6, Chapter 1, Revision 1. These wells were removed during the pre-remediation preparations and during the time the SER was being finalized.

Subsequent to the issuance of the SER Westinghouse investigated the hybrid wells in the vicinity of the Former Process Buildings, and the location where Tc-99 was detected in leachate water above the investigation level. Because the wells, BD-01, BD-02, BD-03, BD-04, BD-05, BD-06, BD-08, and BD-13, exceeded the investigation threshold, composite samples of the surrounding soil were collected. The sampling of the soil adjacent to the wells began in July of 2013 and continued through August. The samples were from each 5 foot increment of depth to the top of the screened/filtered interval; from the increment that is equivalent to the top half of the screened/filtered interval; and from the increment that is equivalent to the bottom half of the screened/filtered interval.

Concurrent with the Former Process Building evaluation, hybrid well investigation sampling was performed additional wells that were located in the suspected impacted area and where monitoring well samples exceeded an investigation threshold. These addition wells included BP-17, EP-14, EP-15, EP-16, LF-08, LF-09, PL-06, and WS-32. The results of this investigation were reported in HDP-RPT-FSS-302. The removal of the hybrid wells and surrounding impacted soil in these areas, combined with the FSS, indicate that there is not a threat of cross-communication between the impacted silty clay and the underlying sand/gravel HSU.

There are still existing hybrid wells on site but they are installed at locations that were not found to be impacted by Tc-99 and were remediation of the overburden soil was not required. These well are listed in Table 6.1, Remaining Hybrid Wells. Since there is no residual contamination within the leachate zone at these locations, these wells do not pose a cross-communication threat between the silty clay overburden and the underlying sand/gravel HSU.

Table 6-1
Remaining Hybrid Wells

Well Designation	Location
NB-34	South of Railroad
NB-35	South of Railroad
NB-85	South of Railroad, Western Portion
OB-01	West of Site Near Highway P
OB-02	East of Site, South McKee property
PZ-02	South of Railroad
NB-50	North of Building 110
NB-54	In Parking Lot
NB-57A	In Parking Lot
NB-71	South of Laydown Area
NB-80	East of Former Burial Pits
WS-34	West of Building 231

7.0 CONCLUSIONS

There were no indications of Radionuclides of Concern above the EPA MCLs in any of the HSUs at the Westinghouse Hematite Facility during the post-remediation monitoring period.

Prior to remediation and as summarized in FSSFR Volume 6, Chapter 1, Revision 1, the silty clay unit above the Sand/Gravel HSU contained contamination in the form of leachate which is not usable groundwater. As the source term has been removed during the remediation of the site, an overall upward trend in contamination was not anticipated, and has been shown through the post-remediation monitoring not to be occurring. Therefore, the analytical data for the sampling that was conducted post-remediation of the site supports the conclusion that remediation activities did not impact groundwater

In addition, the estimated dose from groundwater sources has been estimated using the post-remediation monitoring data and has shown the dose contribution from groundwater to be less than 4 mrem/year. Therefore, the dose contribution from groundwater will be reduced from 4 mrem/year, down to 0.68 mrem/year for all LSA SUs. This dose will be reflected in the final site dose summary provided in FSSFR Volume 7, Chapter 1.

8.0 REFERENCES

8.1 DO-08-004, Hematite Decommissioning Plan {ML092330123}

8.2 Westinghouse letter HEM-11-56, *"Evaluation of Technetium-99 Under the Process Buildings"*, dated May 5, 2011 {ML111260624}

8.3 Westinghouse letter HEM-16-6, *Revision to the Physical Security Plan Dated September 11, 2013*, dated January 18, 2016 {ML16020A479}

8.4 U. S. NRC Safety Evaluation Report on Westinghouse Amendment Request for Approval of Hematite Decommissioning Plan and Associated Supporting Documents, October 2011 {ML112101630}

8.5 Mann-Kendall Test for Analysis of Groundwater Contaminant Plume Stability and Evaluation of Sampling Frequency for Long-Term Monitoring – 13233, Jeffrey R. Walker and Toby R. Harrison, Elvado Environmental LLC, 9724 Kingston Pike, Suite 603, Knoxville, TN 37922

9.0 APPENDICES (To Be Provided On Separate Data Disc)

APPENDIX A: Laboratory Data Packages Post-remediation Groundwater Monitoring 1st Quarter Results

APPENDIX B: Laboratory Data Packages Post-remediation Groundwater Monitoring 2nd Quarter Results

APPENDIX C: Laboratory Data Packages Post-remediation Groundwater Monitoring 3rd Quarter Results

APPENDIX D: Laboratory Data Packages Post-remediation Groundwater Monitoring 4th Quarter Results

APPENDIX E: HDP-RPT-FSS-302, Summary Report of Investigations of Hybrid Wells and Former Process Buildings Investigation Area

Attachment 1

Post-remediation Groundwater Monitoring Period Summary of Results

JEFFERSON CITY – COTTER HSU

Tc-99 pCi/L

Well ID	1st Quarter			2nd Quarter			3rd Quarter			4th Quarter			Average	Maximum
	Result	MDC	Error	Result	MDC	Error	Result	MDC	Error	Result	MDC	Error		
BR-04-JC	-1.16	2.11	1.21	-0.266	1.9	1.1	0.528	2.61	1.55	0.306	1.56	0.931	0.2085	0.528
BR-13-JC	-0.695	1.98	1.13	-0.117	1.8	1.05	-0.657	1.96	1.13	0.162	1.65	0.978	0.0405	0.162
BR-14-JC	-1.24	2.19	1.22	-0.126	1.87	1.08	-0.927	2.17	1.24	1.19	1.65	1.02	0.2975	1.19
BR-15-JC	-0.33	2.17	1.26	-0.683	2.38	1.38	-0.471	2.02	1.17	0.919	1.56	0.953	0.22975	0.919
BR-16-JC	-0.767	2.11	1.22	-0.946	2.17	1.24	0.567	1.97	1.18	-1.09	1.97	1.12	0.14175	0.567
BR-17-JC	-0.402	2.6	1.51	-0.307	2.05	1.19	-0.901	2	1.14	-0.718	3.59	2.09	0	-0.307
BR-18-JC	0.0809	1.82	1.07	-0.899	2.01	1.15	0.054	1.98	1.16	-0.358	1.63	0.946	0.033725	0.0809
BR-19-JC	0.276	2.31	1.36	-0.648	1.99	1.14	0.0273	2	1.17	0.0784	1.68	1.02	0.095425	0.276

JEFFERSON CITY – COTTER HSU

U-233/234 pCi/L

Well ID	1st Quarter			2nd Quarter			3rd Quarter			4th Quarter			Average	Maximum
	Result	MDC	Error	Result	MDC	Error	Result	MDC	Error	Result	MDC	Error		
BR-04-JC	2.81	0.0288	0.404	3.32	0.0931	0.516	2.89	0.12	0.498	2.68	0.0551	0.397	2.925	3.32
BR-13-JC	4.02	0.0621	0.522	4.16	0.0504	0.49	4.34	0.136	0.655	4.05	0.0827	0.47	4.1425	4.34
BR-14-JC	3.74	0.0319	0.508	3.56	0.0991	0.476	4.01	0.177	0.741	3.21	0.0788	0.395	3.63	4.01
BR-15-JC	1.38	0.0745	0.26	1.33	0.0859	0.27	1.13	0.116	0.301	1.37	0.0871	0.264	1.3025	1.38
BR-16-JC	1.72	0.11	0.283	4.59	0.0744	0.572	5.4	0.09	0.747	4.18	0.0553	0.479	3.9725	5.4
BR-17-JC	11.7	0.249	1.39	4.91	0.0976	0.609	2.73	0.166	0.479	2.84	0.0451	0.372	5.545	11.7
BR-18-JC	2.64	0.0838	0.406	2.25	0.0862	0.354	2.15	0.0995	0.434	2.08	0.0805	0.285	2.28	2.64
BR-19-JC	6.26	0.0538	0.7	7.02	0.0906	0.783	7.21	0.0537	0.939	6.72	0.0933	0.703	6.8025	7.21

JEFFERSON CITY – COTTER HSU
U-235/236

Well ID	1st Quarter			2nd Quarter			3rd Quarter			4th Quarter			Average	Maximum
	Result	MDC	Error	Result	MDC	Error	Result	MDC	Error	Result	MDC	Error		
BR-04-JC	0.0477	0.0358	0.06	0.0705	0.0529	0.0707	-0.0253	0.149	0.0292	0.0145	0.0815	0.038	0.033175	0.0705
BR-13-JC	0.0168	0.0773	0.02	0.0709	0.0266	0.0505	-0.0087	0.116	0.0176	0.0537	0.0611	0.0473	0.03535	0.0709
BR-14-JC	0.0662	0.0397	0.01	0.0474	0.0355	0.0476	0.112	0.27	0.16	0.0554	0.0238	0.0422	0.07025	0.112
BR-15-JC	0.0241	0.0362	0.05	0.0139	0.0417	0.0278	-0.0183	0.144	0.0259	0.0501	0.0376	0.0503	0.022025	0.0501
BR-16-JC	0.0204	0.0781	0.07	0.0286	0.076	0.0444	0.101	0.0608	0.091	0.0394	0.0236	0.0354	0.04735	0.101
BR-17-JC	0.126	0.192	0.18	0.0221	0.097	0.0491	0.0228	0.128	0.0598	0.0267	0.0267	0.0309	0.0494	0.126
BR-18-JC	0.0187	0.0857	0.03	0.0491	0.0368	0.0492	0.0243	0.314	0.157	0.0279	0.0571	0.0358	0.03	0.0491
BR-19-JC	0.149	0.0318	0.0804	0.0468	0.0351	0.047	0.0668	0.0668	0.0773	0.104	0.0241	0.0585	0.09165	0.149

JEFFERSON CITY – COTTER HSU
U-238 pCi/L

Well ID	1st Quarter			2nd Quarter			3rd Quarter			4th Quarter			Average	Maximum
	Result	MDC	Error	Result	MDC	Error	Result	MDC	Error	Result	MDC	Error		
BR-04-JC	0.402	0.0287	0.129	0.461	0.0781	0.167	0.394	0.131	0.171	0.262	0.0801	0.109	0.37975	0.461
BR-13-JC	0.59	0.0858	0.164	0.299	0.0213	0.0955	0.29	0.111	0.147	0.361	0.075	0.106	0.385	0.59
BR-14-JC	0.435	0.0318	0.141	0.678	0.06	0.171	0.568	0.176	0.258	0.604	0.0786	0.139	0.57125	0.678
BR-15-JC	0.358	0.029	0.121	0.345	0.0334	0.127	0.194	0.0529	0.118	0.237	0.0555	0.101	0.2835	0.358
BR-16-JC	0.655	0.0627	0.158	0.888	0.029	0.2	0.822	0.0898	0.242	0.77	0.0189	0.154	0.78375	0.888
BR-17-JC	2.04	0.0605	0.44	0.828	0.105	0.201	0.49	0.126	0.186	0.436	0.0623	0.12	0.9485	2.04
BR-18-JC	0.433	0.0837	0.145	0.216	0.0295	0.0941	0.239	0.235	0.173	0.118	0.0804	0.0659	0.2515	0.433
BR-19-JC	1.05	0.0255	0.209	1.11	0.0282	0.224	0.995	0.132	0.283	0.972	0.09	0.183	1.03175	1.11

ROUBIDOUX HSU
Tc-99 pCi/L

Well ID	1st Quarter			2nd Quarter			3rd Quarter			4th Quarter			Average	Maximum
	Result	MDC	Error	Result	MDC	Error	Result	MDC	Error	Result	MDC	Error		
BR-03R-RB	-1.08	2.42	1.4	-1.09	2.07	1.18	-0.207	1.98	1.15	-0.0105	1.83	1.07	0	-0.0105
BR-04-RB	-0.478	2.11	1.23	0.394	2.11	1.26	-0.738	1.97	1.13	-0.962	2.1	1.2	0.0985	0.394
BR-08-RB	-0.937	2.11	1.21	-0.37	3.12	1.83	-0.369	2.01	1.16	-1.13	1.96	1.12	0	-0.369
BR-10-RB	-1.13	2.12	1.22	-0.162	1.8	1.05	-1.13	1.99	1.13	0.969	1.58	0.97	0.24225	0.969
WS-04	-0.11	1.92	1.12	-0.37	2.32	1.35	-0.852	2.01	1.15	-1.77	1.97	1.11	0	-0.11

ROUBIDOUX HSU
U-233/234 pCi/L

Well ID	1st Quarter			2nd Quarter			3rd Quarter			4th Quarter			Average	Maximum
	Result	MDC	Error	Result	MDC	Error	Result	MDC	Error	Result	MDC	Error		
BR-03R-RB	1.9	0.142	0.331	2	0.0869	0.346	2.01	0.121	0.422	1.69	0.0682	0.25	1.9	2.01
BR-04-RB	2.41	0.0265	0.355	2.45	0.0613	0.371	2.58	0.133	0.544	2.43	0.0652	0.329	2.4675	2.58
BR-08-RB	6.2	0.11	0.732	5.21	0.061	0.627	6.01	0.15	0.896	6.09	0.0401	0.645	5.8775	6.2
BR-10-RB	2.91	0.0324	0.431	3.21	0.07	0.404	2.82	0.175	0.526	3.26	0.0629	0.401	3.05	3.26
WS-04	1.05	0.096	0.286	0.936	0.0984	0.271	1.25	0.244	0.339	1.12	0.0945	0.203	1.089	1.25

ROUBIDOUX HSU
U-235/236 pCi/L

Well ID	1st Quarter			2nd Quarter			3rd Quarter			4th Quarter			Average	Maximum
	Result	MDC	Error	Result	MDC	Error	Result	MDC	Error	Result	MDC	Error		
BR-03R-RB	0.0392	0.0392	0.0454	0.0422	0.0422	0.0489	0.0134	0.127	0.0497	0.000953	0.0667	0.0272	0.0239383	0.0422
BR-04-RB	0.00412	0.0695	0.0259	0	0.0362	0.0151	0.0473	0.165	0.0881	0.0168	0.0253	0.0239	0.017055	0.0473
BR-08-RB	0.0757	0.101	0.0737	0.0722	0.0361	0.0592	-0.0472	0.228	0.0473	0.0237	0.0237	0.0275	0.0429	0.0757
BR-10-RB	0.0185	0.0848	0.0416	0.00867	0.026	0.0174	0.0237	0.071	0.0474	0	0.0244	0.0102	0.0127175	0.0237
WS-04	0.0216	0.0648	0.0433	0.0222	0.0665	0.0444	0.0395	0.167	0.0849	0.0347	0.0735	0.0451	0.0295	0.0395

ROUBIDOUX HSU
U-238 pCi/L

Well ID	1st Quarter			2nd Quarter			3rd Quarter			4th Quarter			Average	Maximum
	Result	MDC	Error	Result	MDC	Error	Result	MDC	Error	Result	MDC	Error		
BR-03R-RB	0.169	0.147	0.11	0.158	0.0338	0.0855	0.158	0.102	0.112	0.115	0.047	0.0566	0.15	0.169
BR-04-RB	0.204	0.0771	0.0919	0.281	0.0291	0.107	0.206	0.132	0.146	0.241	0.0519	0.0854	0.233	0.281
BR-08-RB	0.426	0.0667	0.14	0.306	0.0742	0.115	0.503	0.149	0.223	0.381	0.0554	0.106	0.404	0.503
BR-10-RB	0.123	0.068	0.0765	0.125	0.0209	0.0599	0.144	0.105	0.109	0.135	0.0501	0.0632	0.13175	0.144
WS-04	0.607	0.052	0.211	0.508	0.0982	0.197	0.541	0.199	0.221	0.717	0.0426	0.152	0.59325	0.717

SAND/GRAVEL HSU

Tc-99 pCi/L

Well ID	1st Quarter			2nd Quarter			3rd Quarter			4th Quarter			Average	Maximum
	Result	MDC	Error	Result	MDC	Error	Result	MDC	Error	Result	MDC	Error		
GW-BB	-0.036	1.79	1.05	0.405	1.79	1.07	1.93	1.97	1.24	0.793	1.57	0.952	0.782	1.93
GW-CC	3.6	1.94	1.31	2.66	2.29	1.46	3.95	1.91	1.32	6.12	1.68	1.32	4.0825	6.12
GW-DD	4.82	2.12	1.48	5.06	2.18	1.53	3.91	1.96	1.34	4.23	2.18	1.48	4.505	5.06
GW-EE	1.72	1.81	1.14	1.51	2.08	1.29	1.95	1.94	1.23	1.51	1.73	1.08	1.6725	1.95
GW-FF	3.05	1.84	1.23	3.58	2.08	1.39	1.93	1.96	1.24	1.32	2.53	1.54	2.47	3.58
GW-GG	-0.563	2.34	1.32	-0.0554	2.03	1.19	-0.667	2.88	1.66	1	1.74	1.06	0.25	1
GW-HH	-0.513	1.93	1.11	-0.478	1.81	1.04	-0.234	1.97	1.15	-0.764	1.97	1.13	0	-0.234
GW-II	-0.252	2.09	1.2	-1.27	2.12	1.2	0.0832	2.18	1.28	0.243	1.56	0.928	0.08155	0.243
GW-JJ	5.69	1.98	1.48	4.12	1.91	1.34	3.28	1.98	1.32	6.83	1.71	1.38	4.98	6.83
GW-V	5.12	1.83	1.36	4.88	1.9	1.38	4.68	1.85	1.33	2.65	2.08	1.34	4.3325	5.12
GW-W	1.17	2.25	1.37	0.322	1.95	1.16	0.373	2.09	1.25	0.486	1.56	0.937	0.58775	1.17
GW-X	61.4	1.83	6.43	71	1.8	7.32	80.3	2.01	8.24	75.7	1.97	7.78	72.1	80.3
GW-Y	3.29	2.04	1.36	3.68	1.83	1.26	3.35	1.99	1.33	2.65	2.08	1.34	3.2425	3.68
NB-34	2.27	2.22	1.4	4.5	1.8	1.3	3.46	1.99	1.33	2.17	2.46	1.54	3.1	4.5
NB-35	2.38	2.11	1.35	1.33	2.01	1.23	1.94	2	1.25	3.02	1.64	1.1	2.1675	3.02
NB-71	0.23	2	1.18	-1.03	2.13	1.22	-0.315	1.98	1.15	-0.989	1.97	1.13	0.0575	0.23
NB-80	0.522	1.81	1.08	-0.414	2.08	1.21	-0.153	1.99	1.16	-1.3	1.97	1.12	0.1305	0.522
PZ-02	2.5	2.03	1.31	4.73	1.95	1.4	3.86	1.86	1.28	2.29	2.07	1.31	3.345	4.73

SAND/GRAVEL HSU
U-233/234 pCi/L

Well ID	1st Quarter			2nd Quarter			3rd Quarter			4th Quarter			Average	Maximum
	Result	MDC	Error	Result	MDC	Error	Result	MDC	Error	Result	MDC	Error		
GW-BB	0	0.0472	0.0131	0.0251	0.0966	0.0514	0.0306	0.107	0.057	0.0417	0.0618	0.0419	0.02435	0.0417
GW-CC	0.97	0.12	0.187	0.928	0.0804	0.214	0.746	0.17	0.259	0.709	0.0674	0.182	0.83825	0.97
GW-DD	0.148	0.0817	0.0763	0.0422	0.137	0.0764	0.0378	0.176	0.0906	0.00875	0.0402	0.0197	0.0591875	0.148
GW-EE	0.226	0.0856	0.122	0.0392	0.0733	0.0487	0.0185	0.112	0.0534	0.00657	0.1	0.0458	0.0725675	0.226
GW-FF	0.723	0.0899	0.179	0.366	0.0673	0.13	0.284	0.125	0.148	0.649	0.0561	0.142	0.5055	0.723
GW-GG	0.0868	0.0859	0.0776	0	0.123	0.0566	0.235	0.235	0.272	0.00929	0.279	0.0186	0.0827725	0.235
GW-HH	0.518	0.0278	0.145	1.02	0.0293	0.218	0.3	0.122	0.156	4.5	0.0534	0.518	1.5845	4.5
GW-II	0.127	0.0425	0.0856	0.0406	0.0304	0.0407	0.00902	0.166	0.0725	0.0602	0.0642	0.0532	0.059205	0.127
GW-JJ	0.0371	0.0694	0.0462	0.00882	0.0836	0.0328	-0.0221	0.233	0.0864	-0.0152	0.0756	0.028	0.01148	0.0371
GW-V	0.0833	0.0416	0.0684	0.0645	0.0892	0.0627	0.0458	0.168	0.0902	-0.00312	0.095	0.0392	0.0484	0.0833
GW-W	0.0691	0.0414	0.062	0.0225	0.0867	0.0461	0.0482	0.166	0.0896	-0.00632	0.0764	0.0247	0.03495	0.0691
GW-X	0.00503	0.0969	0.043	0.0188	0.0828	0.0419	0.0496	0.156	0.0866	0.0353	0.0472	0.0344	0.0271825	0.0496
GW-Y	0.33	0.0807	0.143	0.287	0.116	0.115	0.374	0.0916	0.163	0.279	0.0322	0.112	0.3175	0.374
NB-34	0.058	0.198	0.11	0.0621	0.0964	0.0669	0.109	0.103	0.087	0.0777	0.114	0.0758	0.0767	0.109
NB-35	-0.0461	0.167	0.0696	0.0275	0.0731	0.0427	0.131	0.167	0.122	0.04	0.0593	0.0402	0.049625	0.131
NB-71	0.0831	0.0626	0.0612	0.0536	0.0915	0.06	0.0343	0.0514	0.0486	0.0581	0.0194	0.039	0.057275	0.0831
NB-80	-0.00721	0.0729	0.0144	0.118	0.0559	0.0679	-0.00471	0.139	0.0464	0.0269	0.0202	0.027	0.036225	0.118
PZ-02	0.0382	0.132	0.071	0.0247	0.0551	0.0338	0.0893	0.131	0.0902	0.00724	0.0712	0.0307	0.03986	0.0893

SAND/GRAVEL HSU
U-235/236 pCi/L

Well ID	1st Quarter			2nd Quarter			3rd Quarter			4th Quarter			Average	Maximum
	Result	MDC	Error	Result	MDC	Error	Result	MDC	Error	Result	MDC	Error		
GW-BB	0	0.0587	0.0163	0.0125	0.0375	0.025	0	0.0721	0.02	-0.00499	0.0505	0.01	0.003125	0.0125
GW-CC	0.047	0.105	0.0629	0.013	0.0391	0.0261	0.0245	0.0735	0.049	0.0638	0.0383	0.0573	0.037075	0.0638
GW-DD	0.0276	0.0703	0.0412	0.00543	0.0915	0.0342	0.0358	0.125	0.0667	0	0.0238	0.0099	0.0172075	0.0358
GW-EE	0	0.0578	0.0161	0	0.0433	0.0181	-0.0072	0.0955	0.0144	0.0368	0.0368	0.0426	0.0092	0.0368
GW-FF	0.0697	0.0349	0.0572	0.0398	0.0398	0.046	-0.00527	0.155	0.052	0.0459	0.0614	0.0447	0.03885	0.0697
GW-GG	0.0193	0.058	0.0387	-0.1	0.185	0.0563	0	0.293	0.325	0.0116	0.0347	0.0231	0.007725	0.0193
GW-HH	0.0115	0.0346	0.0231	0	0.0364	0.0152	0.0134	0.127	0.05	0.121	0.0259	0.0655	0.036475	0.121
GW-II	0.0176	0.0528	0.0353	0.0126	0.0379	0.0253	-0.00935	0.124	0.0187	-0.00506	0.0672	0.0101	0.00755	0.0176
GW-JJ	0	0.041	0.0171	0	0.0565	0.0157	-0.0075	0.221	0.0739	0.011	0.0504	0.0247	0.00275	0.011
GW-V	0	0.0518	0.0144	0.00211	0.0896	0.033	-0.019	0.15	0.0269	0	0.035	0.00971	0.0005275	0.00211
GW-W	0	0.0516	0.0143	-0.007	0.0707	0.014	0.015	0.142	0.0557	0	0.0354	0.00983	0.00375	0.015
GW-X	0.0125	0.0376	0.0251	0.0134	0.0402	0.0268	0.00668	0.161	0.0658	0.0305	0.0229	0.0306	0.01577	0.0305
GW-Y	0	0.0545	0.0151	0.0227	0.0739	0.0402	0.0412	0.0619	0.0584	0.0134	0.0401	0.0267	0.019325	0.0412
NB-34	0.0176	0.166	0.0757	-0.00677	0.0899	0.0136	0.0102	0.0964	0.0378	-0.0191	0.138	0.0536	0.00695	0.0176
NB-35	-0.0148	0.137	0.0522	0.0054	0.0909	0.034	-0.0322	0.19	0.0372	0.0307	0.023	0.0308	0.009025	0.0307
NB-71	0	0.037	0.0154	-0.00814	0.0823	0.0163	0	0.064	0.0178	0.00301	0.0507	0.0189	0.0007525	0.00301
NB-80	-0.018	0.11	0.0254	-0.00688	0.0696	0.0138	-0.0195	0.154	0.0277	0.00837	0.0251	0.0168	0.0020925	0.00837
PZ-02	0.0204	0.0611	0.0408	-0.00808	0.0686	0.0162	-0.00783	0.104	0.0157	0	0.036	0.01	0.0051	0.0204

SAND/GRAVEL HSU

U-238 pCi/L

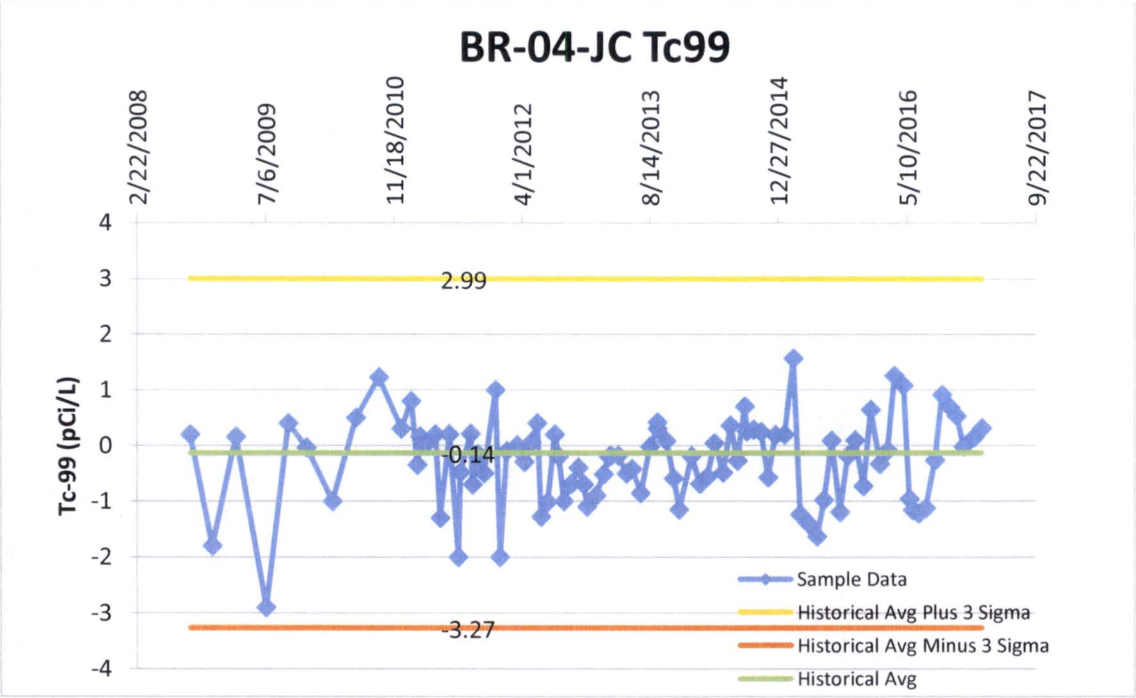
Well ID	1st Quarter			2nd Quarter			3rd Quarter			4th Quarter			Average	Maximum
	Result	MDC	Error	Result	MDC	Error	Result	MDC	Error	Result	MDC	Error		
GW-BB	0.00915	0.0867	0.034	0.0438	0.0632	0.0466	-0.00803	0.107	0.0161	0.0561	0.0493	0.0423	0.0272625	0.0561
GW-CC	0.704	0.0695	0.149	0.606	0.0313	0.167	0.663	0.145	0.241	0.518	0.0566	0.153	0.62275	0.704
GW-DD	0.103	0.0706	0.0631	0.0218	0.121	0.0613	0.101	0.1	0.0905	0.0214	0.0401	0.0267	0.0618	0.103
GW-EE	0.00901	0.0854	0.0335	0.00434	0.0731	0.0273	0.0358	0.0766	0.0494	0.041	0.0647	0.0456	0.0225375	0.041
GW-FF	0.494	0.0279	0.142	0.128	0.0319	0.0744	0.156	0.179	0.13	0.287	0.0492	0.0908	0.26625	0.494
GW-GG	0.0465	0.0465	0.0539	-0.0111	0.103	0.0394	0.261	0.777	0.437	0.0332	0.0512	0.038	0.085175	0.261
GW-HH	0.203	0.0277	0.0883	0.185	0.0292	0.0863	0.0925	0.0555	0.0831	1.1	0.0208	0.198	0.395125	1.1
GW-II	0.0989	0.0424	0.0752	0.0607	0.0304	0.0498	0.018	0.054	0.036	0.0114	0.0641	0.0299	0.04725	0.0989
GW-JJ	0.011	0.0329	0.022	0.0692	0.0835	0.0689	-0.0321	0.244	0.0886	0.0216	0.0405	0.0269	0.02545	0.0692
GW-V	0.0416	0.0416	0.0481	0.0203	0.0305	0.0288	-0.00457	0.135	0.0451	0.00701	0.0689	0.0297	0.0172275	0.0416
GW-W	0.0138	0.0414	0.0276	0.0157	0.069	0.0349	-0.0344	0.166	0.0345	0.0394	0.0622	0.0439	0.017225	0.0394
GW-X	0.0314	0.0878	0.05	0.043	0.0322	0.0431	0.0495	0.156	0.0864	0.0145	0.0387	0.0226	0.0346	0.0495
GW-Y	0.277	0.0437	0.129	0.233	0.101	0.102	0.164	0.143	0.119	0.169	0.079	0.0908	0.21075	0.277
NB-34	0.0334	0.101	0.0565	0.0728	0.0721	0.0651	0.14	0.042	0.0892	0.0865	0.0839	0.0672	0.083175	0.14
NB-35	0.0289	0.0809	0.0461	0.0274	0.0729	0.0426	0.0361	0.152	0.0775	0.0169	0.0473	0.0269	0.027325	0.0361
NB-71	0.0099	0.0297	0.0198	0.0313	0.0313	0.0363	0.00285	0.113	0.0397	0.00644	0.0193	0.0129	0.0126225	0.0313
NB-80	0.0115	0.0346	0.0231	0.0773	0.0679	0.0584	0.011	0.104	0.0407	0.0269	0.0201	0.027	0.031675	0.0773
PZ-02	0.0286	0.121	0.0614	0.0337	0.0681	0.0424	0.0565	1.11	0.071	0.00161	0.0634	0.0224	0.0301	0.0565

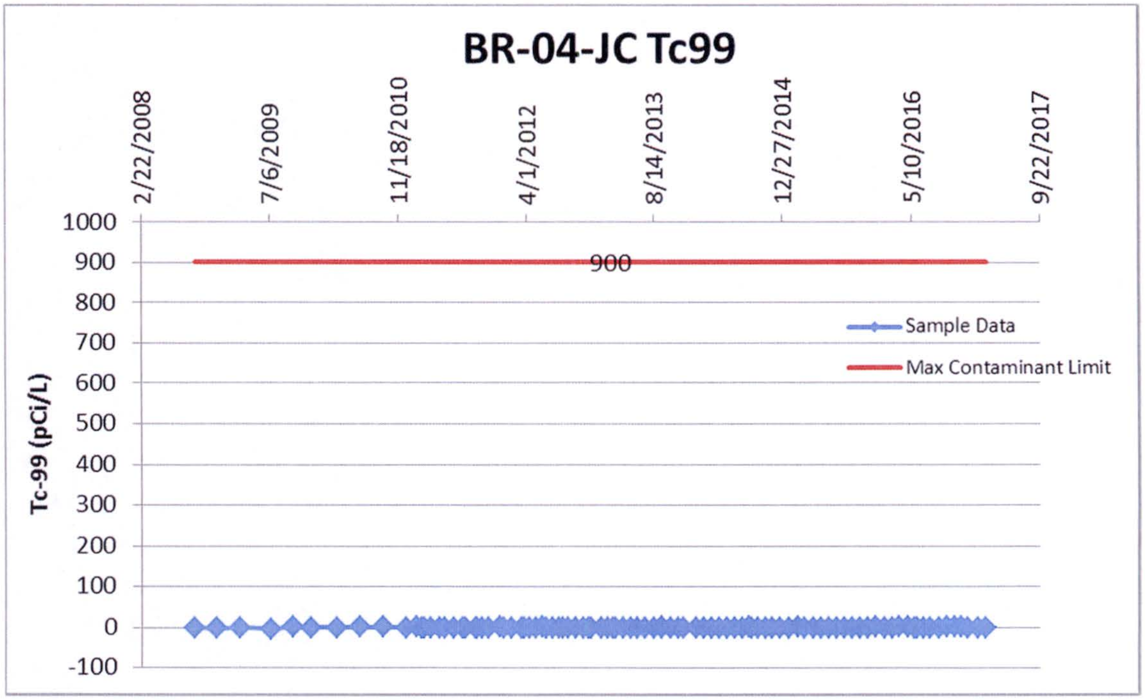
Attachment 2

Mann-Kendall Analysis and Sample Results Graphs

Attachment 2
Mann-Kendall Analysis and Sample Results Graphs

JEFFERSON CITY – COTTER HSU





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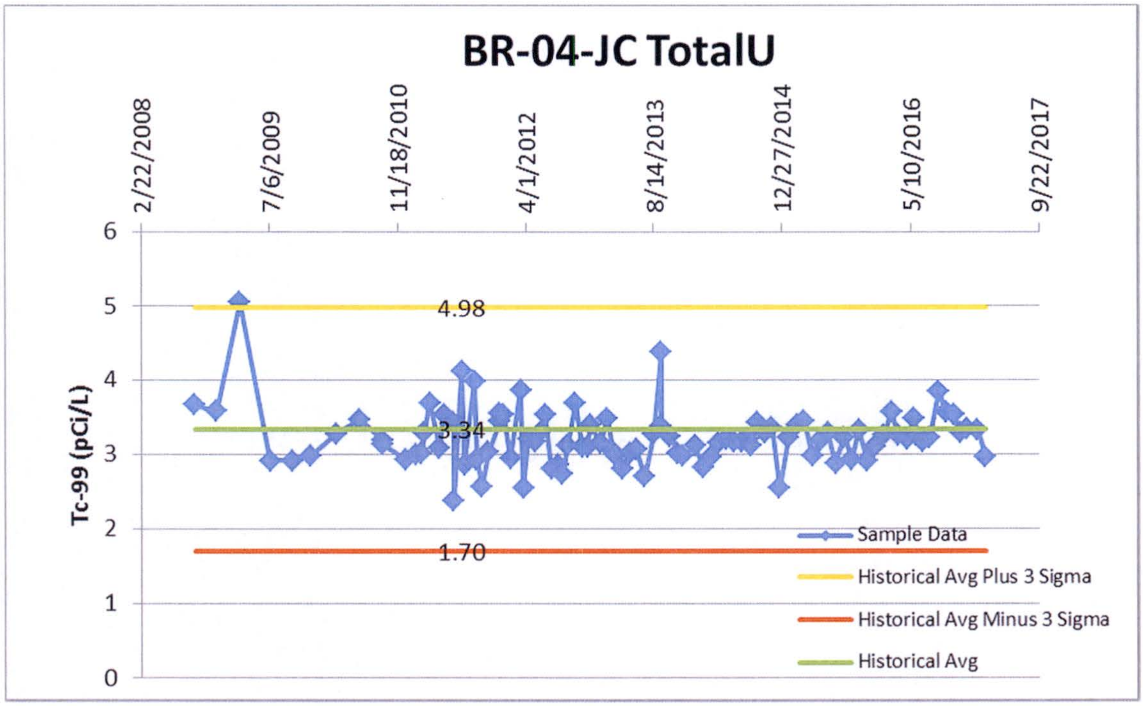

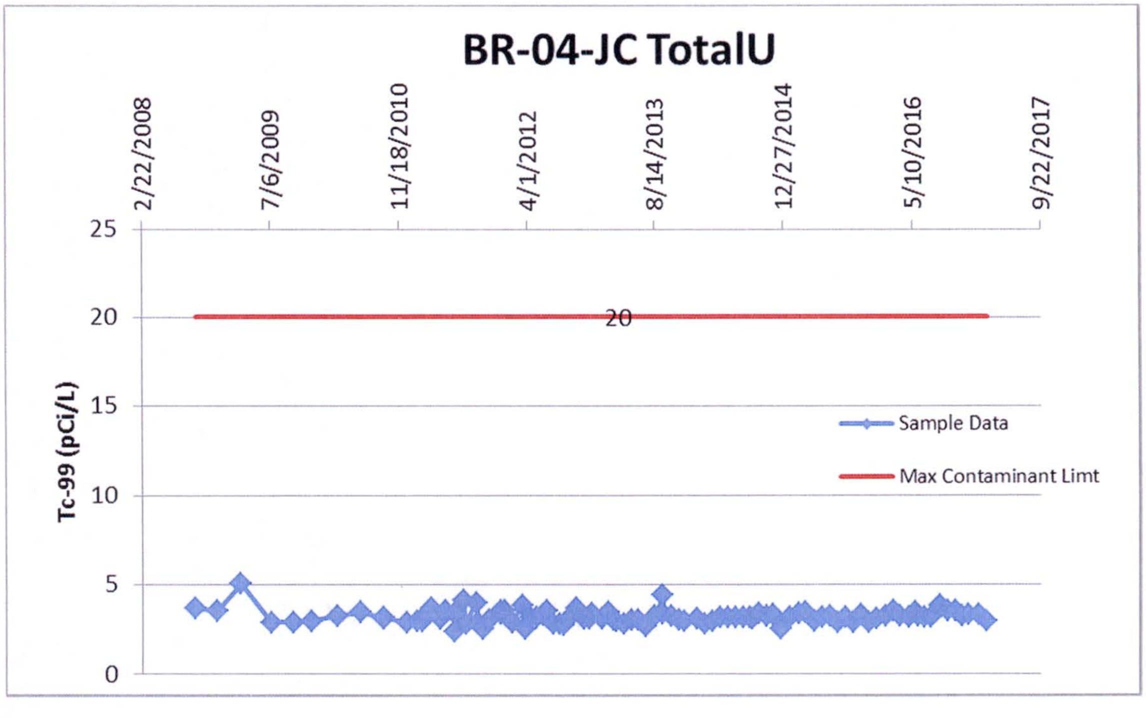

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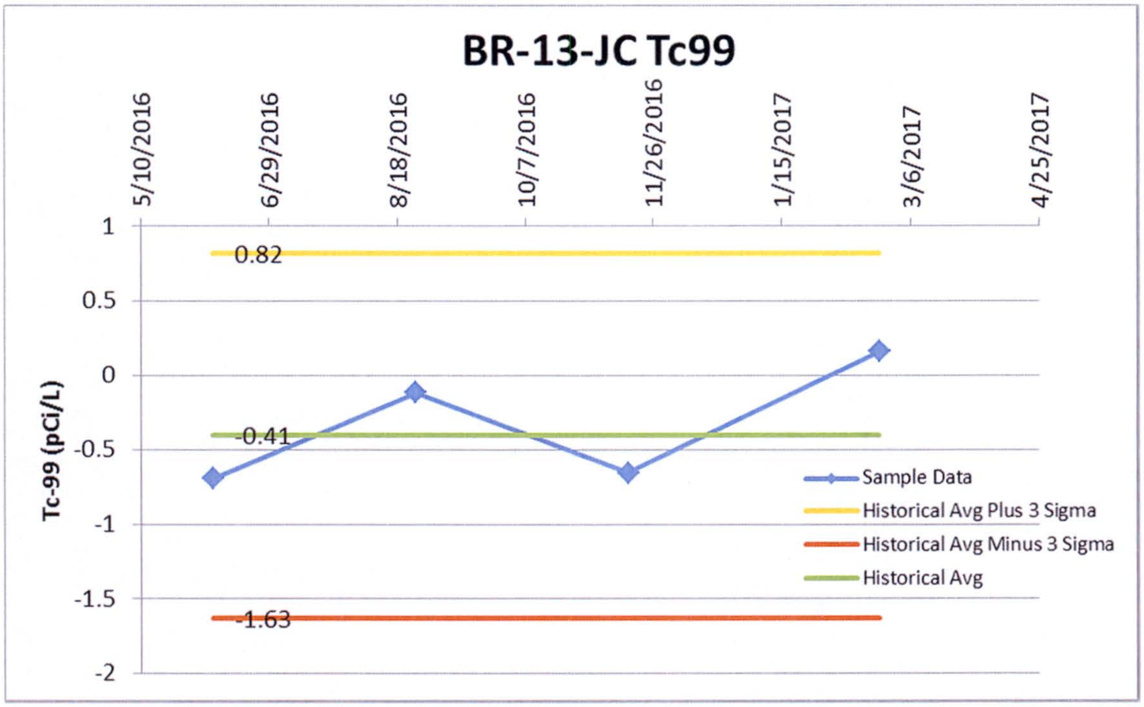

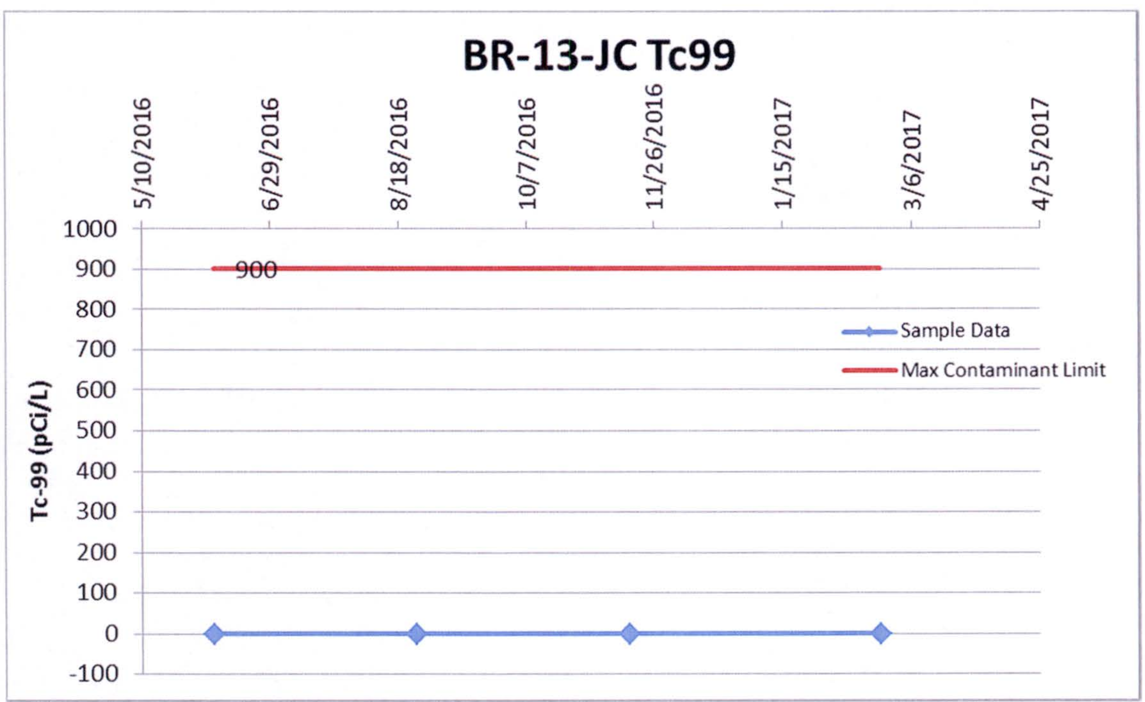

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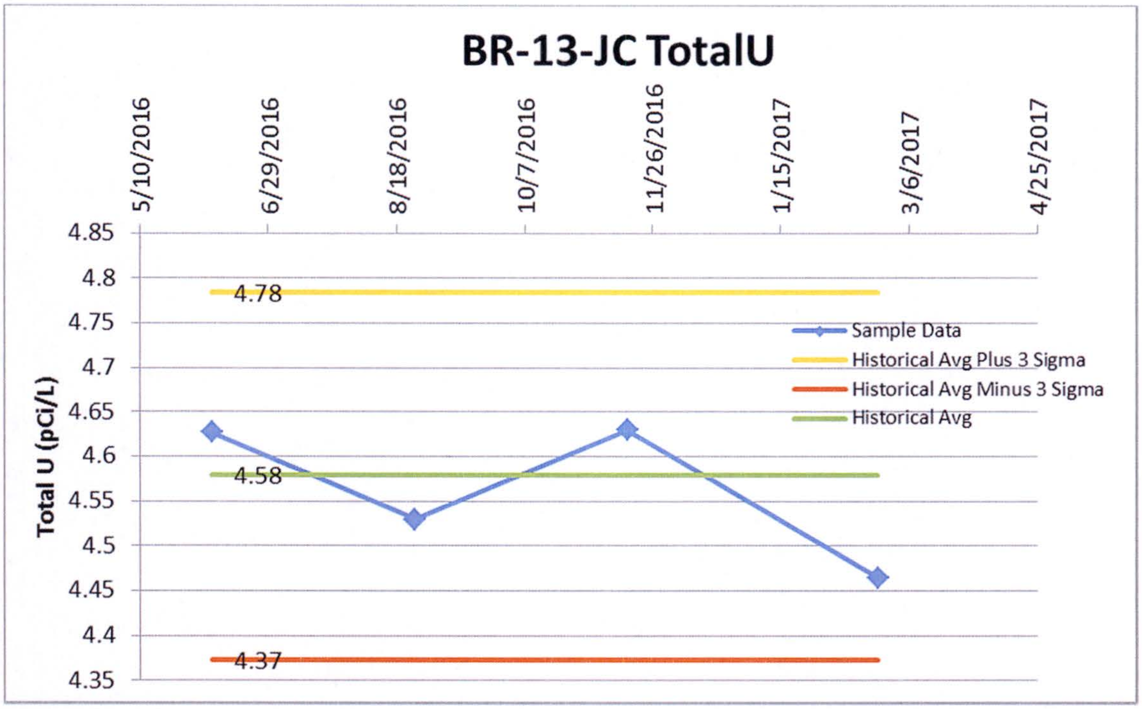

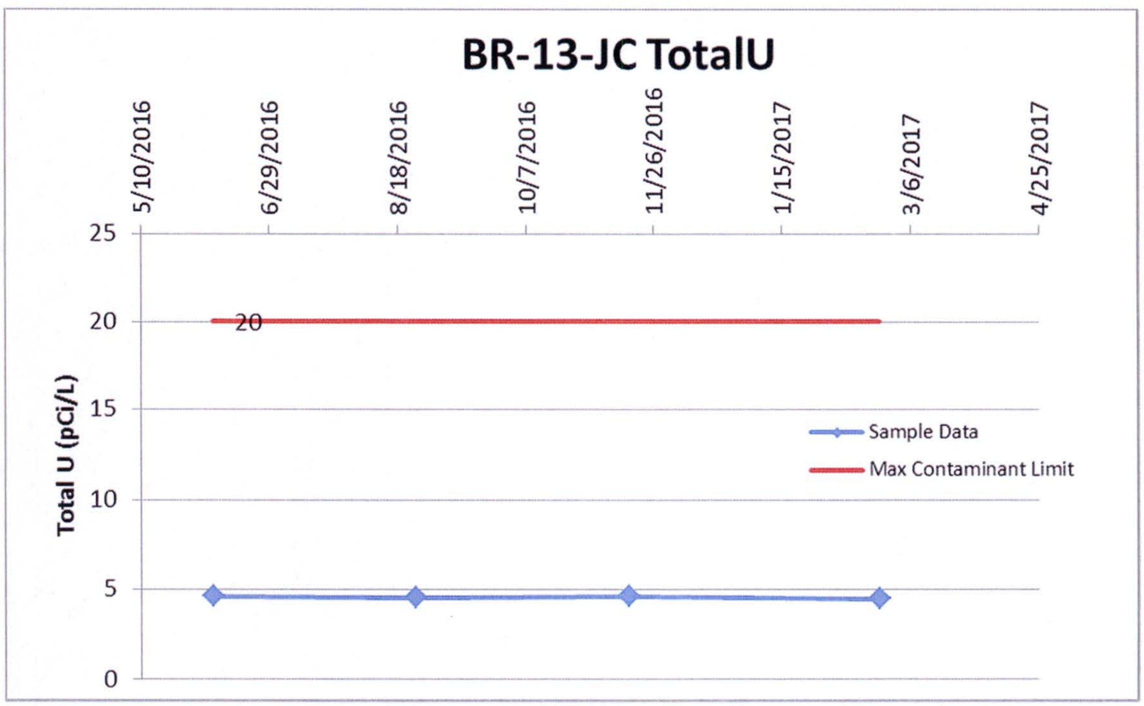

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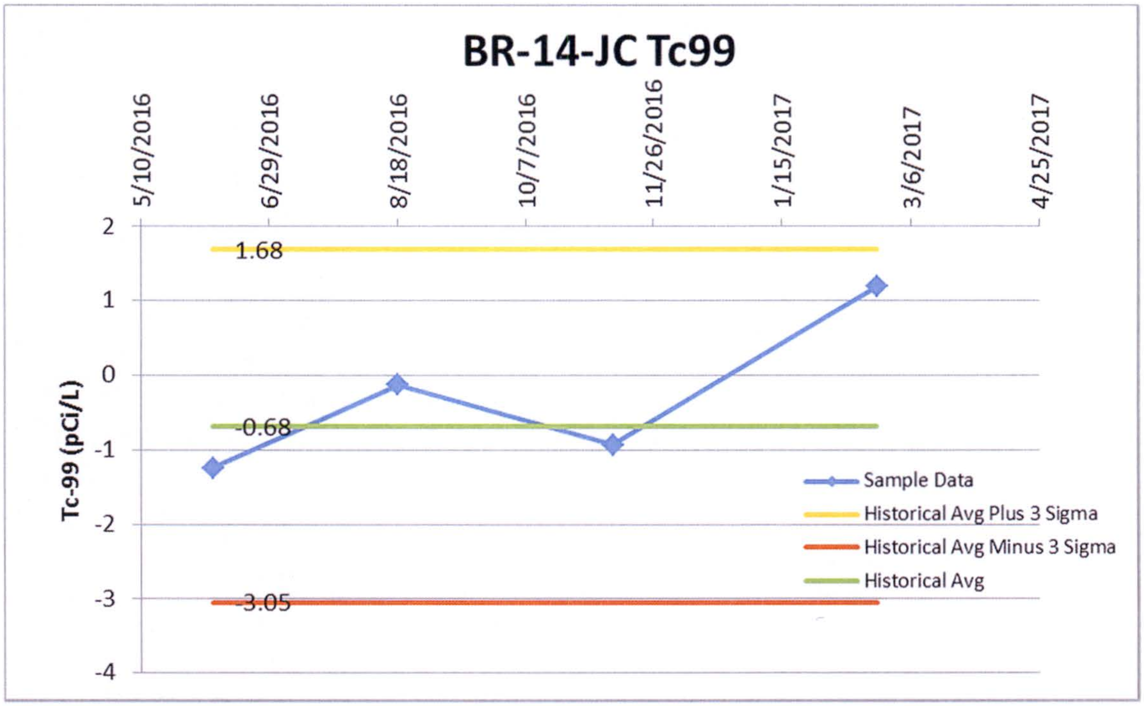

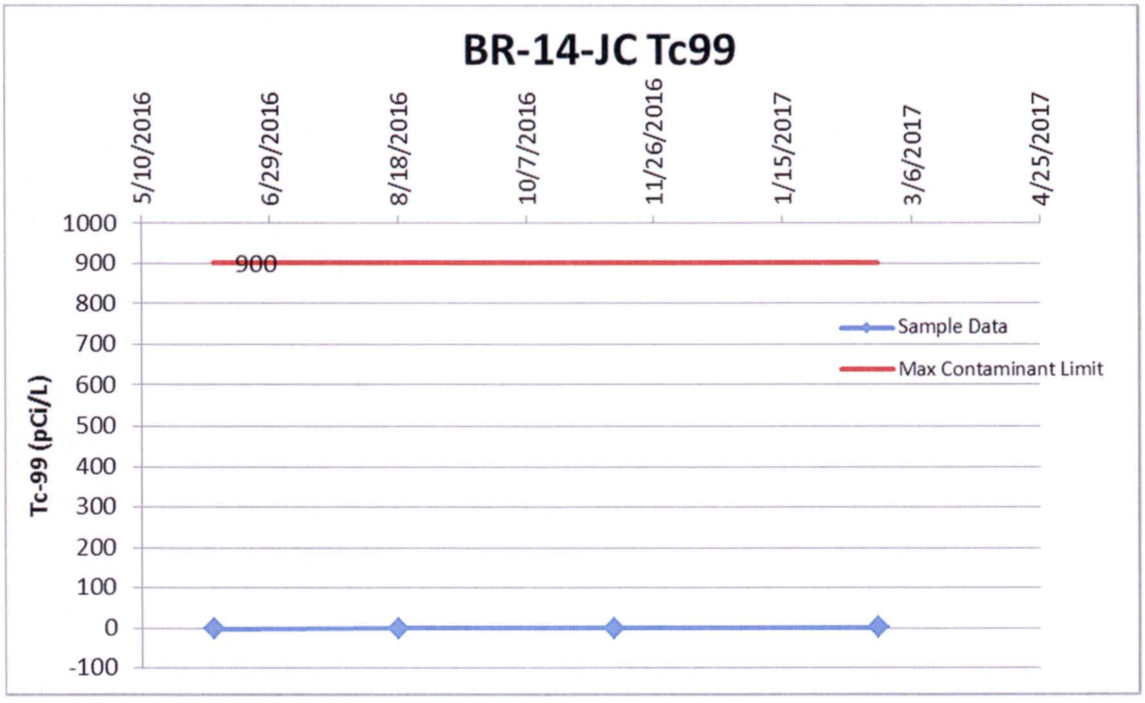

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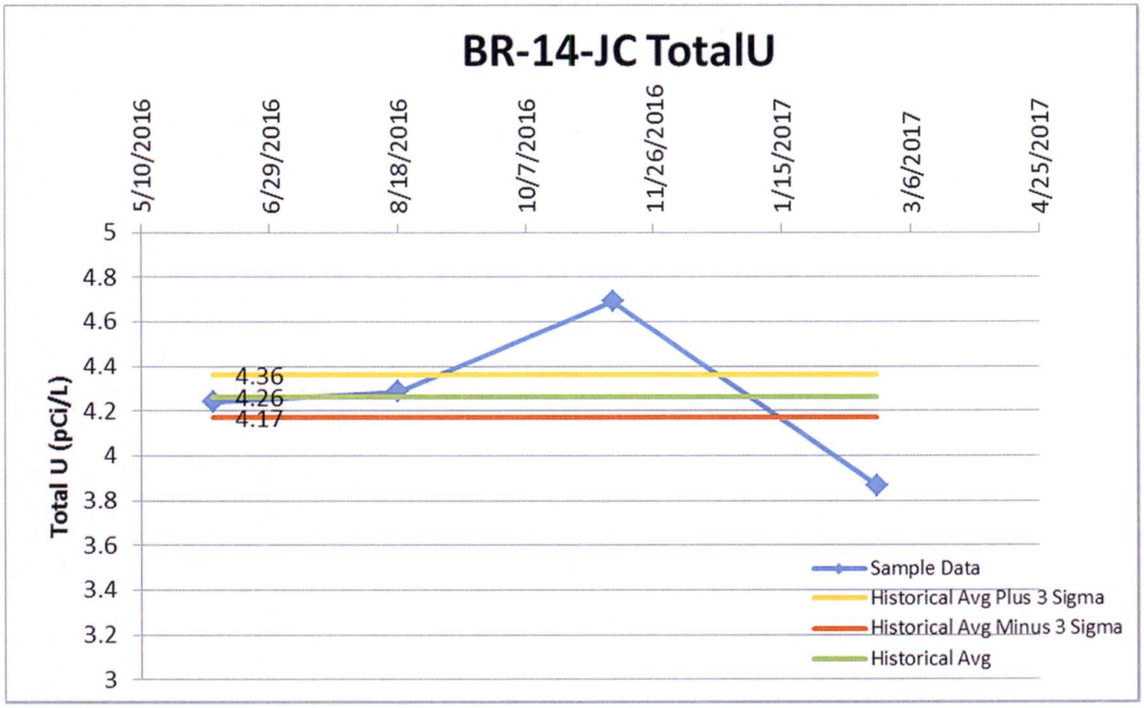

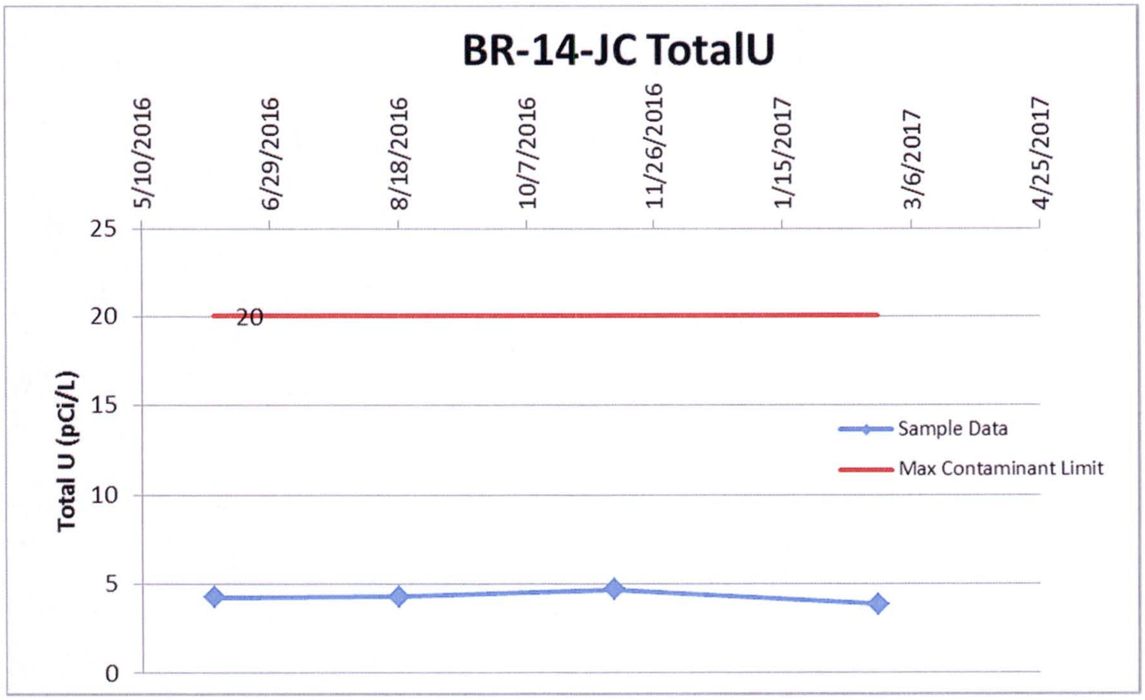

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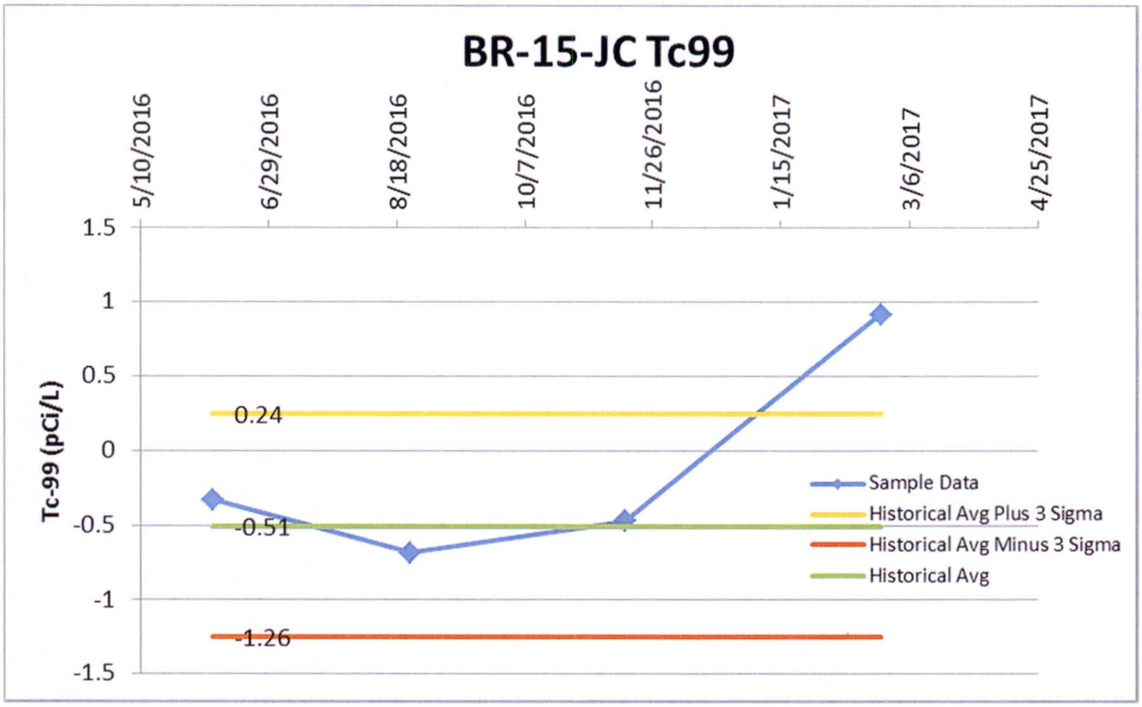

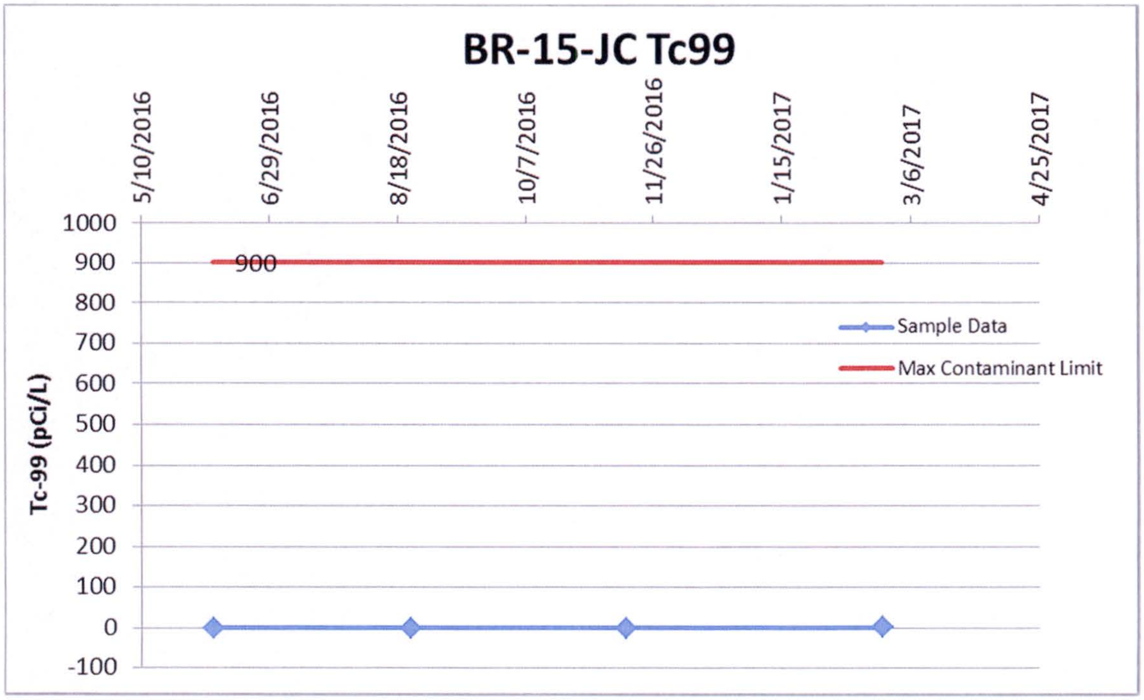

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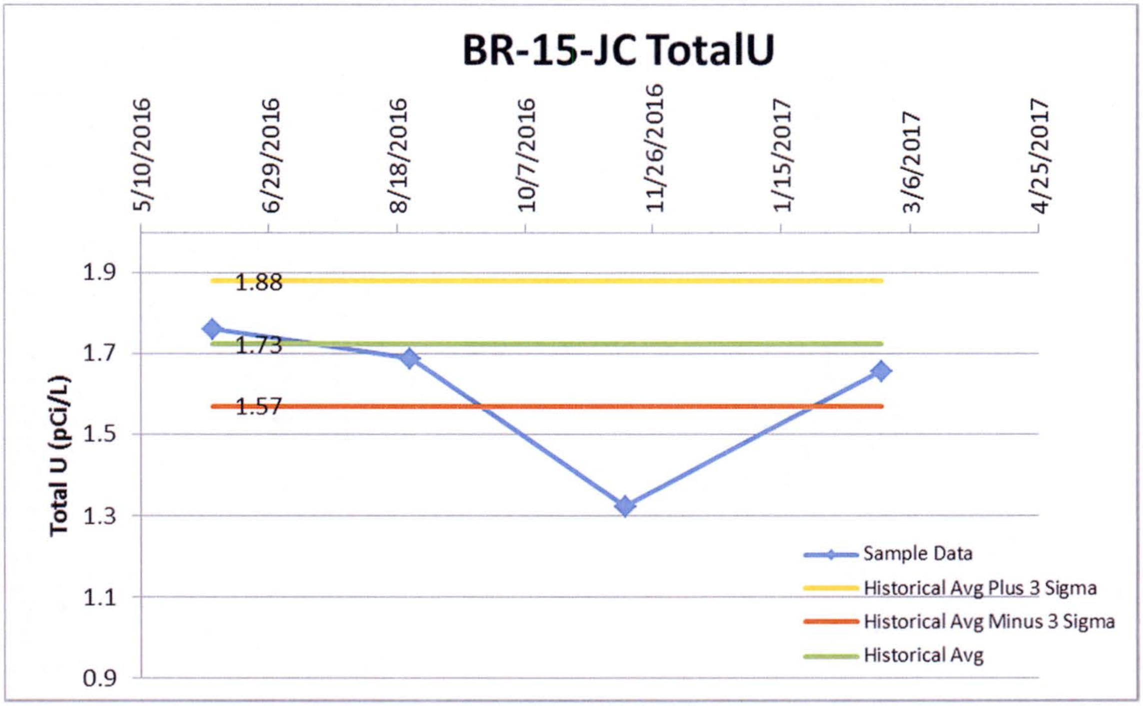

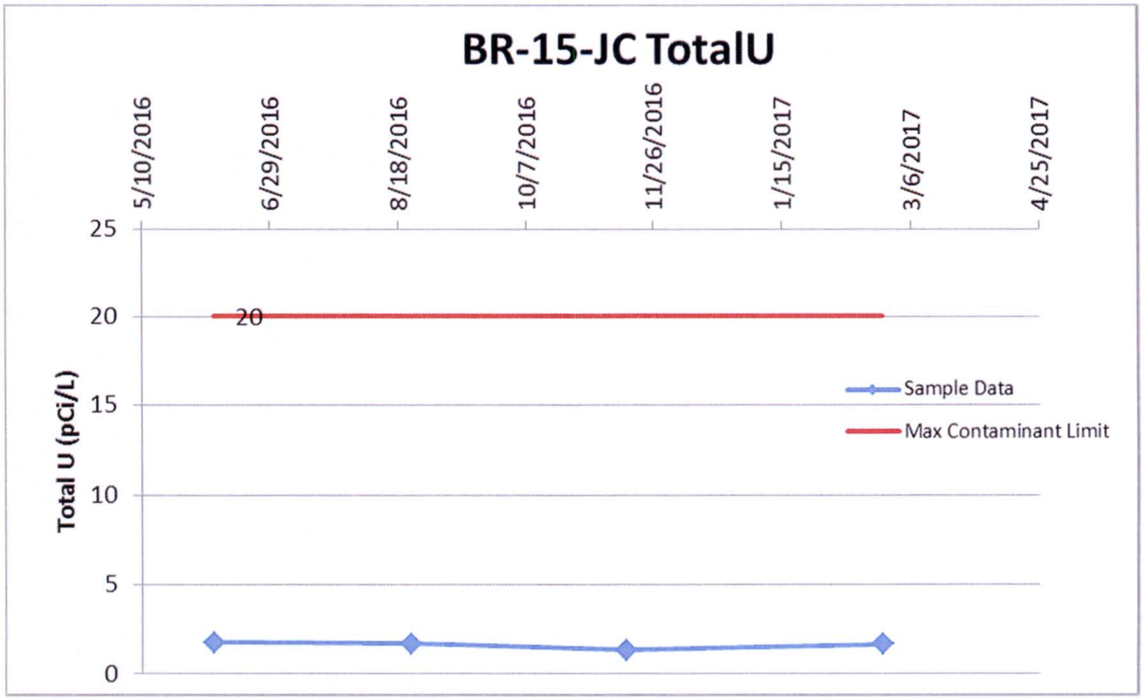

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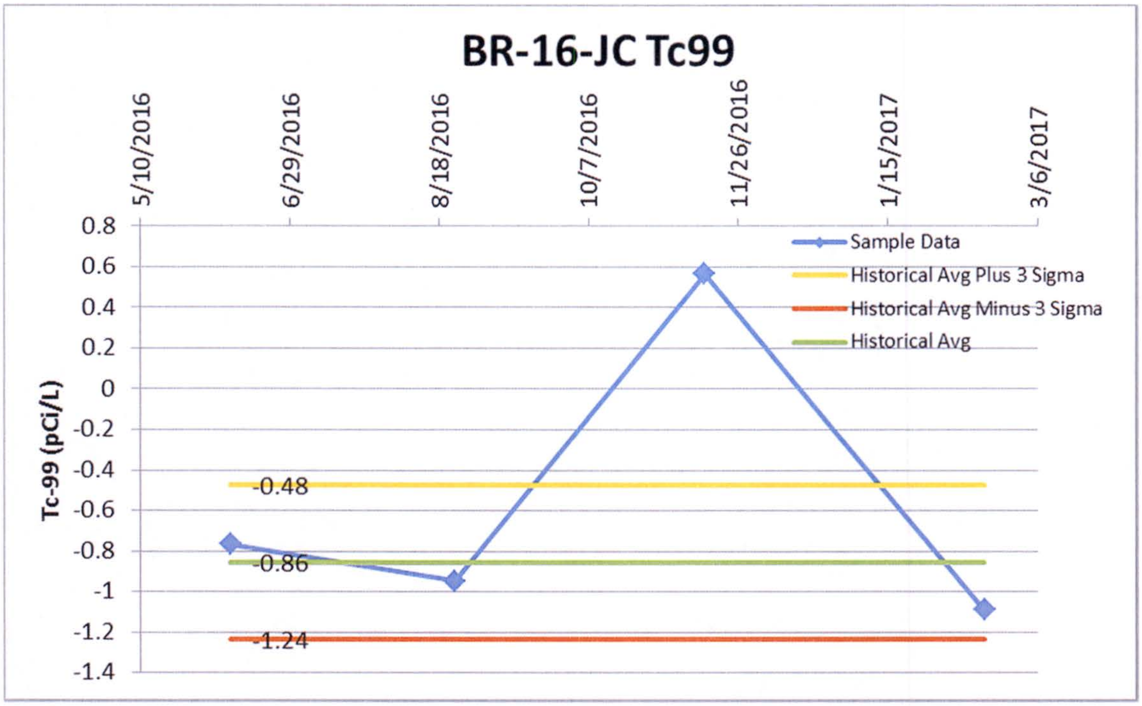

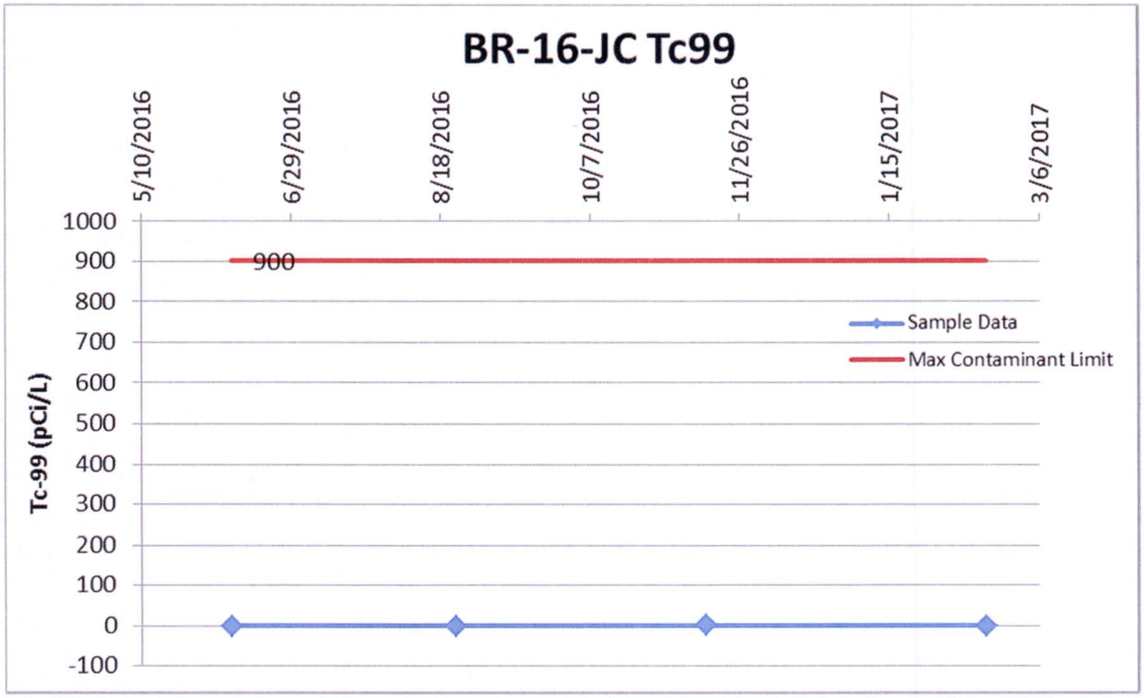

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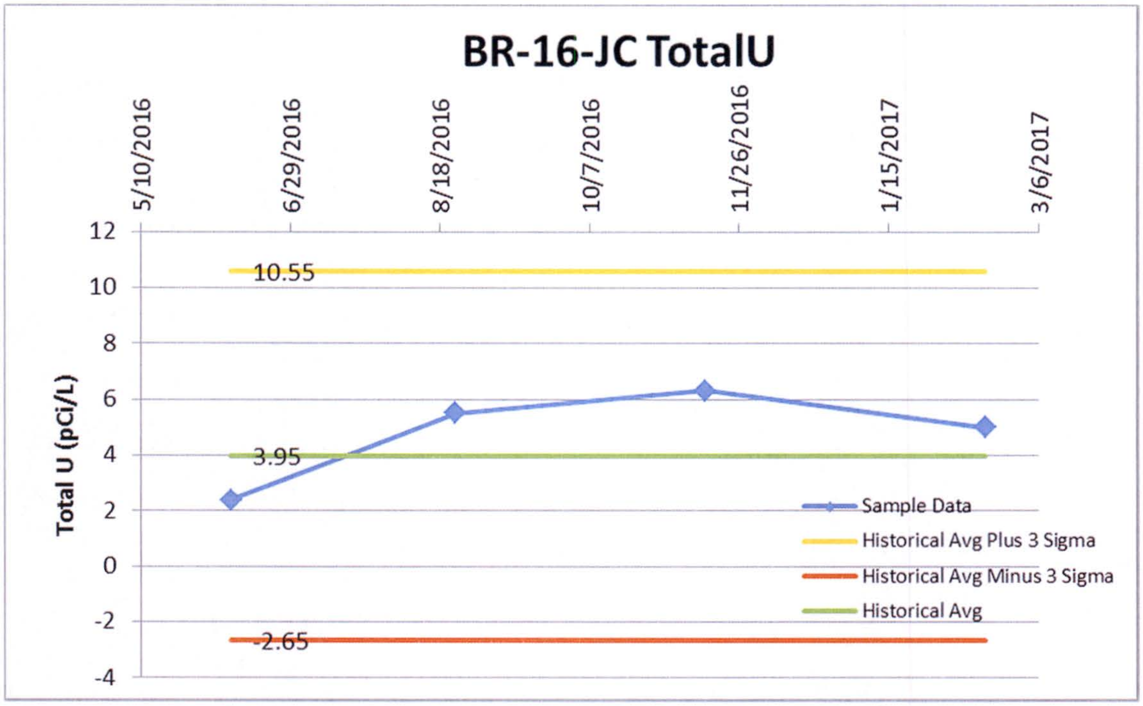

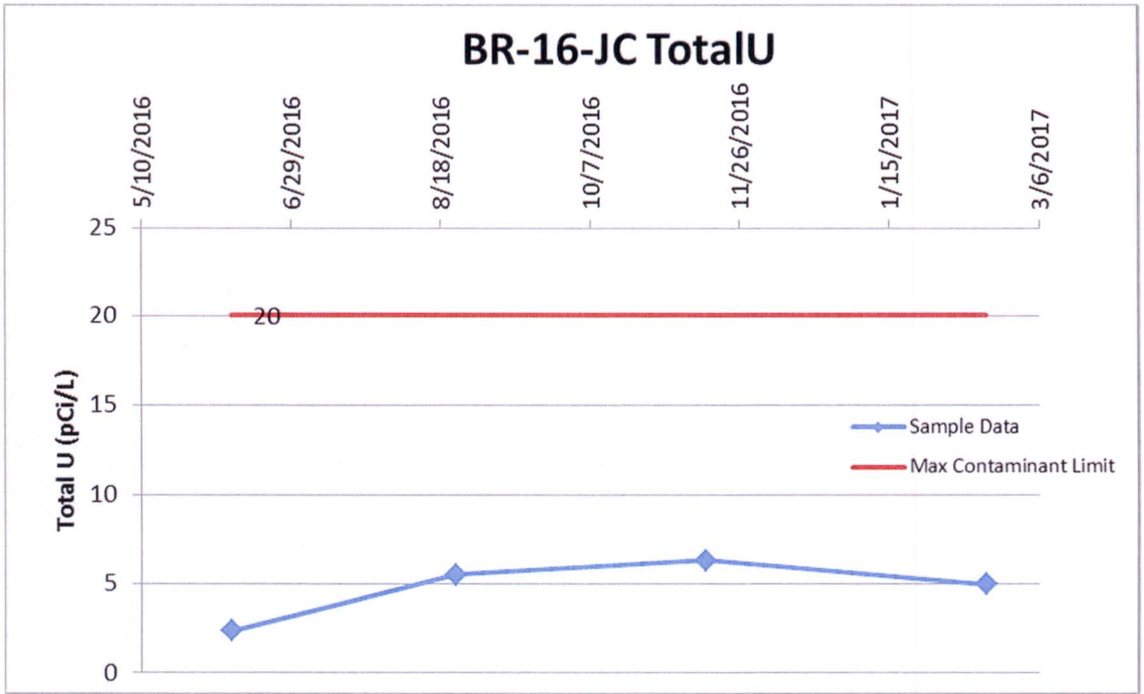

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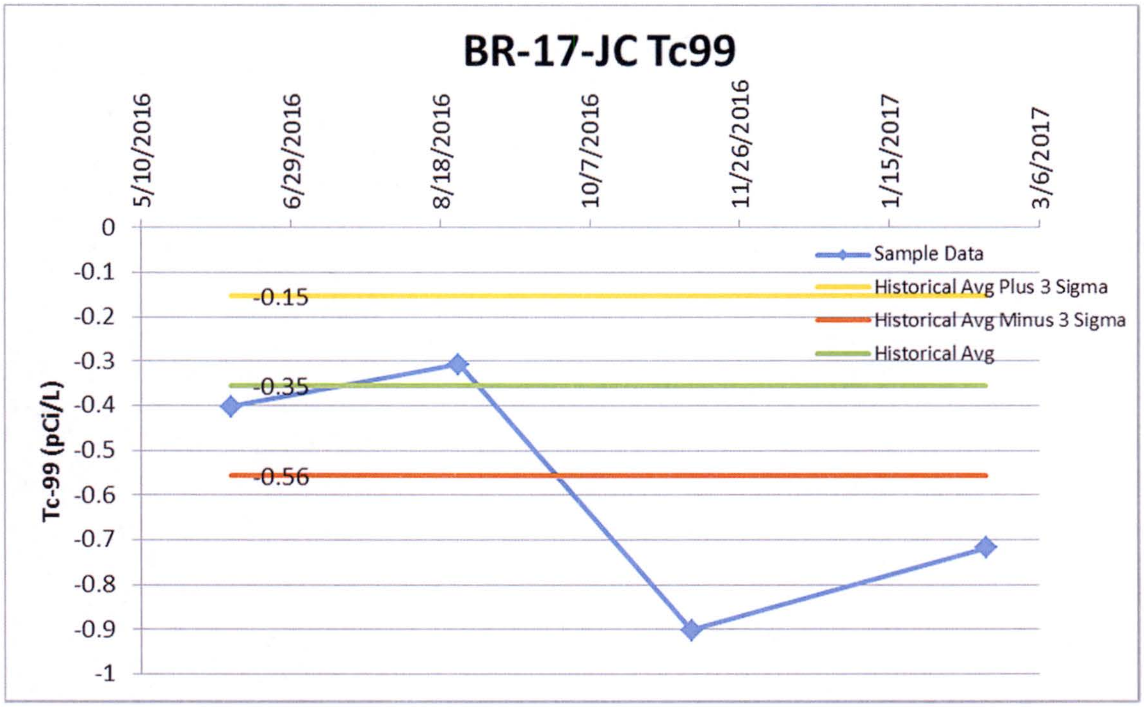

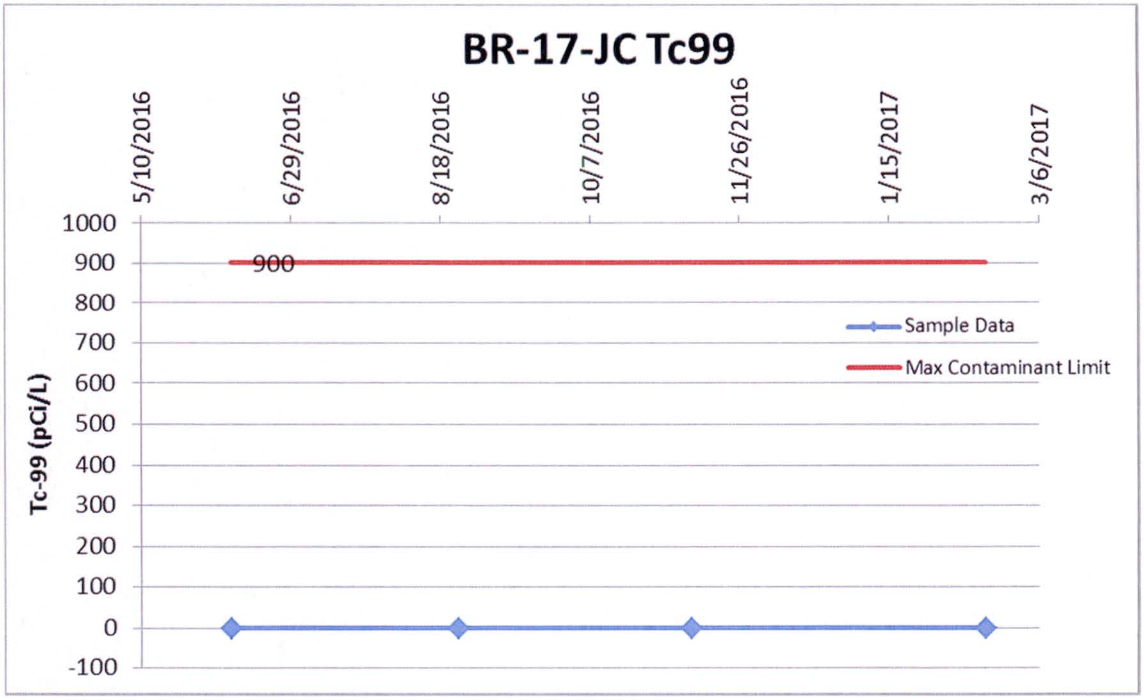

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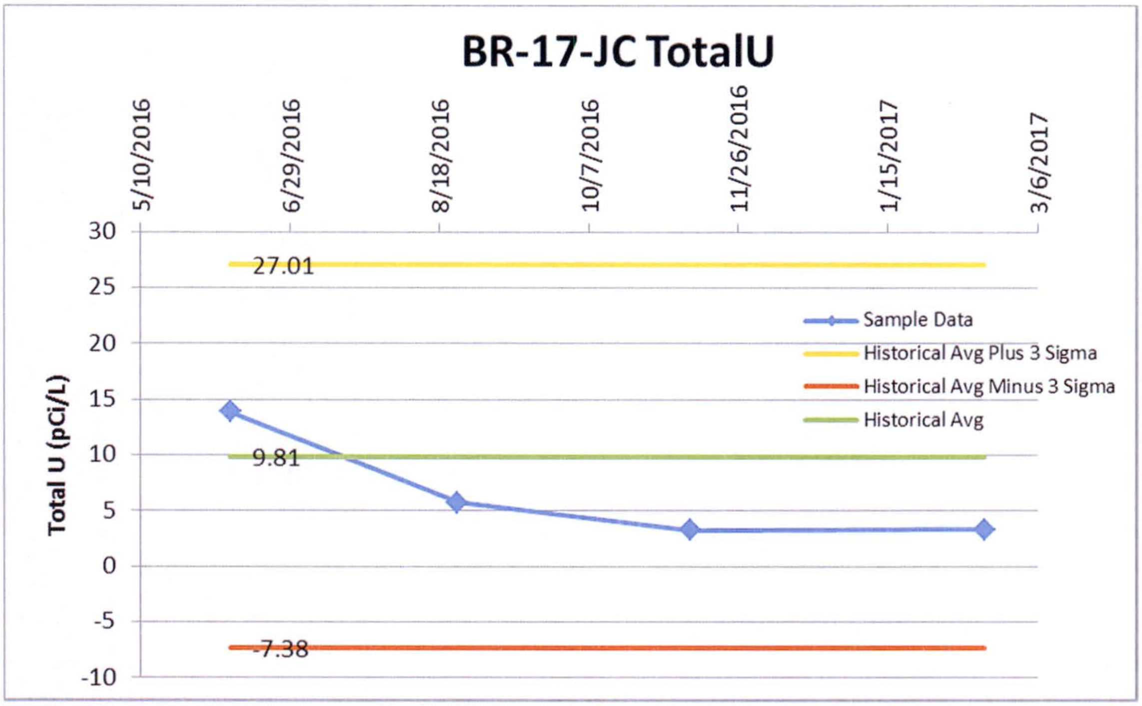

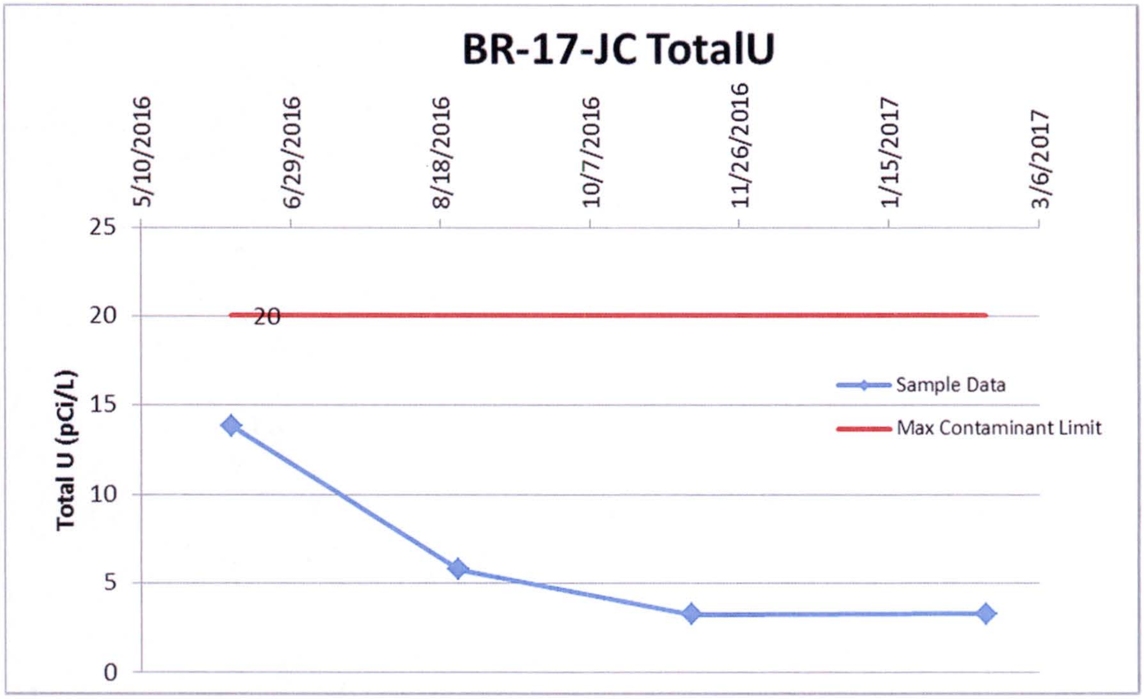

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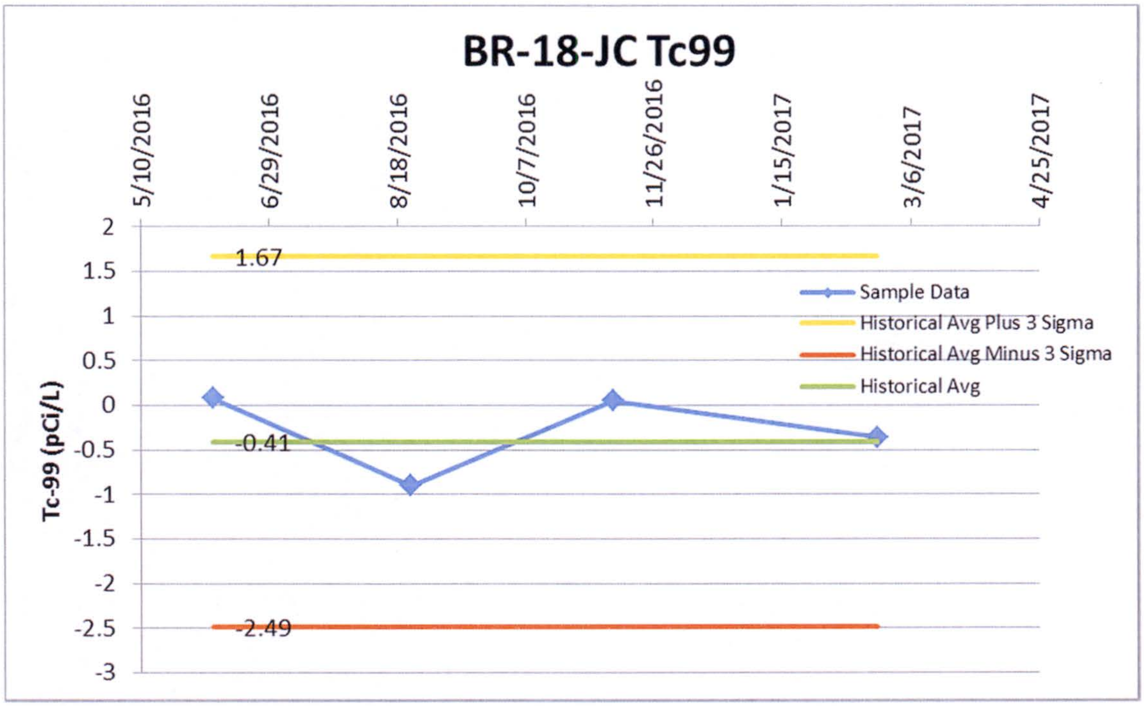
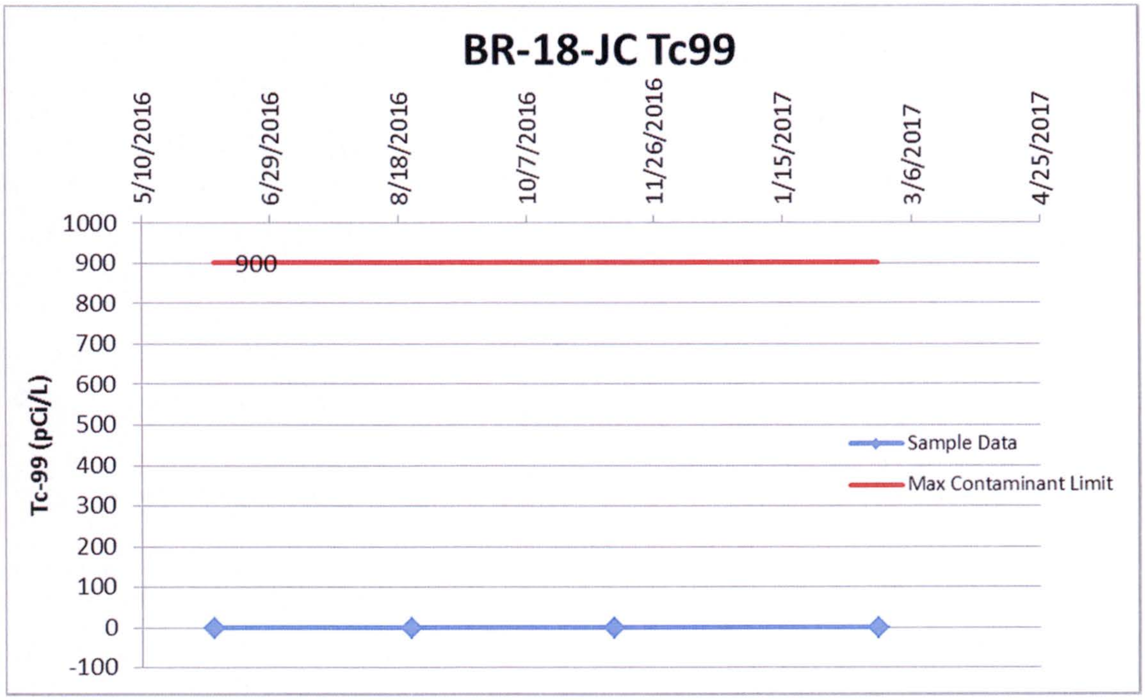
JEFFERSON CITY – COTTER HSU





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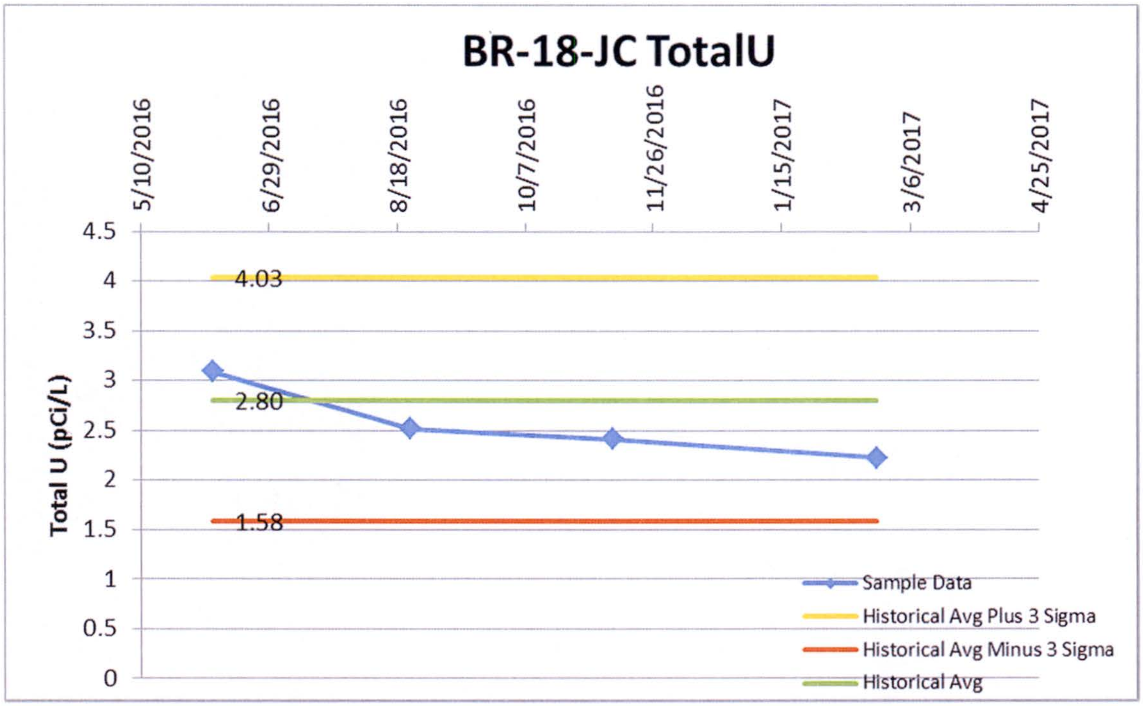
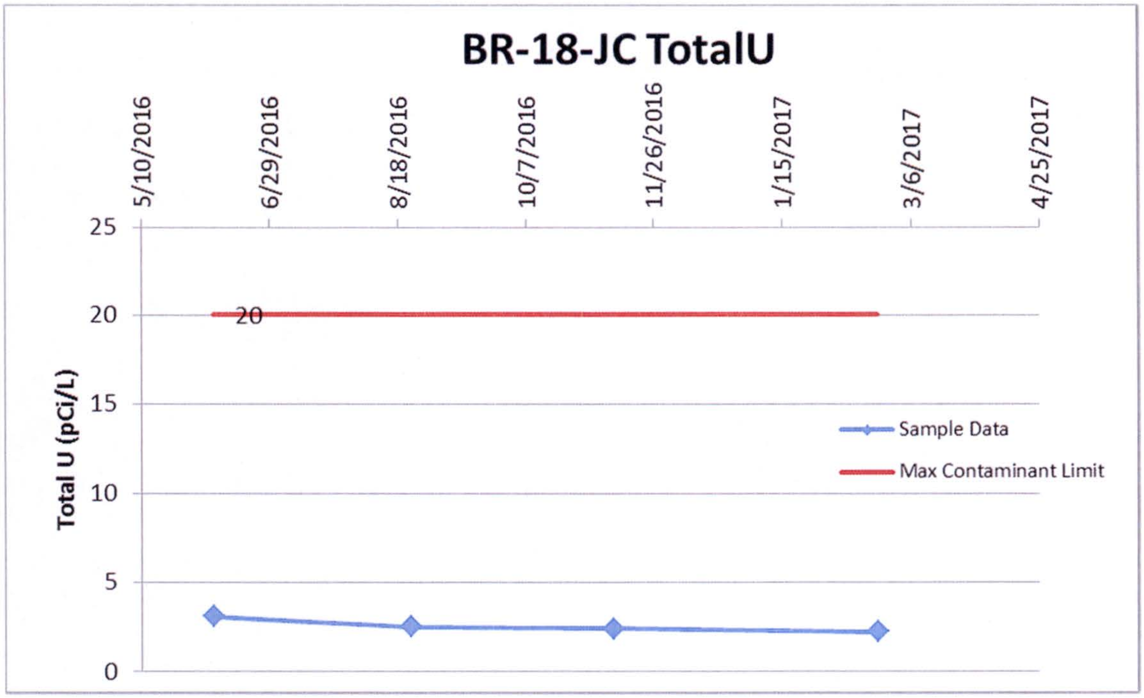
JEFFERSON CITY – COTTER HSU





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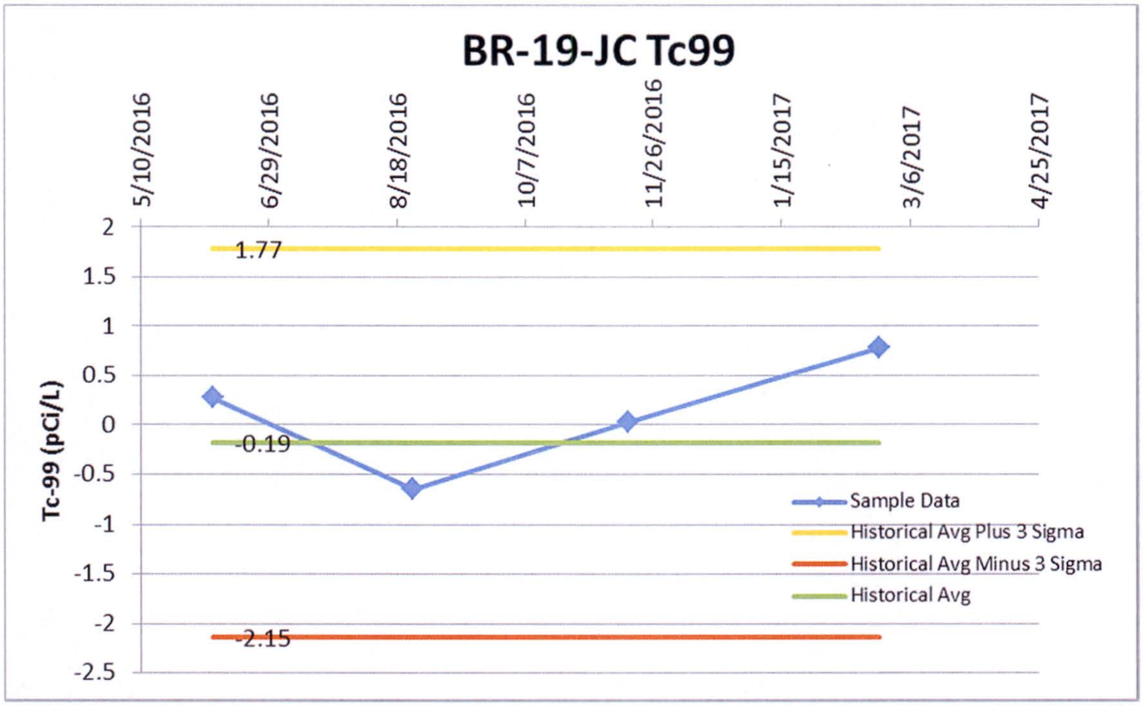
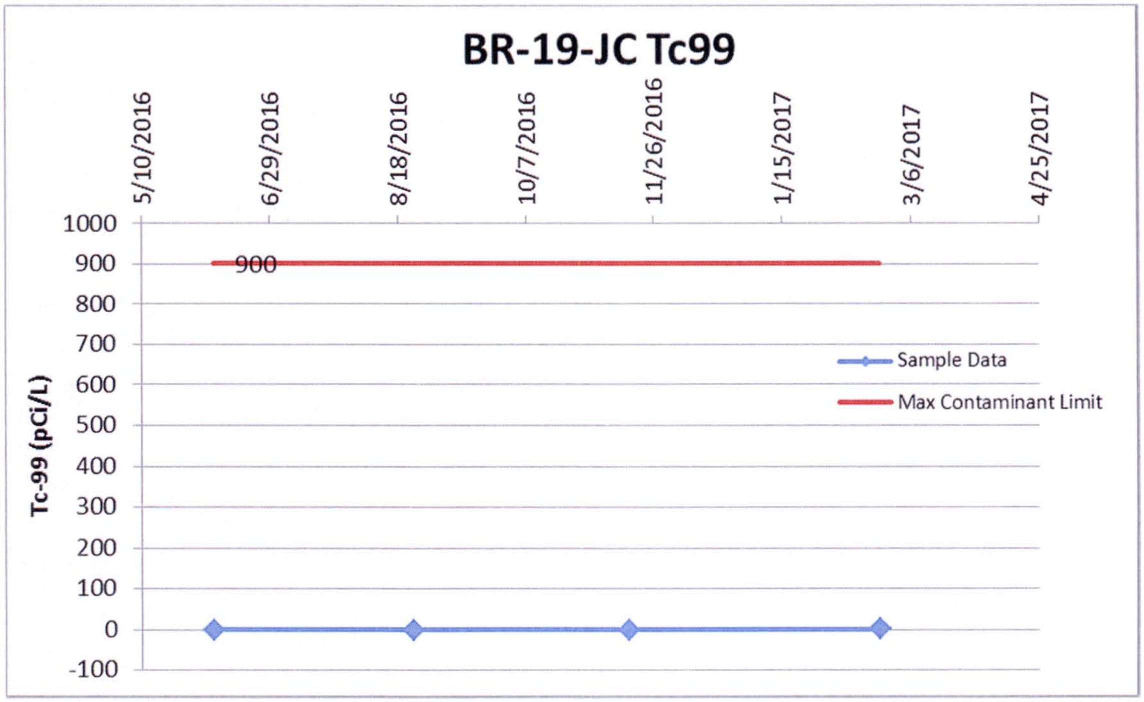
JEFFERSON CITY – COTTER HSU





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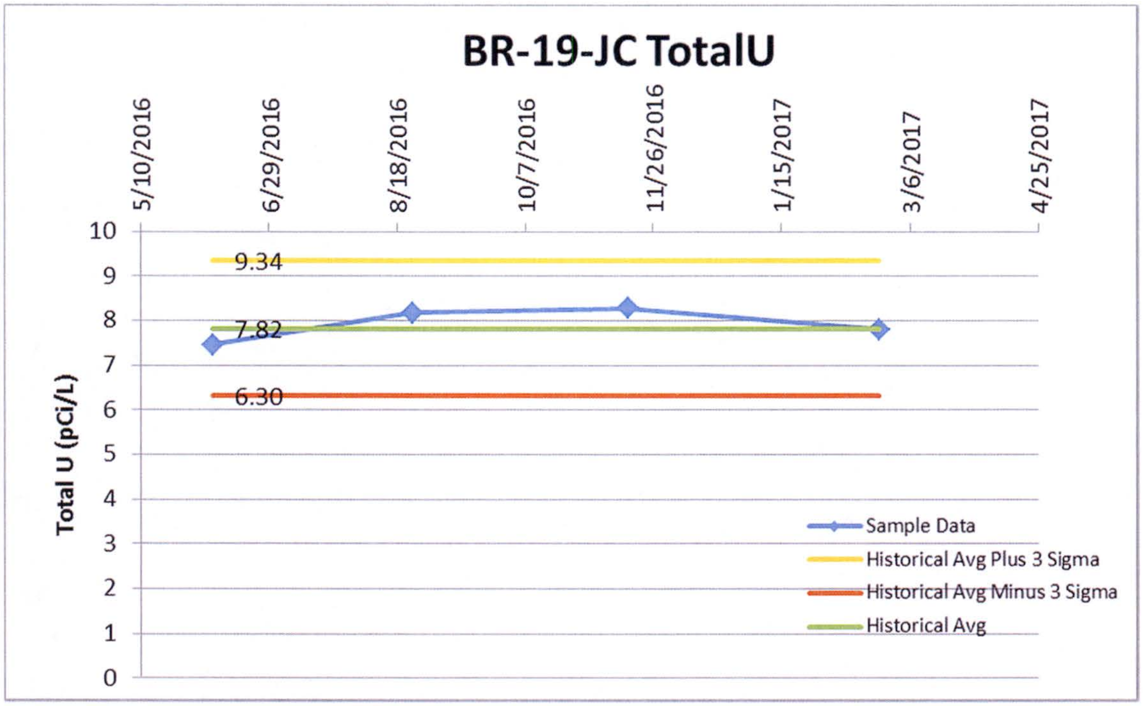
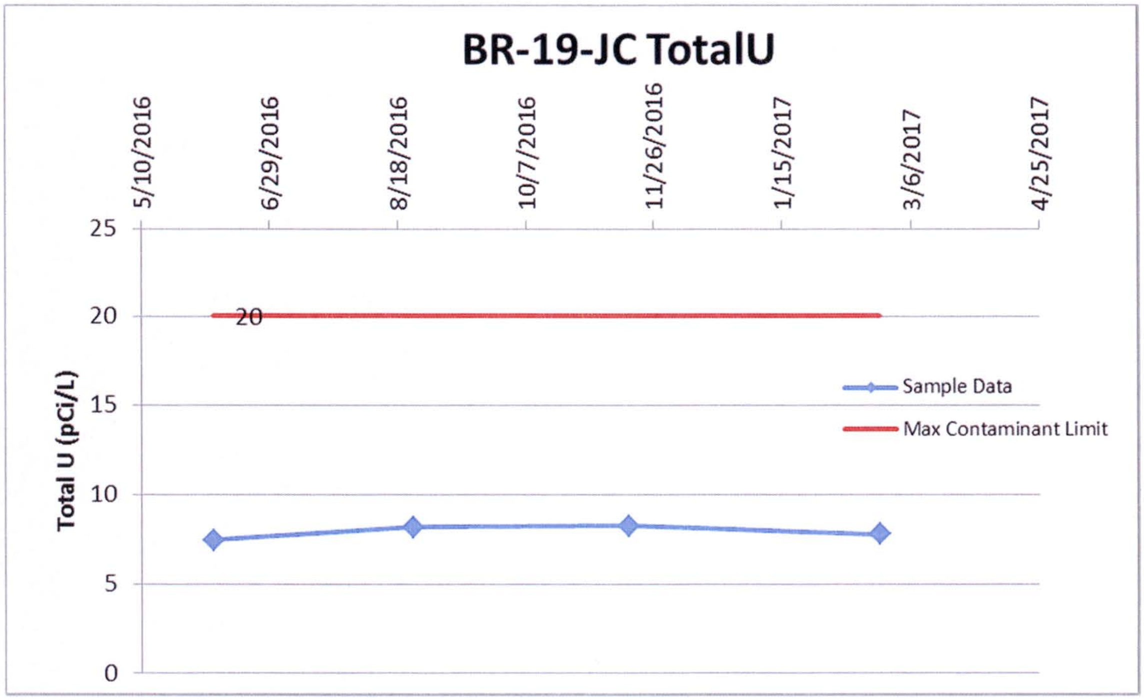
Mann-Kendall Analysis and Sample Results Graphs

JEFFERSON CITY – COTTER HSU





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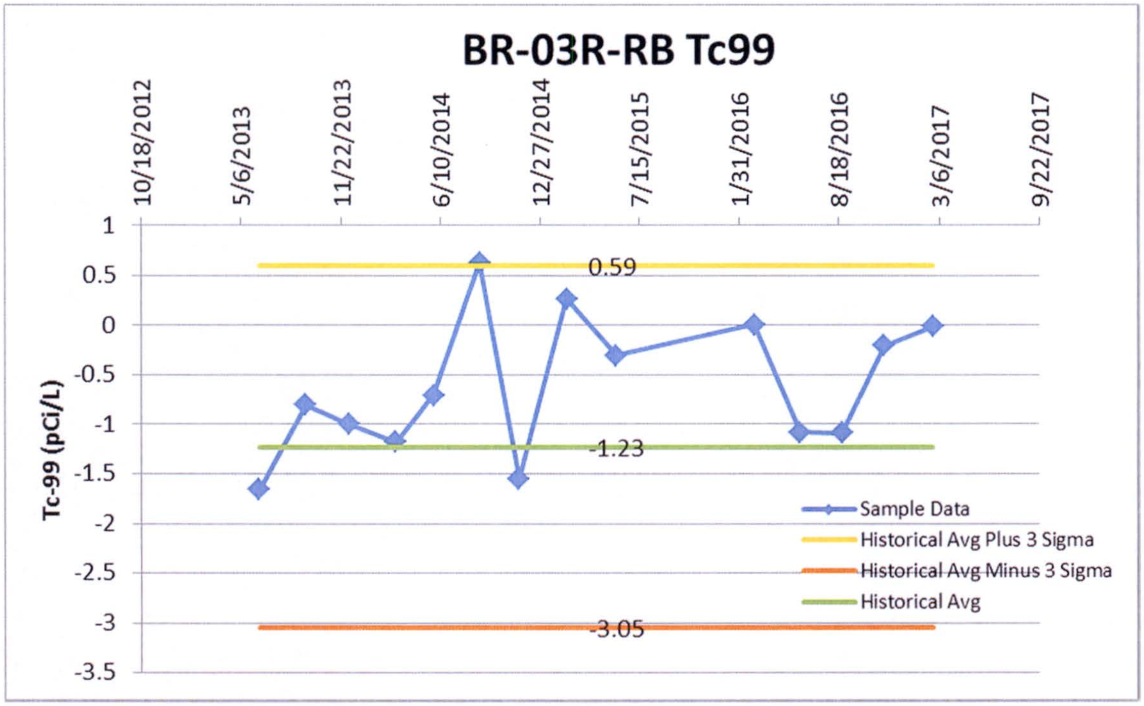

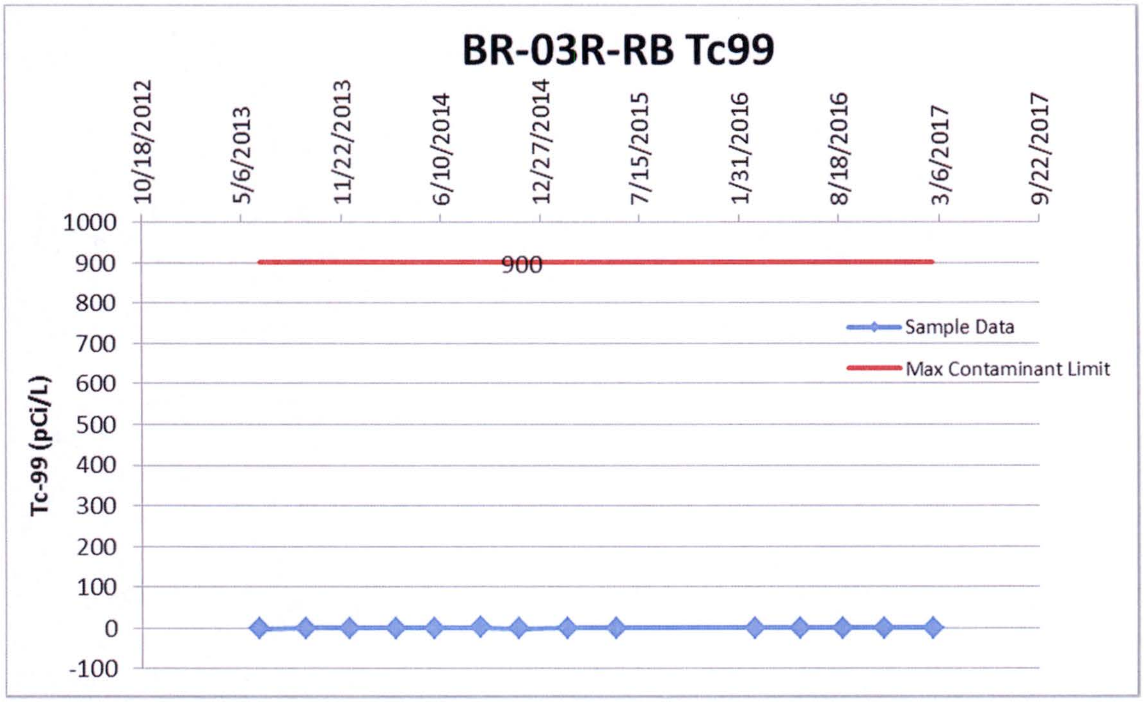

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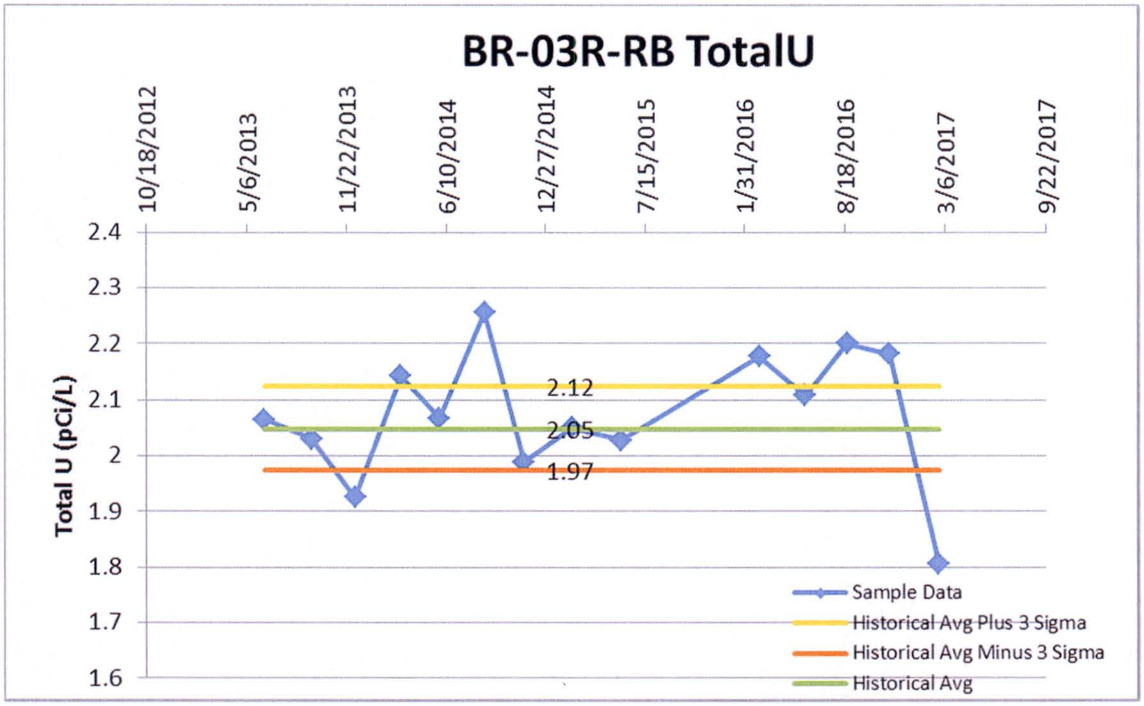

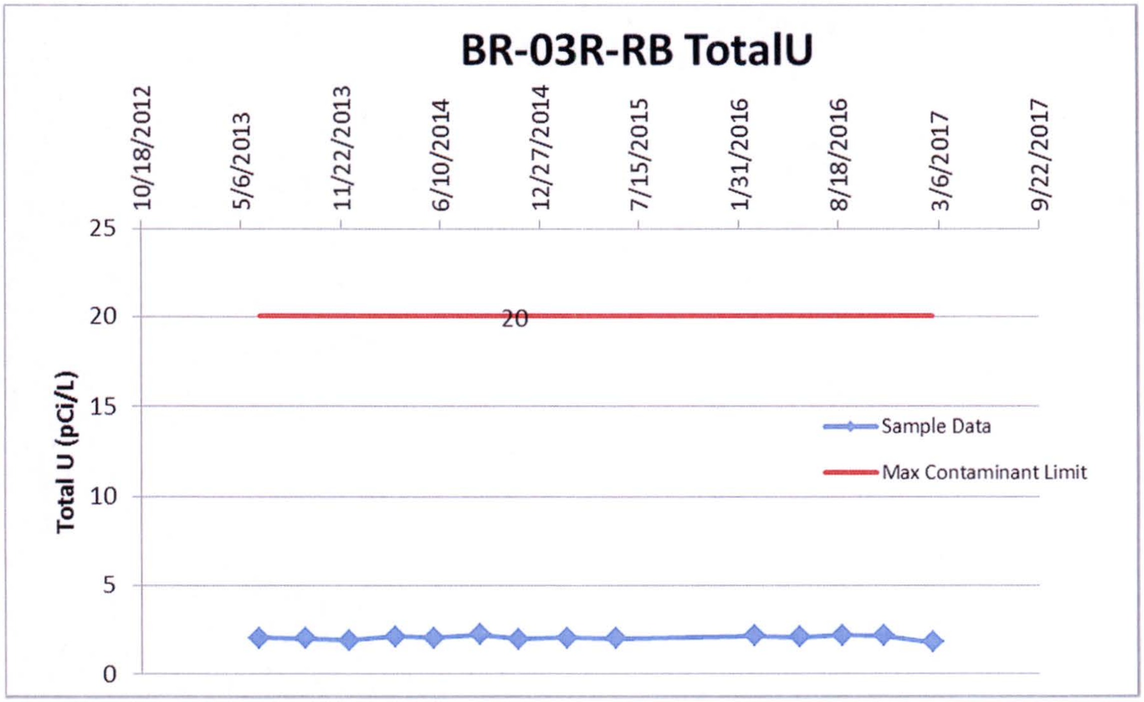

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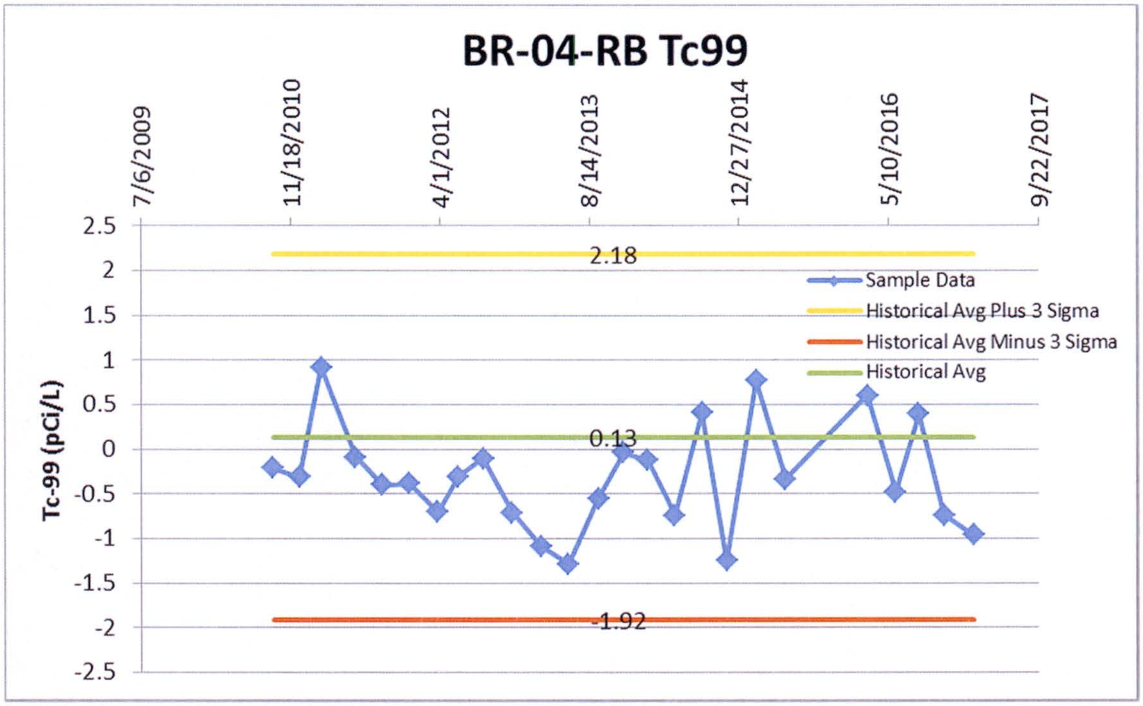

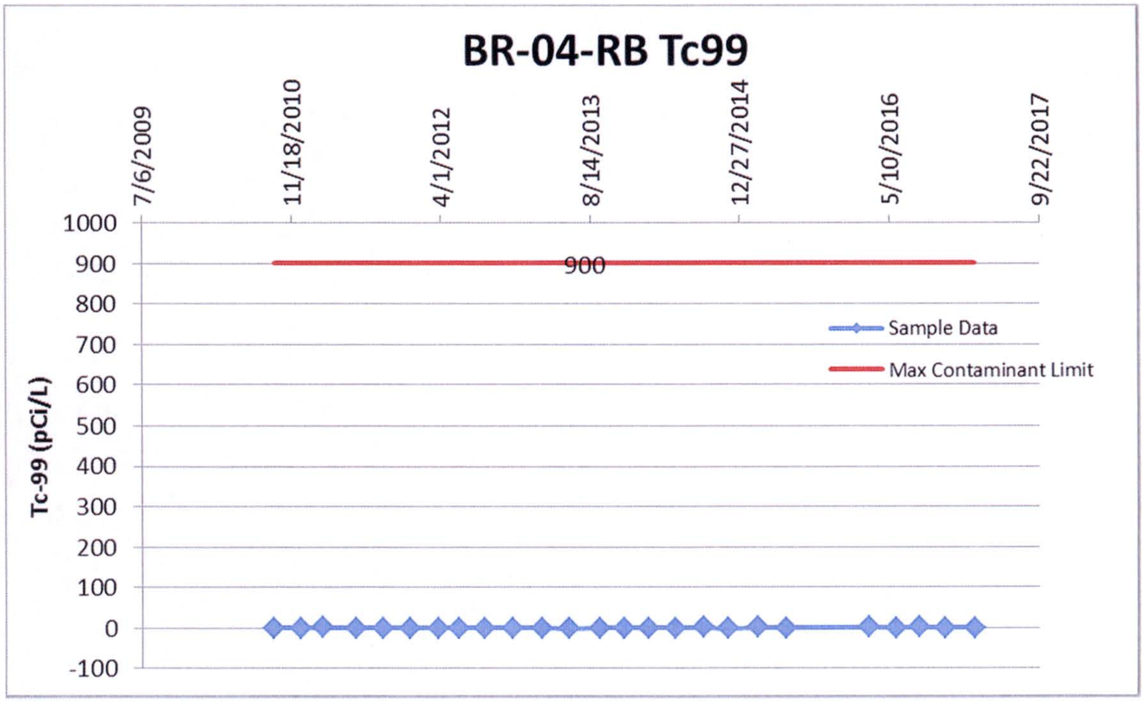

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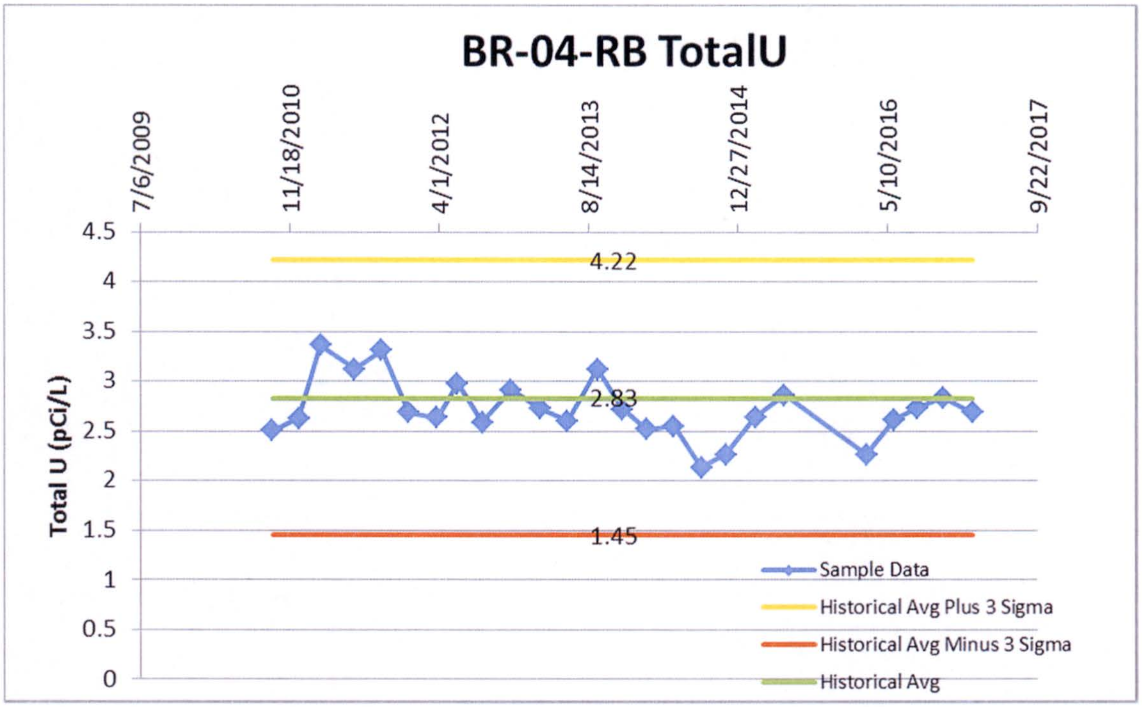

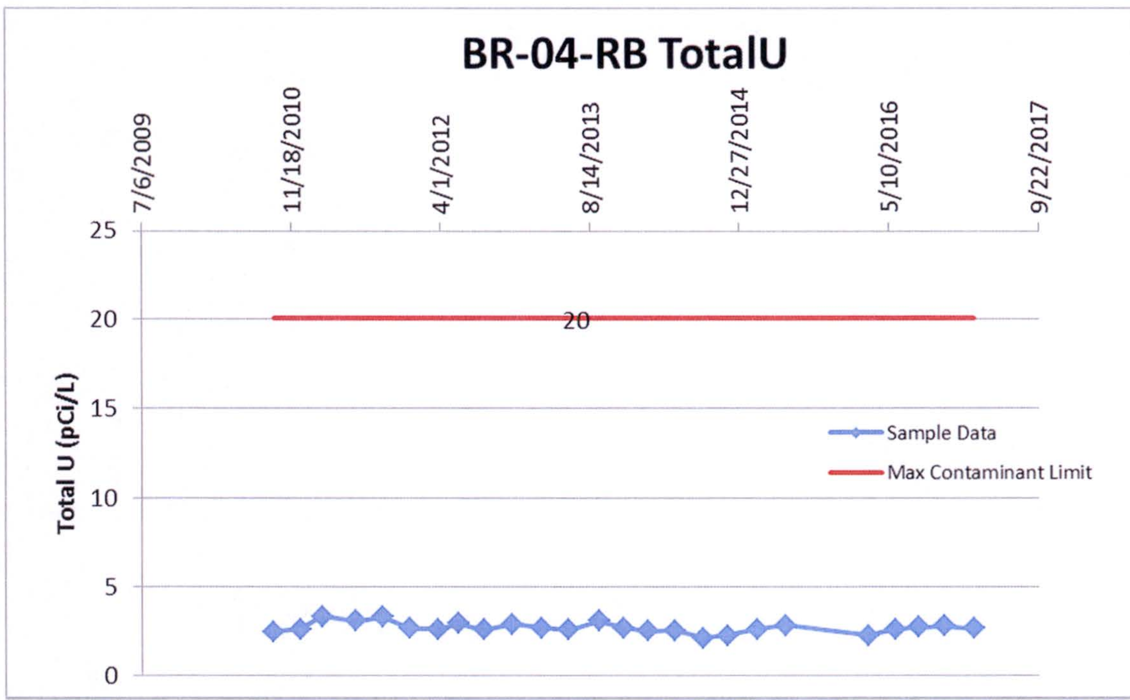

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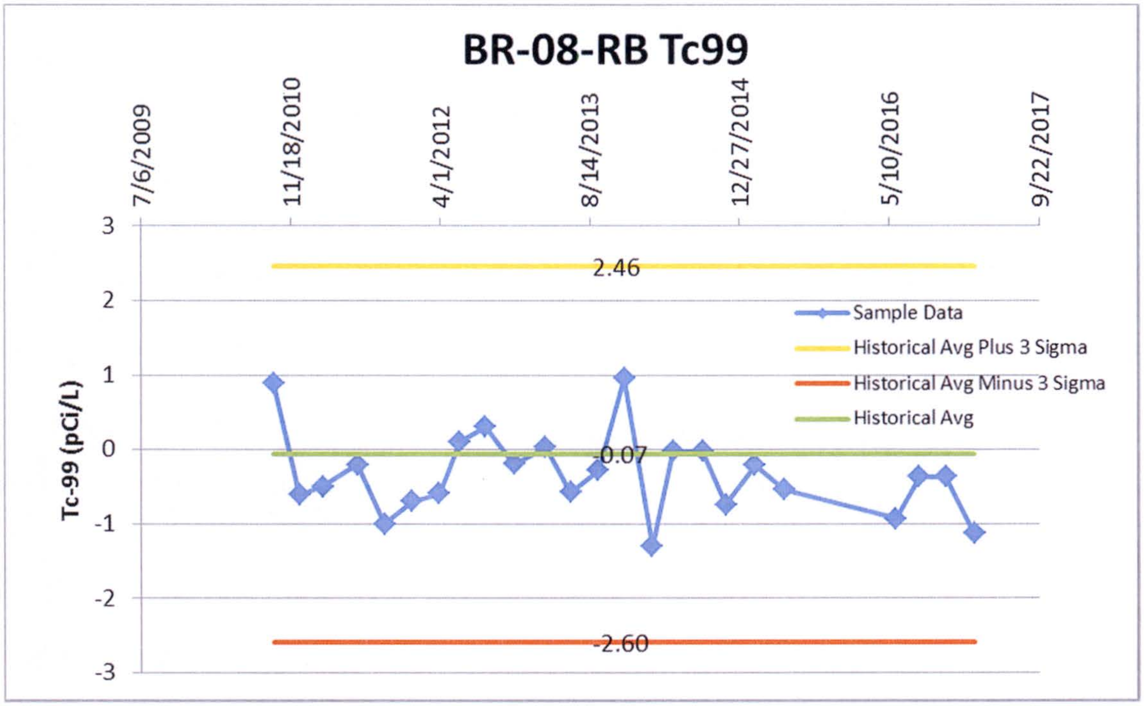

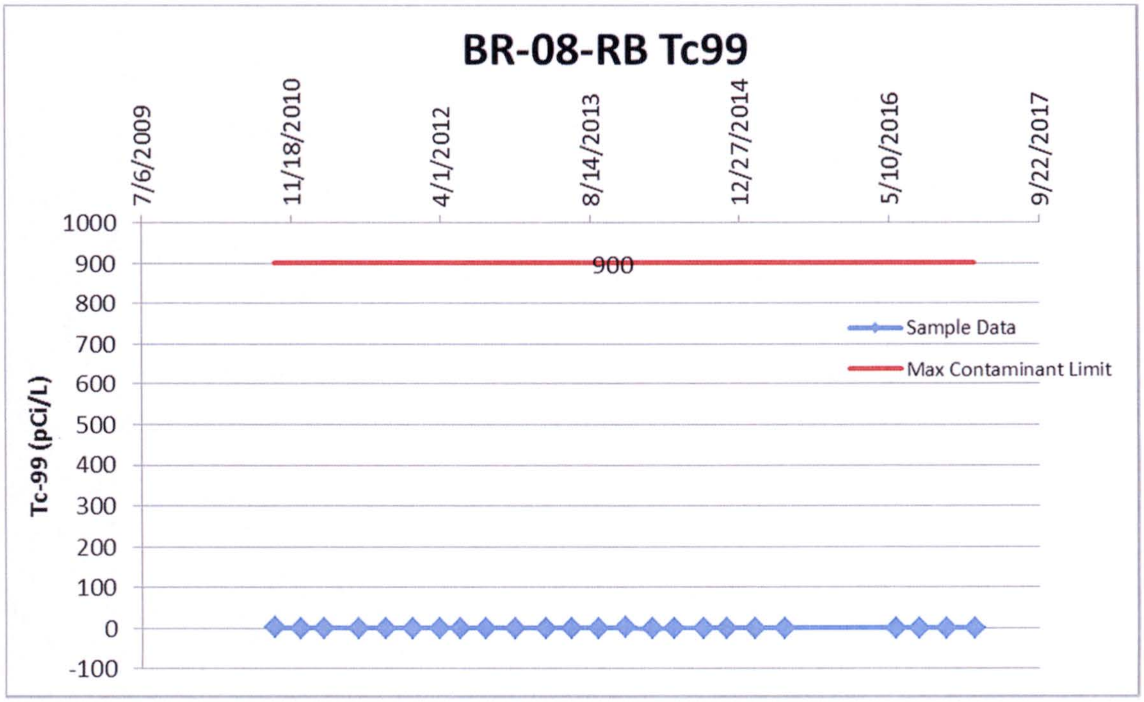

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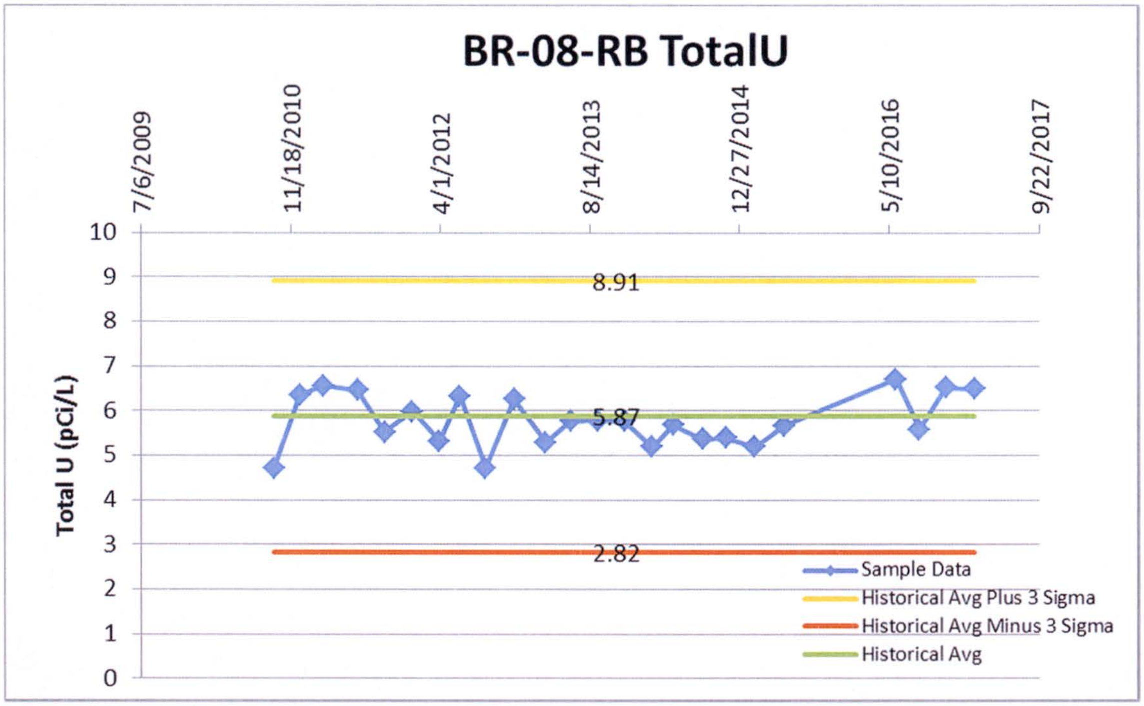

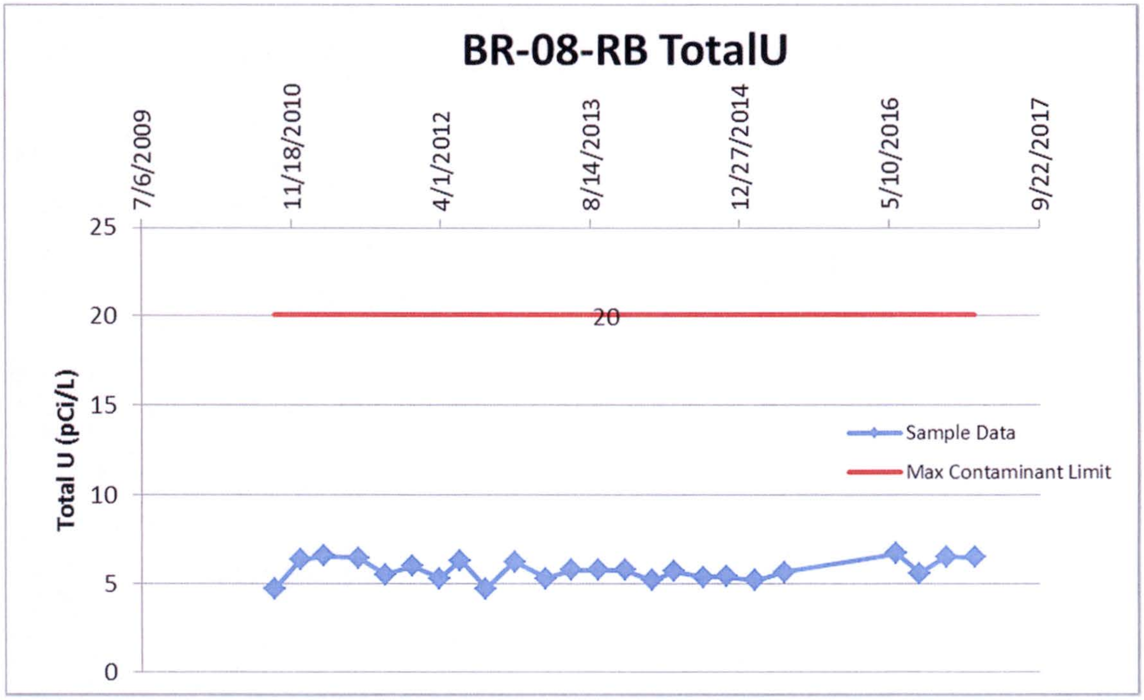

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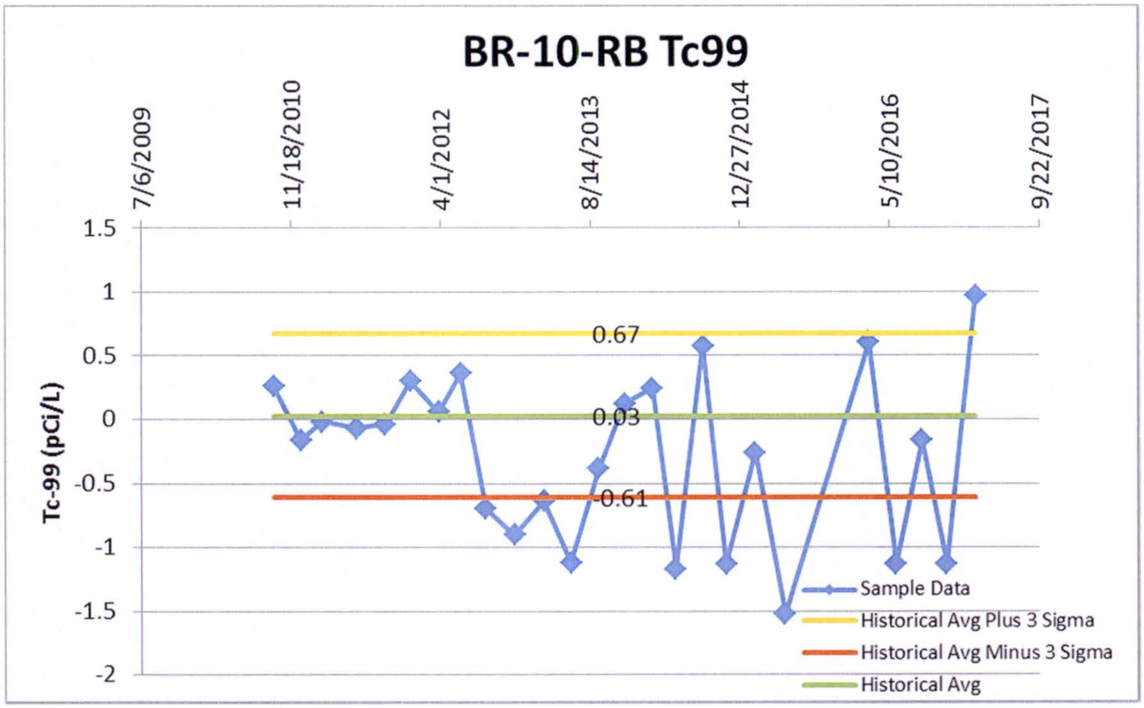

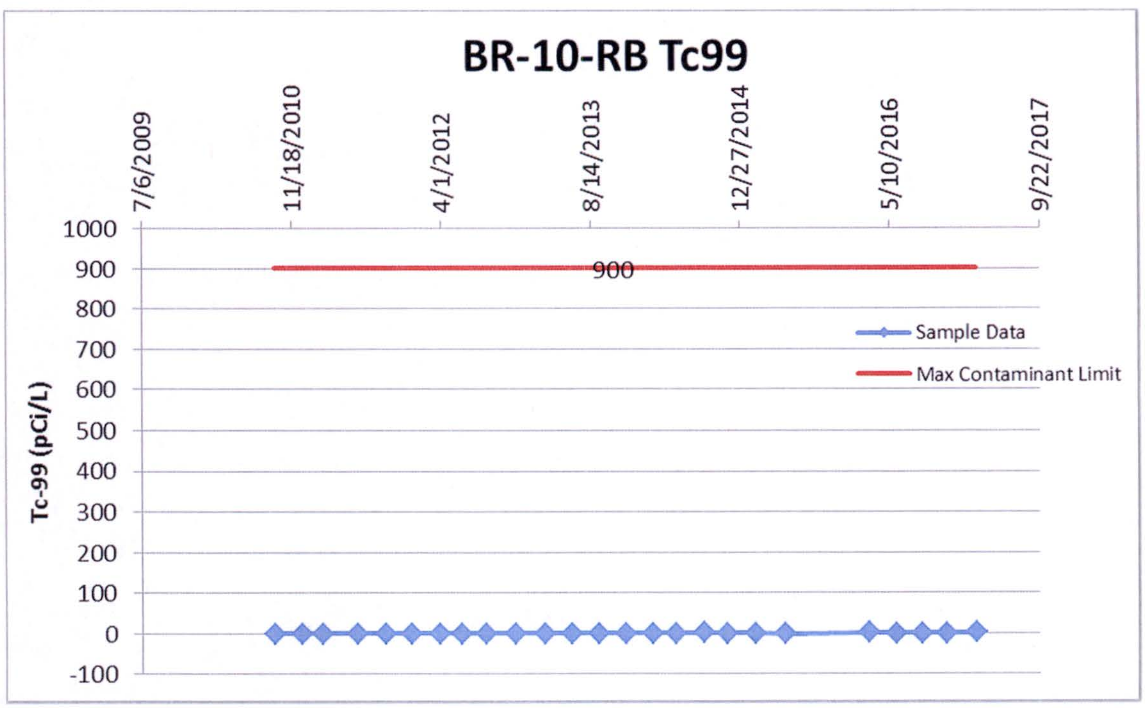

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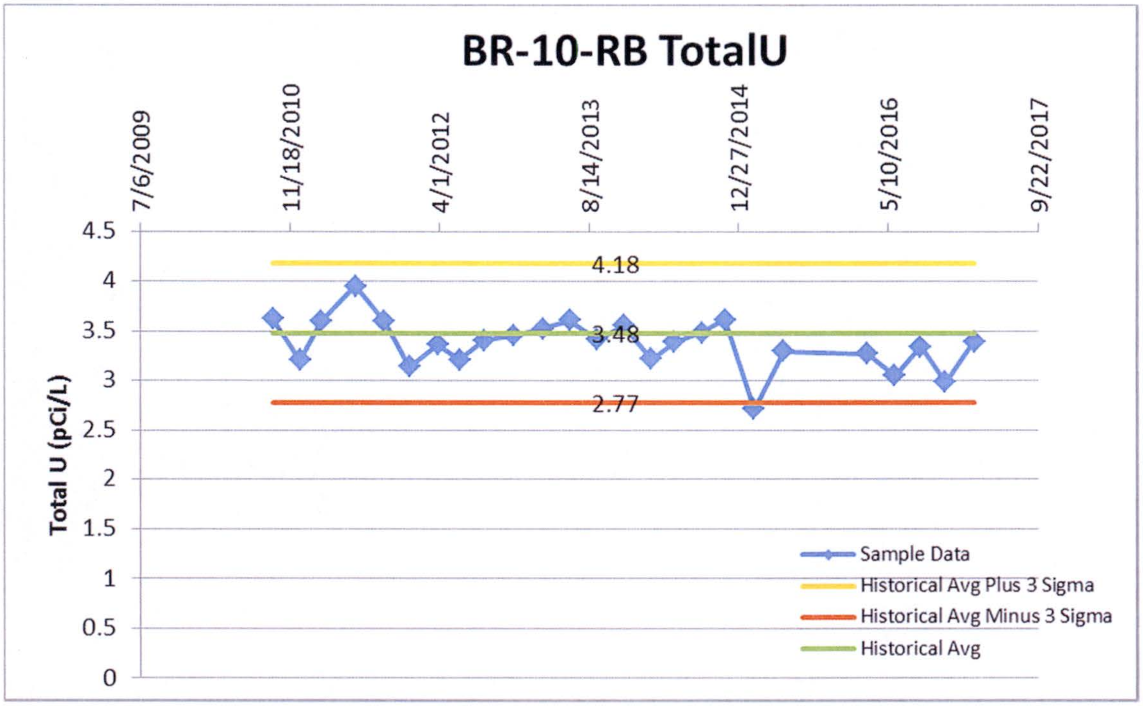

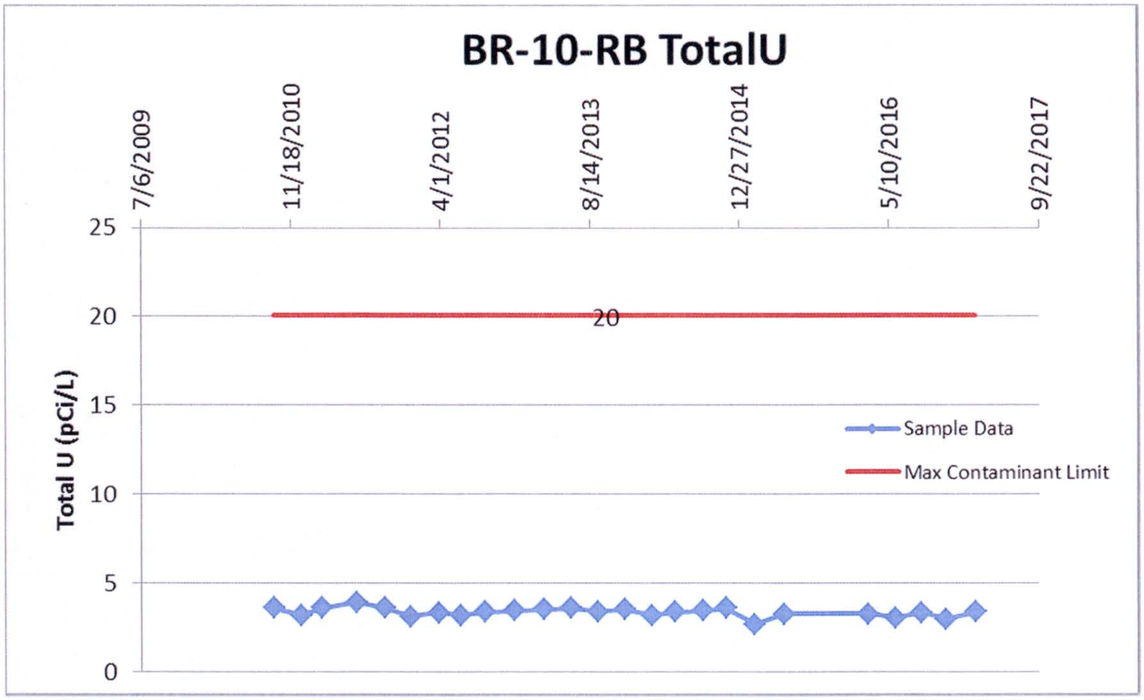

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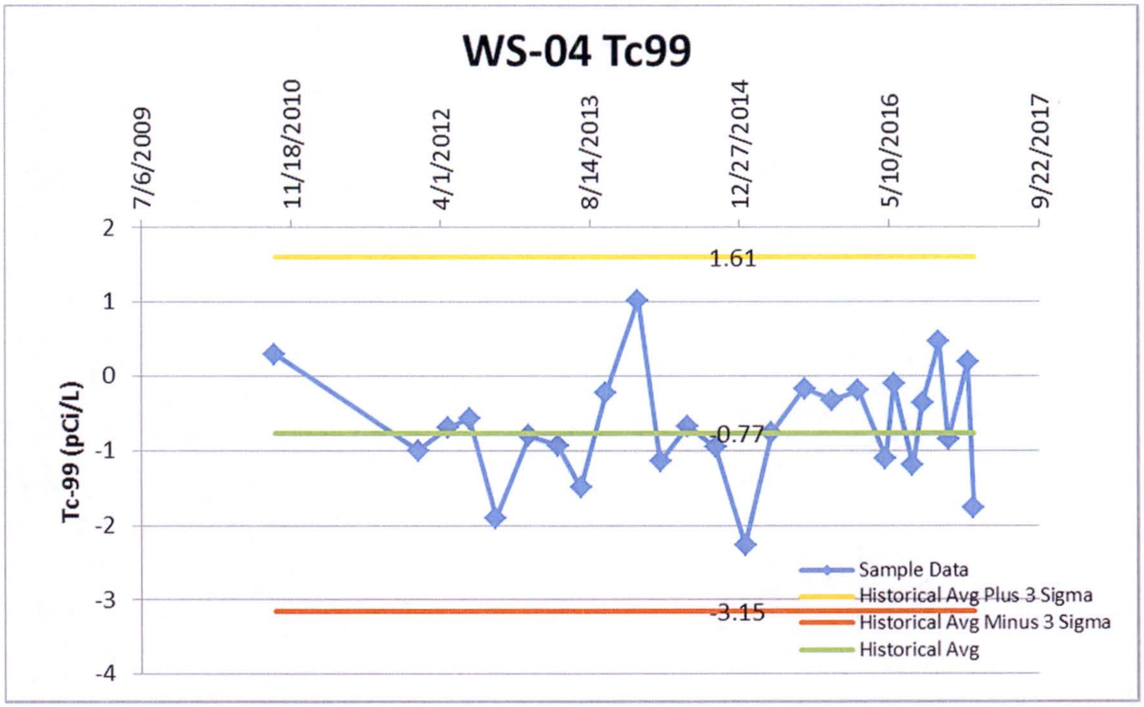

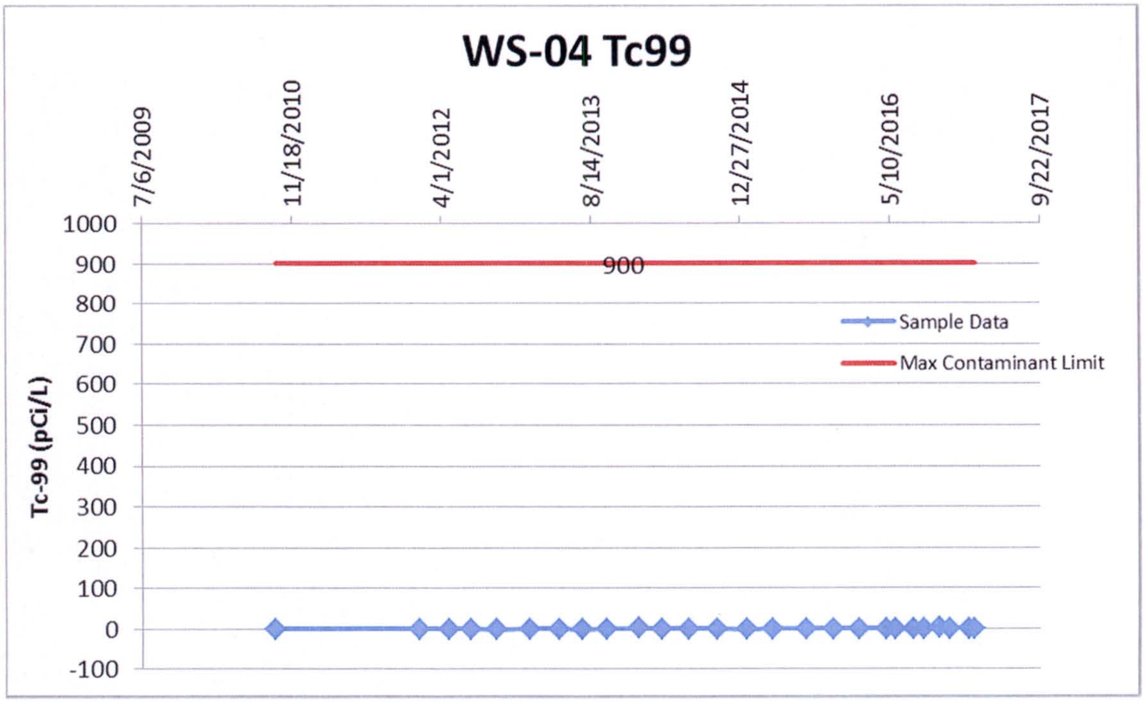

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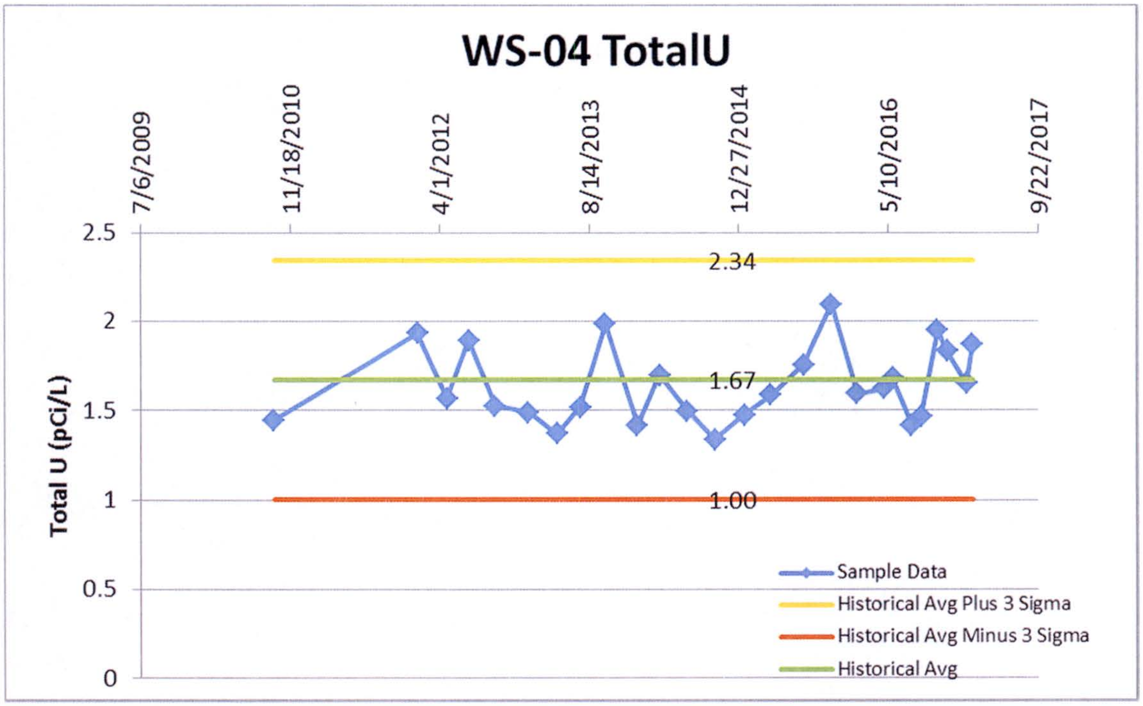

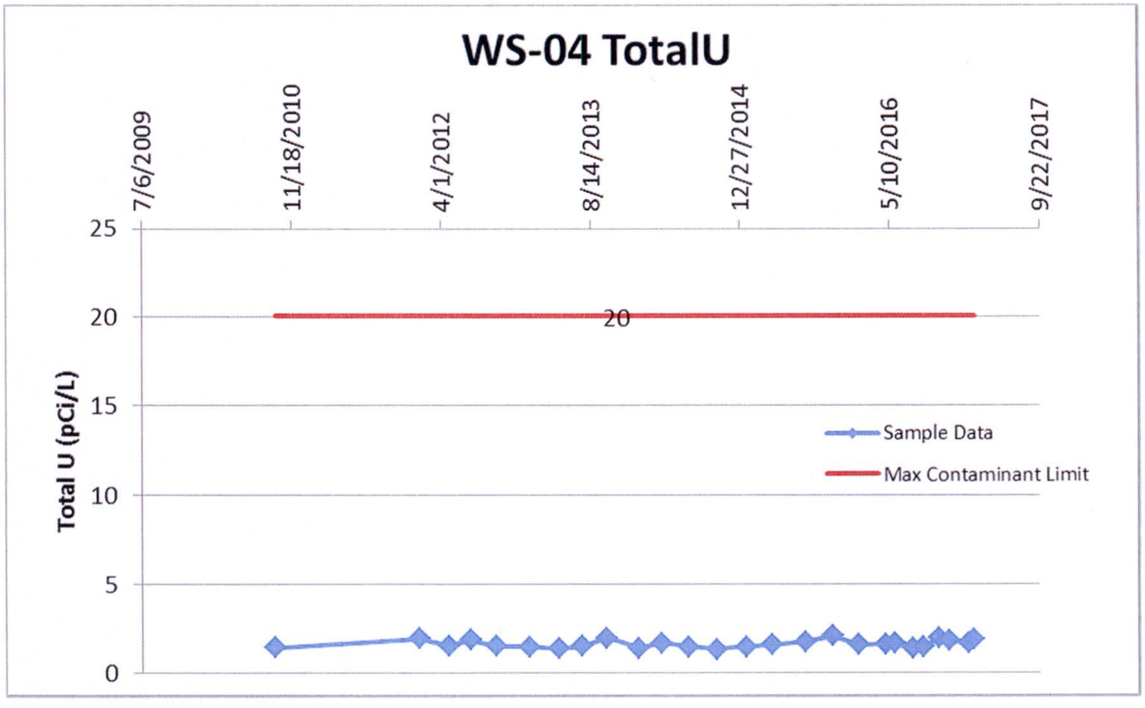

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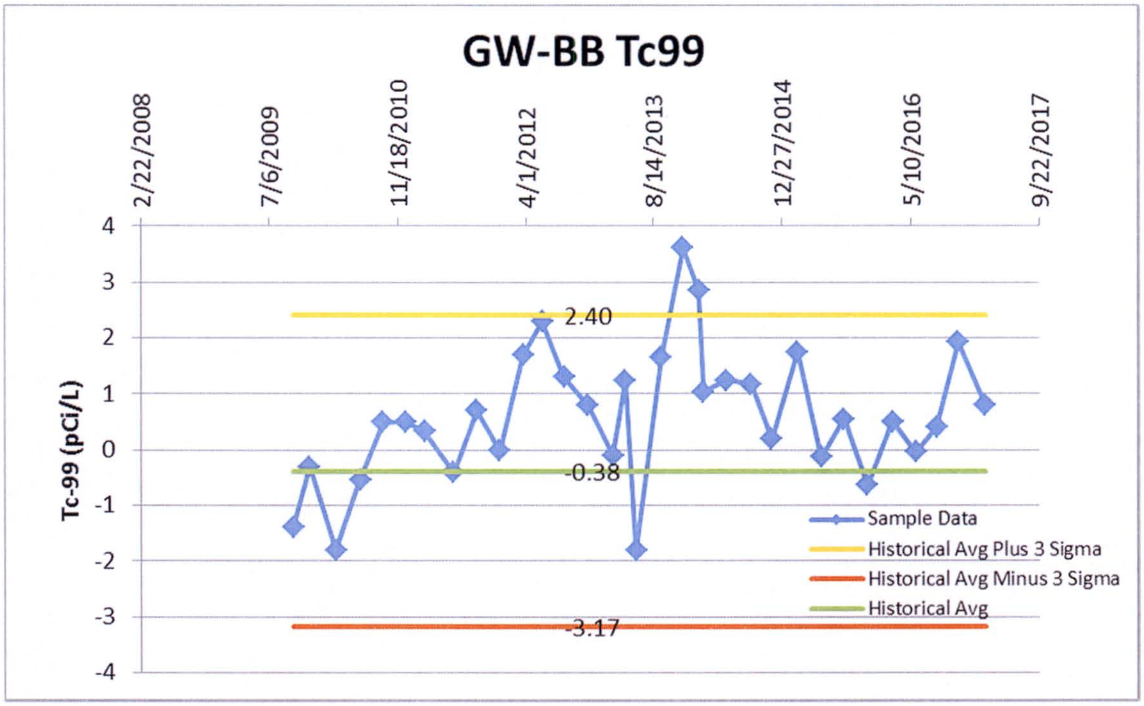

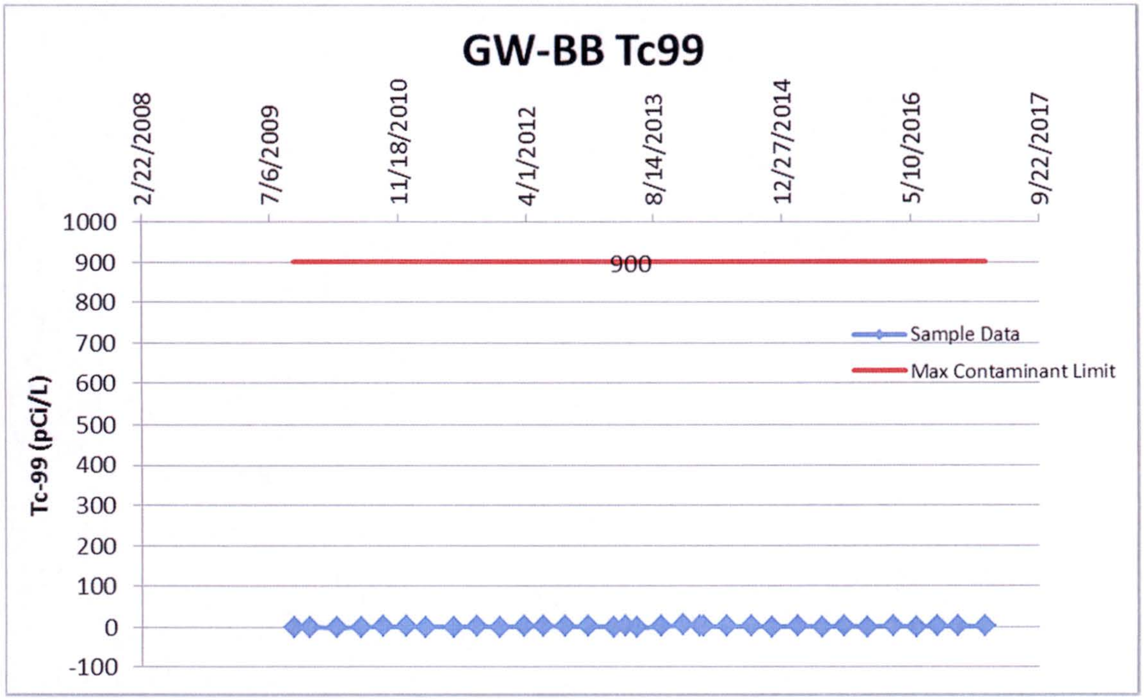

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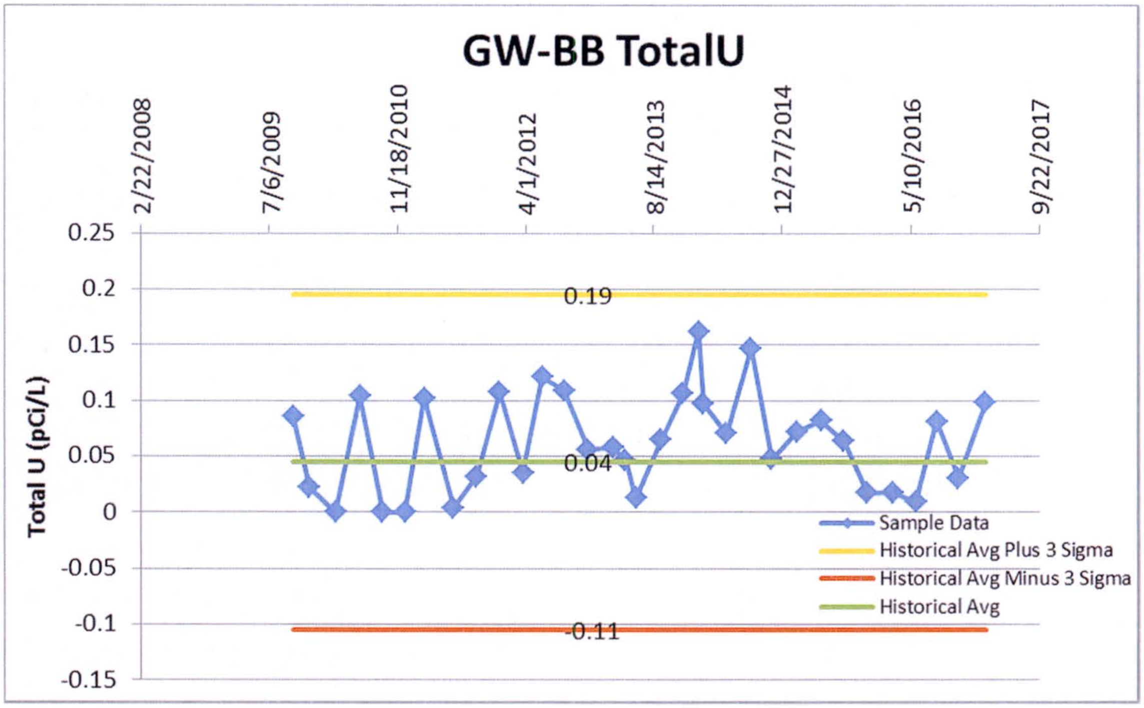

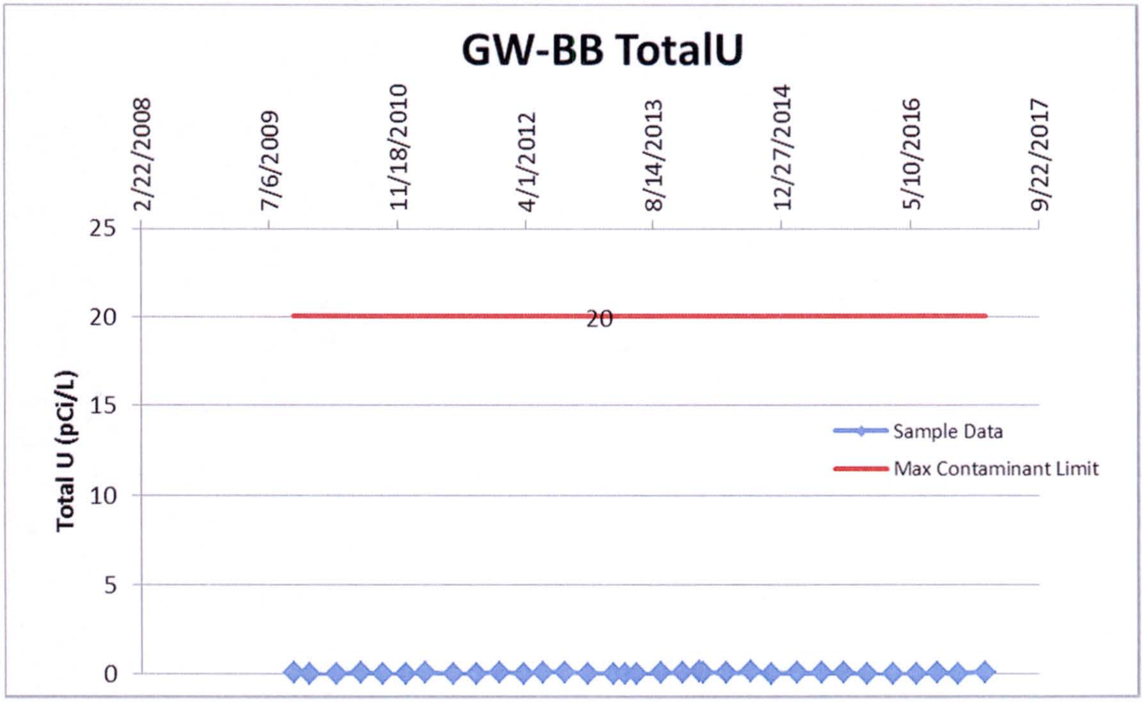

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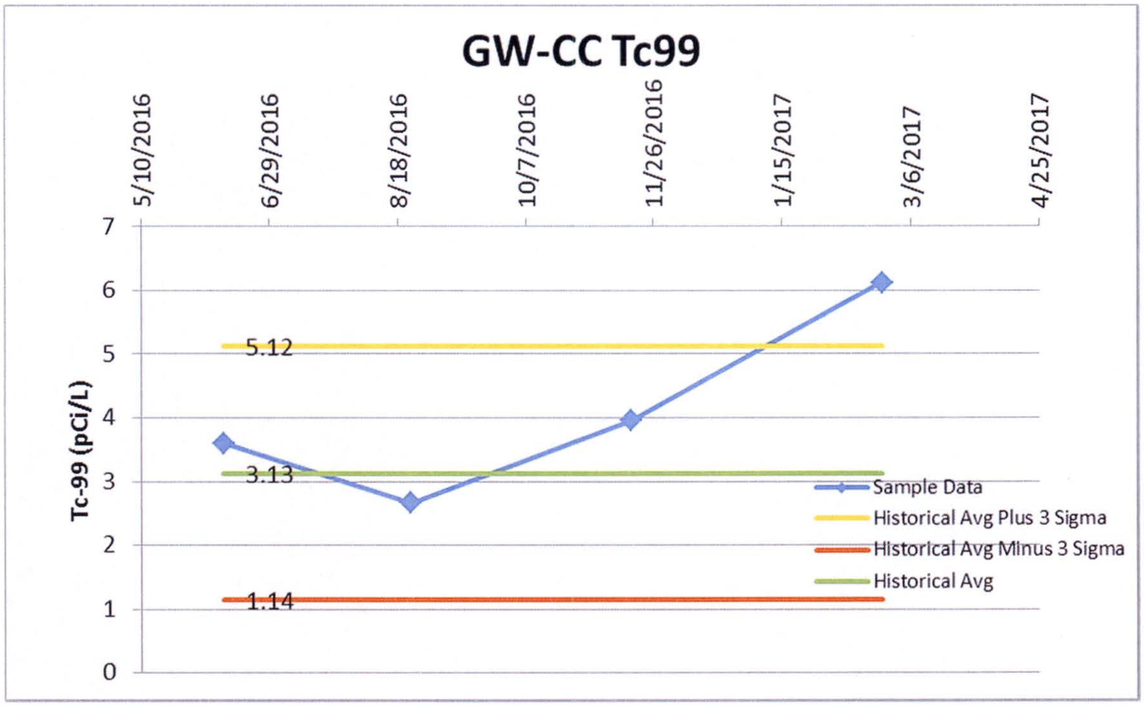

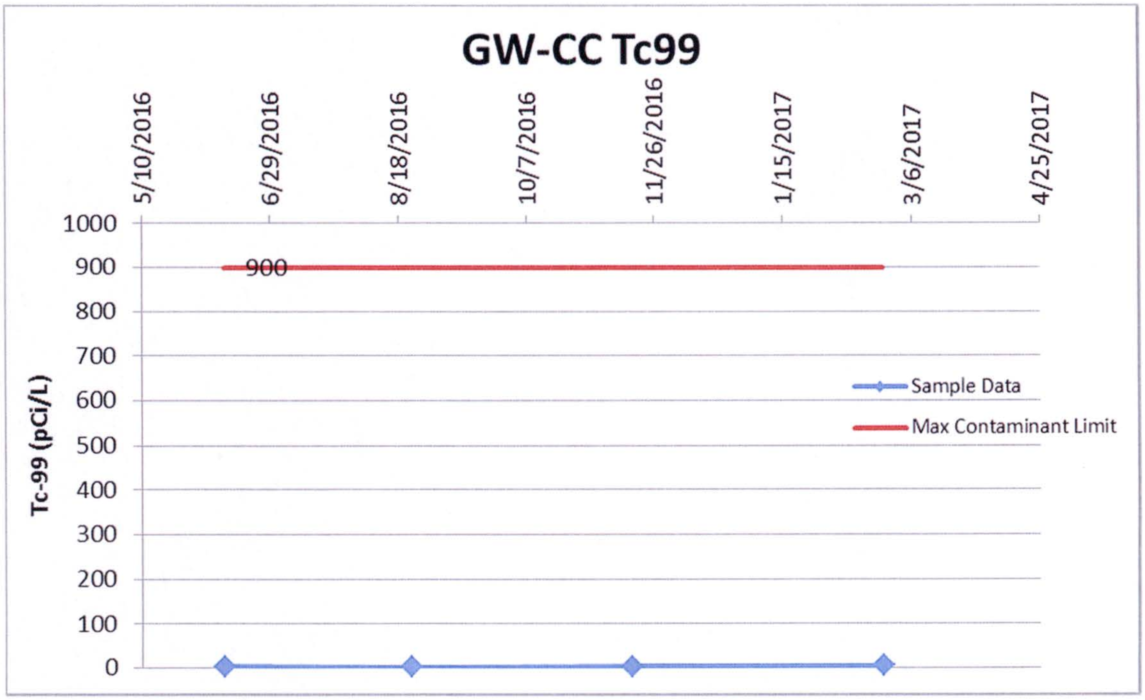

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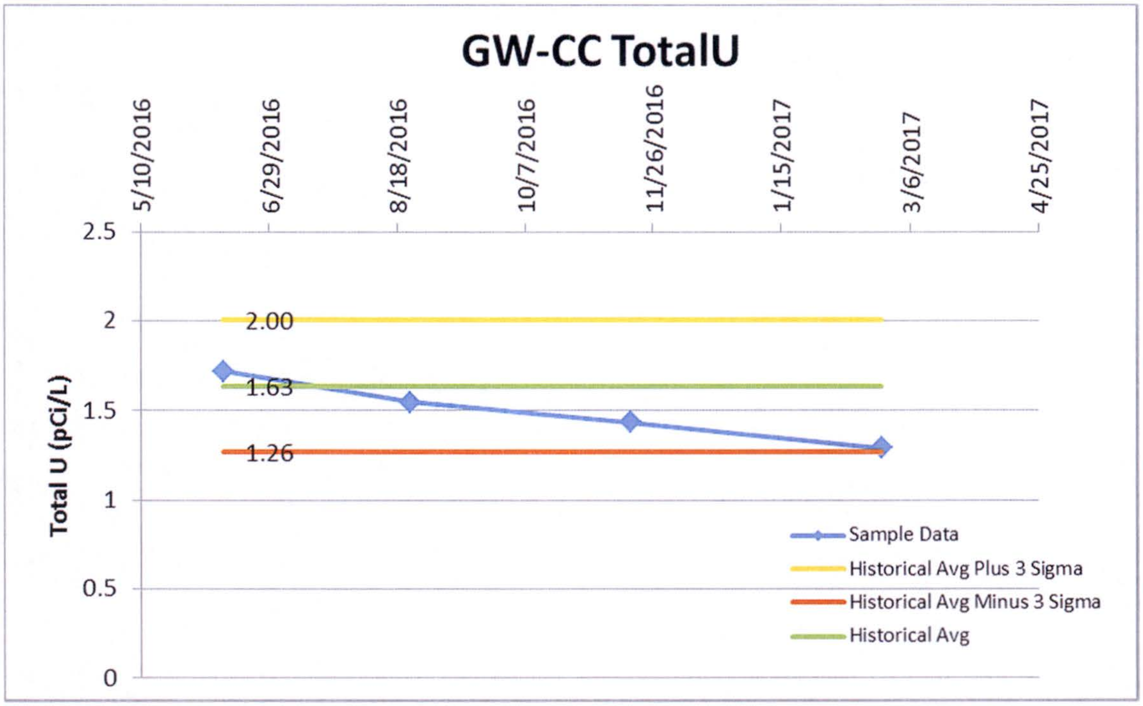

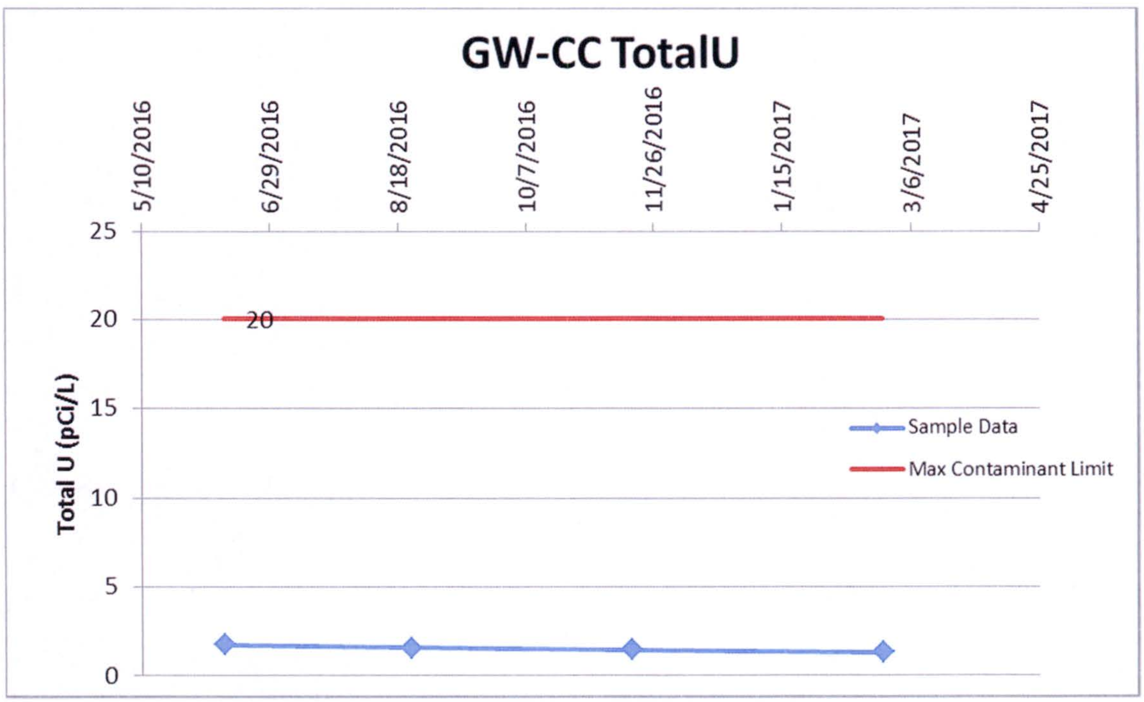

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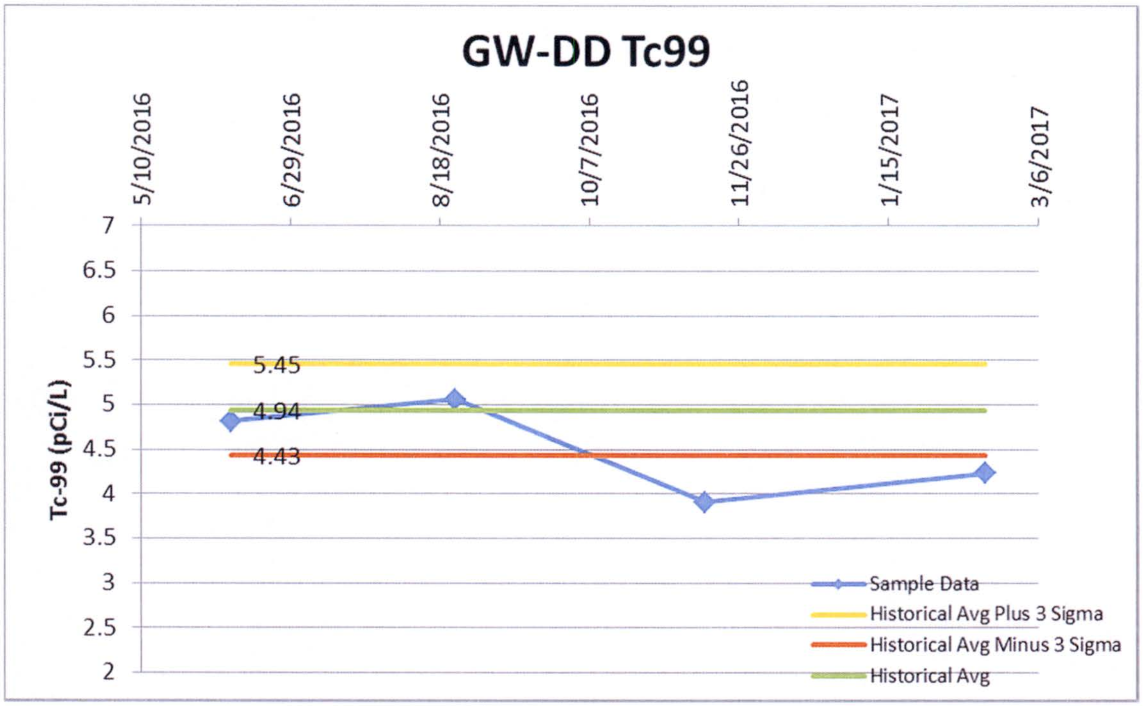

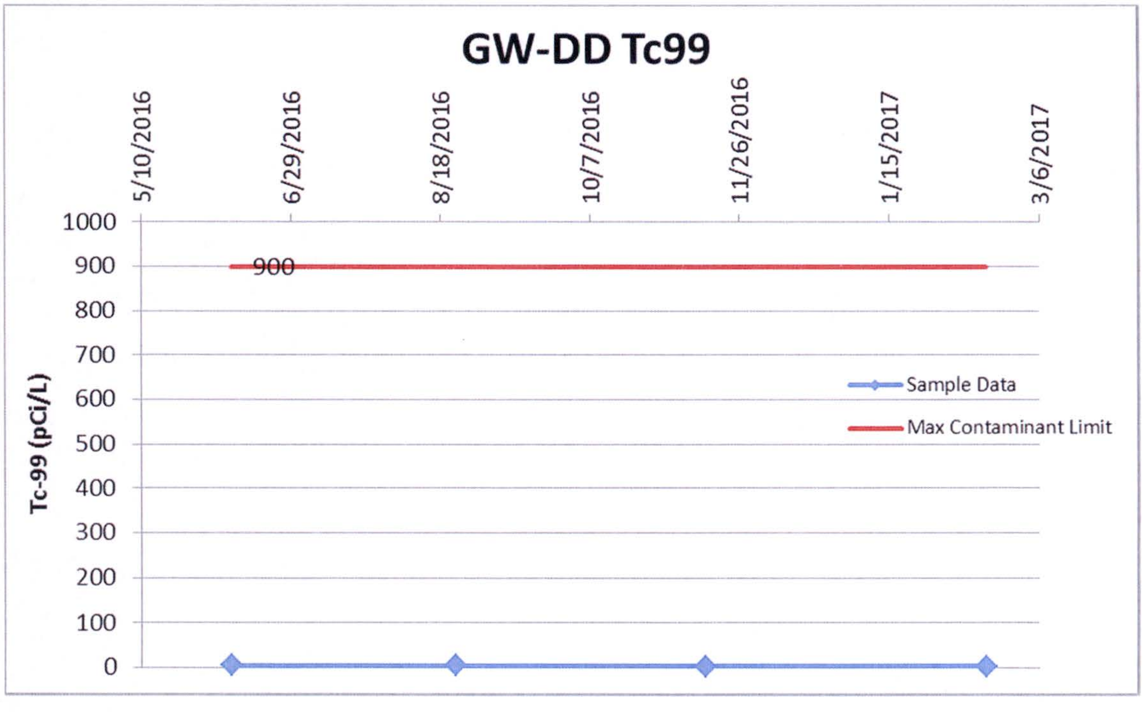

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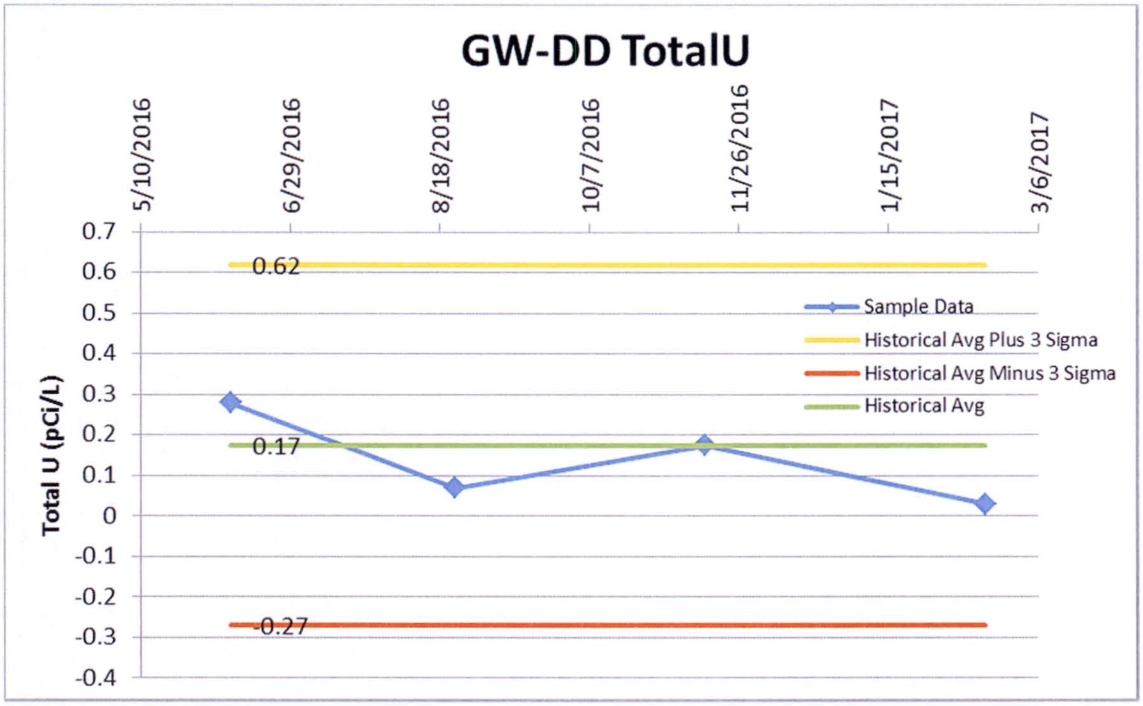

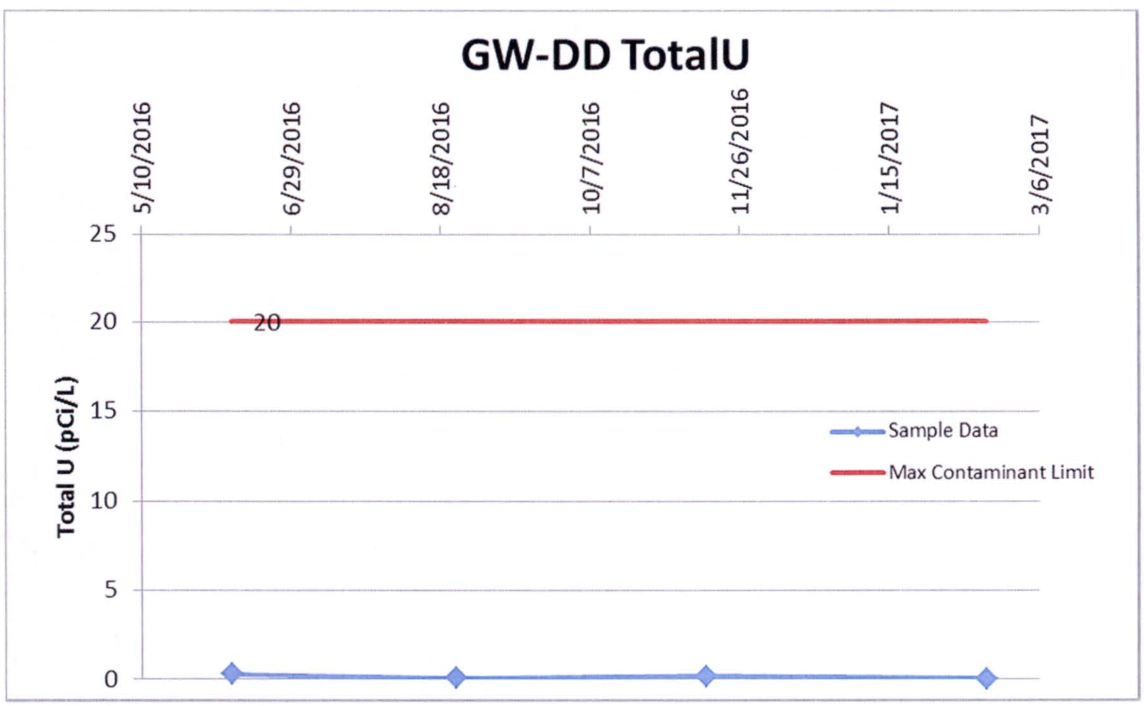

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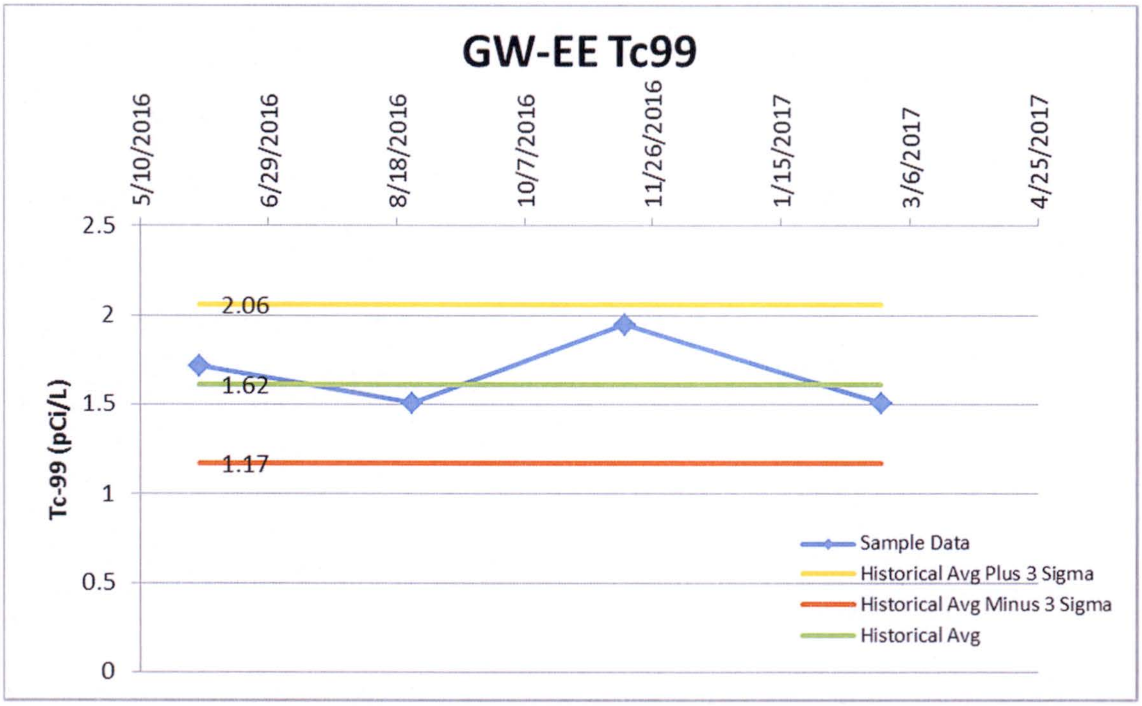

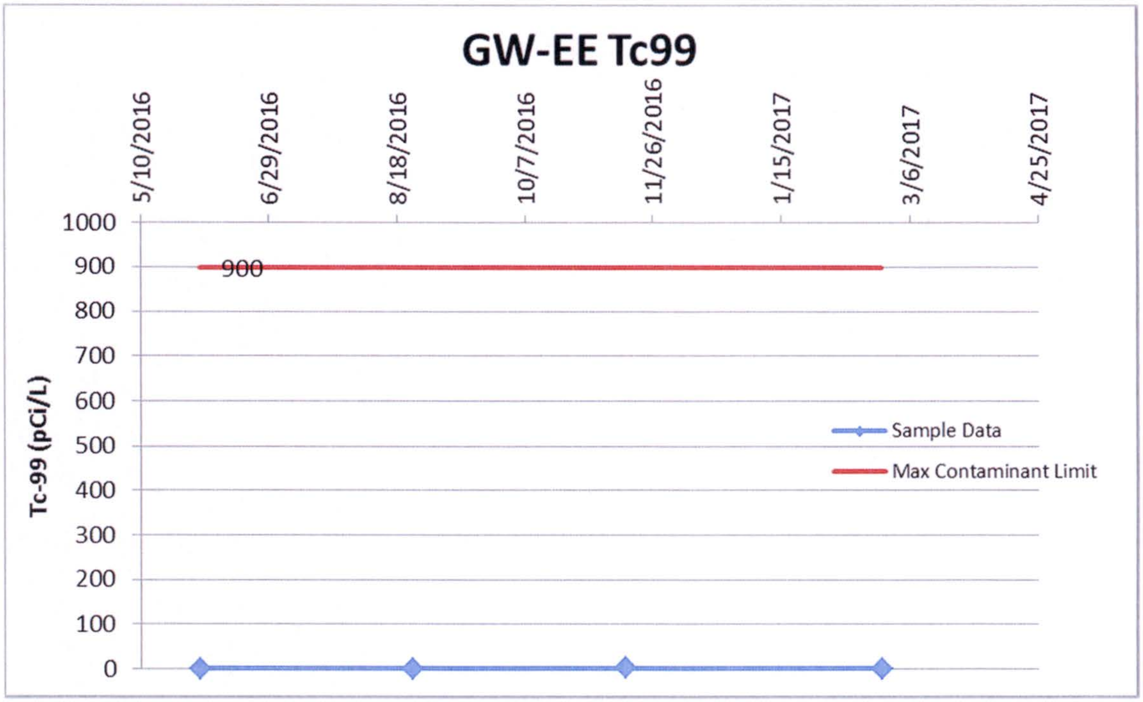

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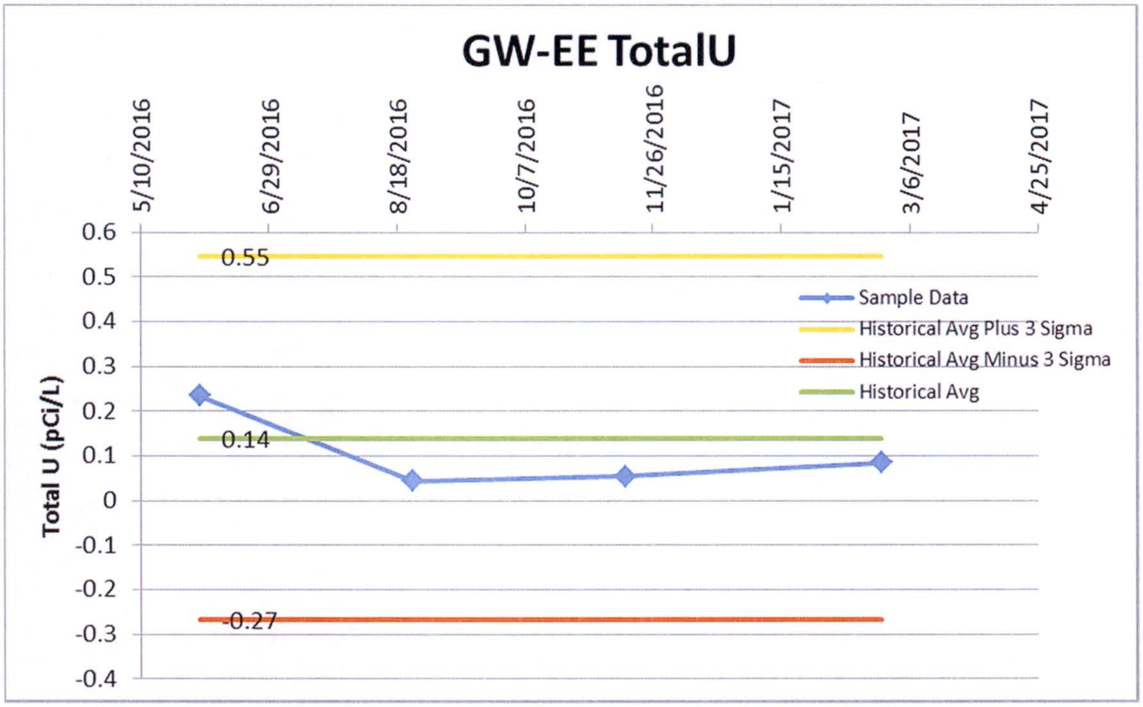

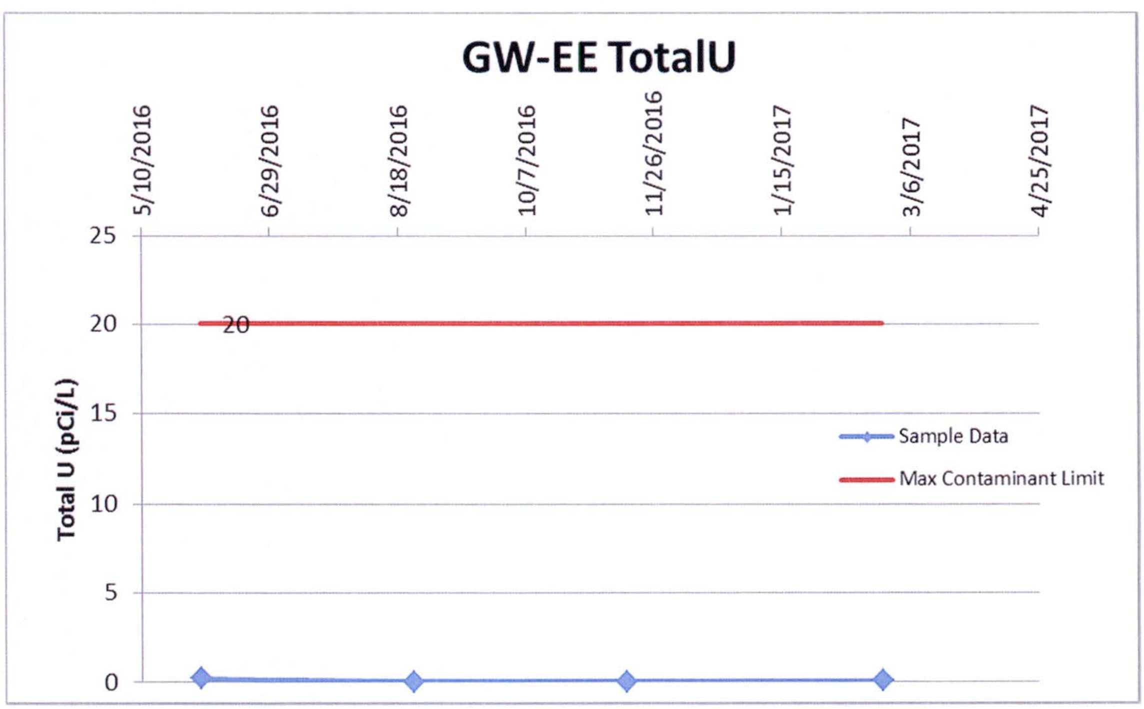

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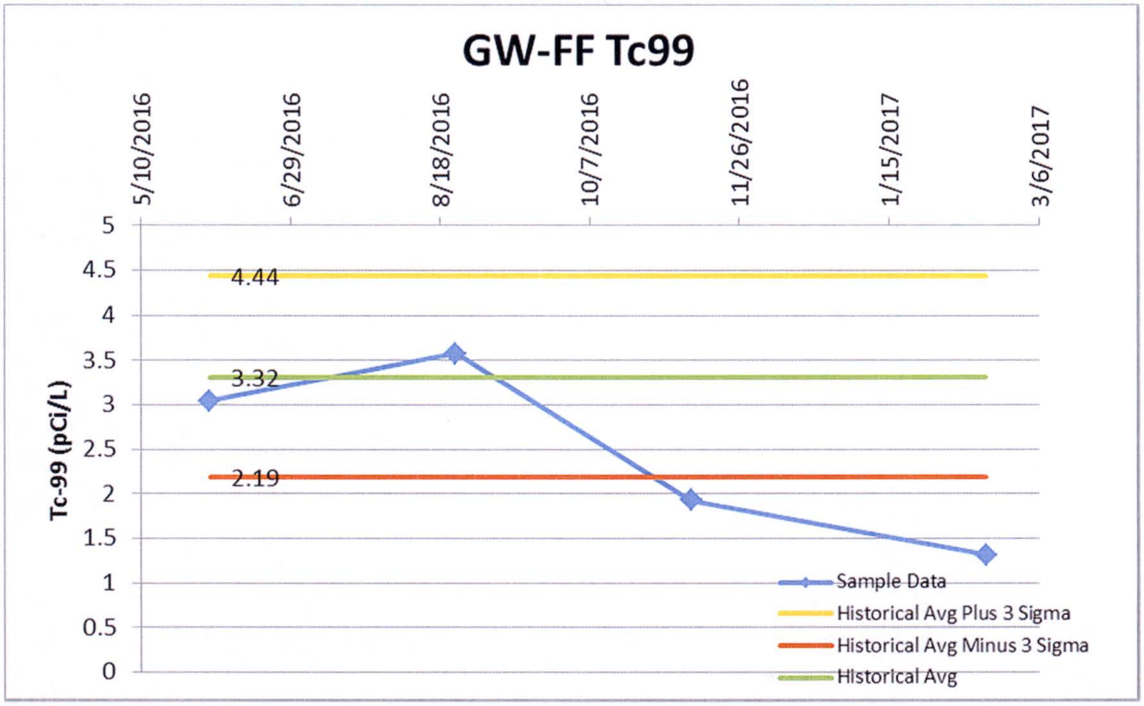

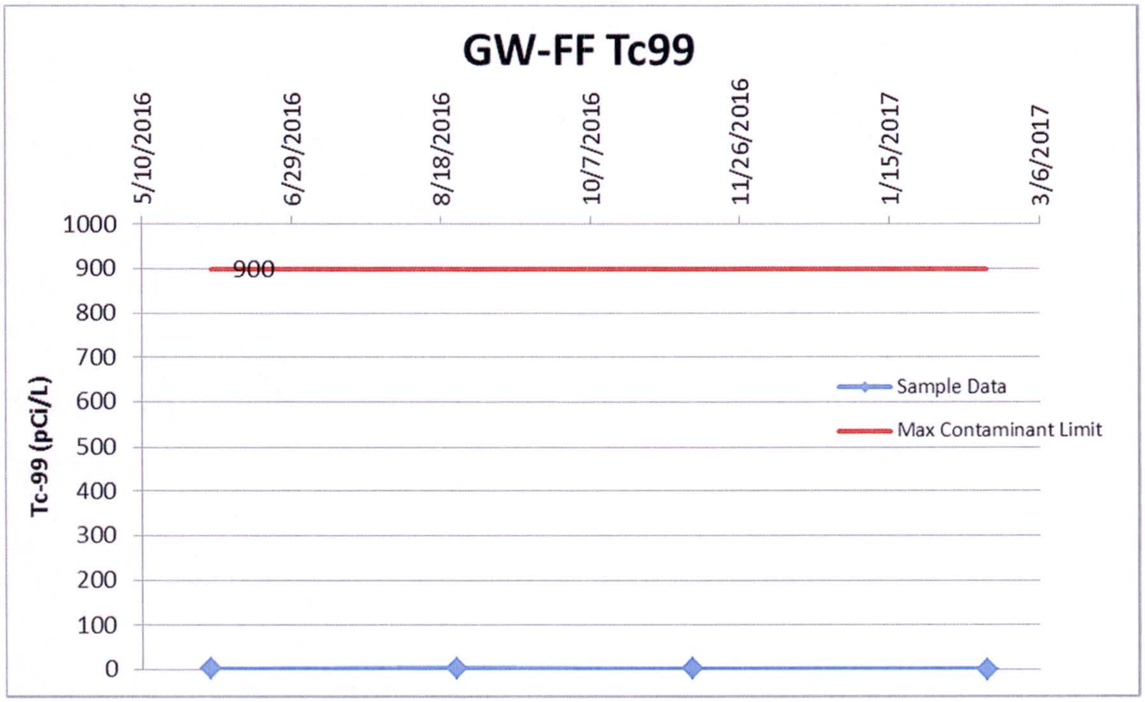

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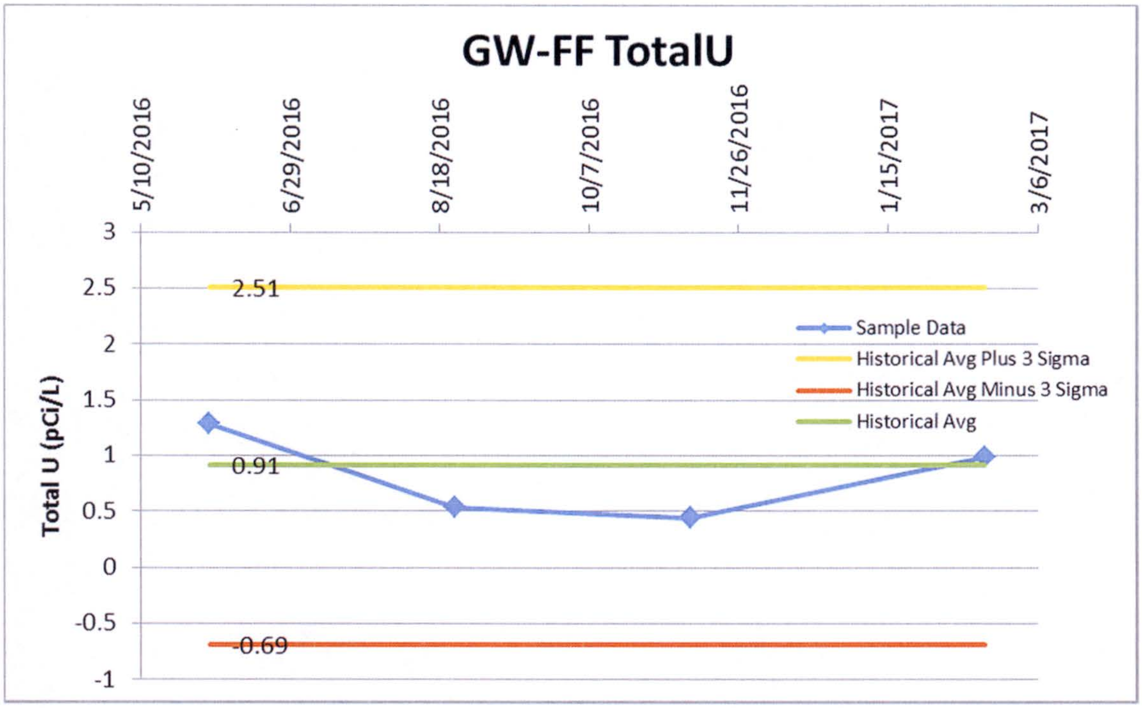

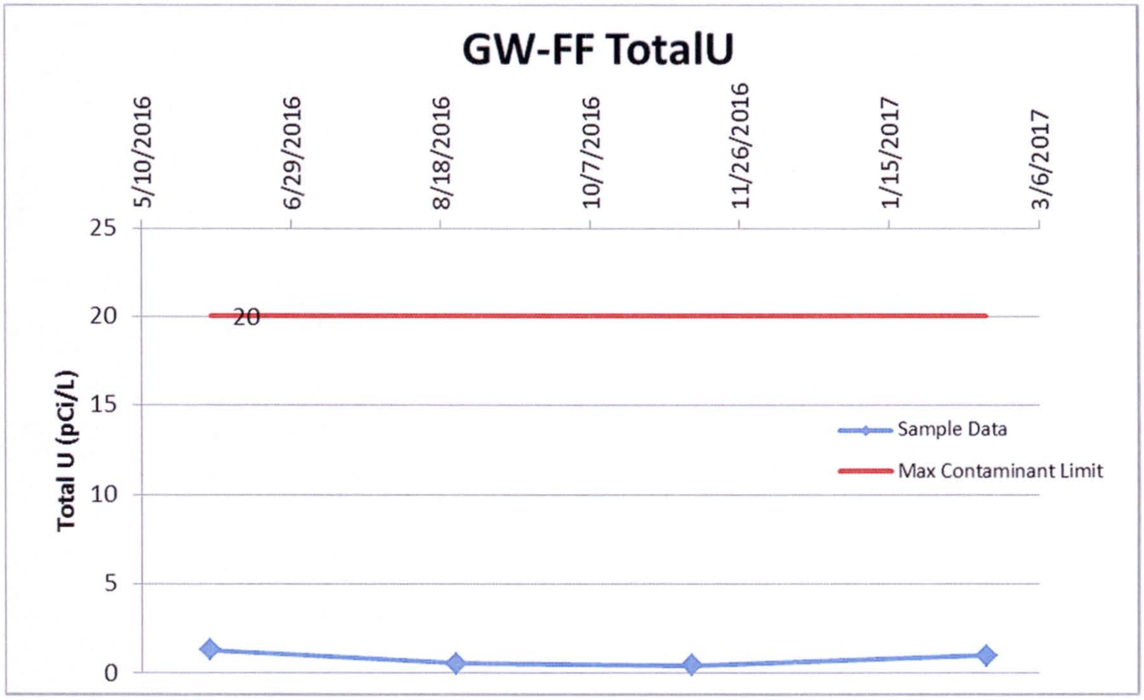

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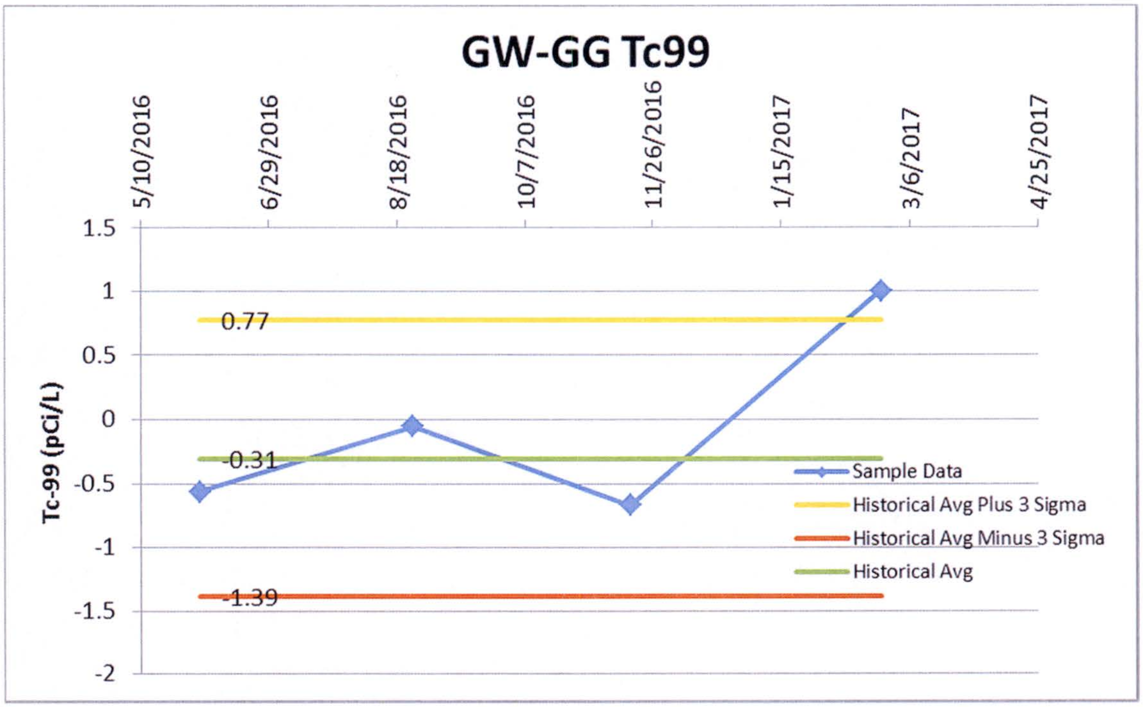

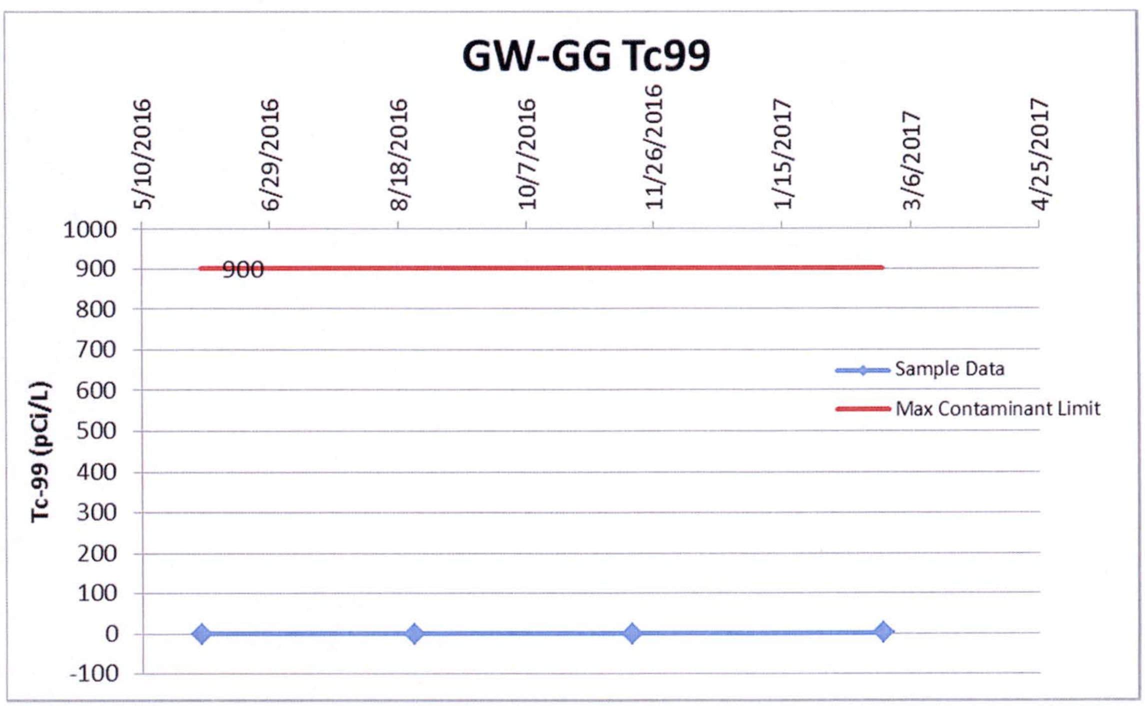

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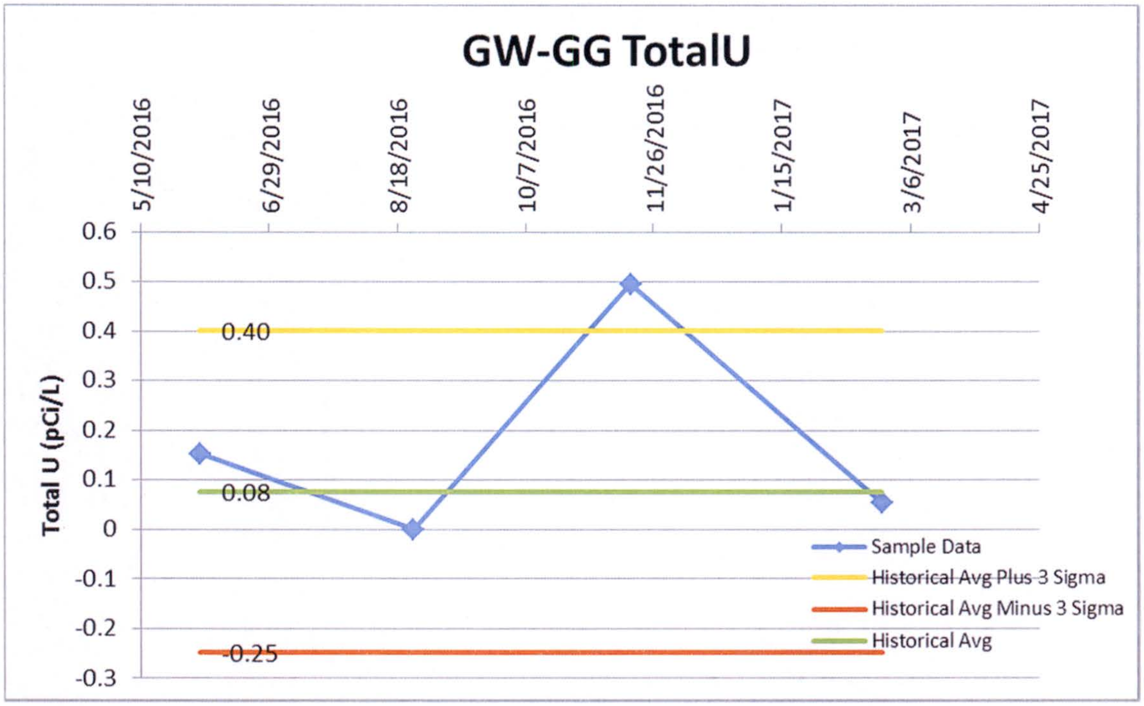

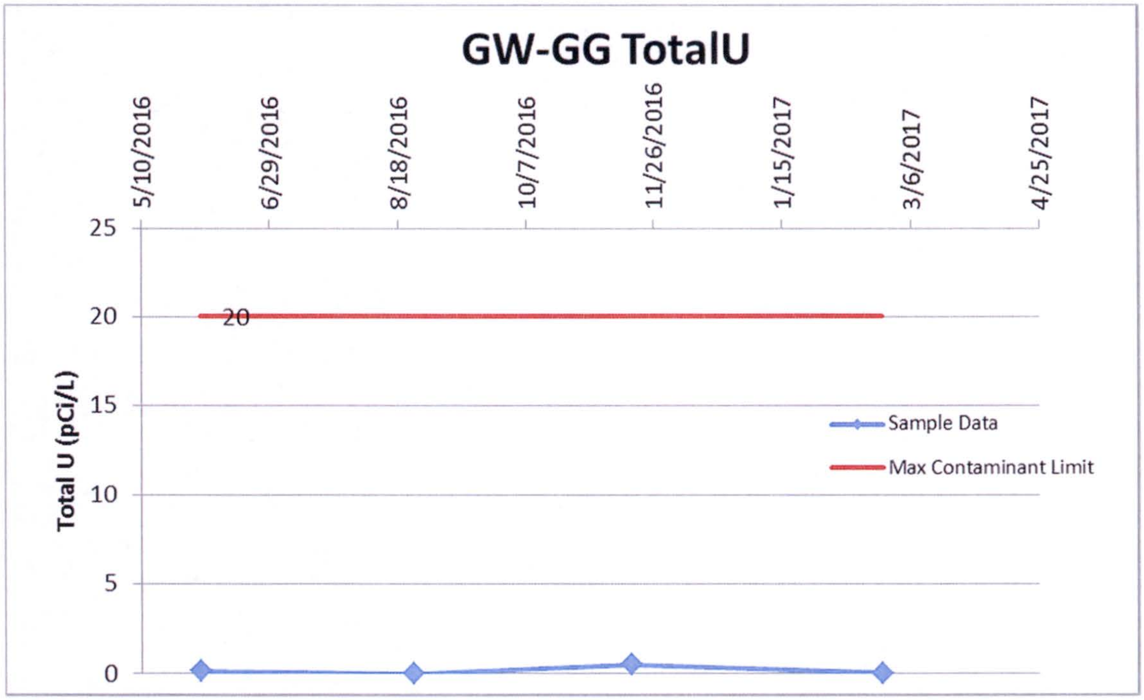

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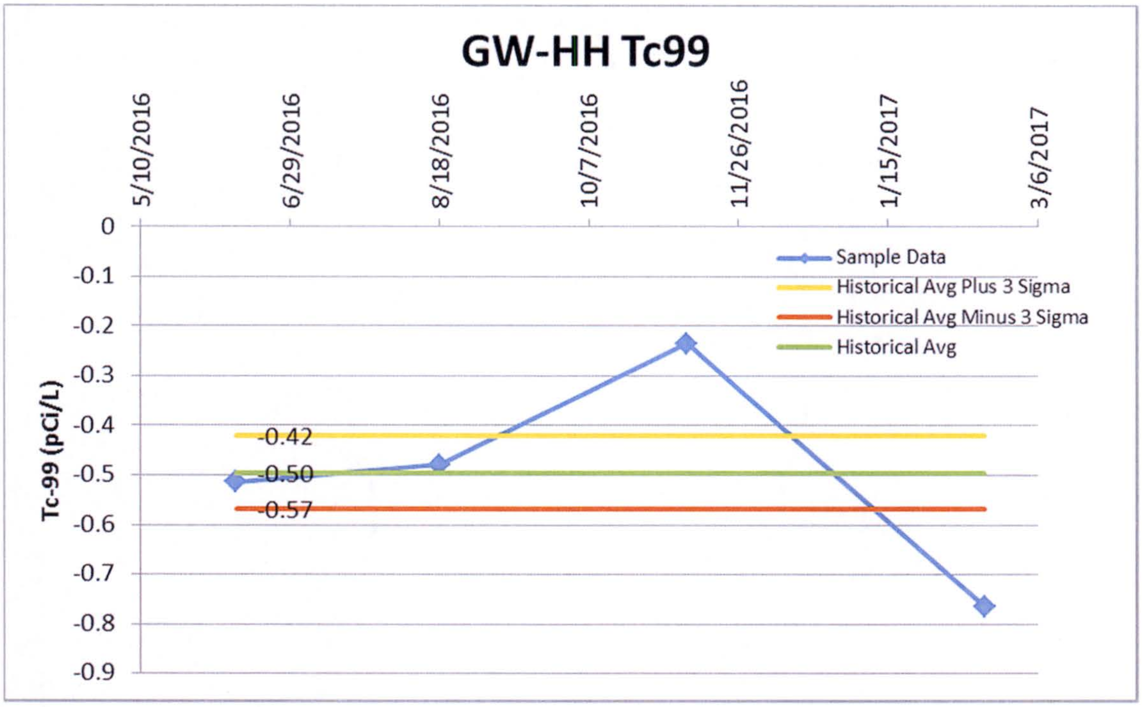

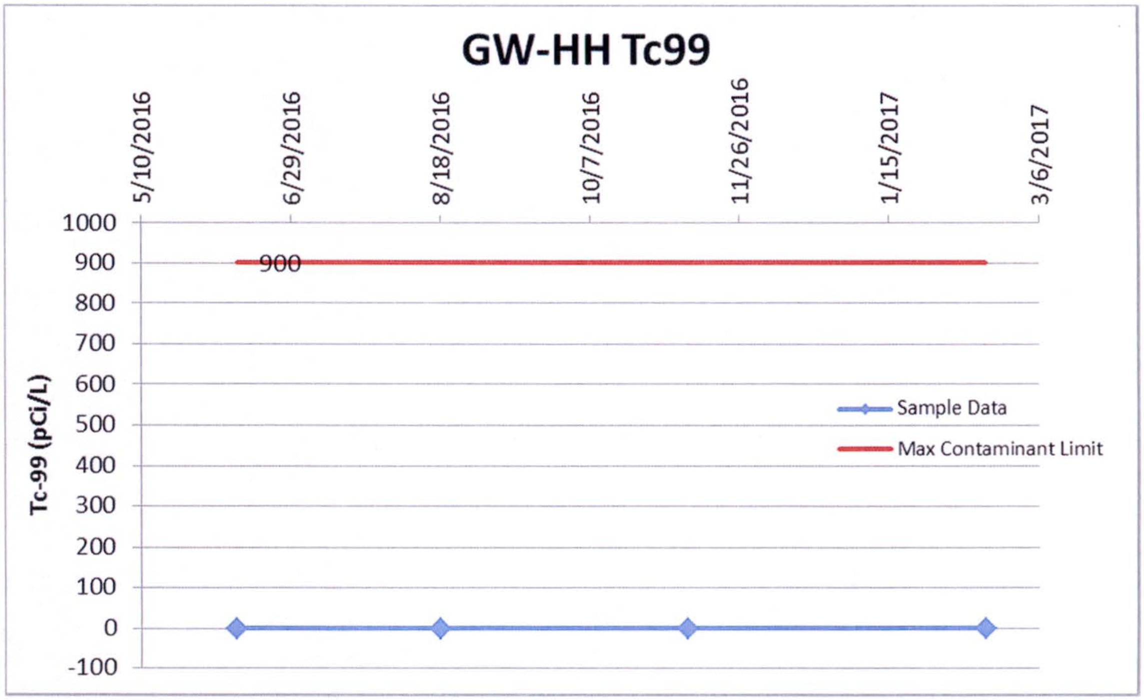

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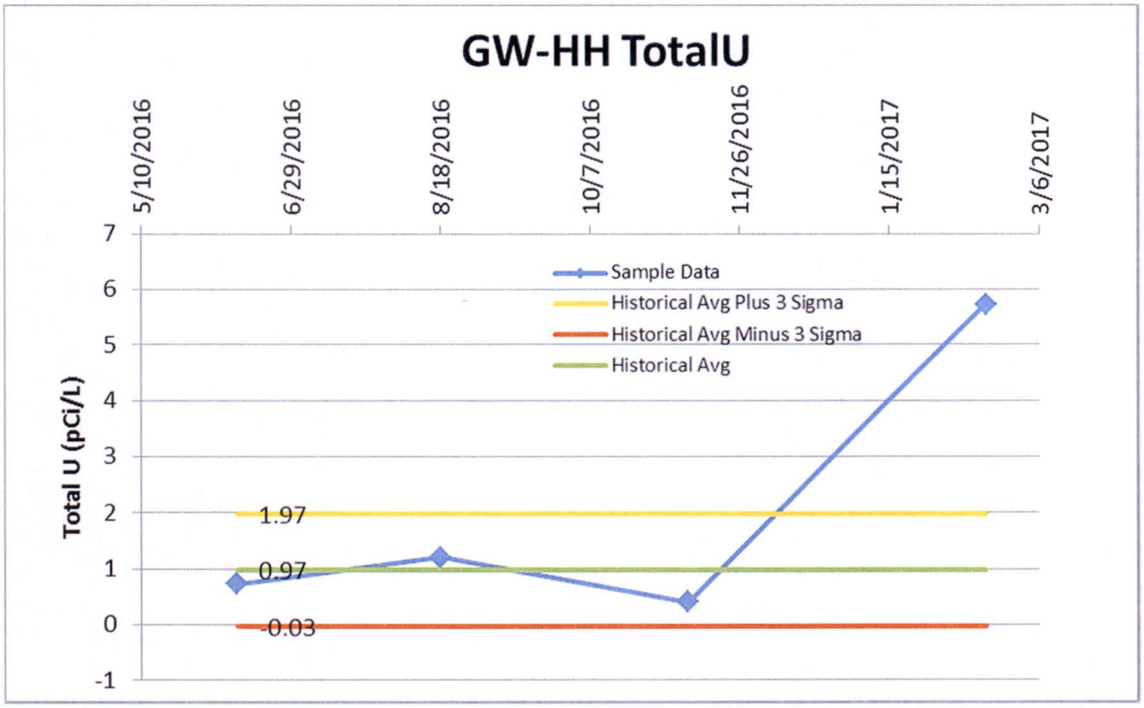

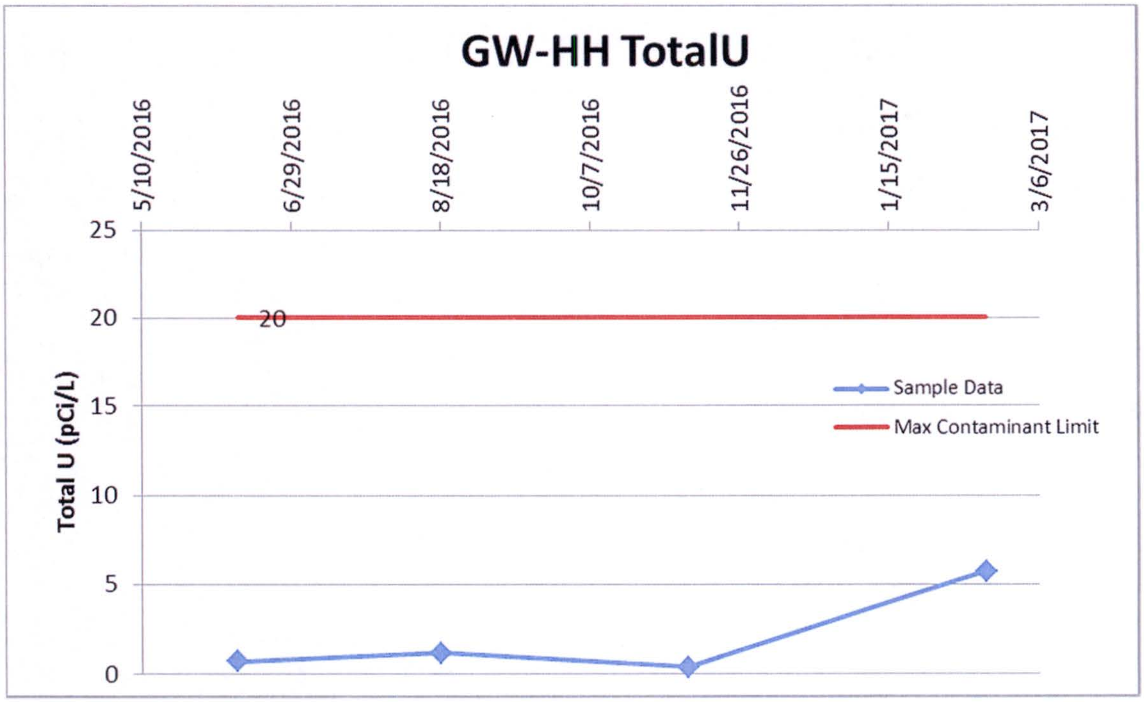

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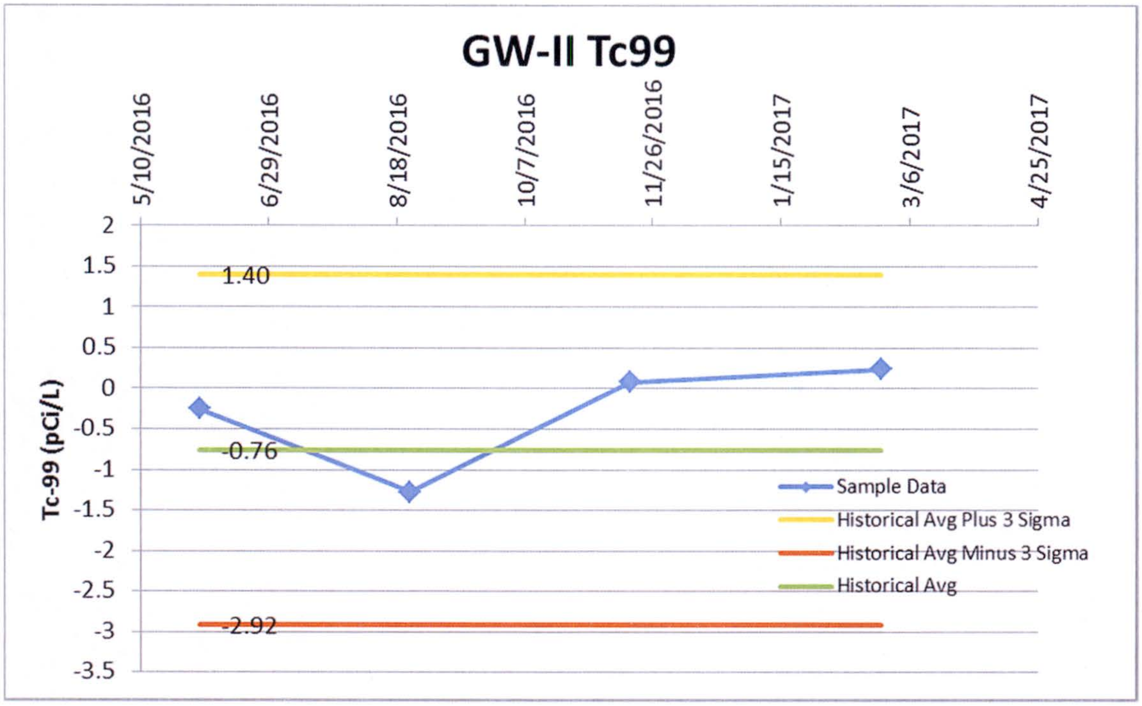

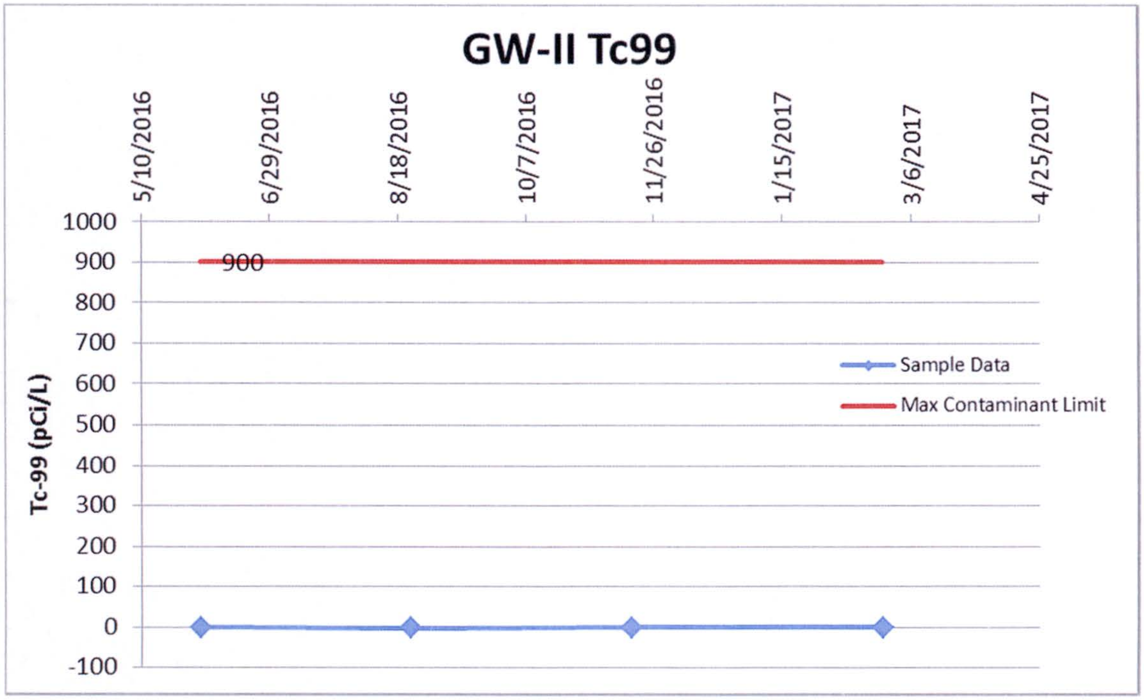

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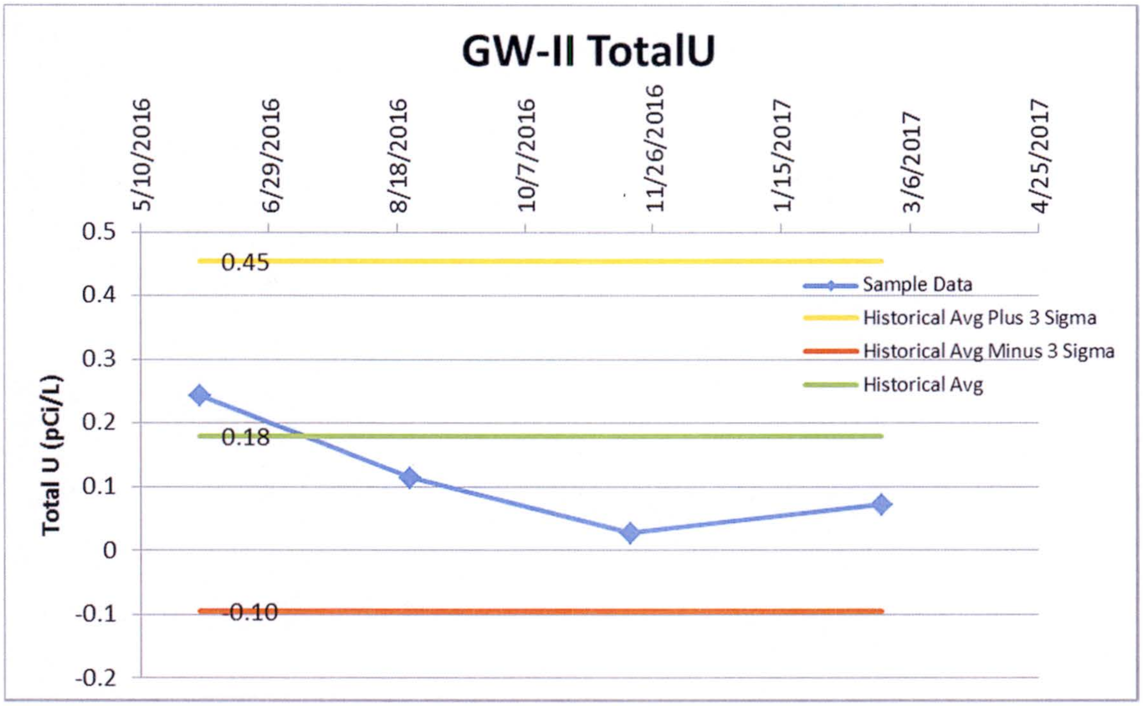

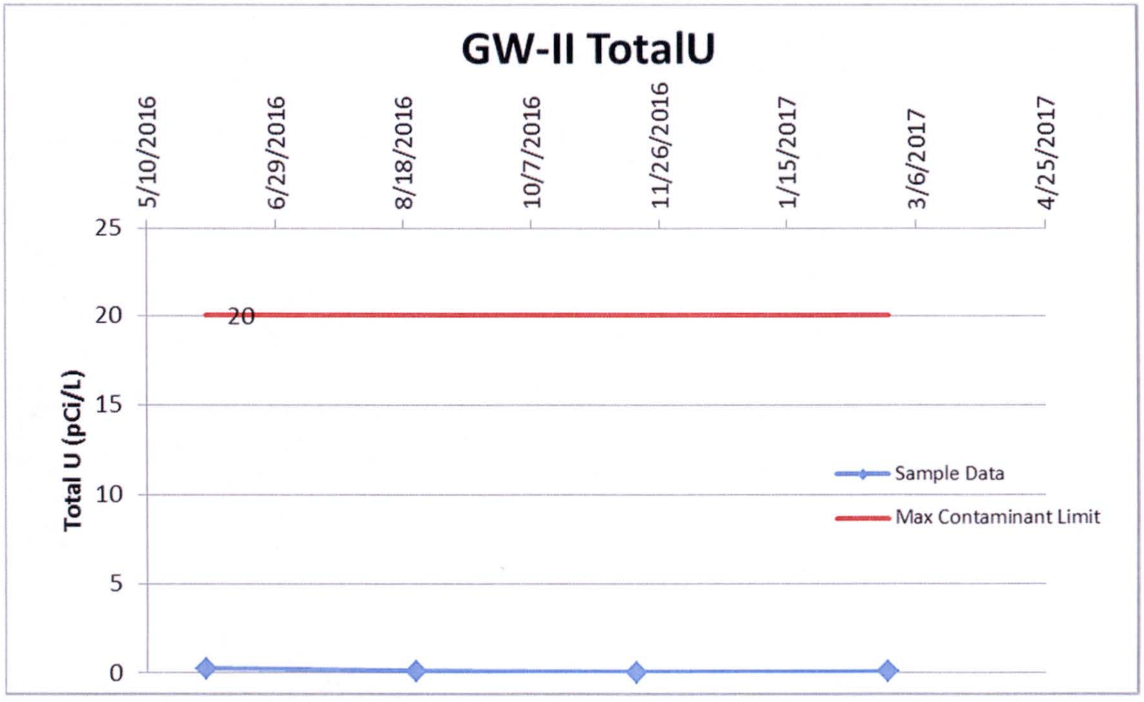

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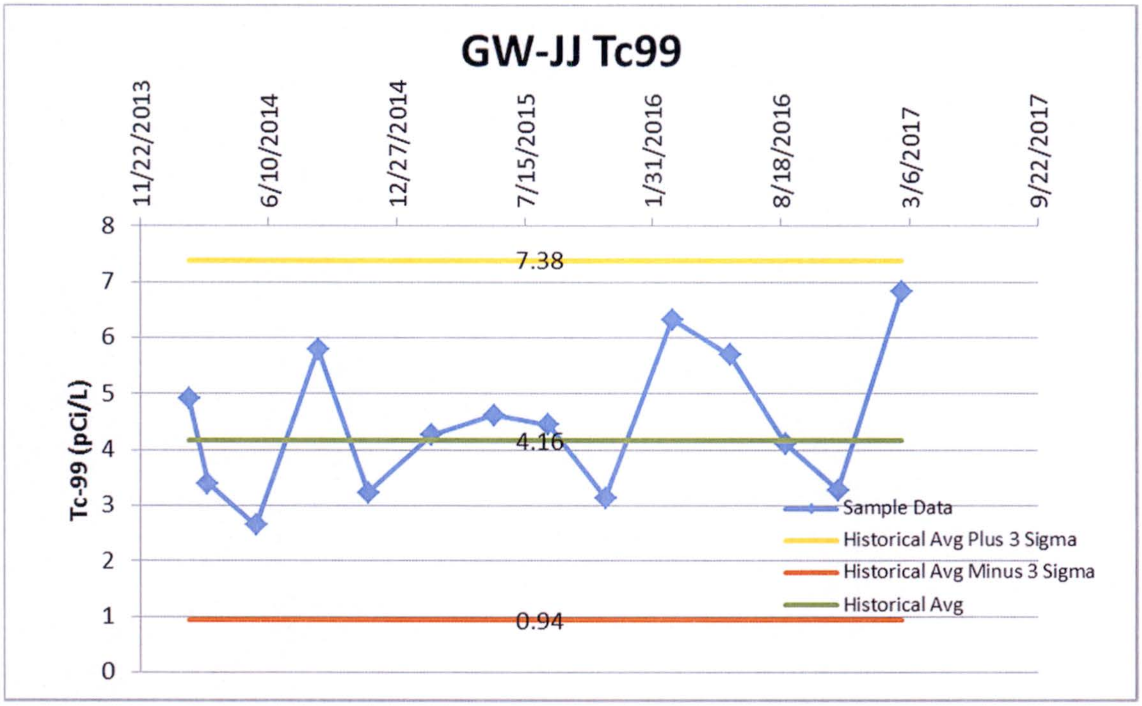

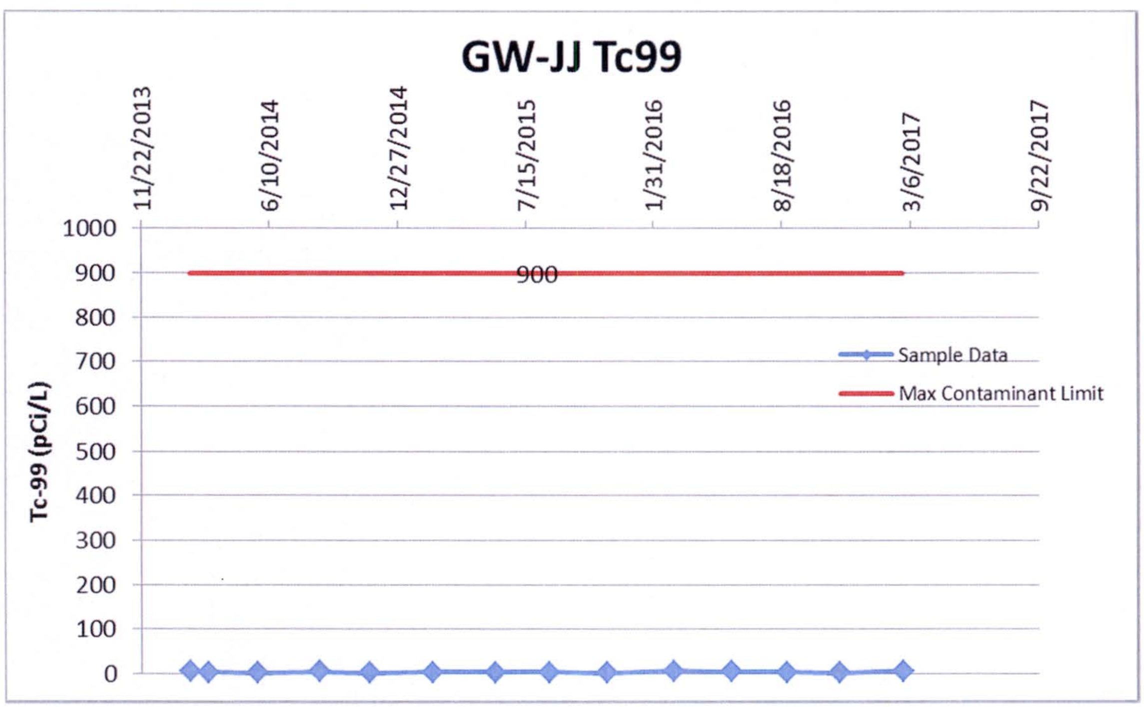

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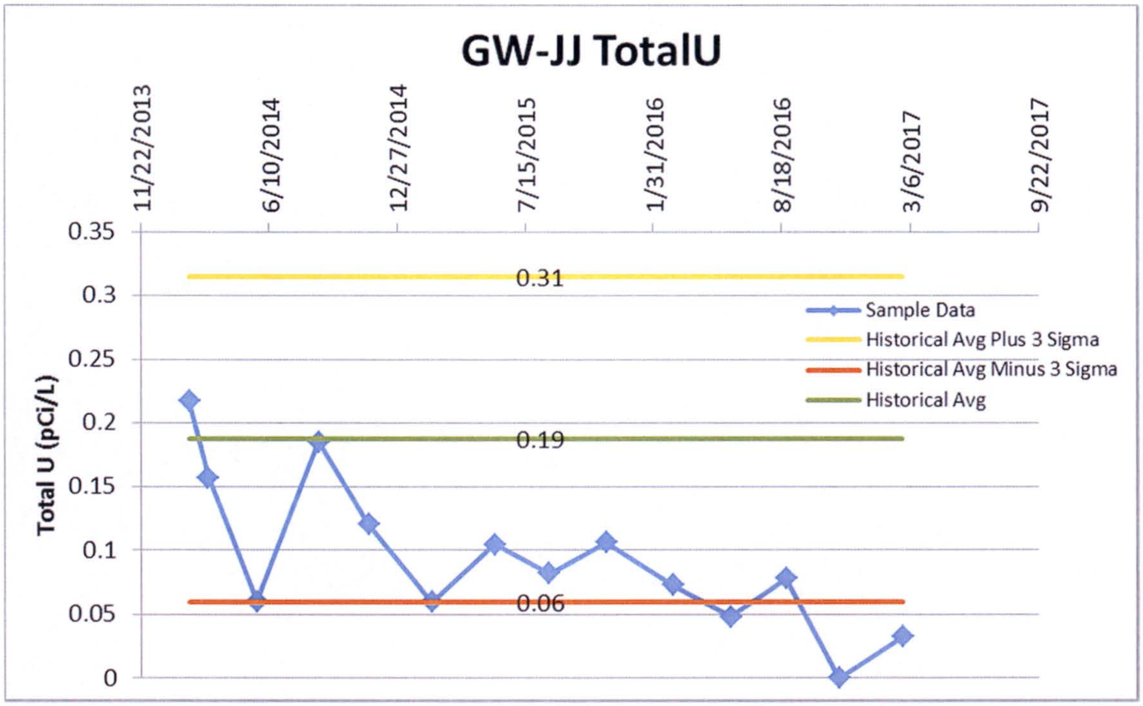

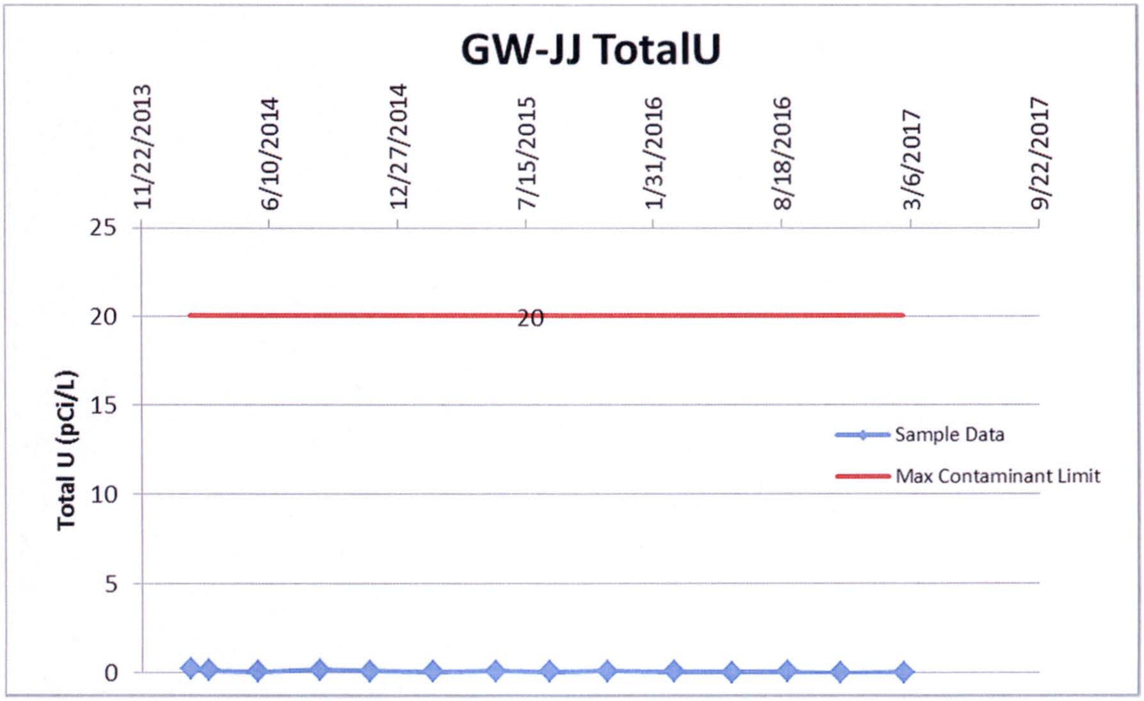

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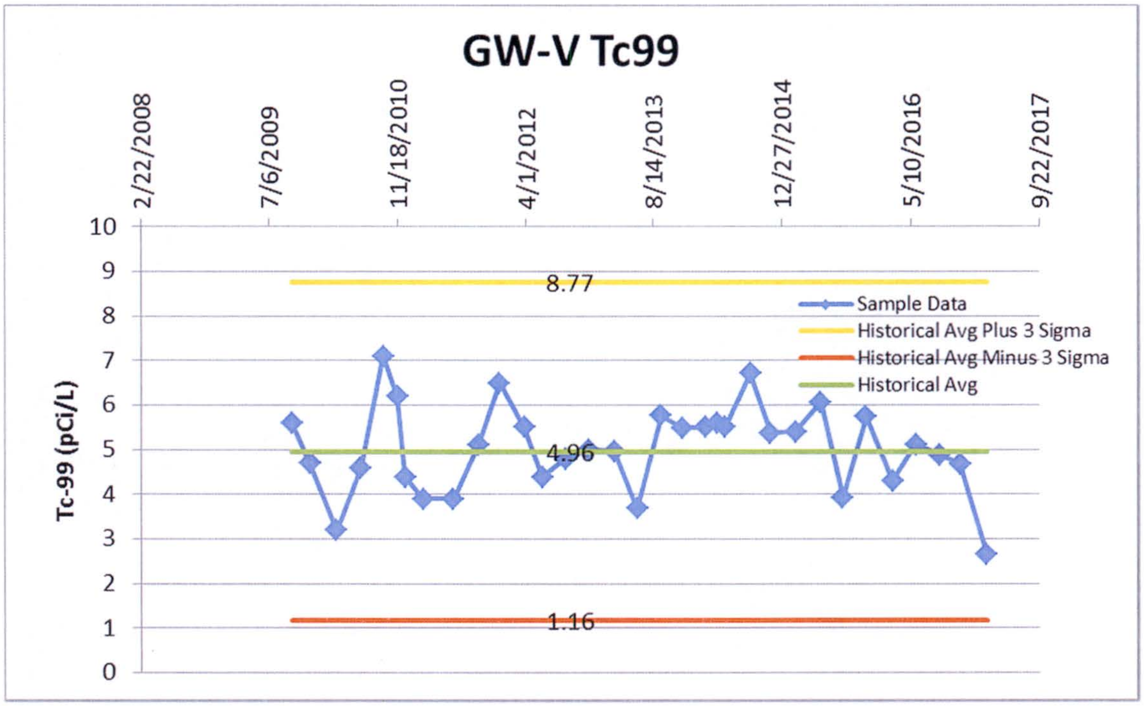

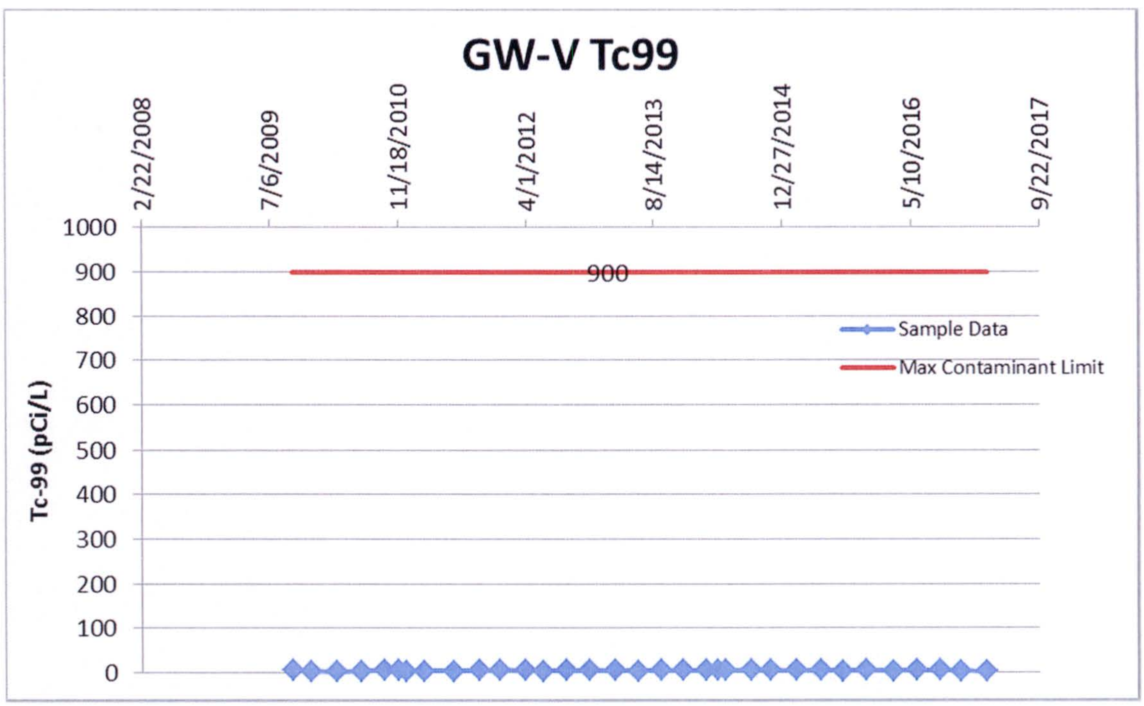

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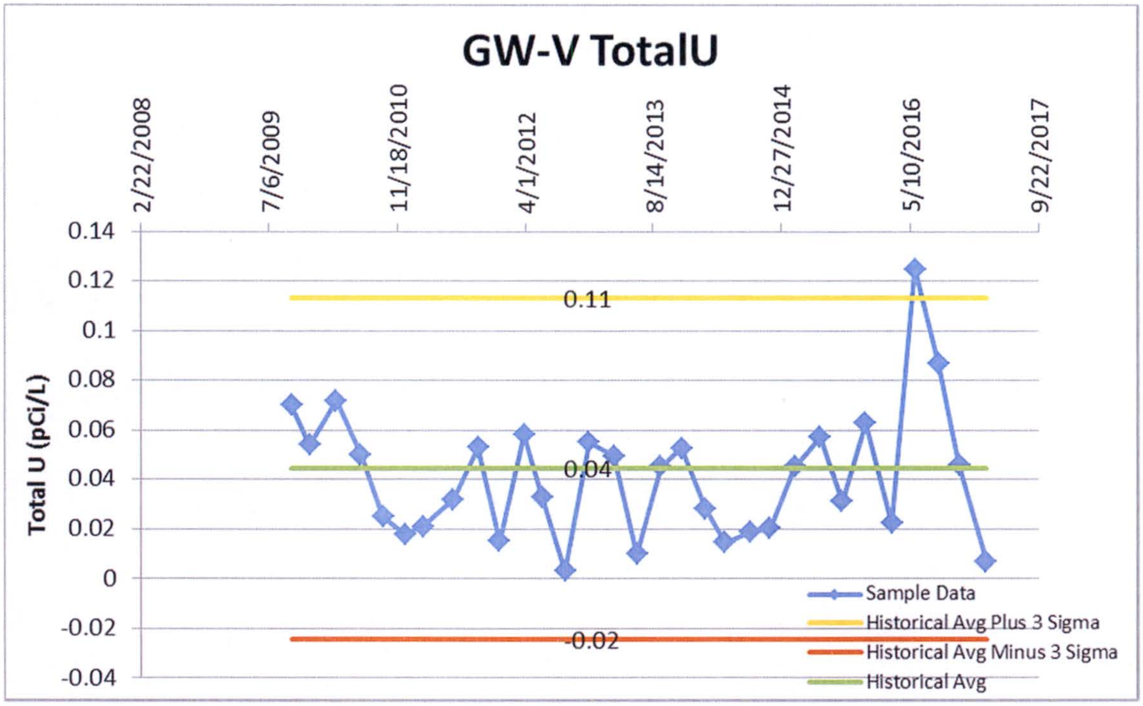

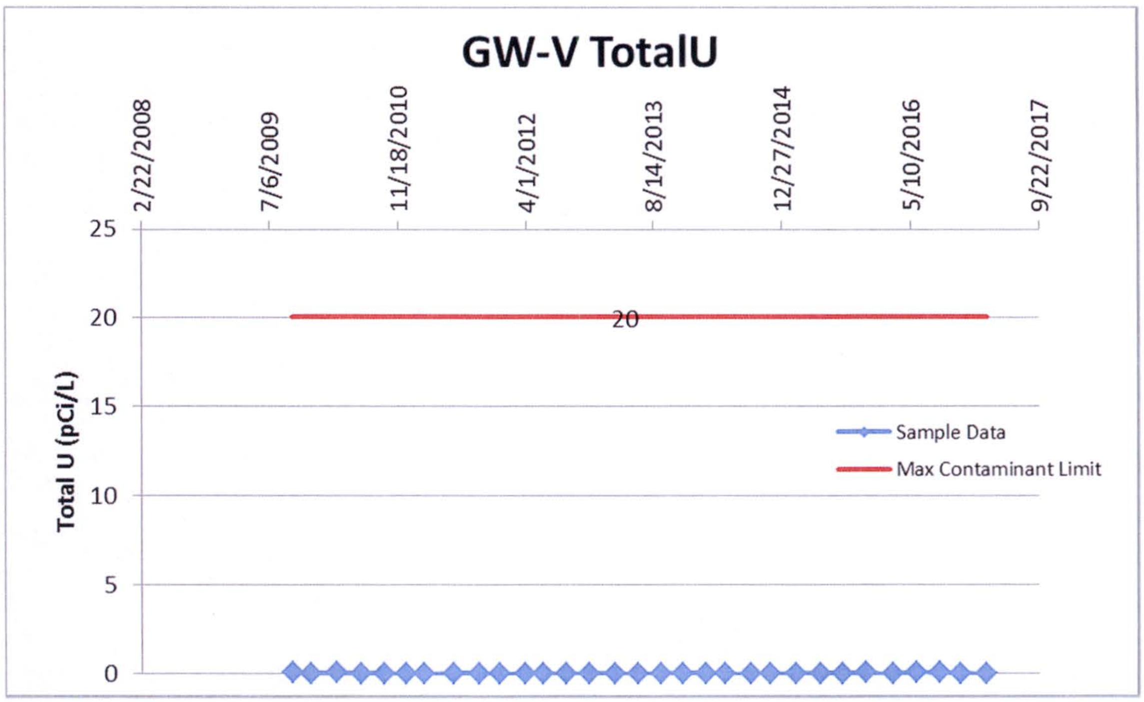

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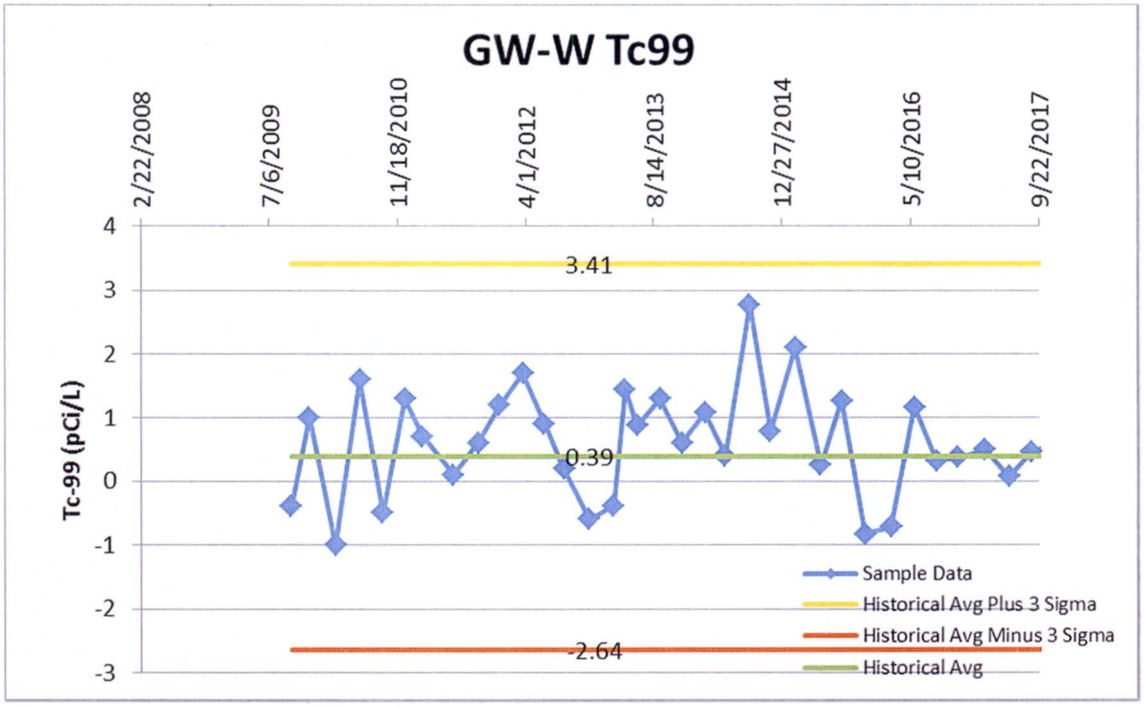

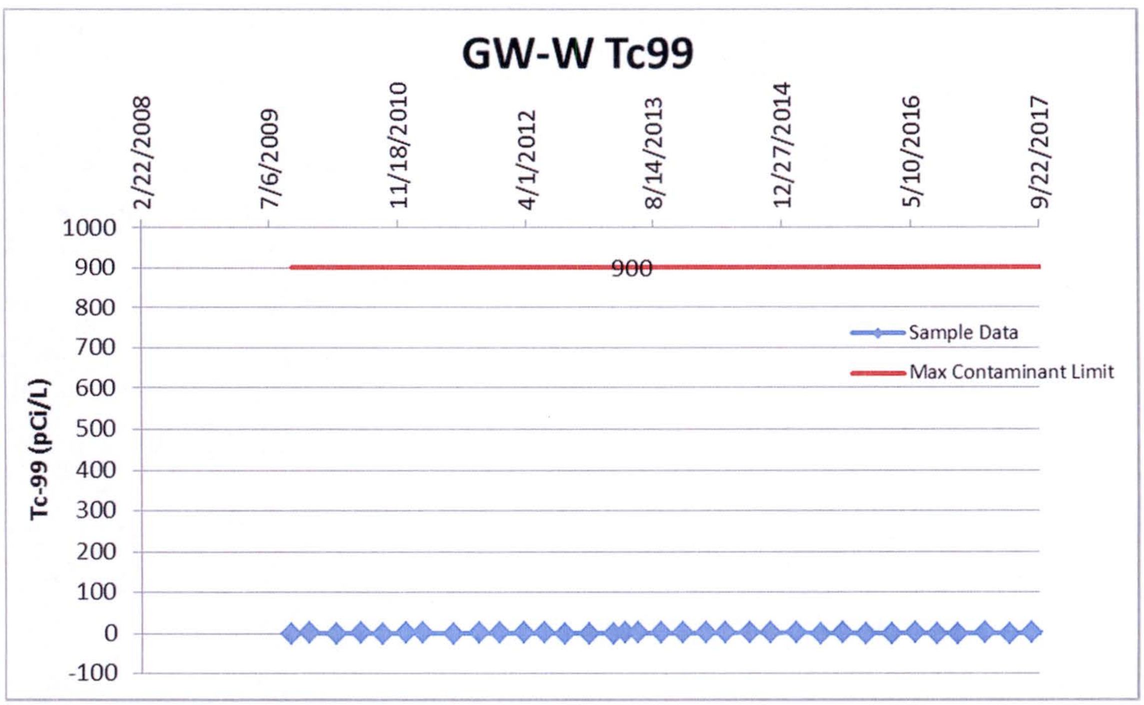

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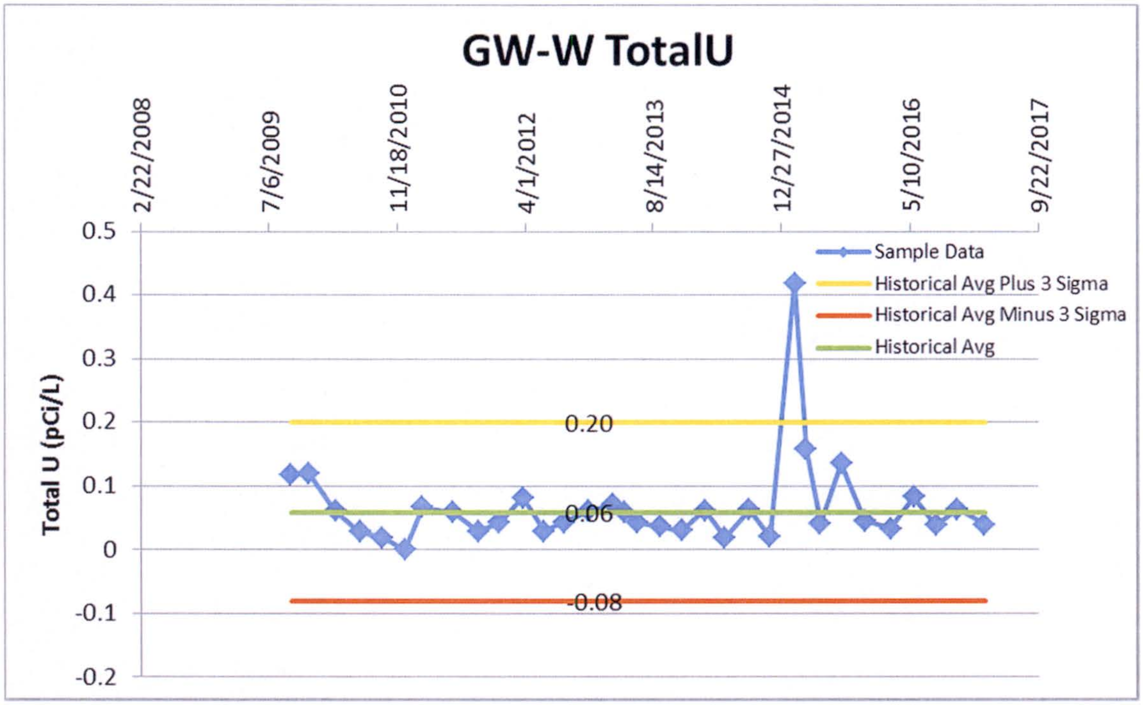

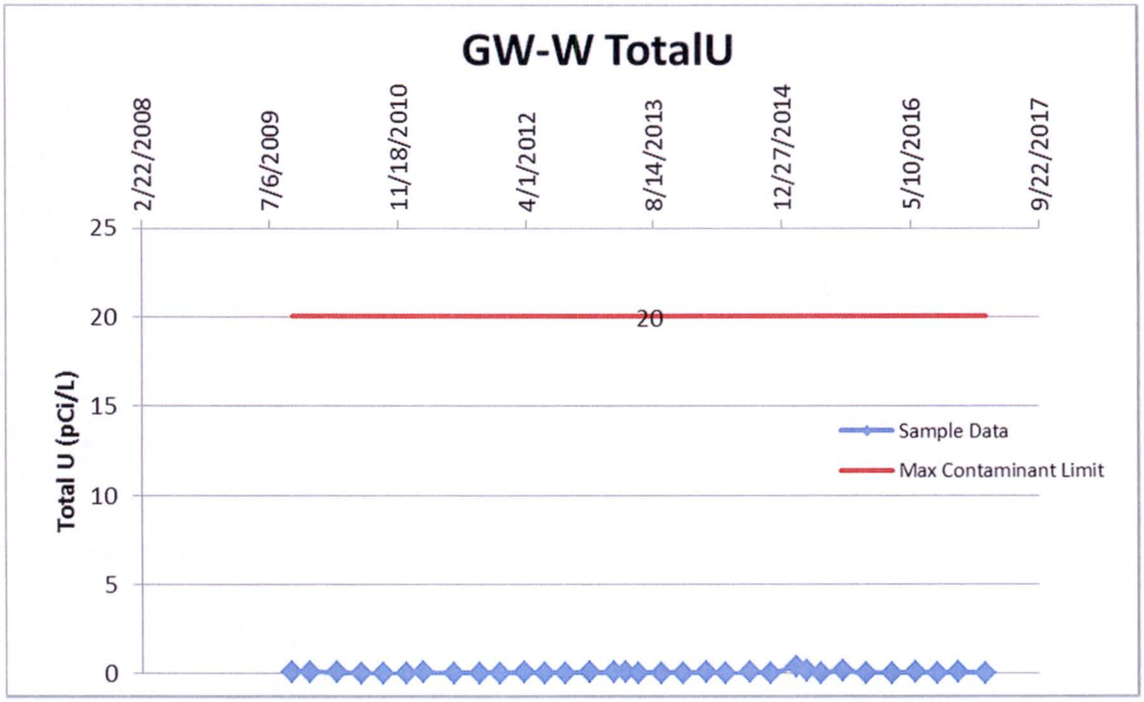

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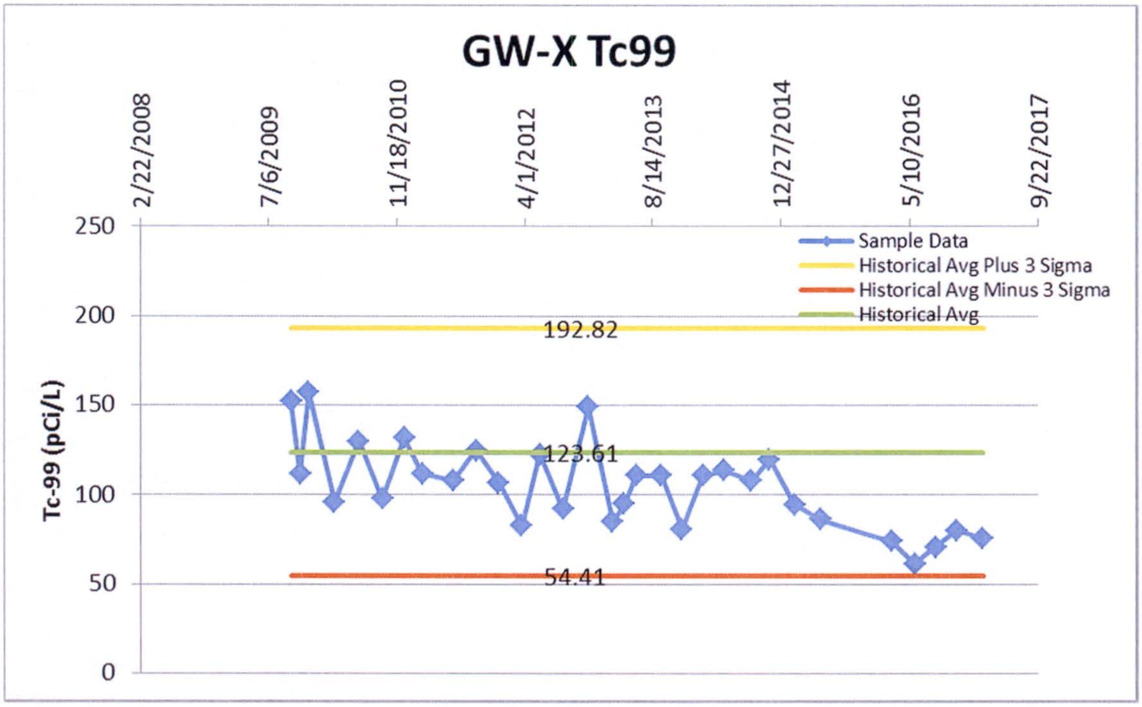

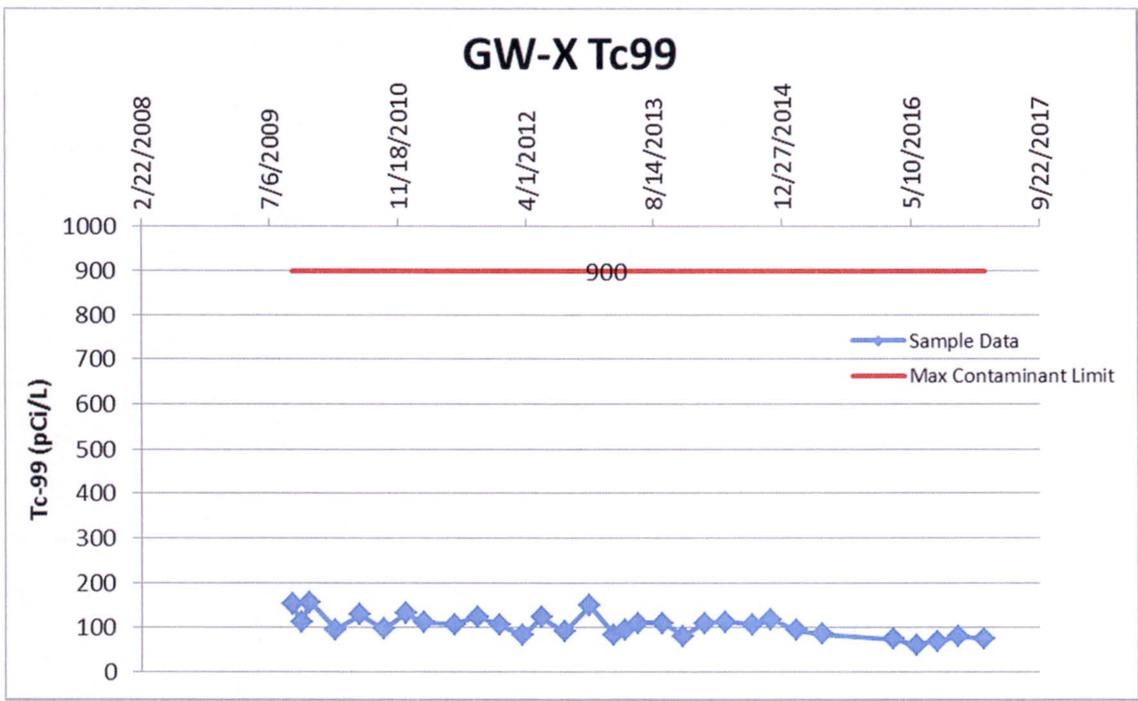

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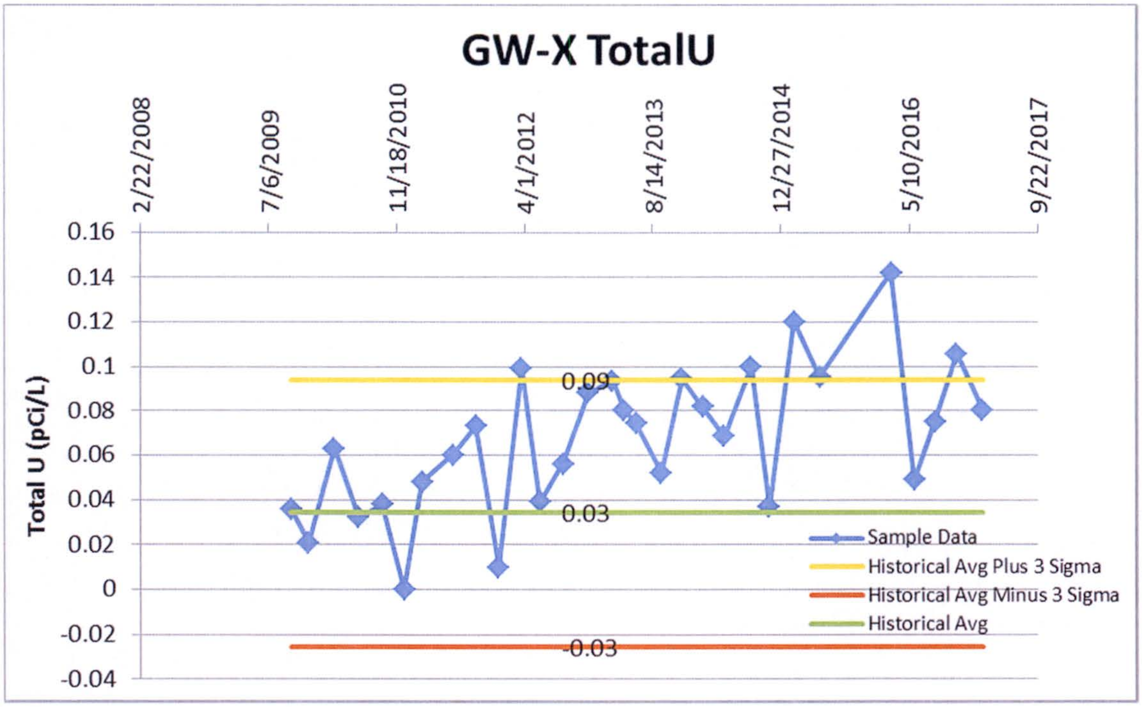

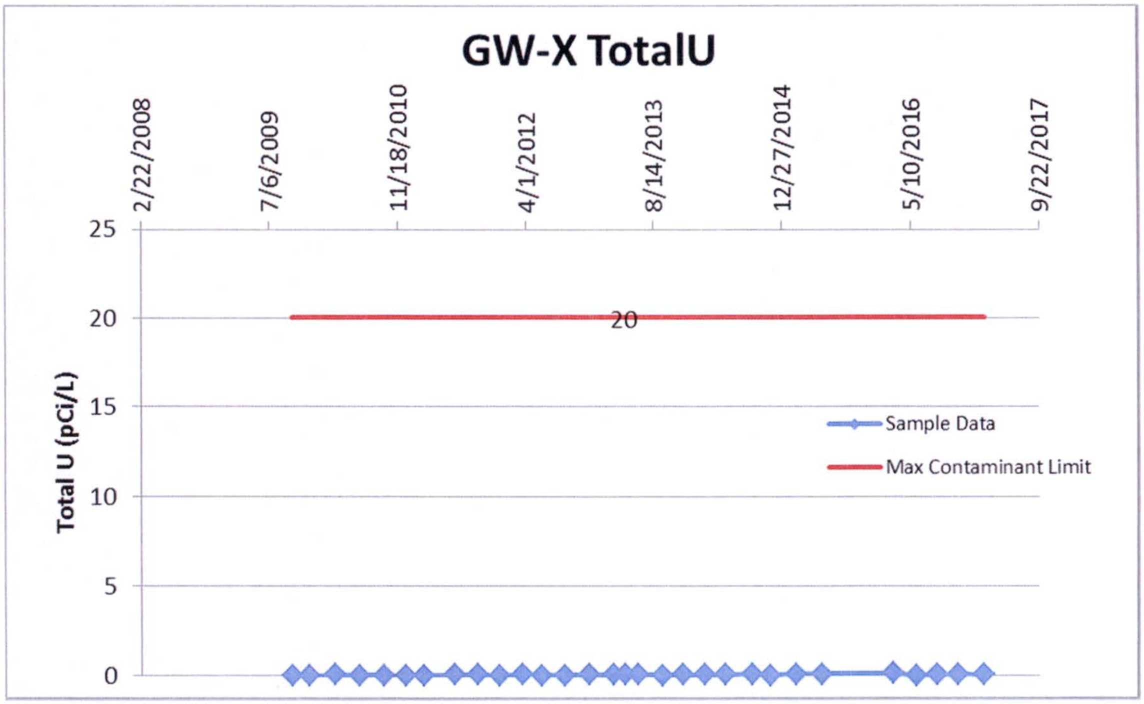

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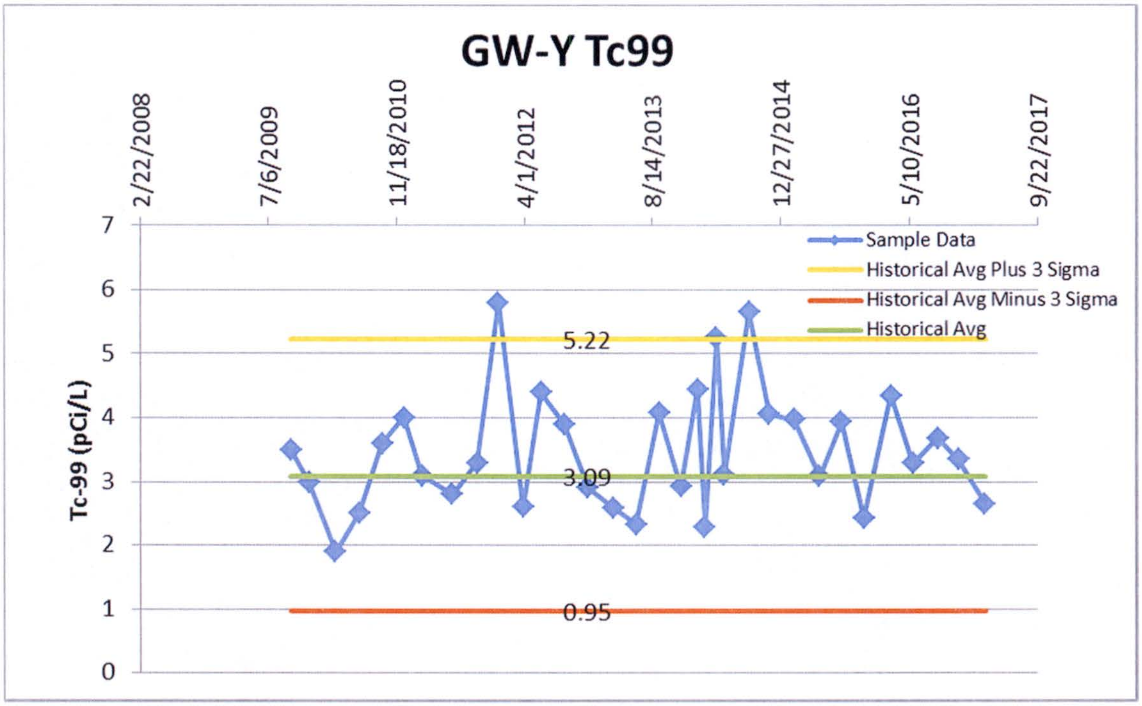

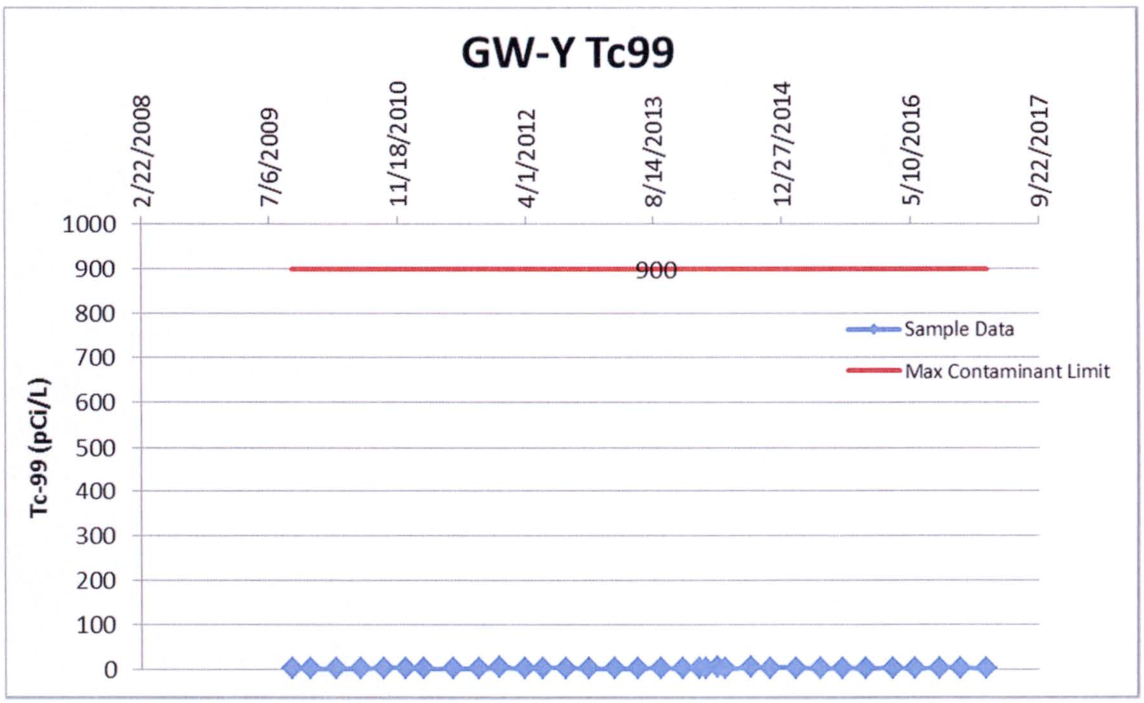

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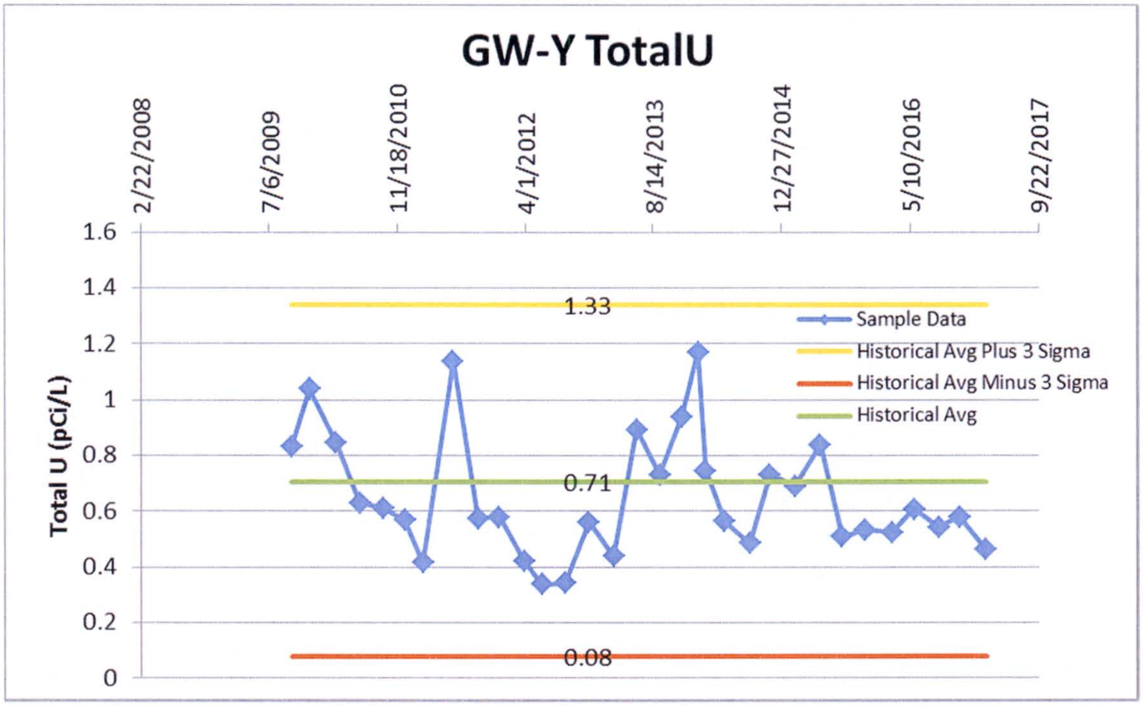

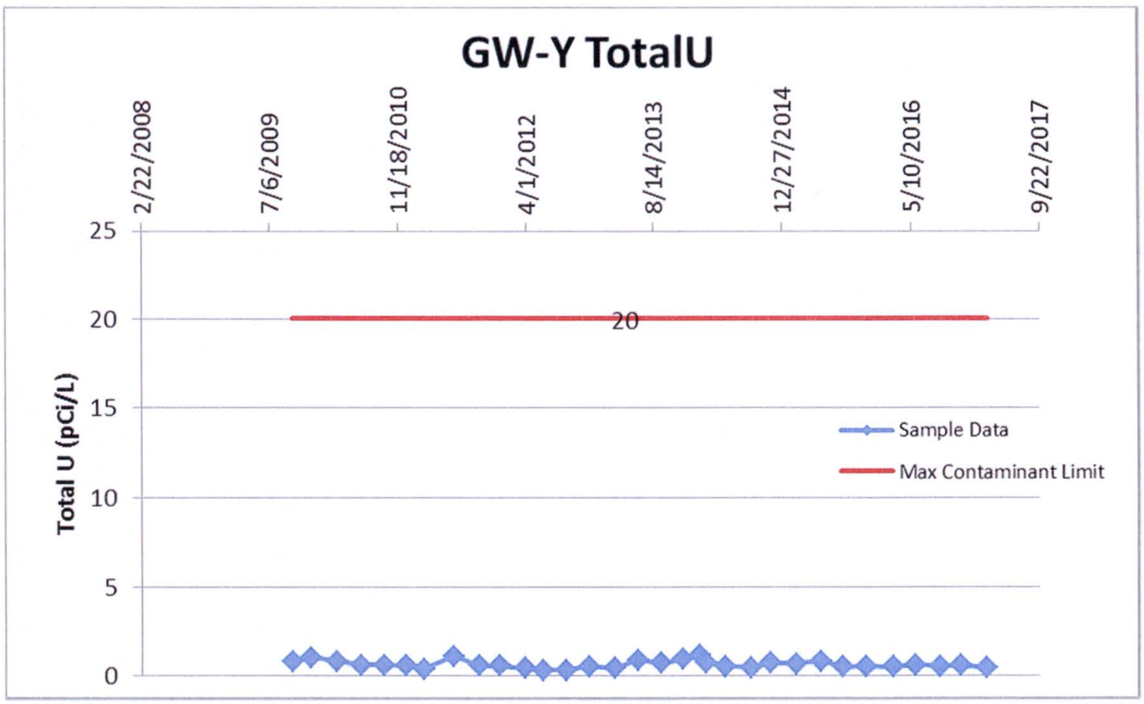

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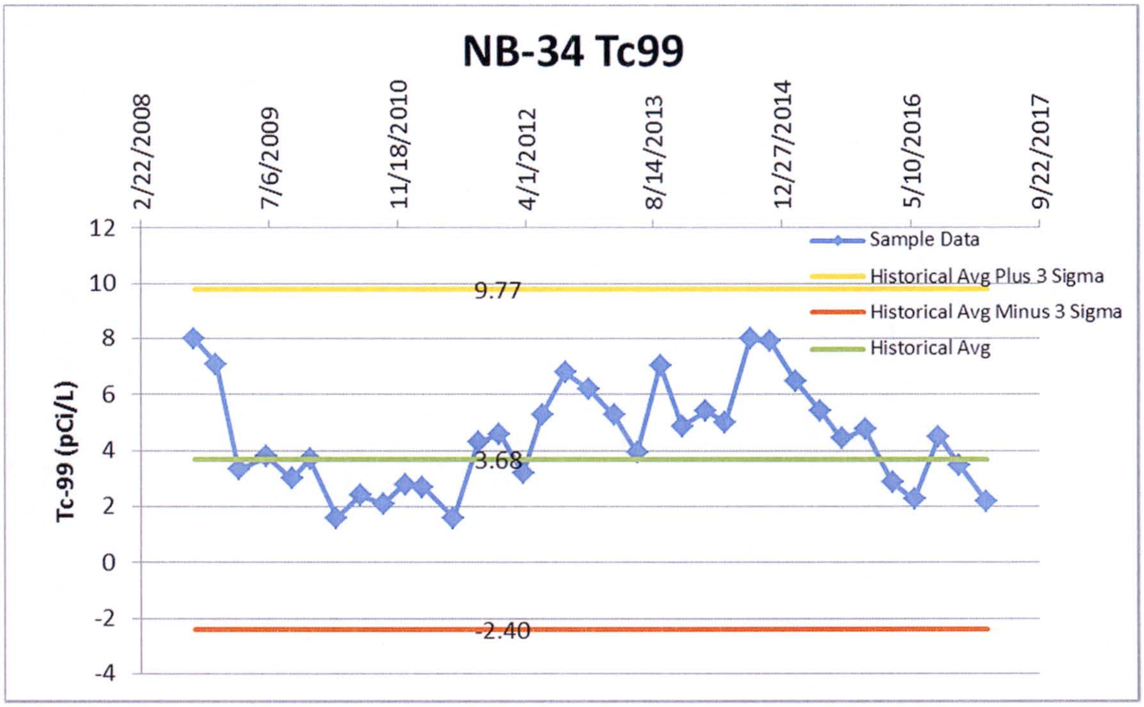

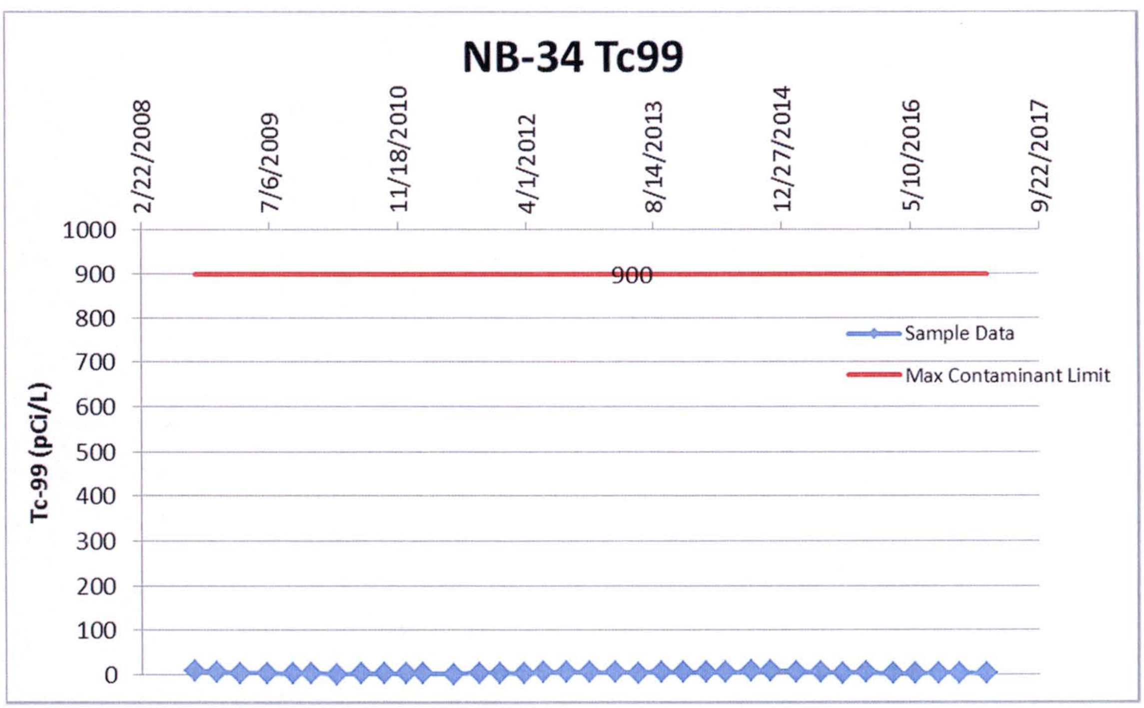

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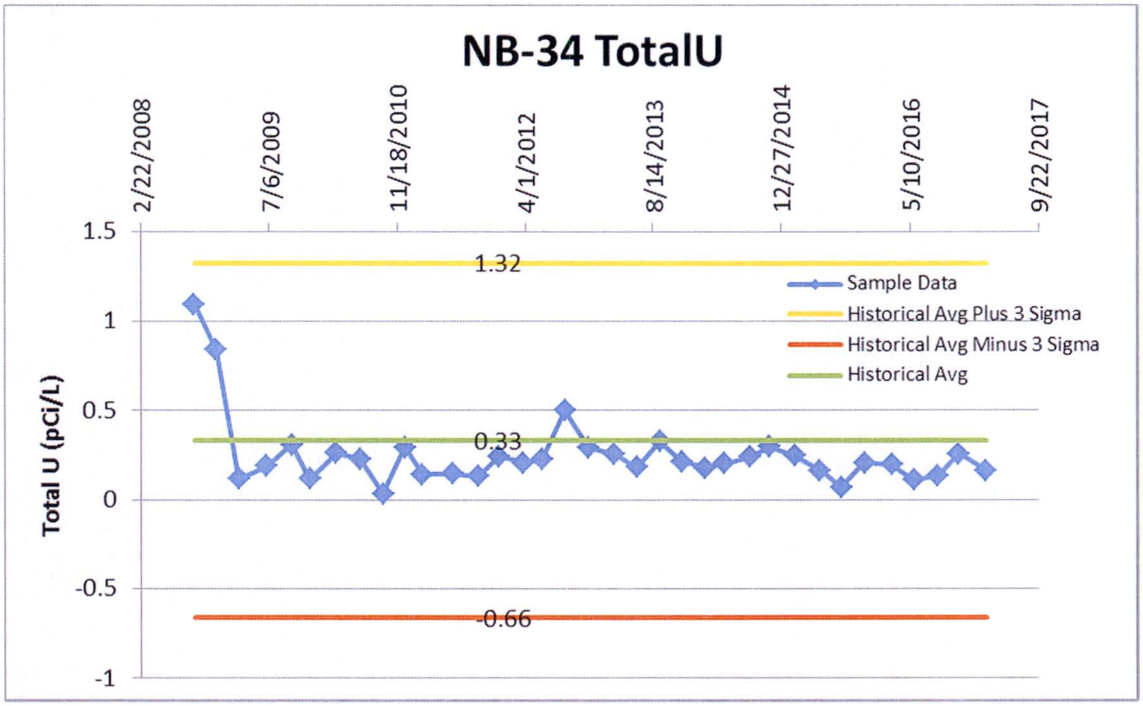

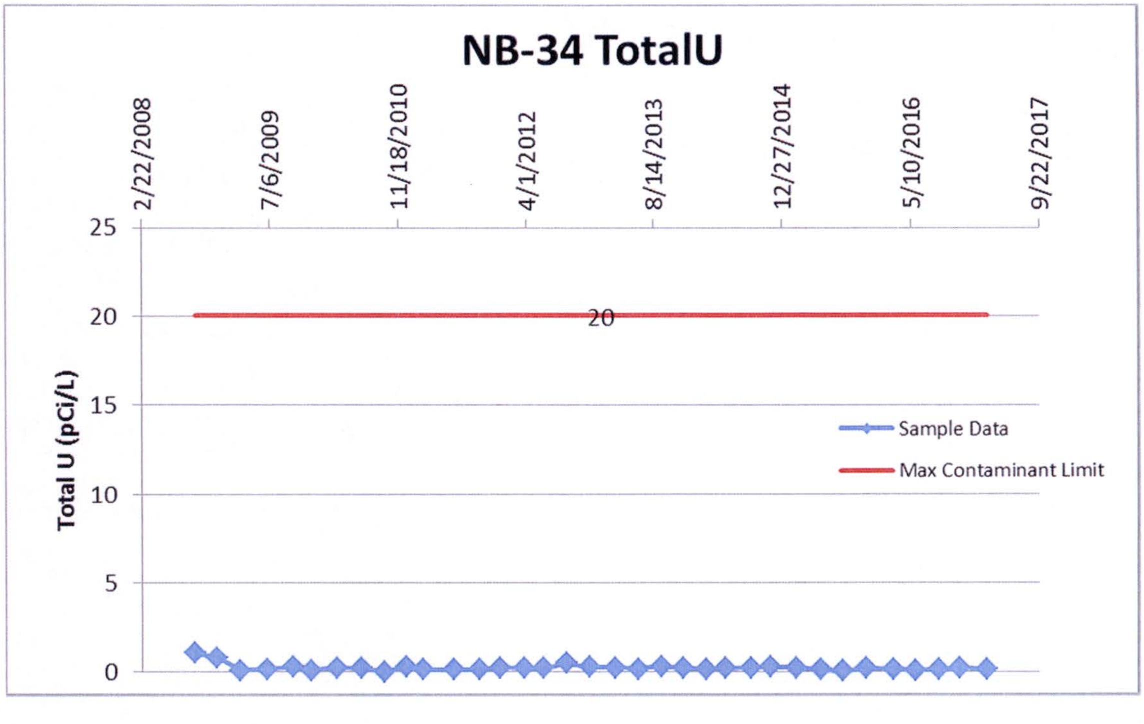

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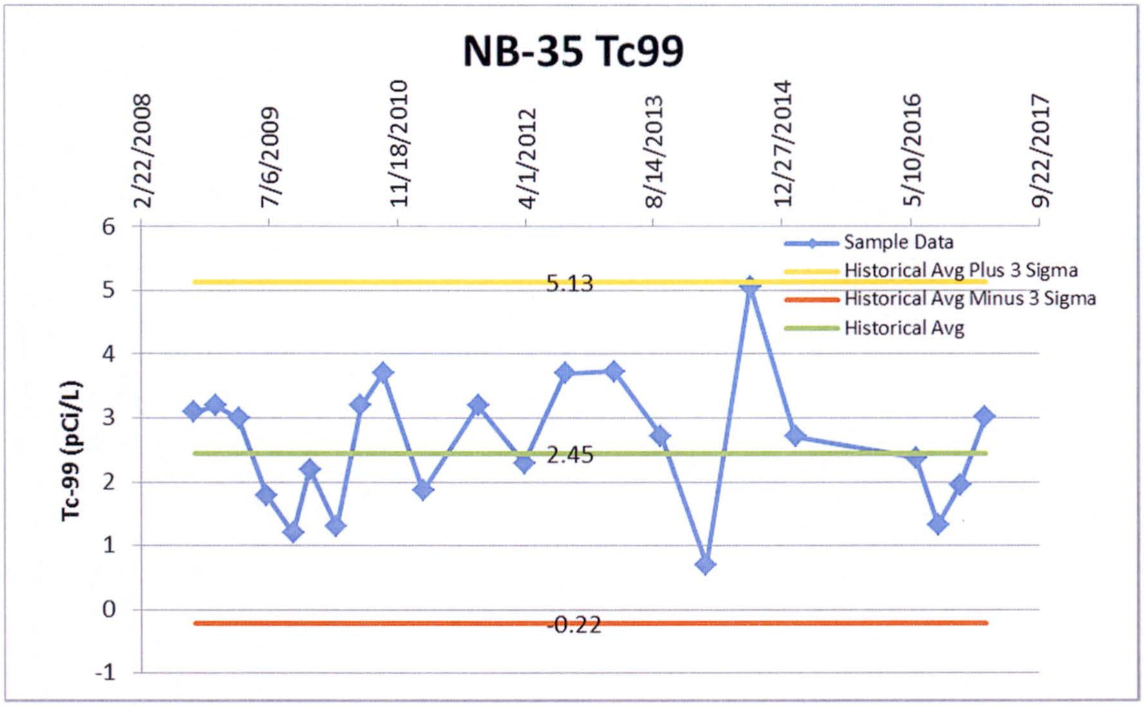

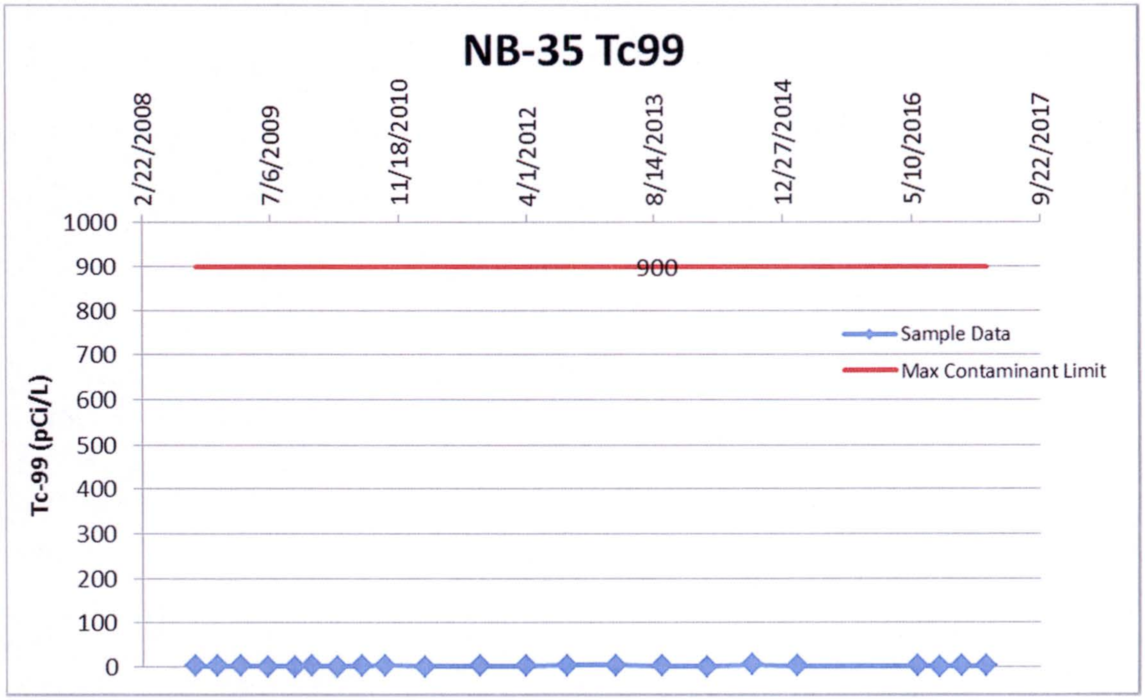

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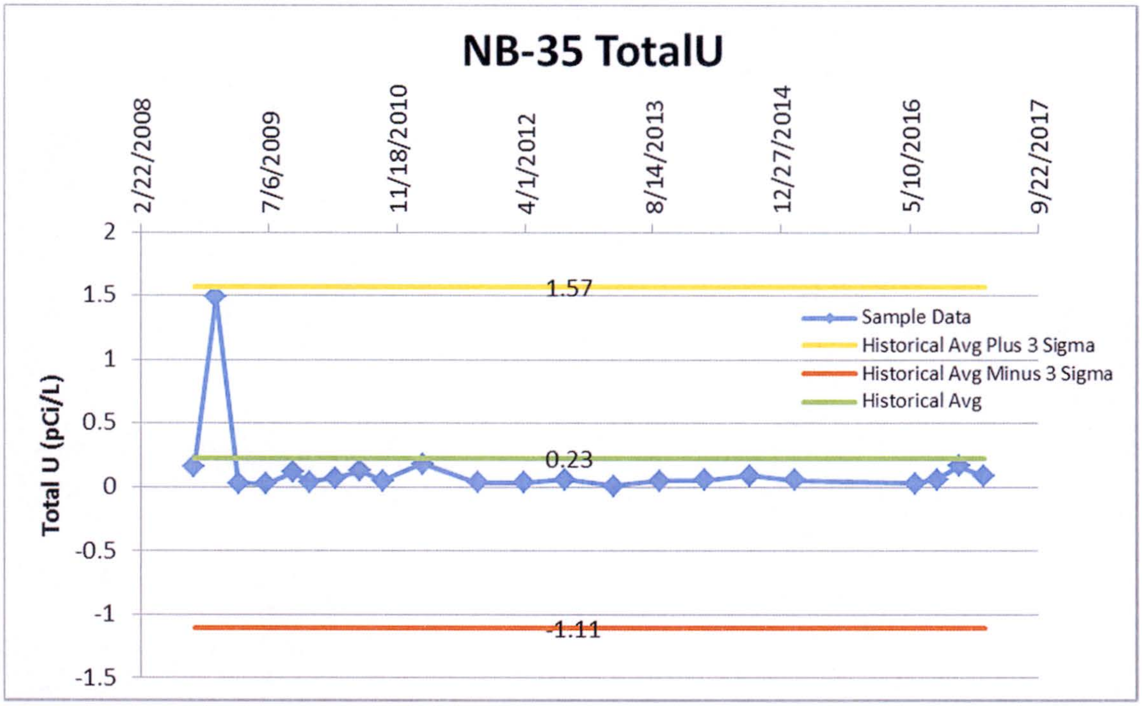

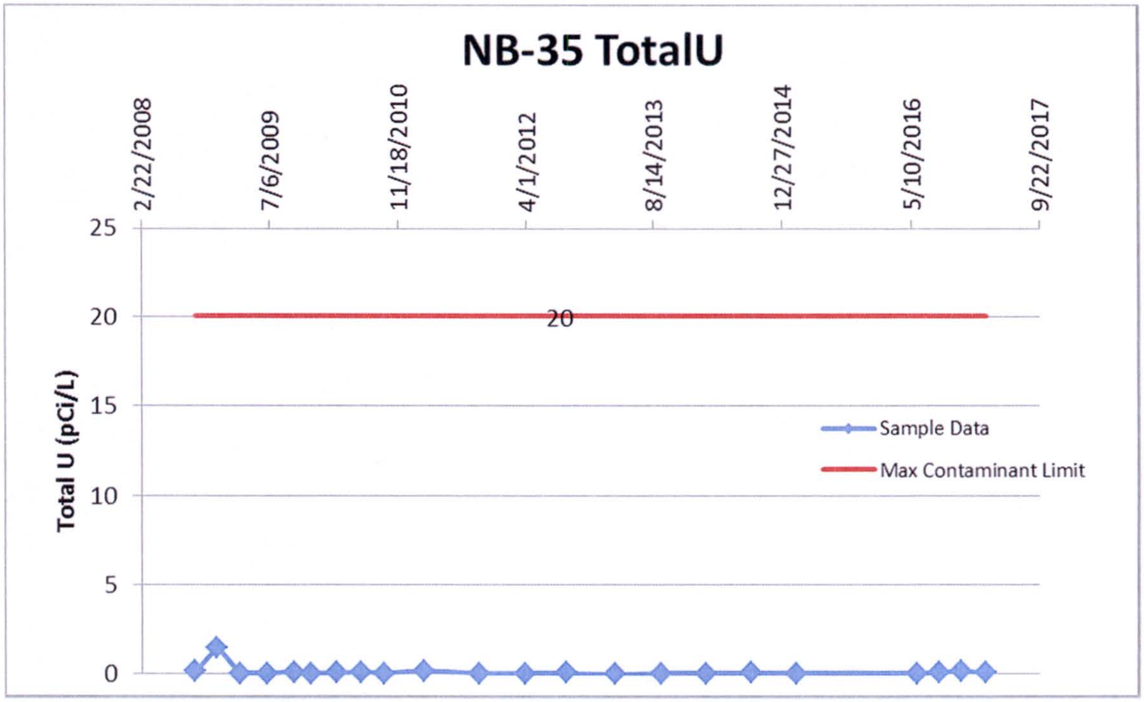

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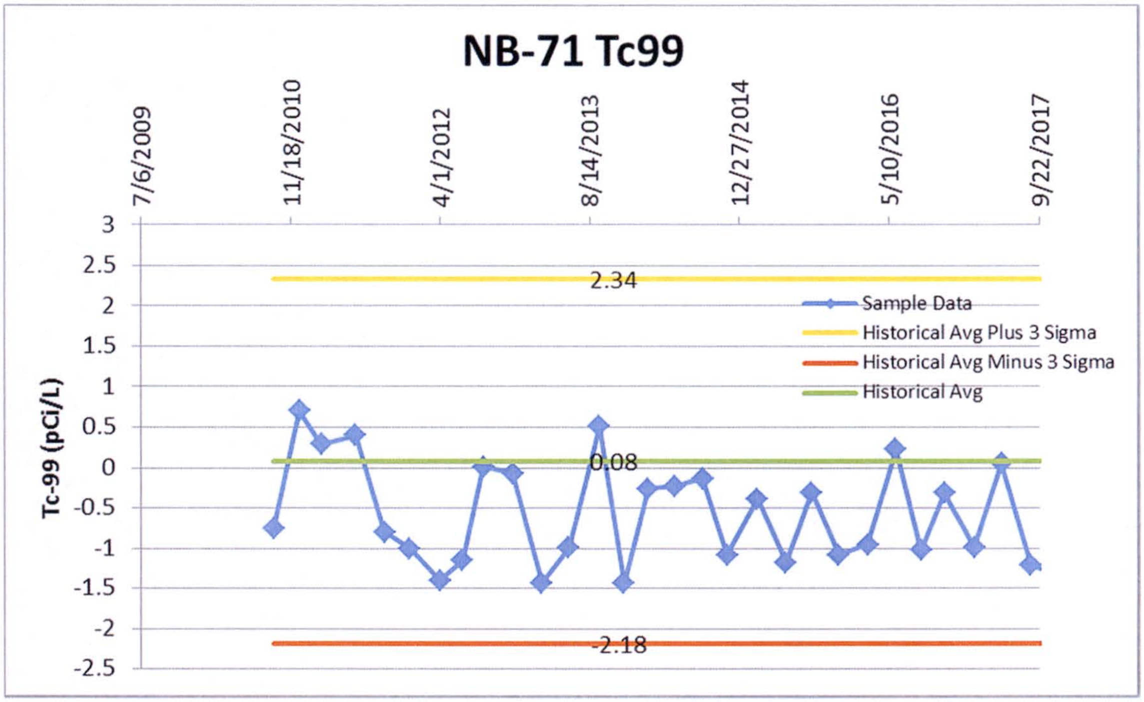

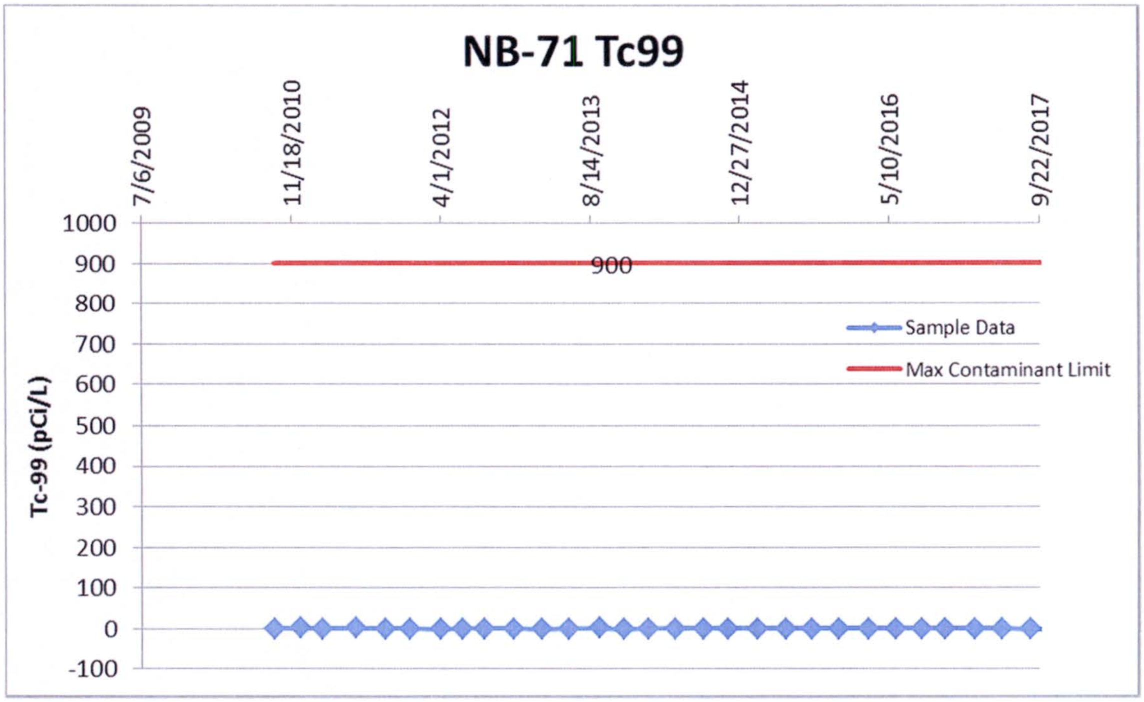

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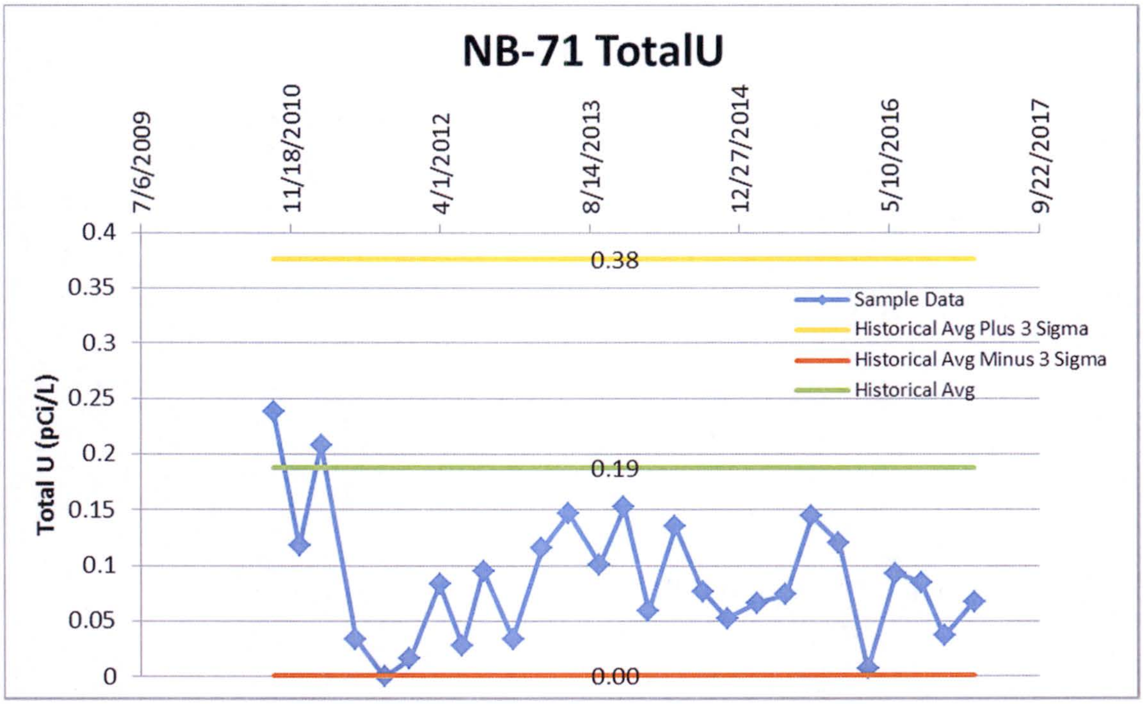

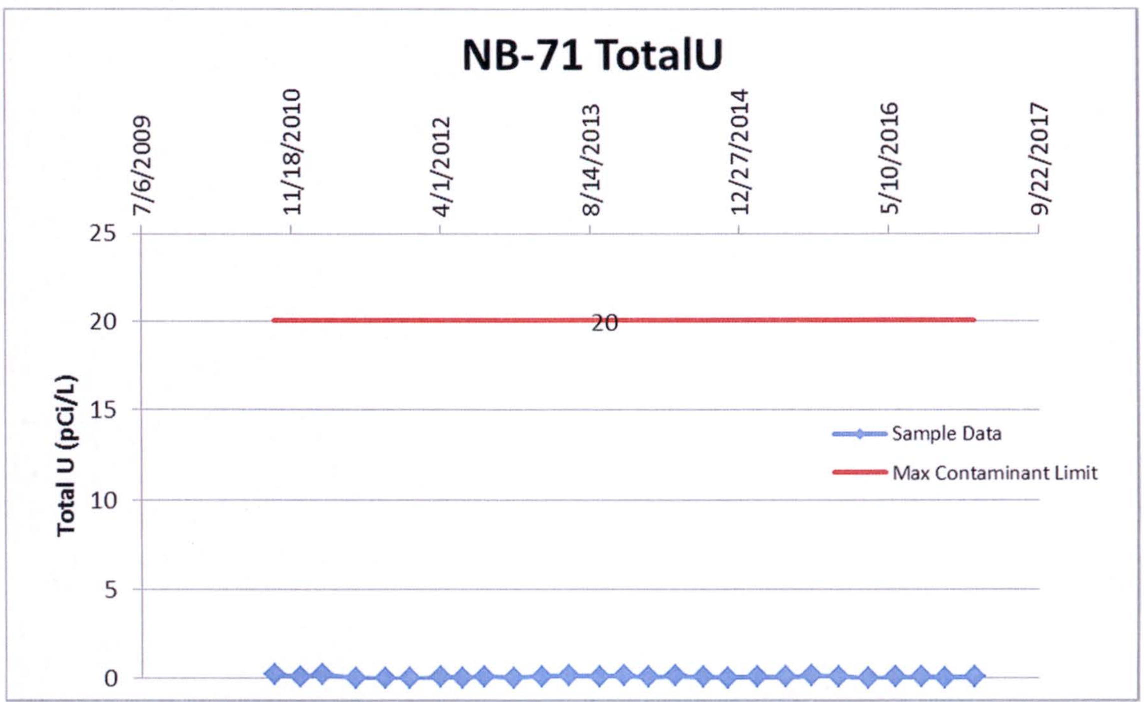

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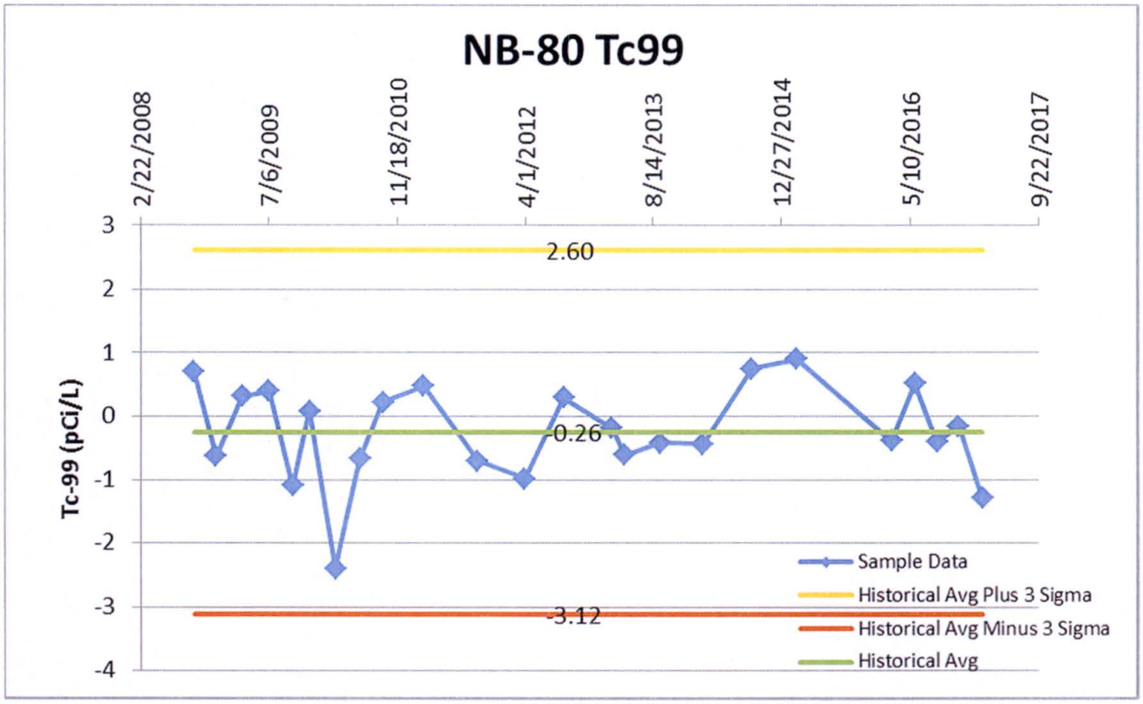

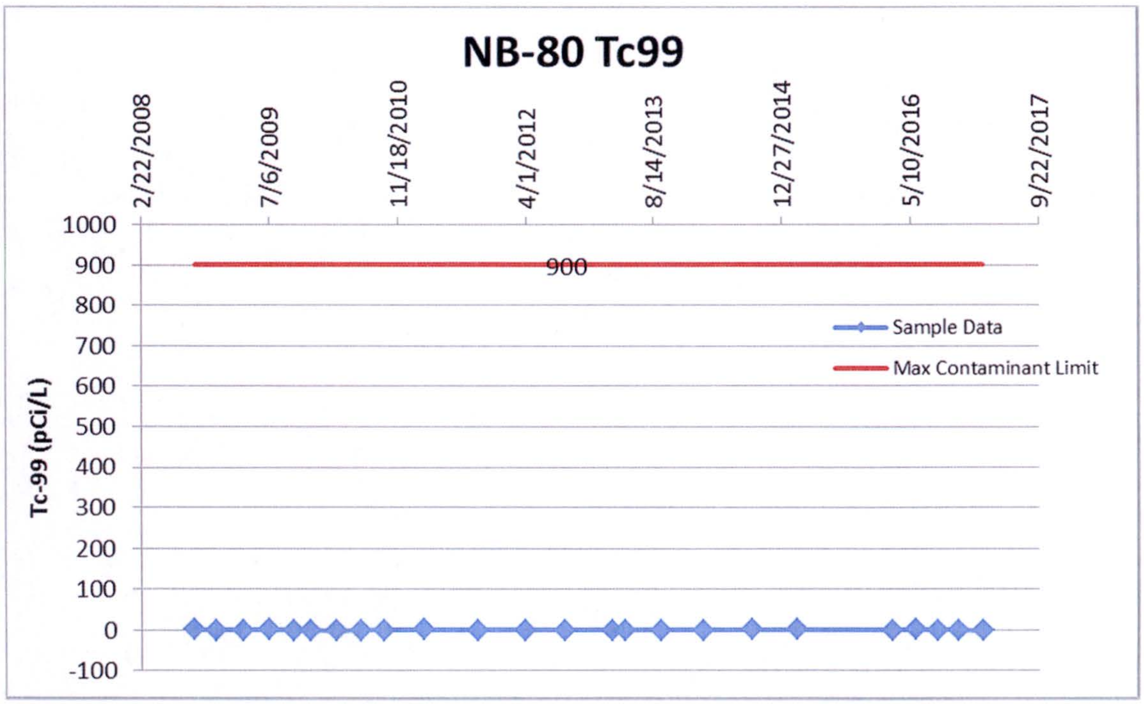

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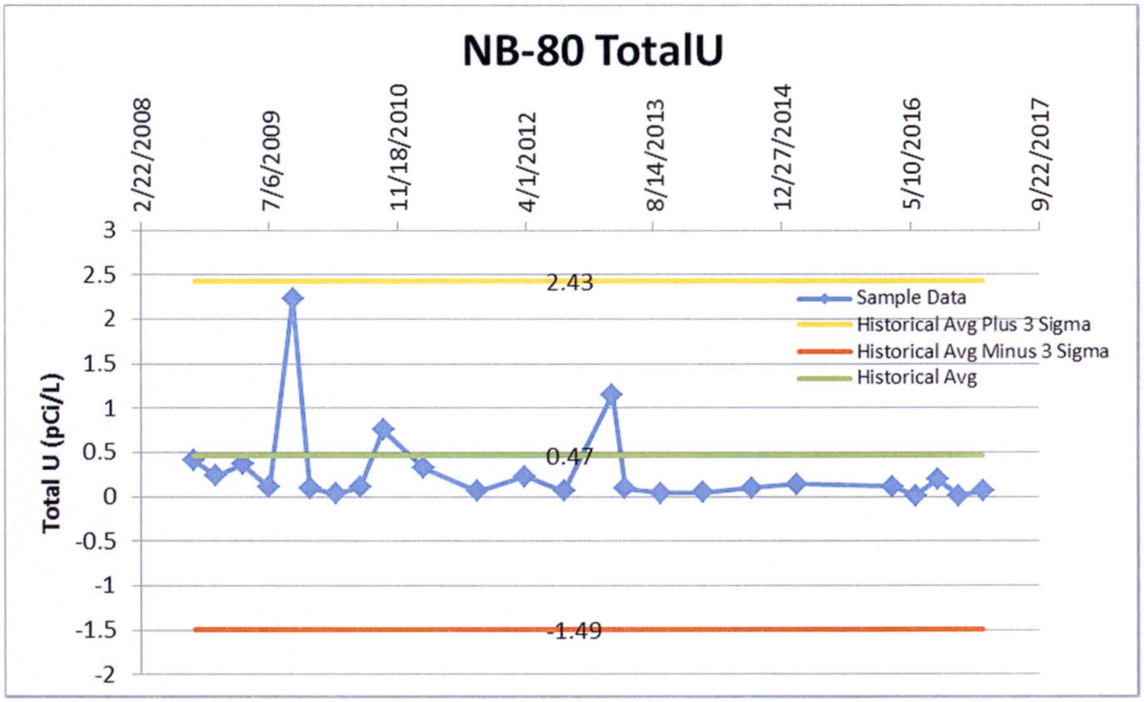

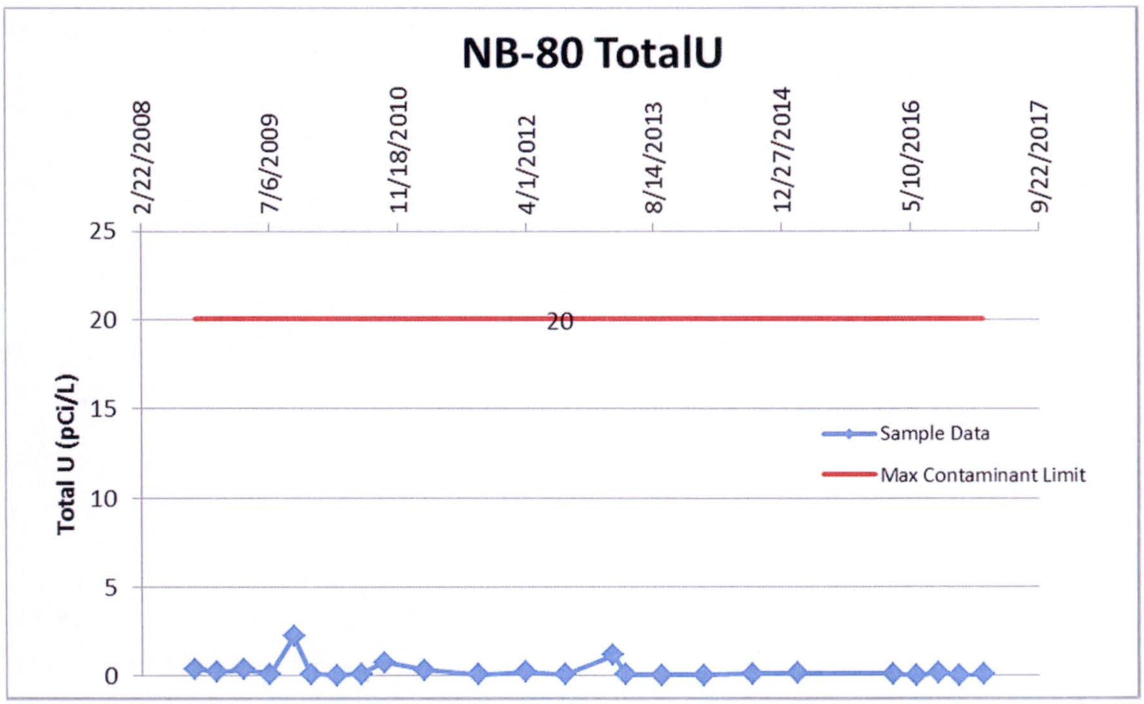

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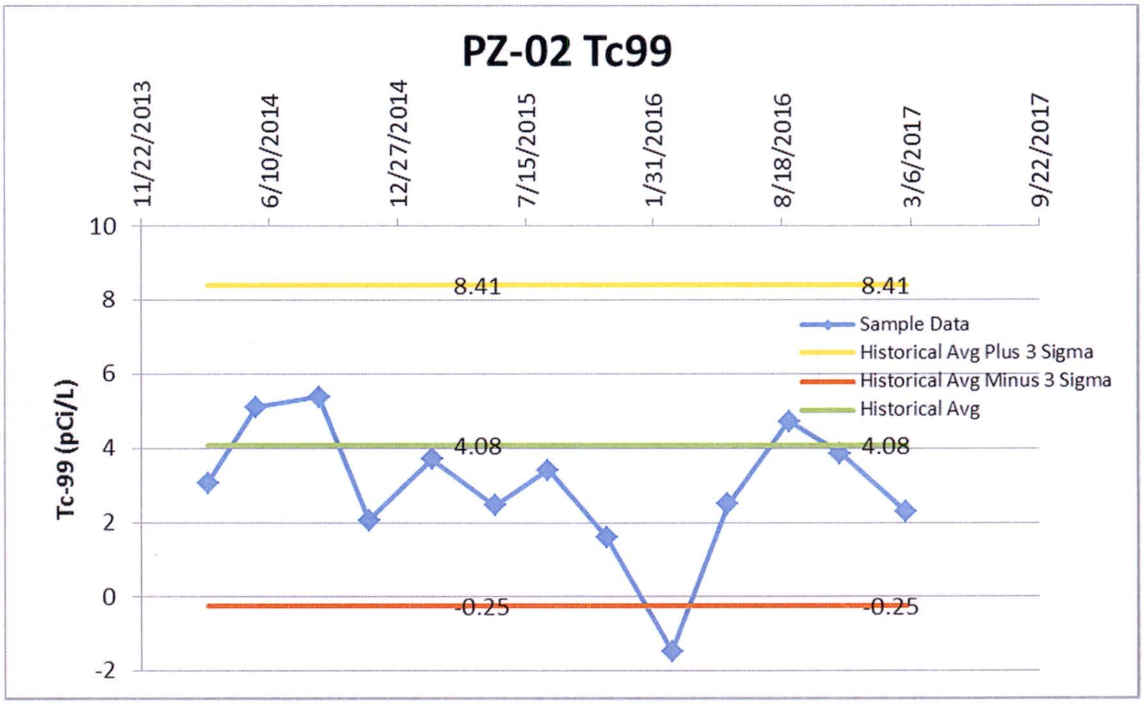

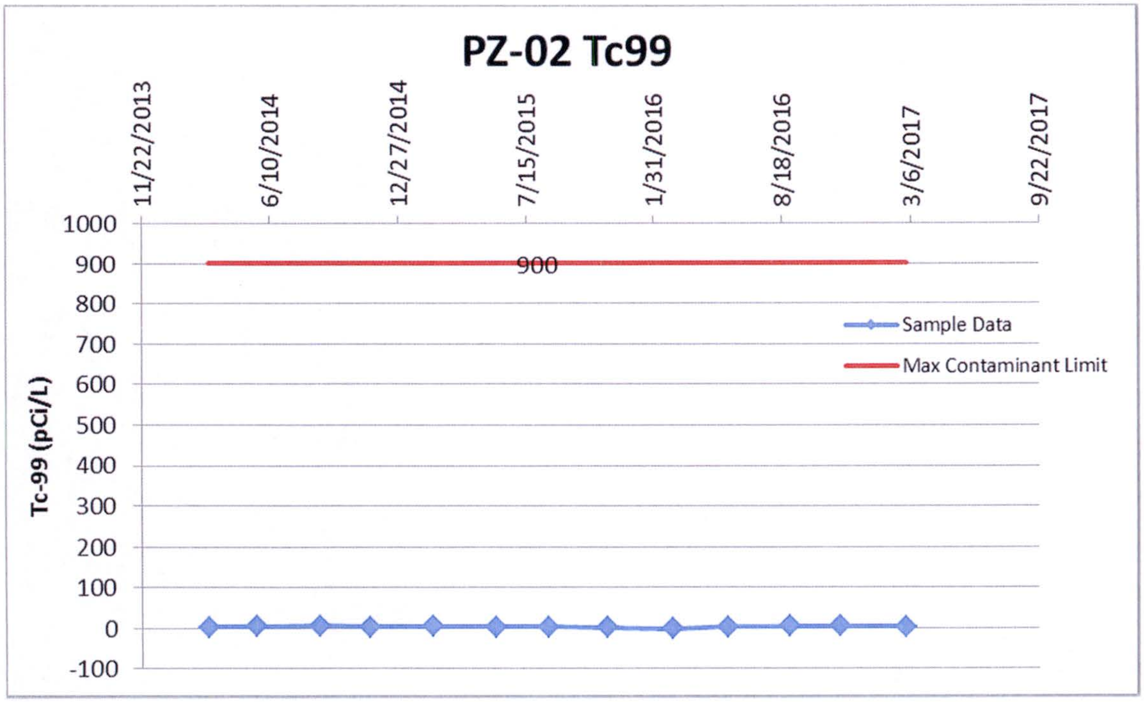

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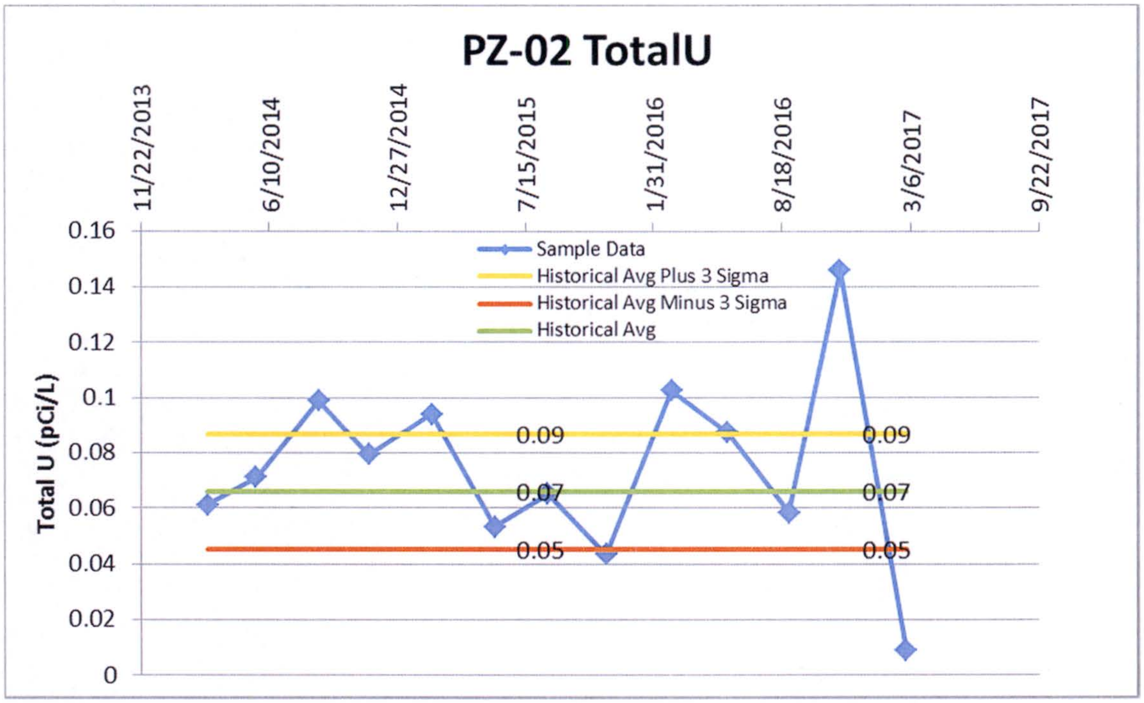
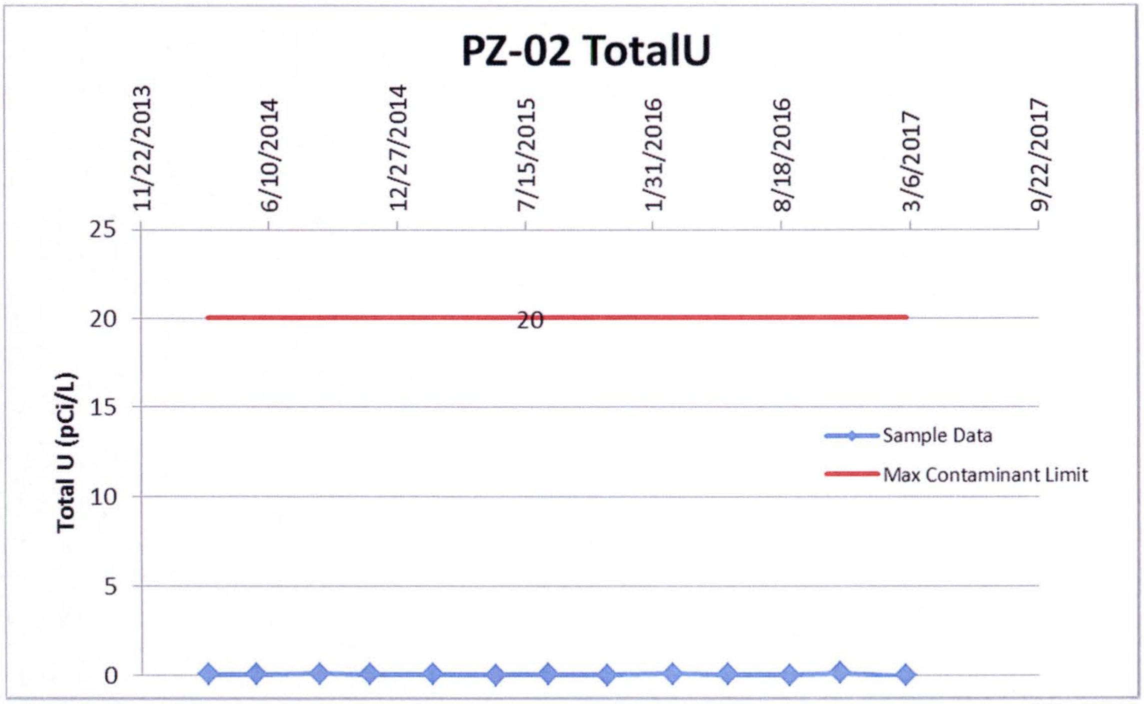


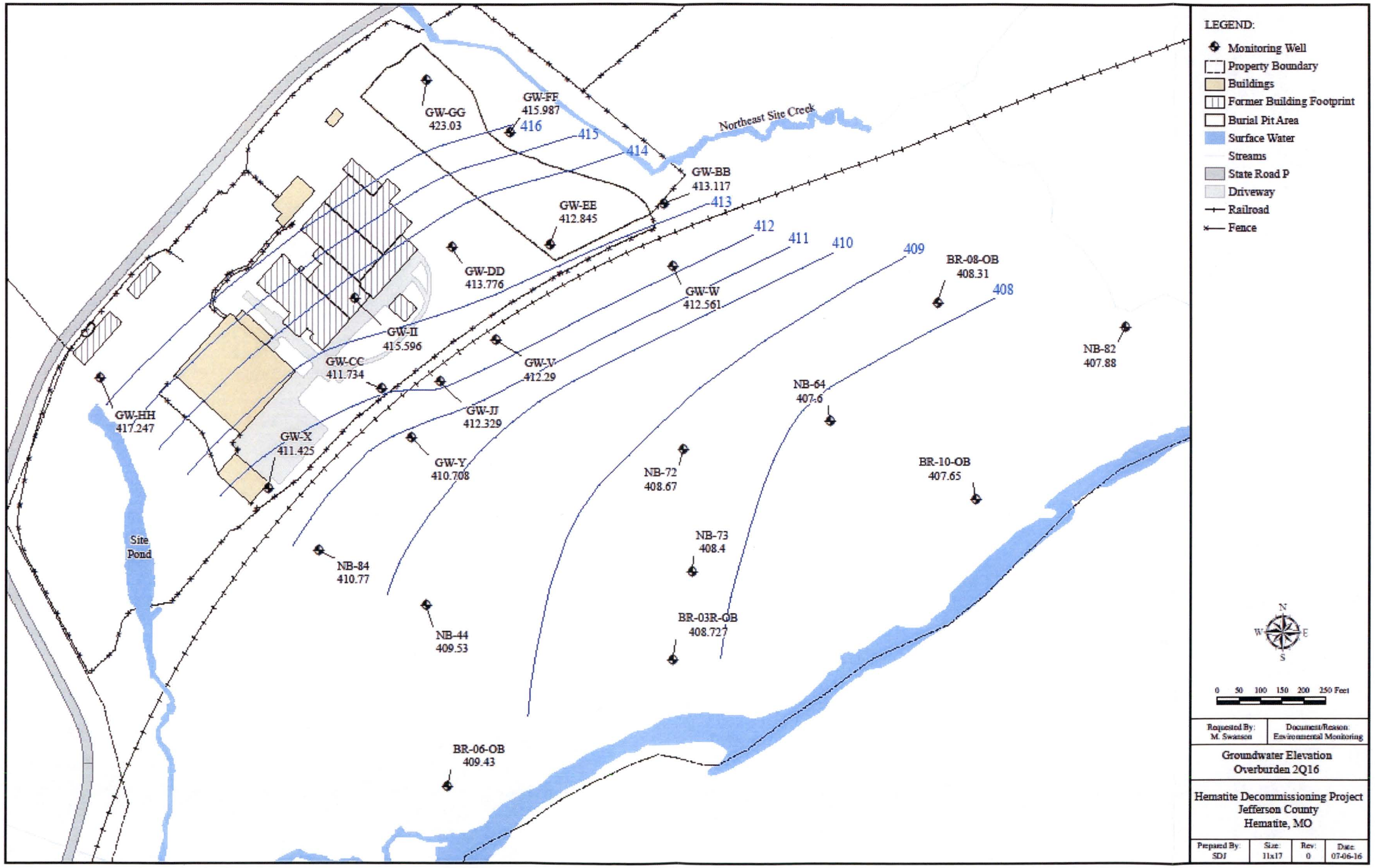


Attachment 3

Quarterly Groundwater Elevation Contour Maps

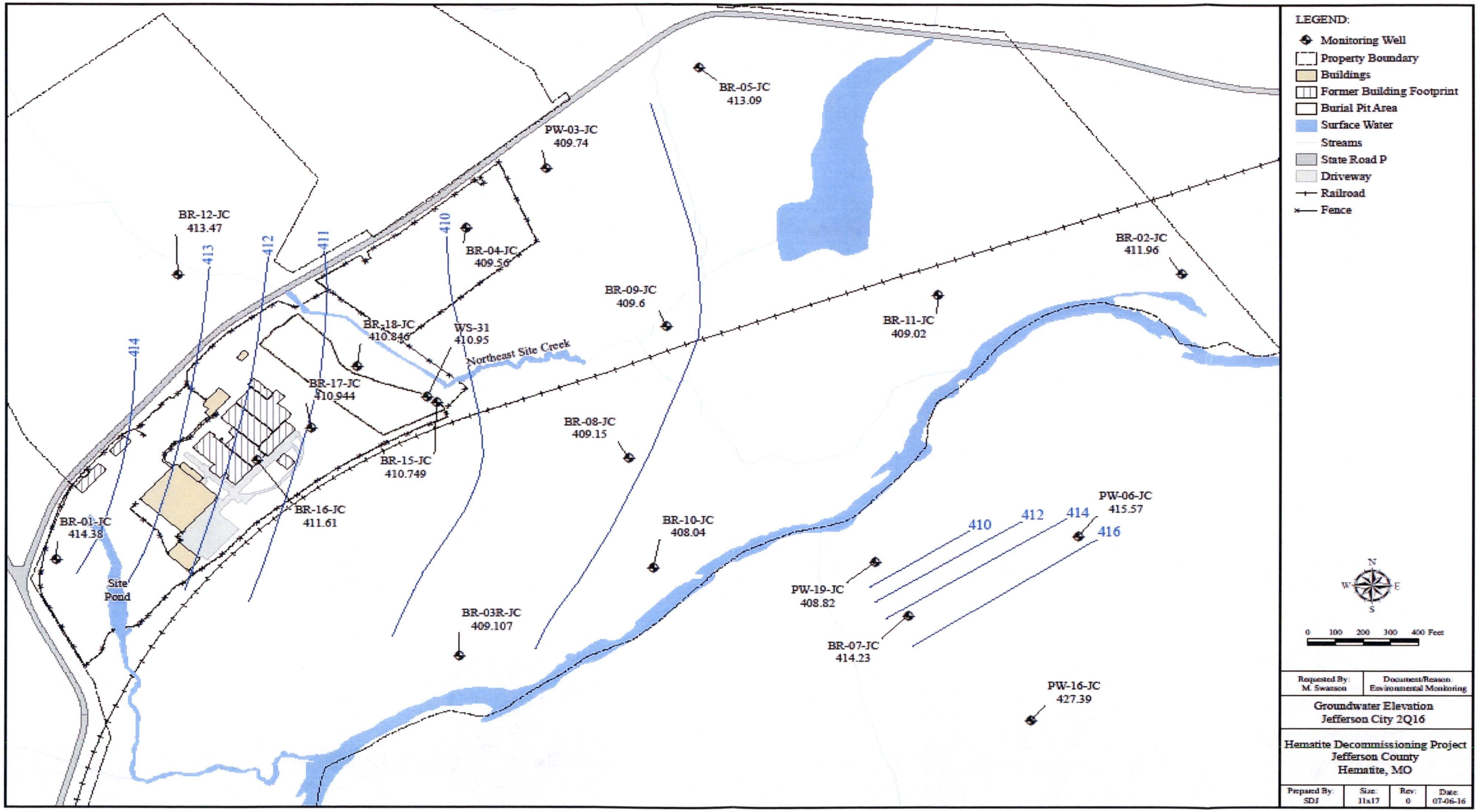
1st Quarter Post-remediation Groundwater Elevation Contour Map

SAND/GRAVEL HSU



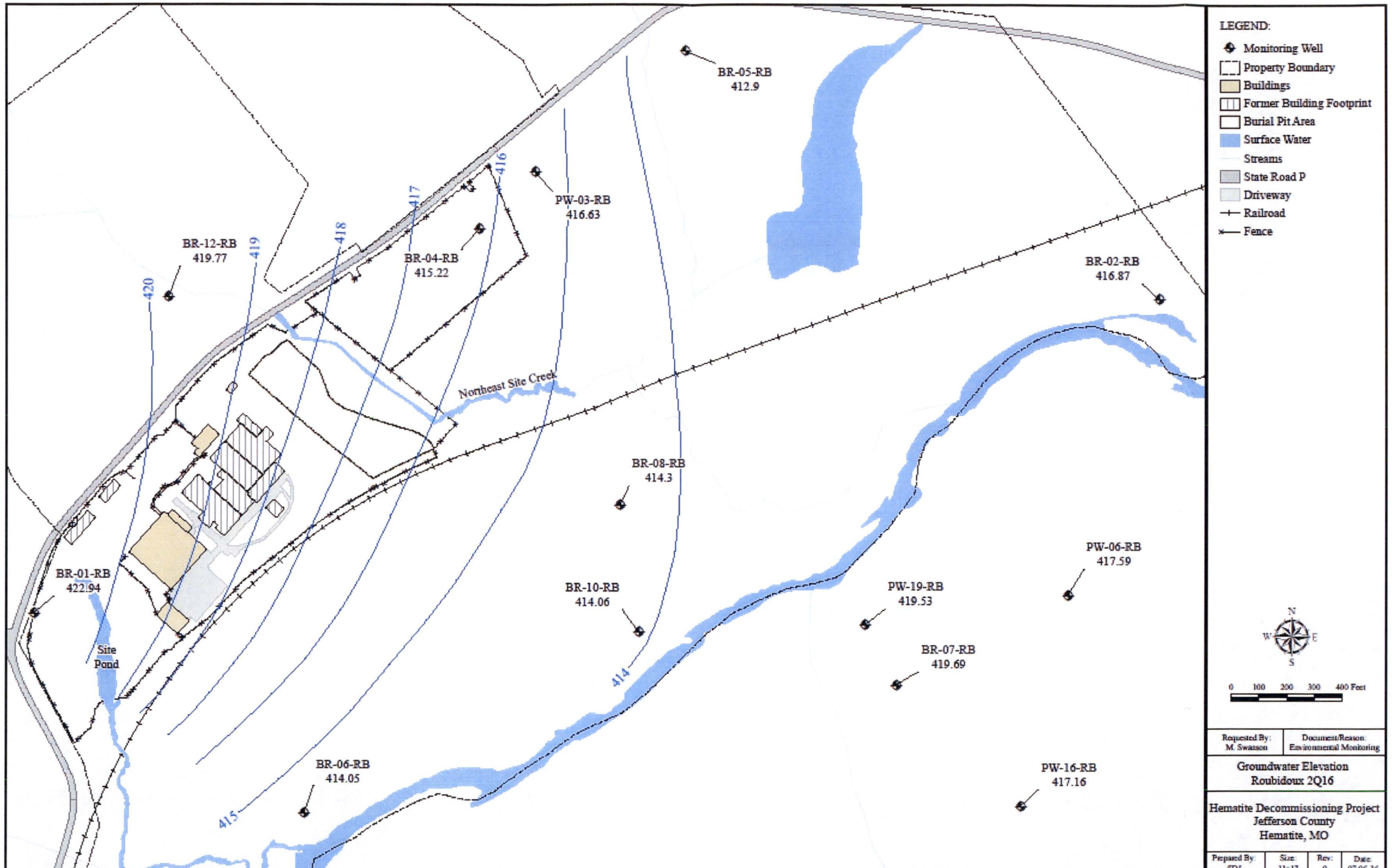
1st Quarter Post-remediation Groundwater Elevation Contour Map

JEFFERSON CITY – COTTER HSU



1st Quarter Post-remediation Groundwater Elevation Contour Map

ROUBIDOUX HSU



2nd Quarter Post-remediation Groundwater Elevation Contour Map

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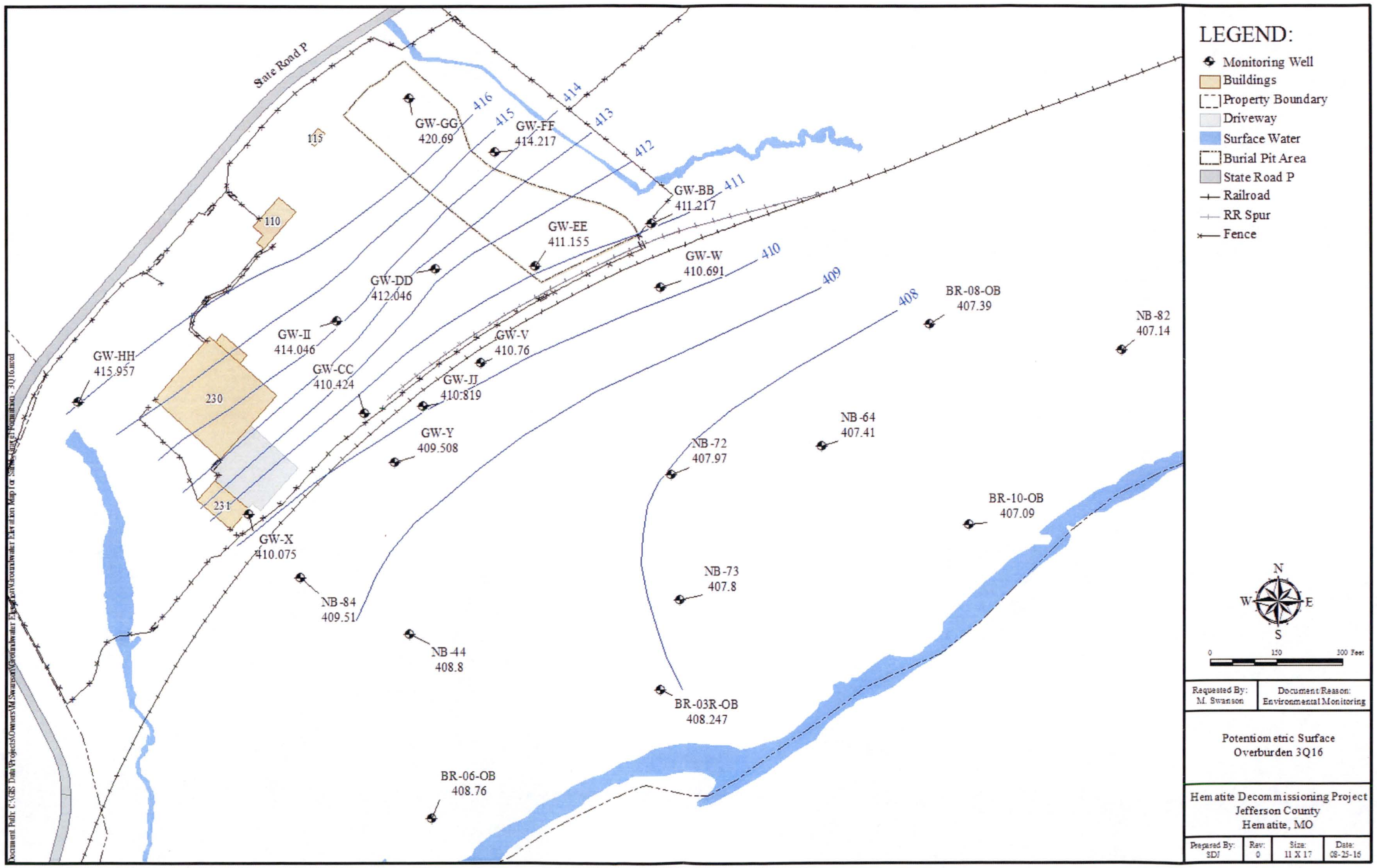
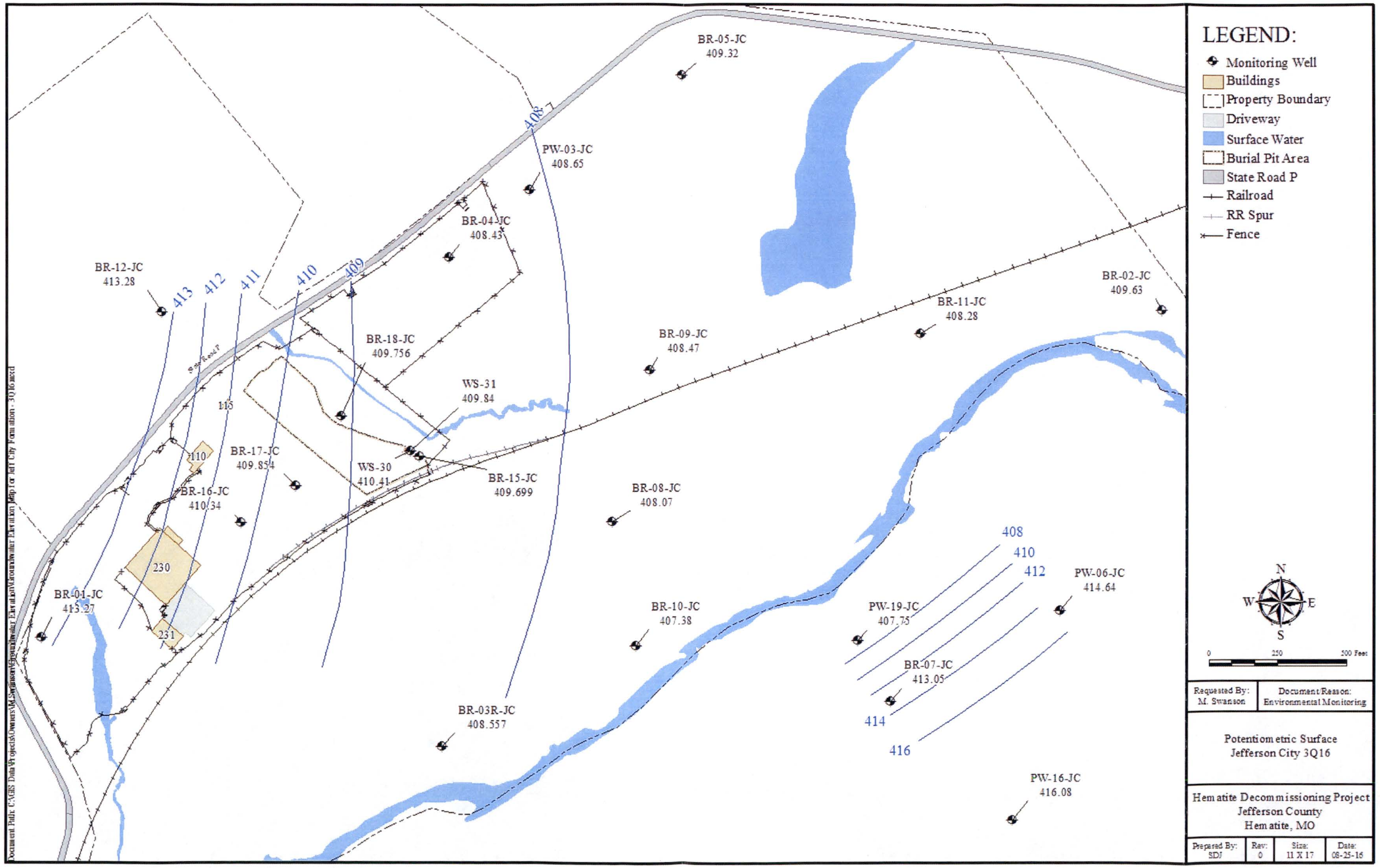


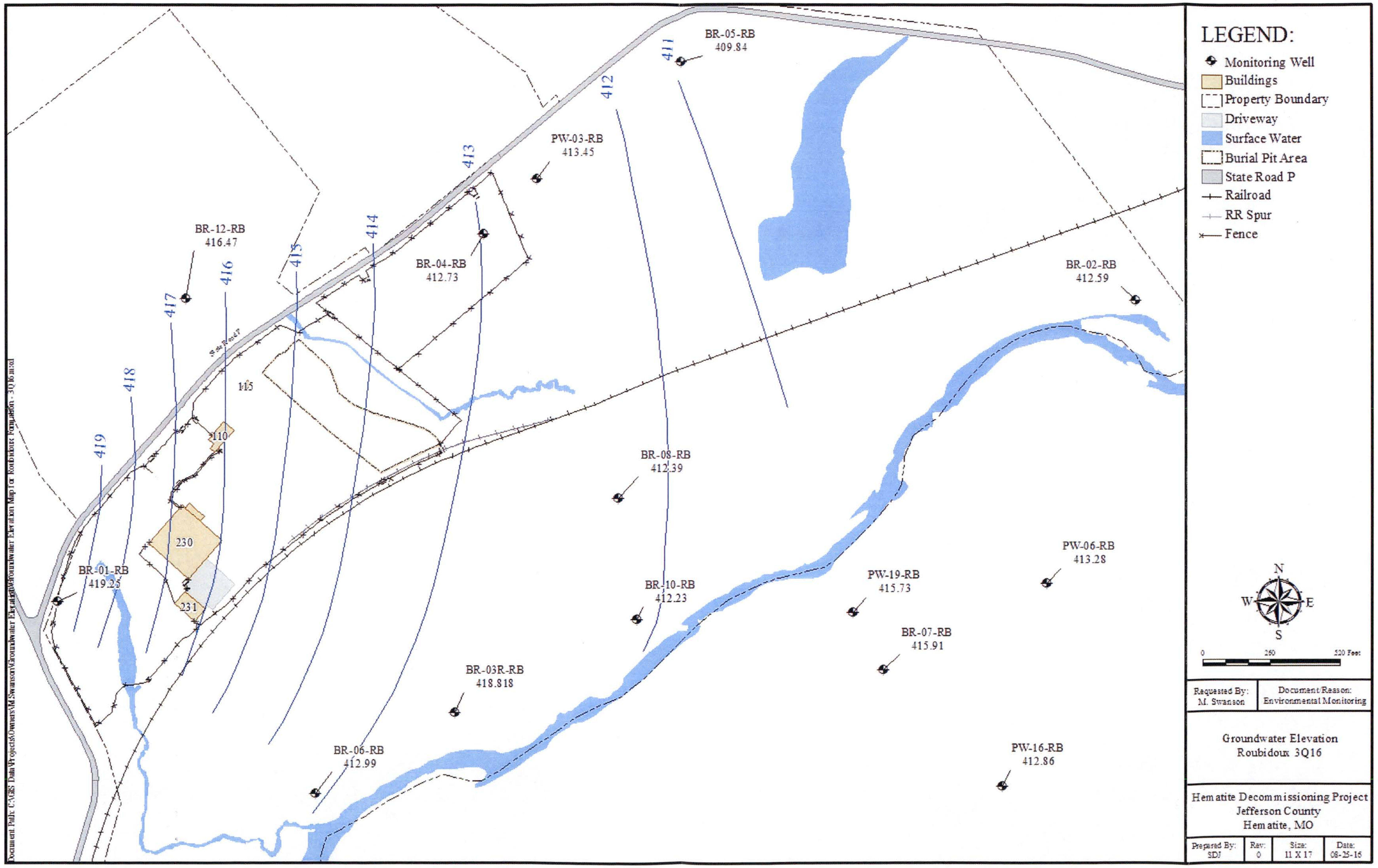
2nd Quarter Post-remediation Groundwater Elevation Contour Map

JEFFERSON CITY – COTTER HSU



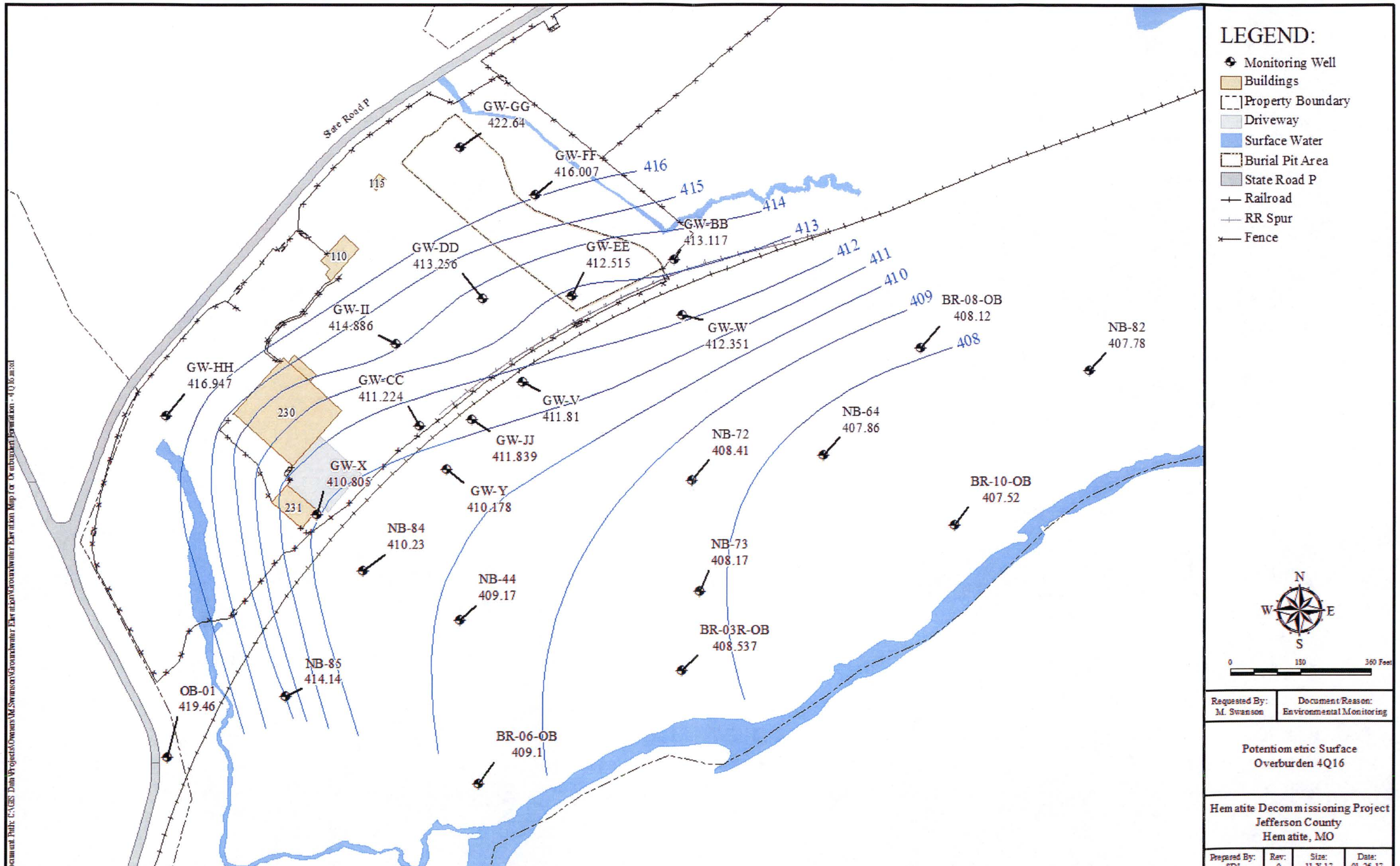
2nd Quarter Post-remediation Groundwater Elevation Contour Map

ROUBIDOUX HSU



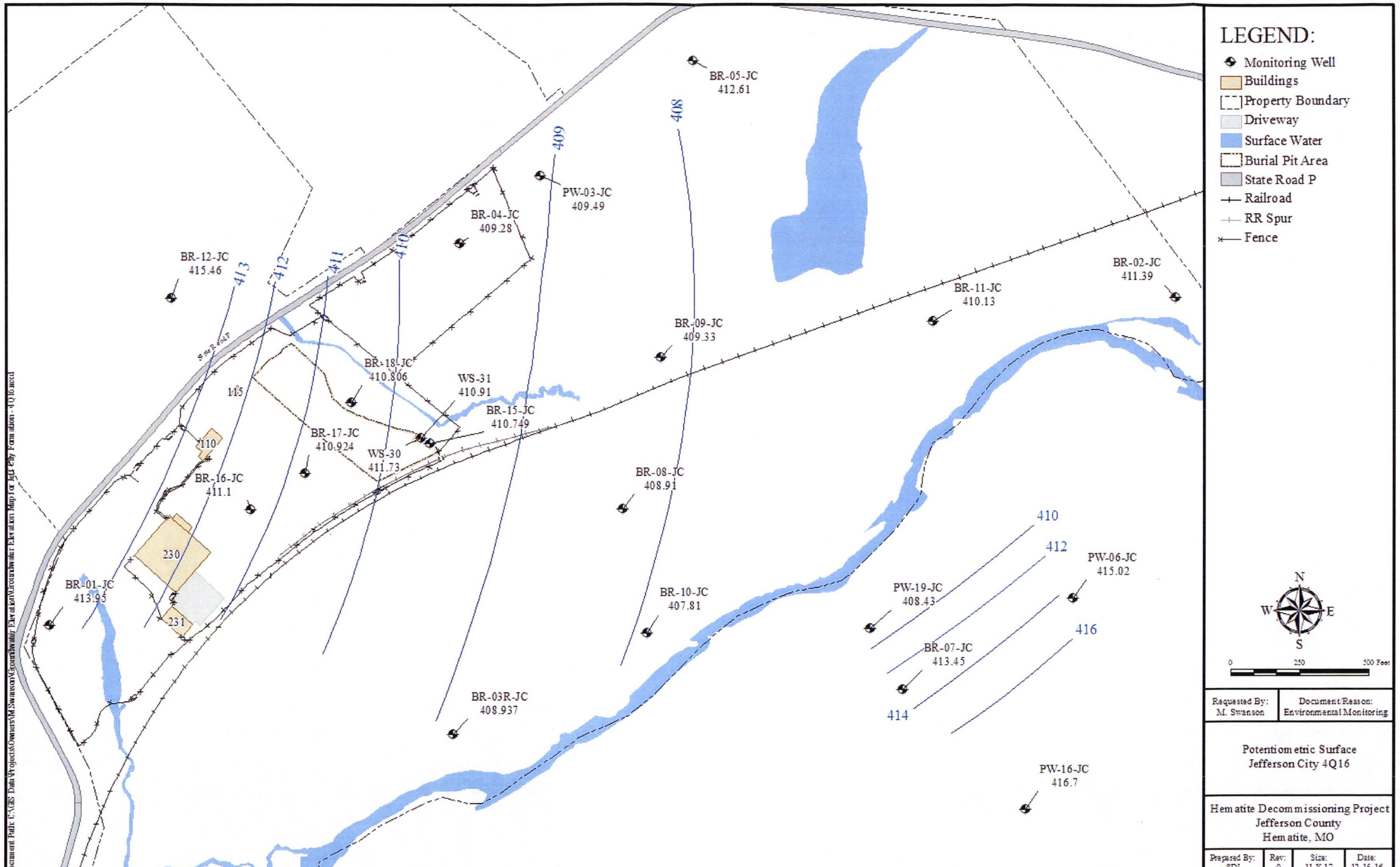
3rd Quarter Post-remediation Groundwater Elevation Contour Map

SAND/GRAVEL HSU



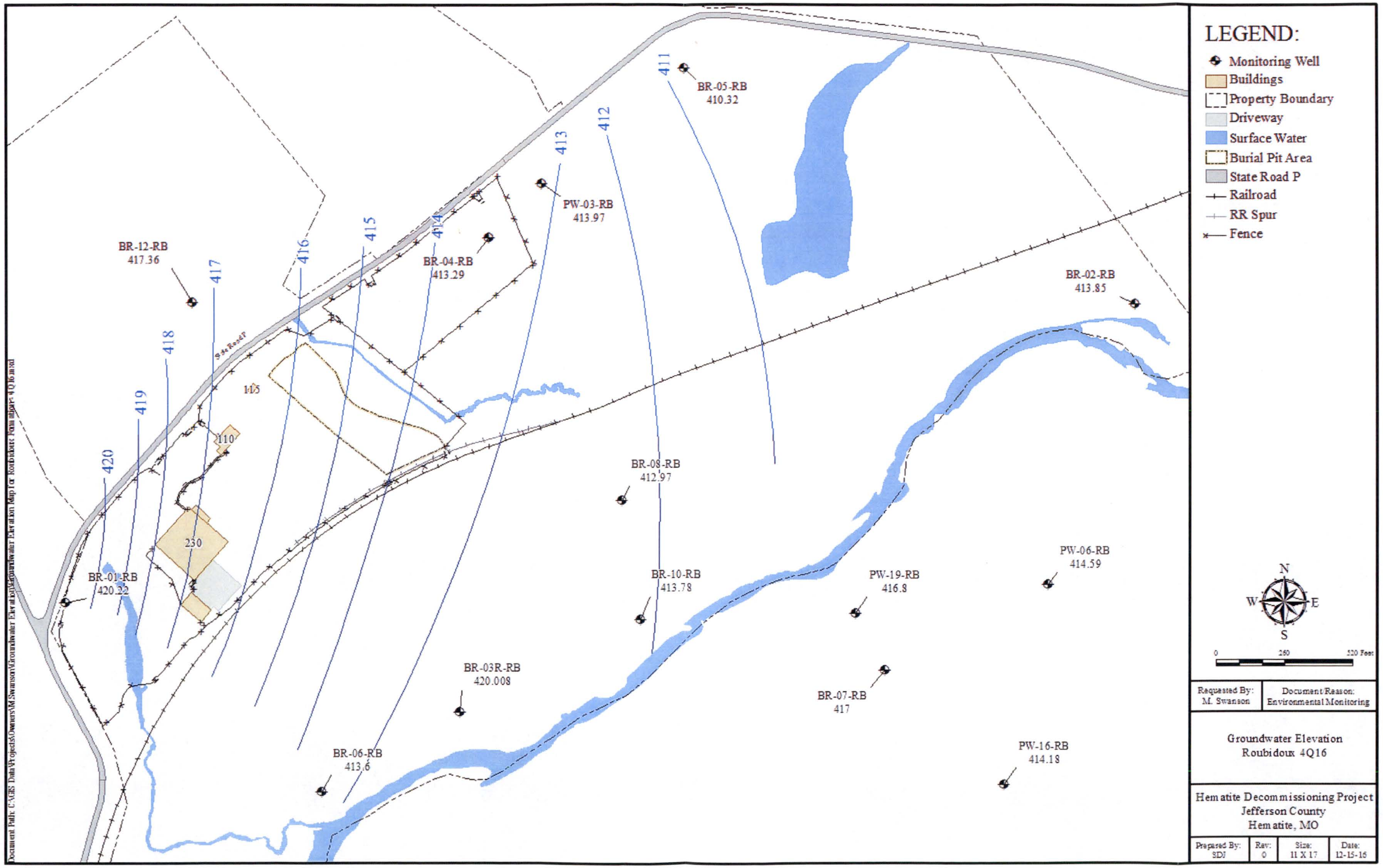
3rd Quarter Post-remediation Groundwater Elevation Contour Map

JEFFERSON CITY – COTTER HSU



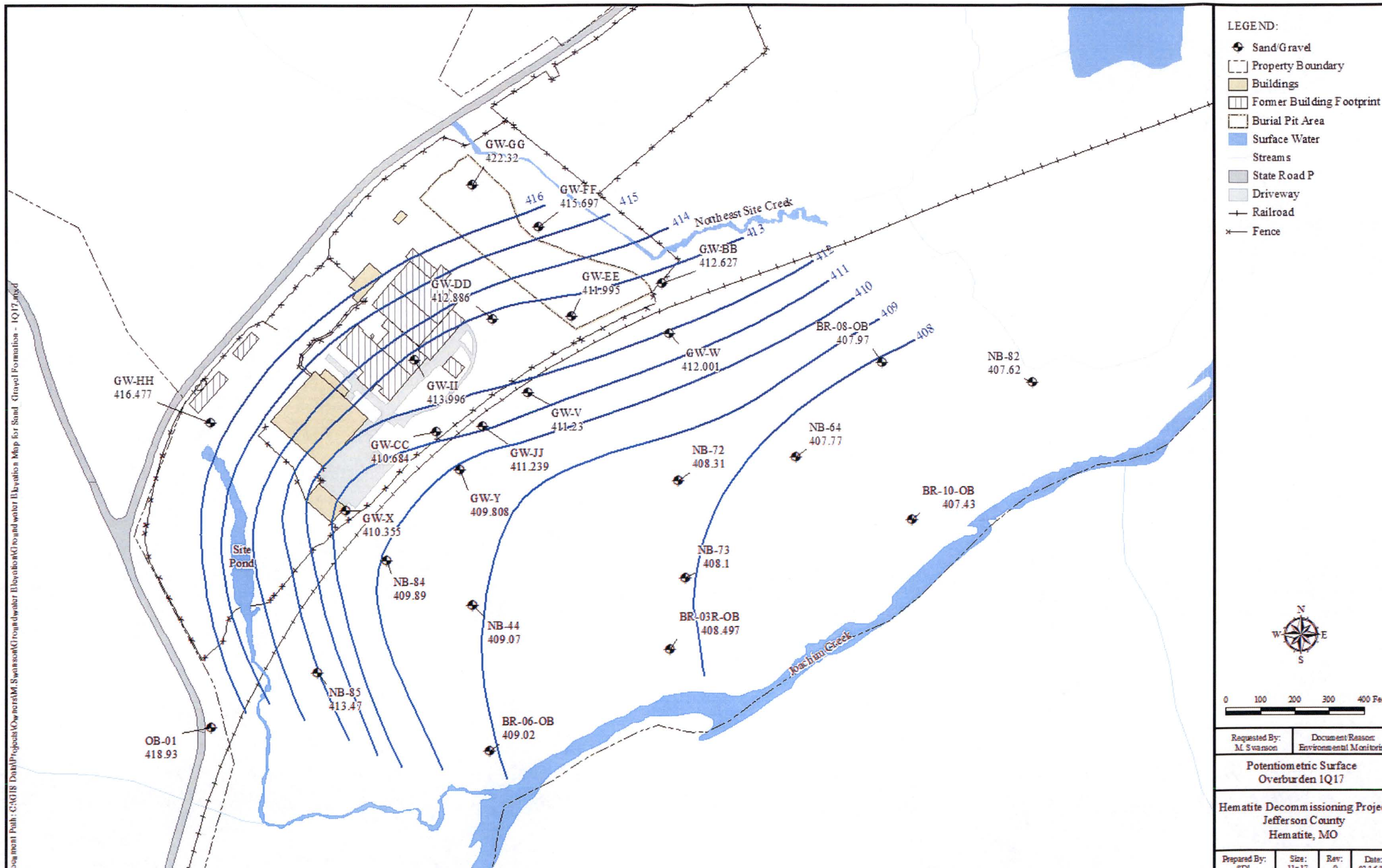
3rd Quarter Post-remediation Groundwater Elevation Contour Map

ROUBIDOUX HSU



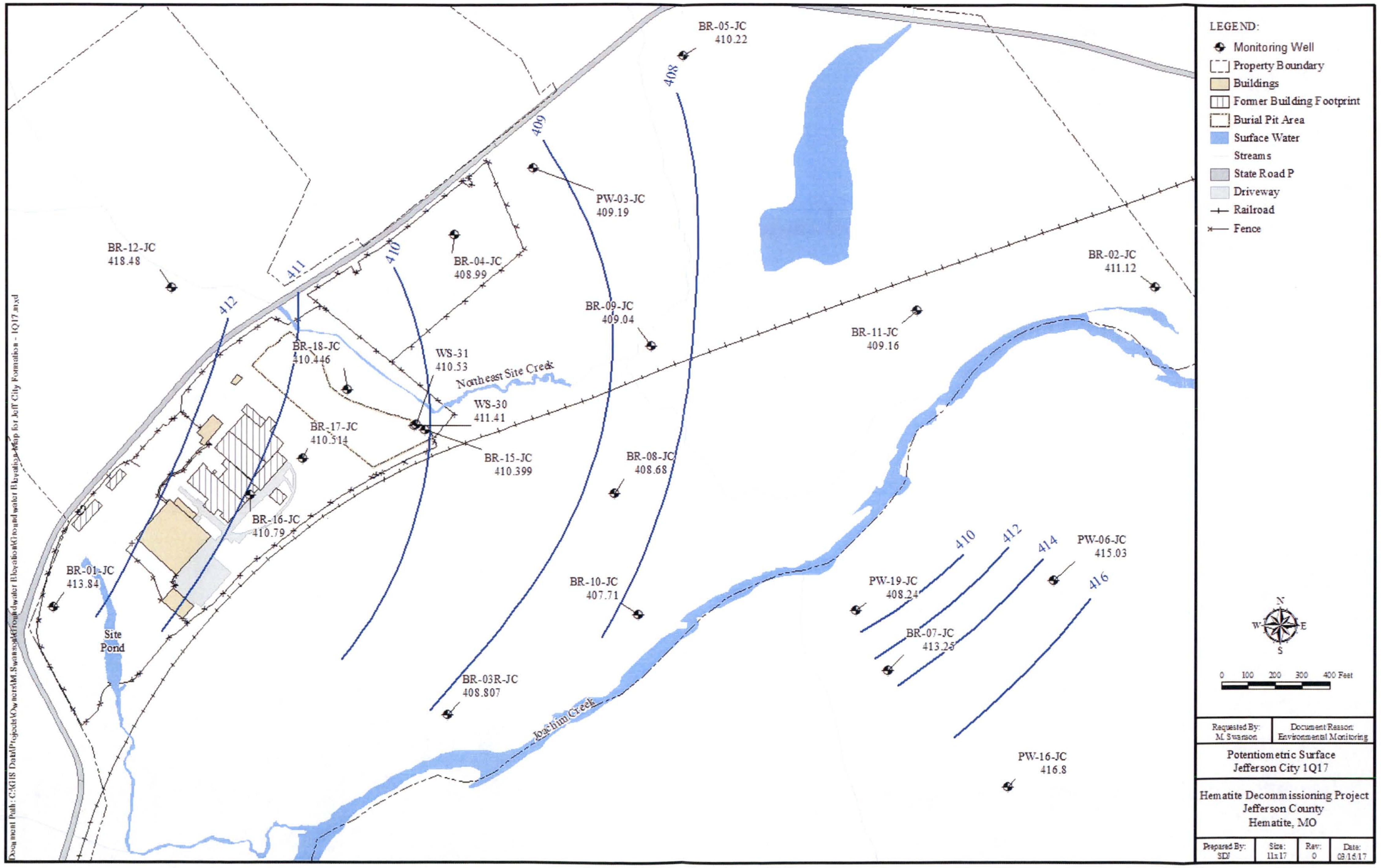
4th Quarter Post-remediation Groundwater Elevation Contour Map

SAND/GRAVEL HSU



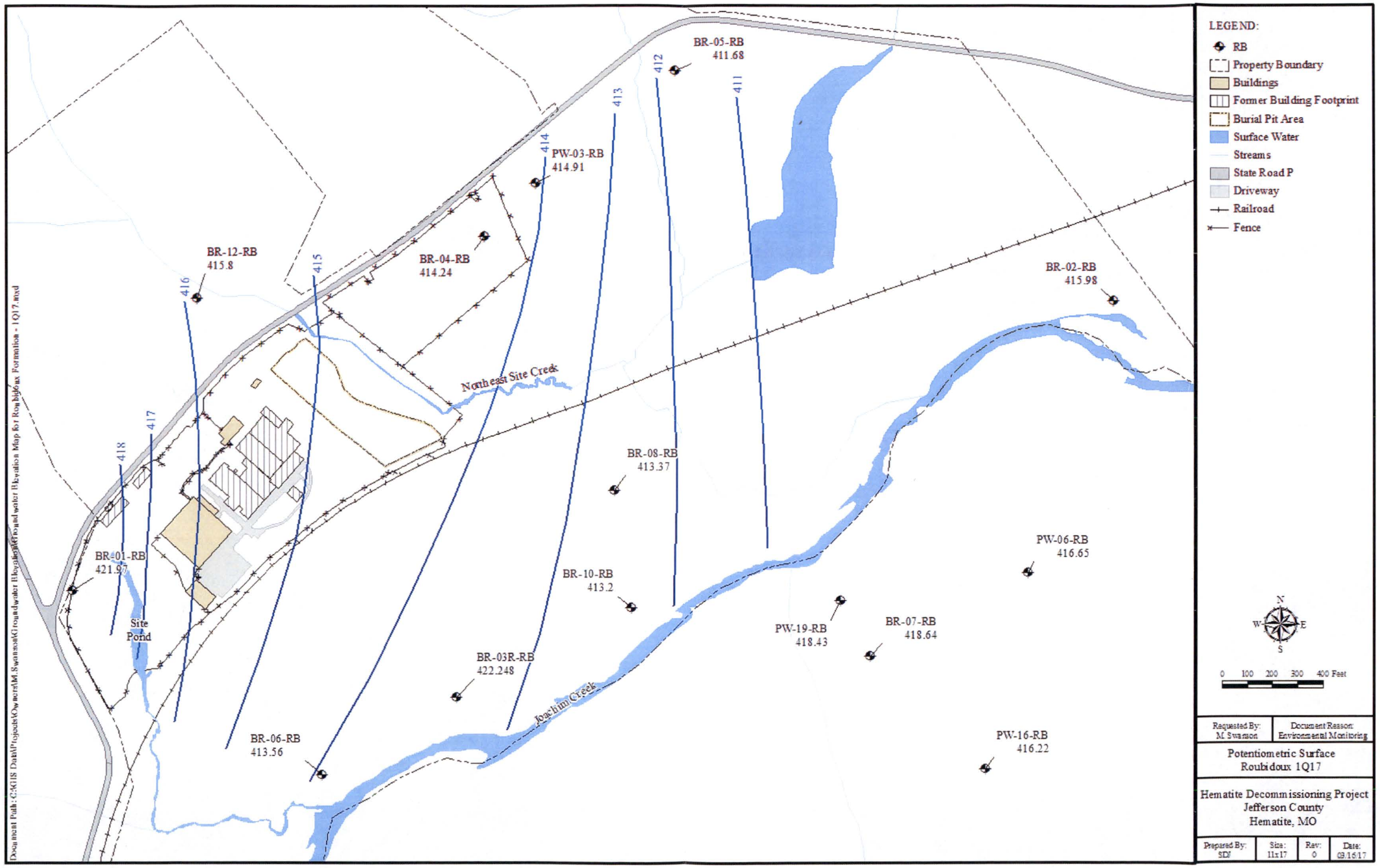
4th Quarter Post-remediation Groundwater Elevation Contour Map

JEFFERSON CITY – COTTER HSU



4th Quarter Post-remediation Groundwater Elevation Contour Map

ROUBIDOUX HSU



Attachment 2

Final Status Survey Final Report Volume 6, Chapter 7, Revision 1

Post-remediation Groundwater Monitoring Summary
Track Change Version

Westinghouse Electric Company LLC, Hematite Decommissioning Project

Docket No. 070-00036

Westinghouse

Final Status Survey Report

Hematite Decommissioning Project

Final Status Survey Final Report Volume 6, Chapter 7

TITLE: **Post-remediation Groundwater Monitoring Summary**

REVISION: **1**

EFFECTIVE DATE: MAR 13 2018

TRACK CHANGE VERSION

Approvals:

Author:	Kenneth E. Pallagi.	03-13-2018 Date
Reviewed By:	for Kevin M. Harris, P.E.	03-13-2018 Date
Owner/Manager:	W. Clark Evers, CHP	3/13/18 Date

HDP-RPT-FSS-507
Revision 1

REVISION LOG	
Revision No. Effect. Date	**Revision**
0 08/09/2017	Revision 0 is the initial issuance of the FSSFR Volume 6, Chapter 7, Post-remediation Groundwater Monitoring Summary.
1 See Cover Page	The NRC provided feedback during a recurring weekly publicly noticed teleconference with a subsequent written follow-up in regards to comments on FSSFR Volume 6, Chapter 7, Post-remediation Groundwater monitoring Summary. During a subsequent publicly noticed teleconference Westinghouse and the NRC discussed the path forward and resolution of the NRC comments. This revision to FSSFR Volume 6, Chapter 7, implements the resolution discussed during the weekly publicly noticed teleconference. This revision also contains minor editorial corrections.

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LIST OF ACRONYMS AND SYMBOLS

AOC	Area of Concern
DP	Hematite Decommissioning Plan
FSSFR	Final Status Survey Final Report
HDP	Hematite Decommissioning Project
HSU	Hydrostratigraphic Unit
MCL	Maximum Contaminant Level
NRC	United States Nuclear Regulatory Commission
msl	mean sea level
pCi/L	picocuries per liter
RAI	Request for Additional Information
ROC	Radionuclides of Concern
SOF	Sum Of Fractions
Tc	Technetium
U	Uranium

1.0 INTRODUCTION

The purpose of this document, Final Status Survey Final Report (FSSFR) Volume 6, Chapter 7, *Post-remediation Groundwater Monitoring Summary,* is to provide the radiological groundwater sampling results summary and analysis from the monitoring that was conducted for the Hematite Decommissioning Project (HDP) for the post-remediation groundwater monitoring period which commenced at the completion of radiological remediation and site restoration. Individual quarter results and trends have been presented in FSSFR Volume 6, Chapter 3 {ML16287A528}, Chapter 4 {ML16342B552}, Chapter 5 {ML17018A105}, and Chapter 6 {ML17142A356}. This Chapter will summarize the post-remediation groundwater monitoring period results, present the trending over the monitoring period, calculate an average concentration of for each of the radionuclides of concern (ROCs), calculate an annual dose contribution for the radionuclides in groundwater, and demonstrate that the residual dose attributed to groundwater does not exceed 4 mrem/year.

2.0 BACKGROUND

During the approval process for the Hematite Decommissioning Plan (DP), the NRC issued a Request for Additional Information (RAI) in letters dated October 14, 2010, NRC letter to Westinghouse, "Hematite Decommissioning Plan Review Requests for Additional Information for Decommissioning Plan Chapters 1, 4, 6 and 7," {ML102810455} and February 9, 2011, NRC letter to Westinghouse, "NRC Request for Additional Information from Westinghouse on Hematite Decommission Plan Chapter 3" {ML110210533}.

In response to the NRC's RAIs, Westinghouse committed to make modifications to its groundwater monitoring program regarding well placements and post-remediation sampling to protect the groundwater from future radioactive contamination. These commitments were captured by the NRC in the Safety Evaluation Report {ML112101630} that was issued in conjunction with the approval of the DP and associated documents. These commitments included:

1. Remove the 'leachate" impacted with radionuclides in the overburden clay. During soil excavation the contaminated "leachate" entering the excavation pit will be pumped to and treated for radionuclides by the Water Treatment System prior to its release in accordance with the effluent discharge requirements.
2. Abandon selected wells that contain screens that cross both the silty clay overburden and the sand/gravel unit below. The cross communication resulted in the transport of contaminated water from the silty clay overburden to the sand/gravel unit. New monitoring wells will be installed in the sand/gravel unit in close proximity to the abandoned wells which will monitor for groundwater during and after site remediation.
3. Conduct borings in the close proximity to four specified wells and collect soil samples to the top of sand/gravel layer for radionuclide analysis. Further soil excavation will be conducted if spent limestone and soil above the release criteria are found below the initially proposed excavation depth.
4. Monitor groundwater post-remediation.

In Westinghouse letter HEM-16-15, dated February 10, 2016, Westinghouse submitted to the NRC FSSFR Volume 6, Chapter 1, *Groundwater Overview* {ML16041A340}, which described the groundwater monitoring program regarding well placements and post-remediation sampling to support that Westinghouse has met its commitments to the NRC in supporting the unrestricted release of the site at license termination in regard to groundwater and the commitments as provided in the SER.

FSSFR Volume 6, Chapter 1 provided the basis for post-remediation groundwater monitoring, the objectives of post-remediation groundwater monitoring, and the summary of data collected prior to and during the radiological remediation of the Site. Westinghouse indicated in FSSFR Volume 6, Chapter 1 that that "*monitoring would be discontinued when it could be determined that the radioactivity concentrations did not pose an unacceptable potential for dose.*" and "*at the completion of the fourth quarter of post-remediation monitoring, an evaluation of the groundwater sample data will be performed to determine if the concentrations are stable, or are showing an increasing or decreasing trend as compared to historical data (2009 – 2015).*"

FSSFR Volume 6, Chapter 1 also provided that "*As there are no previous sample analysis results with indication of radionuclide contamination in the groundwater (Jefferson City-Cotter HSU, and the Roubidoux HSUs) exceeding MCLs or a dose limit of 4 mrem/year, the purpose of post-remediation sampling is to verify that remediation of the source area had not contributed radionuclide contamination to the groundwater.*"

Having completed a review of FSSFR Volume 6, Chapter 1 the NRC provided via email the Pre-Audit Submittal Table for FSSFR Volume 6, Chapter 1 which contained comments generated by the review. During a subsequent recurring weekly publicly noticed teleconference Westinghouse and the NRC discussed the path forward and resolution of the NRC comments for FSSFR Volume 6, Chapter 1.

In Westinghouse letter HEM-16-70, dated October 10, 2016, Westinghouse submitted to the NRC FSSFR Volume 6, Chapter 1, Revision 1 {ML16287A528} which contained the Westinghouse response to the comments provided in the Pre-Audit Submittal Table for FSSFR Volume 6, Chapter 1.

As discussed in FSSFR Volume 6, Chapter 1, the data provided in this chapter is intended to support the conclusion that remediation activities at HDP did not impact groundwater (Jefferson City-Cotter Hydrostratigraphic Unit (HSU), and the Roubidoux HSUs), and that the annual dose contribution due to radionuclides in groundwater is less than 4 mrem/year.

3.0 POST-REMEDIATION GROUNDWATER MONITORING WELL NETWORK

The post-remediation groundwater monitoring well network is composed of 18 monitoring wells screened in the sand/gravel HSU, eight wells screened in the Jefferson City-Cotter HSU, and five wells screened in the Roubidoux HSU. New monitoring wells were installed after site restoration and prior to the initiation of the post-remediation groundwater sampling. The new monitoring wells included installation of seven in the sand/gravel HSU and seven in the

Jefferson City-Cotter HSU. Figure 3-1, *Post-remediation Groundwater Monitoring Well Network,* provides the locations of all monitoring wells that are monitored for radiological purposes post-remediation. Table 3-1 below lists the wells included in the sampling network.

Post-remediation monitoring well locations were selected at locations down gradient from the former potential source areas. The radiologically impacted soil from these potential source areas was removed during the remediation process. The description of the remediation process of a specific are is provided in the FSSFR Volume 3 Chapter in which the area is located. Nevertheless, to demonstrate that the soil remediation did not have a deleterious effect on the groundwater, monitoring wells down gradient from each of the areas have been sampled as part of this program.

Monitoring well locations were selected based on the proximity to the potential source area and the predominate direction of groundwater flow. In addition, the groundwater flow rates, taken from the groundwater modeling effort presented in the Remedial Investigation, were used for each HSU to determine the likely movement of groundwater over the course of the annual monitoring. Table 3-2, Post-remediation Groundwater Monitoring Well Locations, indicates the monitoring well, the HSU being monitored, the area of concern (AOC) being monitored, the distance from the well to the center of the AOC, the distance from the well to the leading edge of the AOC, and the expected yearly flow for groundwater within that HSU. This indicates that radiological contamination, if contained within the groundwater, would be intercepted by the wells within the one year timeframe. Therefore, if contamination was present due to remedial activities, it would be present and detectable in the groundwater samples collected from the post-remediation monitoring wells.

Monitoring wells GW-BB, GW-EE, GW-FF, GW-GG, GW-W, NB-71, and NB-10 are positioned down gradient (northeast, east, and southeast) of the former burial pits to assess ground water quality following removal of contaminated soil/materials from this area.

Monitoring wells GW-DD, GW-II, GW-JJ, and GW-V are positioned down gradient (southeast) of the Process Building to assess groundwater quality following building demolition and removal of contaminated soil from this area.

Monitoring wells GW-CC, GW-X, GW-Y, NB-34, NB-35 and PZ-02 are positioned down gradient (southeast) of the Evaporation Ponds and former Leach Field to assess groundwater quality following removal of contaminated soil from these areas.

Monitoring well GW-HH is positioned down gradient (southeast) of the Red Room Roof Burial Area and Cistern/Burn Pit to assess groundwater quality following removal of contaminated soil and materials from these areas.

Three new monitoring wells (BR-14-JC, BR-15-JC, and BR-18-JC) have been installed in the Jefferson City-Cotter HSU down gradient of the Burial Pit and Tc-99 source areas. The wells are placed at locations to the south and east of the Documented Burial Pit Area. These wells are located closer to the central tract than the previously sampled wells and are located in areas that,

if contaminant migration is occurring, will identify the degradation of the water within the post-remediation monitoring timeframe.

Post-remediation monitoring of the Jefferson City-Cotter HSU in the vicinity of the former Process Building is accomplished by monitoring three newly installed monitoring wells (BR-13-JC, BR-16-JC, and BR-17-JC) within the source and down gradient of the areas beneath the former Process Buildings where the highest levels of contamination were removed. These wells are being used to evaluate the potential for contaminant migration from the overburden into the shallow bedrock.

Post-remediation monitoring of the Jefferson City-Cotter HSU in the vicinity of the former Evaporation Ponds is accomplished by monitoring of a newly installed monitoring well (BR-19-JC) at a location down gradient of the primary (deep) Evaporation Pond.

Post-remediation monitoring of the Roubidoux HSU is being or will be conducted using the sentry wells designated as BR-03-RB, BR-04-RB, BR-08-RB, and BR-10-RB. In addition, a background well (WS-04), which is located off-site at the Hematite Post Office, is being monitored.

Figure 3-1
Post-remediation Groundwater Monitoring Well Network

Table 3-1
Post-remediation Groundwater Monitoring Wells

Well ID No.	HSU	Post-remediation Protocol			Existing or New*
		Purpose	Parameters	Sample Frequency	
GW-BB	Sand/Gravel	Burial Pit	Tc-99, Isotopic U	Quarterly	Existing
GW-EE	Sand/Gravel	Burial Pit	Tc-99, Isotopic U	Quarterly	New
GW-FF	Sand/Gravel	Burial Pit	Tc-99, Isotopic U	Quarterly	New
GW-GG	Sand/Gravel	Burial Pit	Tc-99, Isotopic U	Quarterly	New
GW-W	Sand/Gravel	Burial Pit	Tc-99, Isotopic U	Quarterly	Existing
NB-71	Sand/Gravel	Burial Pit	Tc-99, Isotopic U	Quarterly	Existing
NB-80	Sand/Gravel	Burial Pit	Tc-99, Isotopic U	Quarterly	Existing
GW-V	Sand/Gravel	Former Building Slabs	Tc-99, Isotopic U	Quarterly	Existing
GW-DD	Sand/Gravel	Former Building Slabs	Tc-99, Isotopic U	Quarterly	New
GW-II	Sand/Gravel	Former Building Slabs	Tc-99, Isotopic U	Quarterly	New
GW-JJ	Sand/Gravel	Former Building Slabs	Tc-99, Isotopic U	Quarterly	Existing
GW-CC	Sand/Gravel	Evaporation Pond	Tc-99, Isotopic U	Quarterly	New
GW-X	Sand/Gravel	Evaporation Pond	Tc-99, Isotopic U	Quarterly	Existing
GW-Y	Sand/Gravel	Evaporation Pond	Tc-99, Isotopic U	Quarterly	Existing
NB-34	Sand/Gravel	Evaporation Pond	Tc-99, Isotopic U	Quarterly	Existing
NB-35	Sand/Gravel	Evaporation Pond	Tc-99, Isotopic U	Quarterly	Existing
PZ-02	Sand/Gravel	Evaporation Pond	Tc-99, Isotopic U	Quarterly	Existing
GW-HH	Sand/Gravel	Red Room Rood Burial Area	Tc-99, Isotopic U	Quarterly	New
BR-04-JC	Jefferson City Cotter	Burial Pit	Tc-99, Isotopic U	Quarterly	Existing
BR-13-JC	Jefferson City Cotter	Former Building Slabs	Tc-99, Isotopic U	Quarterly	New
BR-14-JC	Jefferson City Cotter	Burial Pit	Tc-99, Isotopic U	Quarterly	New
BR-15-JC	Jefferson City Cotter	Burial Pit	Tc-99, Isotopic U	Quarterly	New
BR-16-JC	Jefferson City Cotter	Former Building Slabs	Tc-99, Isotopic U	Quarterly	New
BR-17-JC	Jefferson City Cotter	Former Building Slabs	Tc-99, Isotopic U	Quarterly	New
BR-18-JC	Jefferson City Cotter	Burial Pit	Tc-99, Isotopic U	Quarterly	New

Well ID No.	HSU	Post-remediation Protocol			Existing or New*
		Purpose	Parameters	Sample Frequency	
BR-19-JC	Jefferson City Cotter	Evaporation Pond	Tc-99, Isotopic U	Quarterly	New
BR-04-RB	Roubidoux	Deep Bedrock	Tc-99, Isotopic U	Quarterly	Existing
BR-08-RB	Roubidoux	Deep Bedrock	Tc-99, Isotopic U	Quarterly	Existing
BR-10-RB	Roubidoux	Deep Bedrock	Tc-99, Isotopic U	Quarterly	Existing
BR-03R-RB	Roubidoux	Deep Bedrock	Tc-99, Isotopic U	Quarterly	Existing
WS-04	Roubidoux	Deep Bedrock	Tc-99, Isotopic U	Quarterly	Existing

* Indicates if the well was an existing well or a new well installed for post-remediation monitoring.

Table 3-2
Post-remediation Groundwater Monitoring Well Locations

Well ID #	Horizon[1]	Area of Concern	Distance to Center of AOC (feet)	Distance to Down Gradient Edge of AOC (feet)	Average Annual Groundwater Flow Distance (feet)
BR-03R-RB	BR	Evaporation Ponds	945.81	929.53	3,600
BR-04-JC	BR	Burial Pits	772.54	720.74	1,000
BR-04-RB	BR	Burial Pits	859.08	807.31	3,600
BR-08-RB	BR	Burial Pits	1106.7	701.15	3,600
BR-10-RB	BR	Burial Pits	1370.86	1048.59	3,600
BR-13-JC	BR	Process Buildings	412.31	306.7	1,000
BR-14-JC	BR	Burial Pits	487.95	151.41	1,000
BR-15-JC	BR	Burial Pits	366.15	NA	1,000
BR-16-JC	BR	Process Buildings	92.14	NA	1,000
BR-17-JC	BR	Process Buildings	293.36	83.8	1,000
BR-18-JC	BR	Burial Pits	87.21	33.65	1,000
BR-19-JC	BR	Evaporation Ponds	136.84	152.19	1,000
GW-BB	OB	Burial Pits	421.65	62.32	6,208
GW-CC	OB	Evaporation Ponds	41.01	22.7	6,208
GW-DD	OB	Process Buildings	313.22	107.13	6,208
GW-EE	OB	Burial Pits	245.76	NA	6,208
GW-FF	OB	Burial Pits	85.54	33.55	6,208
GW-GG	OB	Burial Pits	226.44	NA	6,208
GW-HH	OB	Cistern Burn Pits/Red Room Roof	29.76	16.47	6,208

Well ID #	Horizon[1]	Area of Concern	Distance to Center of AOC (feet)	Distance to Down Gradient Edge of AOC (feet)	Average Annual Groundwater Flow Distance (feet)
GW-II	OB	Process Buildings	81.25	NA	6,208
GW-JJ	OB	Process Buildings	347.24	249.95	6,208
GW-V	OB	Process Buildings	419.03	312.93	6,208
GW-W	OB	Burial Pits	493.61	157.87	6,208
GW-X	OB	Process Buildings	476.54	374.83	6,208
GW-Y	OB	Evaporation Ponds	166.79	150.45	6,208
NB-34	OB	Evaporation Ponds	239.28	222.68	6,208
NB-35	OB	Evaporation Ponds	277.54	259.23	6,208
NB-71	OB	Burial Pits	442.96	380.47	6,208
NB-80	OB	Burial Pits	161.45	97.21	6,208
PZ-02	OB	Evaporation Ponds	170.39	155.32	6,208
WS-04	BR	Background			

[1] **BR-** Indicates the monitoring well is installed in the bedrock (Jefferson City-Cotter or Roubidoux HSU).
OB- Indicates the monitoring well is installed in the overburden (sand/gravel HSU).

4.0 POST-REMEDIAITION GROUNDWATER MONITORING SUMMARY REPORT

The post-remediation groundwater monitoring program was initiated after the completion of remediation of the site. The NRC was notified of completion of remediation in Westinghouse letter HEM-16-6 (Fussell) to NRC (Document Control Desk), dated January 18, 2016. The four quarters of sampling were conducted as follows:

1st Quarter – May 26 through June 11, 2016;
2nd Quarter – August 11 through September 29, 2016;
3rd Quarter – November 3 through November 21, 2016; and
4th Quarter - February 9 and February 28, 2017.

The post-remediation monitoring for radiological constituents was conducted simultaneous with the Interim Groundwater Monitoring Program with the exception of the first quarter, in which the IGMP monitoring was conducted after the radiological sampling was completed. The IGMP program focuses on the chemical contamination, primarily chlorinated volatile organics, present in the groundwater at the site, and utilizes many of the same monitoring wells as the post-remediation monitoring.

Results of each quarterly monitoring event were presented in previous chapters of FSSFR Volume 6, Chapters 2 and 3 (1st Quarter){ML16287A528}, Chapter 4 (2nd Quarter) {ML16342B552}, Chapter 5 (3rd Quarter){ML17018A105}, and Chapter 6 (4th quarter){ML17142A356}. These chapters did not include the original laboratory data packages, from the contracted analytical laboratory, Test America. These packages are included within this chapter as Appendix A through D. It should be noted that data for chemical results are included with the packages for Quarter 2 through Quarter 4, due to the radiological and chemical samples being collected and submitted concurrently.

Each of the Quarterly monitoring chapters within this volume included trending of the data, using Mann-Kendall analysis. The purpose of the Mann-Kendall analysis was to identify statistically significant increasing or decreasing concentration trends, if they exist, or to identify stable concentrations. The Mann-Kendall analysis was chosen based on its prior use at the U.S. Department of Energy Oak Ridge Reservation, as presented at the Waste Management Conference, Phoenix, Arizona, February 2013. Specifically, the abstract states:

"*This paper describes a spreadsheet-based approach for applying the Mann-Kendall (MK) Test to identify statistically significant increasing or decreasing concentration trends, stable concentration trends (not increasing or decreasing), and indeterminate concentration trends (no trend) defined by time-series groundwater monitoring data for inorganic, organic, or radiological contaminants. The approach has been applied in support of ongoing long-term monitoring (LTM) of groundwater contamination at the U.S. Department of Energy (DOE) Y-12 National Security Complex (Y-12) in Oak Ridge, Tennessee and elsewhere on the DOE Oak Ridge Reservation (ORR), and has proven effective at minimizing subjective bias in the evaluation and interpretation of contaminant concentration trend data. Application of the approach for the purposes of optimizing groundwater sampling frequency for LTM also is outlined*"

The abstract further states that "*contaminant concentration data from a minimum of four and no more than ten independent sampling events*" is to be used to perform the Mann-Kendall trending analysis.

Since the technical approach requires a minimum of four independent sampling events arranged in chronological order by sampling date and time, the Mann-Kendall trending analysis was not conducted for the newly installed wells during the first three quarters of monitoring, as four data points were not available. FSSFR Volume 6, Chapter 6 which summarized the fourth quarter sampling results was the first opportunity to present the results of the Mann-Kendall trending analysis with four quarters of data for the newly installed post-remediation groundwater monitoring wells. The data in the tables and graphs from that chapter are also included in this chapter, as they are inclusive of all four quarters of data.

4.1 Jefferson City-Cotter HSU Data Set

The data set for each radiological constituent [Tc-99, U-233/234, U-235/236, and U-238], including the MDC and Error, is provided in Attachment 1, *Post-Remediation Groundwater Monitoring Period Summary of Results*. In Attachment 2, *Mann-Kendall Analysis and Sample Results Graphs,* the data set for each radiological constituent has been graphed for each monitoring well versus the respective Maximum Contaminant Level (MCL), along with the Mann-Kendell trend graph, as described previously. The full laboratory data packages for each sampling event are contained in Appendix A through D.

For discussion purposes, summary tables for each radiological constituent showing the four quarterly results, the average concentration of the radiological constituent for each well, and the maximum detected concentration of the radiological constituent for each Jefferson City-Cotter HSU monitoring well are presented in Table 4-1 through Table 4-4 below.

Table 4-1
Jefferson City-Cotter HSU Monitoring Period Summary of Technetium - 99

JEFFERSON CITY – COTTER HSU Tc-99 pCi/L						
Well ID	**1st Quarter Result**	**2nd Quarter Result**	**3rd Quarter Result**	**4th Quarter Result**	**Average**	**Maximum**
BR-04-JC	-1.16	-0.266	0.528	0.306	0.2085	0.528
BR-13-JC	-0.695	-0.117	-0.657	0.162	0.0405	0.162
BR-14-JC	-1.24	-0.126	-0.927	1.19	0.2975	1.19
BR-15-JC	-0.33	-0.683	-0.471	0.919	0.22975	0.919
BR-16-JC	-0.767	-0.946	0.567	-1.09	0.14175	0.567
BR-17-JC	-0.402	-0.307	-0.901	-0.718	0	N/A
BR-18-JC	0.0809	-0.899	0.054	-0.358	0.033725	0.0809
BR-19-JC	0.276	-0.648	0.0273	0.0784	0.095425	0.276

Table 4-2
Jefferson City-Cotter HSU Monitoring Period Summary of Uranium - 233/234

JEFFERSON CITY – COTTER HSU U-233/234 pCi/L						
Well ID	**1st Quarter Result**	**2nd Quarter Result**	**3rd Quarter Result**	**4th Quarter Result**	**Average**	**Maximum**
BR-04-JC	2.81	3.32	2.89	2.68	2.925	3.32
BR-13-JC	4.02	4.16	4.34	4.05	4.1425	4.34
BR-14-JC	3.74	3.56	4.01	3.21	3.63	4.01
BR-15-JC	1.38	1.33	1.13	1.37	1.3025	1.38
BR-16-JC	1.72	4.59	5.4	4.18	3.9725	5.4
BR-17-JC	11.7	4.91	2.73	2.84	5.545	11.7
BR-18-JC	2.64	2.25	2.15	2.08	2.28	2.64
BR-19-JC	6.26	7.02	7.21	6.72	6.8025	7.21

Table 4-3
Jefferson City-Cotter HSU Monitoring Period Summary of Uranium - 235/236

JEFFERSON CITY – COTTER HSU U-235/236						
Well ID	**1st Quarter Result**	**2nd Quarter Result**	**3rd Quarter Result**	**4th Quarter Result**	**Average**	**Maximum**
BR-04-JC	0.0477	0.0705	-0.0253	0.0145	0.033175	0.0705
BR-13-JC	0.0168	0.0709	-0.0087	0.0537	0.03535	0.0709
BR-14-JC	0.0662	0.0474	0.112	0.0554	0.07025	0.112
BR-15-JC	0.0241	0.0139	-0.0183	0.0501	0.022025	0.0501
BR-16-JC	0.0204	0.0286	0.101	0.0394	0.04735	0.101
BR-17-JC	0.126	0.0221	0.0228	0.0267	0.0494	0.126
BR-18-JC	0.0187	0.0491	0.0243	0.0279	0.03	0.0491
BR-19-JC	0.149	0.0468	0.0668	0.104	0.09165	0.149

Table 4-4
Jefferson City-Cotter HSU Monitoring Period Summary of Uranium - 238

JEFFERSON CITY – COTTER HSU U-238 pCi/L						
Well ID	**1st Quarter Result**	**2nd Quarter Result**	**3rd Quarter Result**	**4th Quarter Result**	**Average**	**Maximum**
BR-04-JC	0.402	0.461	0.394	0.262	0.37975	0.461
BR-13-JC	0.59	0.299	0.29	0.361	0.385	0.59
BR-14-JC	0.435	0.678	0.568	0.604	0.57125	0.678
BR-15-JC	0.358	0.345	0.194	0.237	0.2835	0.358
BR-16-JC	0.655	0.888	0.822	0.77	0.78375	0.888
BR-17-JC	2.04	0.828	0.49	0.436	0.9485	2.04
BR-18-JC	0.433	0.216	0.239	0.118	0.2515	0.433
BR-19-JC	1.05	1.11	0.995	0.972	1.03175	1.11

The Jefferson City-Cotter HSU data sets were reviewed for the four quarters of sampling to determine the maximum concentration of each radiological constituent detected during the annual monitoring. Table 4-5 below indicates the maximum concentration detected for each radiological constituent, the monitoring well where the detection occurred, and the quarter in which the maximum detection occurred. In addition, the drinking water MCL and an indication of whether any of the analyses indicated contamination above the MCL. A review of the data set indicates that none of the monitoring well sampling results for any radiological constituent approached or was near the MCL.

Table 4-5
Jefferson City-Cotter HSU Maximum Concentrations of ROCs

Radiological Constituent	Units	Maximum Detected Concentration	MCL	Number of Analyses > MCL	Maximum Location	Maximum Quarter
Technetium-99	pCi/L	1.19 ± 1.02	900	0	BR-14-JC	4th Quarter
Uranium-234	pCi/L	11.7 ± 1.39	20*	0	BR-17-JC	1st Quarter
Uranium-235/236	pCi/L	0.149 ± 0.0804~~2.8~~	20*	0	BR-19-JC	1st Quarter
Uranium-238	pCi/L	2.04 ± 0.44	20*	0	BR-17-JC	1st Quarter

* Isotopic Evaluation Level since MCL is 30 μg/L for total uranium.

The results of the Mann-Kendell trend analysis for the Jefferson City-Cotter HSU are provided in Table 4-6 below. The Mann-Kendall analysis showed a downward trend for Tc-99 in monitoring well BR-04-JC and a downward trend for Total Uranium in monitoring well BR-18-JC. No upward trends were indicated by the analysis, supporting the premise that there is not an expanding plume of radiological contamination within the Jefferson City-Cotter HSU.

Table 4-6
Mann-Kendell Trend Analysis Results – Jefferson City-Cotter HSU

Well ID	Tc-99	Total U
BR-04-JC	Downward Trend	No Trend
BR-13-JC	No Trend	No Trend
BR-14-JC	No Trend	No Trend
BR-15-JC	No Trend	No Trend
BR-16-JC	No Trend	No Trend
BR-17-JC	No Trend	No Trend
BR-18-JC	No Trend	Downward Trend
BR-19-JC	No Trend	No Trend

4.2 Roubidoux HSU Data Set

The data set for each radiological constituent [Tc-99, U-233/234, U-235/236, and U-238], including the MDC and Error, is provided in Attachment 1, *Post-remediation Groundwater Monitoring Period Summary of Results*. In Attachment 2, *Mann-Kendall Analysis and Sample Results Graphs*, the data set for each radiological constituent has been graphed for each well versus the respective MCL, along with the Mann-Kendell trend graph, as described previously. The full laboratory data packages for each sampling event are contained in Appendix A through Appendix D.

For discussion purposes, each radiological constituent showing the four quarterly results, the average concentration of the radiological constituent for each well, and the maximum detected concentration of the radiological constituent for each Roubidoux HSU monitoring well are presented in Tables 4-7 through Table 4-10 below.

Table 4-7
Roubidoux HSU Monitoring Period Summary of Technetium - 99

ROUBIDOUX HSU Tc-99 pCi/L						
Well ID	**1st Quarter Result**	**2nd Quarter Result**	**3rd Quarter Result**	**4th Quarter Result**	**Average**	**Maximum**
BR-03R-RB	-1.08	-1.09	-0.207	-0.0105	0	N/A
BR-04-RB	-0.478	0.394	-0.738	-0.962	0.0985	0.394
BR-08-RB	-0.937	-0.37	-0.369	-1.13	0	N/A
BR-10-RB	-1.13	-0.162	-1.13	0.969	0.24225	0.969
WS-04	-0.11	-0.37	-0.852	-1.77	0	N/A

Table 4-8
Roubidoux HSU Monitoring Period Summary of Uranium - 233/234

ROUBIDOUX HSU U-233/234 pCi/L						
Well ID	**1st Quarter Result**	**2nd Quarter Result**	**3rd Quarter Result**	**4th Quarter Result**	**Average**	**Maximum**
BR-03R-RB	1.9	2	2.01	1.69	1.9	2.01
BR-04-RB	2.41	2.45	2.58	2.43	2.4675	2.58
BR-08-RB	6.2	5.21	6.01	6.09	5.8775	6.2
BR-10-RB	2.91	3.21	2.82	3.26	3.05	3.26
WS-04	1.05	0.936	1.25	1.12	1.089	1.25

Table 4-9
Roubidoux HSU Monitoring Period Summary of Uranium - 235/236

ROUBIDOUX HSU U-235/236 pCi/L						
Well ID	**1st Quarter Result**	**2nd Quarter Result**	**3rd Quarter Result**	**4th Quarter Result**	**Average**	**Maximum**
BR-03R-RB	0.0392	0.0422	0.0134	0.000953	0.02393825	0.0422
BR-04-RB	0.00412	0	0.0473	0.0168	0.017055	0.0473
BR-08-RB	0.0757	0.0722	-0.0472	0.0237	0.0429	0.0757
BR-10-RB	0.0185	0.00867	0.0237	0	0.0127175	0.0237
WS-04	0.0216	0.0222	0.0395	0.0347	0.0295	0.0395

Table 4-10
Roubidoux HSU Monitoring Period Summary of Uranium - 238

ROUBIDOUX HSU U-238 pCi/L						
Well ID	**1st Quarter Result**	**2nd Quarter Result**	**3rd Quarter Result**	**4th Quarter Result**	**Average**	**Maximum**
BR-03R-RB	0.169	0.158	0.158	0.115	0.15	0.169
BR-04-RB	0.204	0.281	0.206	0.241	0.233	0.281
BR-08-RB	0.426	0.306	0.503	0.381	0.404	0.503
BR-10-RB	0.123	0.125	0.144	0.135	0.13175	0.144
WS-04	0.607	0.508	0.541	0.717	0.59325	0.717

The Roubidoux HSU data sets were reviewed for the four quarters of sampling to determine the maximum concentration of each radiological constituent detected during the annual monitoring. Table 4-11 below indicates the maximum concentration detected for each radiological constituent, the monitoring well where the detection occurred, and the quarter in which the maximum detection occurred. In addition, the drinking water MCL and an indication of whether any of the analyses indicated contamination above the MCL. A review of the data set indicates that none of the monitoring well sampling results for any radiological constituent approached or was near the MCL.

Table 4-11
Roubidoux HSU Maximum Concentrations of ROCs

Radiological Constituent	Units	Maximum Detected Concentration	MCL	Number of Analyses > MCL	Maximum Location	Maximum Quarter
Technetium-99	pCi/L	0.969 ± 0.97	900	0	BR-10-RB	4th Quarter
Uranium-234	pCi/L	6.2 ± 0.732	20*	0	BR-08-RB	1st Quarter
Uranium-235/236	pCi/L	0.0757 ± 0.737	20*	0	BR-08-RB	1st Quarter
Uranium-238	pCi/L	0.717 ± 0.152	20*	0	WS-04	4th Quarter

* Isotopic Evaluation Level since MCL is 30 μg/L for total uranium.

The results of the Mann-Kendell trend analysis for the Roubidoux HSU are provided in Table 4-12 below. The Mann-Kendall analysis showed a downward trend for Total Uranium in monitoring well BR-10-RB. No upward trends were indicated by the analysis, supporting the premise that there is not an expanding plume of radiological contamination within the Roubidoux HSU.

Table 4-12
Mann-Kendell Trend Analysis Results – Roubidoux HSU

Well ID	Tc-99	Total U
BR-03R-RB	No Trend	No Trend
BR-04-RB	No Trend	No Trend
BR-08-RB	No Trend	No Trend
BR-10-RB	No Trend	Downward Trend
WS-04	No Trend	No Trend

4.3 Sand/Gravel HSU Data Set

The data set for each radiological constituent [Tc-99, U-233/234, U-235/236, and U-238], including the MDC and Error, is provided in Attachment 1, *Post-remediation Groundwater Monitoring Period Summary of Results*. In Attachment 2, *Mann-Kendall Analysis and Sample Results Graphs*, the data set for each radiological constituent has been graphed for each well versus the respective MCL, along with the Mann-Kendell trend graph, as described previously. The full laboratory data packages for each sampling event are contained in Appendix A through D.

For discussion purposes, each radiological constituent is showing the four quarterly results, the average concentration of the radiological constituent for each monitoring well, and the maximum detected concentration of the radiological constituent for each Sand/Gravel HSU monitoring well are presented in Tables 4-13 through 4-16 below.

Table 4-13
Sand/Gravel HSU Monitoring Period Summary of Technetium - 99

SAND/GRAVEL HSU Tc-99 pCi/L						
Well ID	**1st Quarter Result**	**2nd Quarter Result**	**3rd Quarter Result**	**4th Quarter Result**	**Average**	**Maximum**
GW-BB	-0.036	0.405	1.93	0.793	0.782	1.93
GW-CC	3.6	2.66	3.95	6.12	4.0825	6.12
GW-DD	4.82	5.06	3.91	4.23	4.505	5.06
GW-EE	1.72	1.51	1.95	1.51	1.6725	1.95
GW-FF	3.05	3.58	1.93	1.32	2.47	3.58
GW-GG	-0.563	-0.0554	-0.667	1	0.25	1
GW-HH	-0.513	-0.478	-0.234	-0.764	0	N/A
GW-II	-0.252	-1.27	0.0832	0.243	0.08155	0.243
GW-JJ	5.69	4.12	3.28	6.83	4.98	6.83
GW-V	5.12	4.88	4.68	2.65	4.3325	5.12
GW-W	1.17	0.322	0.373	0.486	0.58775	1.17
GW-X	61.4	71	80.3	75.7	72.1	80.3
GW-Y	3.29	3.68	3.35	2.65	3.2425	3.68
NB-34	2.27	4.5	3.46	2.17	3.1	4.5
NB-35	2.38	1.33	1.94	3.02	2.1675	3.02
NB-71	0.23	-1.03	-0.315	-0.989	0.0575	0.23
NB-80	0.522	-0.414	-0.153	-1.3	0.1305	0.522
PZ-02	2.5	4.73	3.86	2.29	3.345	4.73

Table 4-14
Sand/Gravel HSU Monitoring Period Summary of Uranium - 233/234

SAND/GRAVEL HSU U-233/234 pCi/L						
Well ID	**1st Quarter Result**	**2nd Quarter Result**	**3rd Quarter Result**	**4th Quarter Result**	**Average**	**Maximum**
GW-BB	0	0.0251	0.0306	0.0417	0.02435	0.0417
GW-CC	0.97	0.928	0.746	0.709	0.83825	0.97
GW-DD	0.148	0.0422	0.0378	0.00875	0.0591875	0.148
GW-EE	0.226	0.0392	0.0185	0.00657	0.0725675	0.226
GW-FF	0.723	0.366	0.284	0.649	0.5055	0.723
GW-GG	0.0868	0	0.235	0.00929	0.0827725	0.235
GW-HH	0.518	1.02	0.3	4.5	1.5845	4.5
GW-II	0.127	0.0406	0.00902	0.0602	0.059205	0.127
GW-JJ	0.0371	0.00882	-0.0221	-0.0152	0.01148	0.0371
GW-V	0.0833	0.0645	0.0458	-0.00312	0.0484	0.0833
GW-W	0.0691	0.0225	0.0482	-0.00632	0.03495	0.0691
GW-X	0.00503	0.0188	0.0496	0.0353	0.0271825	0.0496
GW-Y	0.33	0.287	0.374	0.279	0.3175	0.374
NB-34	0.058	0.0621	0.109	0.0777	0.0767	0.109
NB-35	-0.0461	0.0275	0.131	0.04	0.049625	0.131
NB-71	0.0831	0.0536	0.0343	0.0581	0.057275	0.0831
NB-80	-0.00721	0.118	-0.00471	0.0269	0.036225	0.118
PZ-02	0.0382	0.0247	0.0893	0.00724	0.03986	0.0893

Table 4-15
Sand/Gravel HSU Monitoring Period Summary of Uranium - 235/236

SAND/GRAVEL HSU U-235/236 pCi/L						
Well ID	**1st Quarter Result**	**2nd Quarter Result**	**3rd Quarter Result**	**4th Quarter Result**	**Average**	**Maximum**
GW-BB	0	0.0125	0	-0.00499	0.003125	0.0125
GW-CC	0.047	0.013	0.0245	0.0638	0.037075	0.0638
GW-DD	0.0276	0.00543	0.0358	0	0.0172075	0.0358
GW-EE	0	0	-0.0072	0.0368	0.0092	0.0368
GW-FF	0.0697	0.0398	-0.00527	0.0459	0.03885	0.0697
GW-GG	0.0193	-0.1	0	0.0116	0.007725	0.0193
GW-HH	0.0115	0	0.0134	0.121	0.036475	0.121
GW-II	0.0176	0.0126	-0.00935	-0.00506	0.00755	0.0176
GW-JJ	0	0	-0.0075	0.011	0.00275	0.011
GW-V	0	0.00211	-0.019	0	0.0005275	0.00211
GW-W	0	-0.007	0.015	0	0.00375	0.015
GW-X	0.0125	0.0134	0.00668	0.0305	0.01577	0.0305
GW-Y	0	0.0227	0.0412	0.0134	0.019325	0.0412
NB-34	0.0176	-0.00677	0.0102	-0.0191	0.00695	0.0176
NB-35	-0.0148	0.0054	-0.0322	0.0307	0.009025	0.0307
NB-71	0	-0.00814	0	0.00301	0.0007525	0.00301
NB-80	-0.018	-0.00688	-0.0195	0.00837	0.0020925	0.00837
PZ-02	0.0204	-0.00808	-0.00783	0	0.0051	0.0204

Table 4-16
Sand/Gravel HSU Monitoring Period Summary of Uranium - 238

SAND/GRAVEL HSU U-238 pCi/L						
Well ID	**1st Quarter Result**	**2nd Quarter Result**	**3rd Quarter Result**	**4th Quarter Result**	**Average**	**Maximum**
GW-BB	0.00915	0.0438	-0.00803	0.0561	0.0272625	0.0561
GW-CC	0.704	0.606	0.663	0.518	0.62275	0.704
GW-DD	0.103	0.0218	0.101	0.0214	0.0618	0.103
GW-EE	0.00901	0.00434	0.0358	0.041	0.0225375	0.041
GW-FF	0.494	0.128	0.156	0.287	0.26625	0.494
GW-GG	0.0465	-0.0111	0.261	0.0332	0.085175	0.261
GW-HH	0.203	0.185	0.0925	1.1	0.395125	1.1
GW-II	0.0989	0.0607	0.018	0.0114	0.04725	0.0989
GW-JJ	0.011	0.0692	-0.0321	0.0216	0.02545	0.0692
GW-V	0.0416	0.0203	-0.00457	0.00701	0.0172275	0.0416
GW-W	0.0138	0.0157	-0.0344	0.0394	0.017225	0.0394
GW-X	0.0314	0.043	0.0495	0.0145	0.0346	0.0495
GW-Y	0.277	0.233	0.164	0.169	0.21075	0.277
NB-34	0.0334	0.0728	0.14	0.0865	0.083175	0.14
NB-35	0.0289	0.0274	0.0361	0.0169	0.027325	0.0361
NB-71	0.0099	0.0313	0.00285	0.00644	0.0126225	0.0313
NB-80	0.0115	0.0773	0.011	0.0269	0.031675	0.0773
PZ-02	0.0286	0.0337	~~3.86~~0.0565	0.00161	~~0.98097750~~0.0301	~~3.86~~0.0565

The Sand/Gravel HSU data sets were reviewed for the four quarters of sampling to determine the maximum concentration of each radiological constituent detected during the annual monitoring. Table 4-17 below indicates the maximum concentration detected for each radiological constituent, the monitoring well where the detection occurred, and the quarter in which the maximum detection occurred. In addition, the drinking water MCL and an indication of whether any of the analyses indicated contamination above the MCL. A review of the data set indicates that none of the monitoring well sampling results for any radiological constituent approached or was near the MCL.

Table 4-17
Sand/Gravel HSU Maximum Concentrations of ROCs

Radiological Constituent	Units	Maximum Detected Concentration	MCL	Number of Analyses > MCL	Maximum Location	Maximum Quarter
Technetium-99	pCi/L	80.3 ± 8.24	900	0	GW-X	3rd Quarter
Uranium-234	pCi/L	4.5 ± 0.518	20*	0	GW-HH	4th Quarter
Uranium-235/236	pCi/L	0.121 ± 0.0655	20*	0	GW-HH	4th Quarter
Uranium-238	pCi/L	~~3.86 ± 1.280.565~~1.1±~~0.071~~0.198	20*	0	GW-HH~~PZ-02~~	4th Quarter~~3rd Quarter~~

* Isotopic Evaluation Level since MCL is 30 μg/L for total uranium.

The results of the Mann-Kendell trend analysis for the Sand/Gravel HSU are provided in the table below. The Mann-Kendall analysis showed a downward trend for Tc-99 in monitoring well GW-X, which is the sand/gravel well with the highest detected concentration of Tc-99. The Mann-Kendall analysis also indicated downward trends for Total Uranium in monitoring wells GW-CC, GW-JJ, NB-35, and NB-80. No upward trends were indicated by the analysis, supporting the premise that there is not an expanding plume of radiological contamination within the Sand/Gravel HSU.

The results of the Mann-Kendell trend analysis for the Jefferson City-Cotter HSU are provided in the Table 4-18 below. There were no upward trends indicated for either Technetium-99 or total Uranium during the 4th Quarter sampling. There were downward trends indicated in monitoring wells GW-CC, GW-JJ, NB-35, and NB-80 for total Uranium and in monitoring well GW-X for Technetium-99.

Table 4-18
Mann-Kendell Trend Analysis Results – Sand Gravel HSU

Well ID	Tc-99	Total U
GW-BB	No Trend	No Trend
GW-CC	No Trend	Downward Trend
GW-DD	No Trend	No Trend
GW-EE	No Trend	No Trend
GW-FF	No Trend	No Trend
GW-GG	No Trend	No Trend
GW-HH	No Trend	No Trend
GW-II	No Trend	No Trend
GW-JJ	No Trend	Downward Trend
GW-V	No Trend	No Trend
GW-W	No Trend	No Trend
GW-X	Downward Trend	No Trend
GW-Y	No Trend	No Trend
NB-34	No Trend	No Trend
NB-35	No Trend	Downward Trend
NB-71	No Trend	No Trend
NB-80	No Trend	Downward Trend
PZ-02	No Trend	No Trend

4.4 Calculated Groundwater Dose Contribution

FSSFR Volume 3 Chapter 1 in regards to Groundwater Dose states "*In summary, to support the NRC review of LSA survey area release records prior to the completion of the post remediation groundwater monitoring, the SOF for groundwater will be set at the conservative value of 0.16 in the survey area release records for each LSA. This value is based upon groundwater not exceeding the EPA drinking water standard of 4 millirem/year.*"

Having obtained the required post-remediation groundwater monitoring period sample data the dose contribution that will be assigned to all Land Survey Area survey units for the purpose of demonstrating compliance with the unrestricted release criteria can be calculated. The basis for the use of the average radionuclide concentration from the post-remediation monitoring period is considered to be the optimal reasonable and representative data to determine the groundwater dose contribution as it 1) the data is representative of conditions post remediation rather than pre-remediation, 2) the duration of the monitoring period includes effects of seasonal changes, 3) is consistent with the MARSSIM approach for determining dose contribution.

DP Chapter 5, Section 5.3.8 states "*Groundwater dose will be calculated by multiplying the groundwater concentration identified, if any, for a given ROC by the corresponding DSR_{GW} listed in Table 5-14.*"

The Safety Evaluation Report for the DP Section 4.5, Groundwater {ML112101630} states "*The chemical analyses of groundwater samples collected from the monitoring wells completed in various hydrostratigraphic units confirmed that only Uranium-234, Uranium-235, Uranium-238 and Technetium-99 are the primary radionuclides of concern in groundwater.*" As such, Table 4-19 provides the DSR_{GW} for the radionuclides specified as taken from Table 5-14 of the DP.

Table 4-19
Groundwater DSR_{GW}s for the ROCs (from Table 5-14 of DP)

Radionuclide of Concern	DSR_{GW} (mrem/yr per pCi/L)
Tc-99	9.374 E-04
U-234	0.1532
U-235 + D	0.1448
U-238 + D	0.1455

The average monitoring period concentration is used as the "groundwater concentration identified" as it best represents the ROC concentration within the aquifer and therefore is a reasonable representation of the impacts of drinking water on a person living on the property, and consuming drinking water from underground sources. The average monitoring period concentration is representative of the ROC concentration as it considers 1) the ROC concentration over the entirety of the monitoring period, 2) the monitoring period spans the full seasonal cycle impacts experienced over the course of a year, and 3) the Mann-Kendall trend analysis for all ROCs in all aquifers are demonstrated to be stable or showing a downward trend.

To determine the groundwater dose the average monitoring period concentration for each ROC in each aquifer was multiplied by the DSR_{GW} for the ROC. The calculated dose for each ROC within the aquifer was then summed to determine the calculate groundwater dose for the aquifer (Table 4-20).

Therefore, as can be seen in Table 4-20, the dose an individual is expected to receive as a result of groundwater is 0.68 mrem/year (assuming a drinking water well was installed in the Jefferson City-Cotter aquifer).

In FSSFR Volume 7, *Chapter 1, Final Status Summary Final Report – Summary*, which will be submitted with the request to terminate NRC License SNM-33 for the site, the default groundwater dose contribution to each LSA survey unit will be replaced with the determined groundwater dose contribution of 0.68 mrem/year.

4.4.1 Bounding Scenario – Maximum Quarterly Concentration per HSU

To confirm that a there is not a scenario in which the groundwater dose contribution could exceed the EPA drinking water standard of 4 millirem/year a theoretical ROC maximum concentration scenario was also evaluated for bounding purposes. This scenario assumed the maximum ROC concentration in an individual quarterly result in each aquifer was representative of the entire HSU. These results are shown in Table 4-21.

Under this ~~very conservative and~~ extremely unlikely scenario, which assumes a person in the future will install a well within the Jefferson City-Cotter aquifer, and that the maximum observed ROC concentration was received consistently throughout the entire year, the maximum dose received from groundwater would be 2.11 mrem/year, which is 52.75 % of the EPA drinking water standard.

This evaluation bounds an intruder scenario which assumes a person in the future will install an illegal and unlicensed well within the sand/gravel layer (not a source of potable water), and that the maximum observed ROC concentrations were received consistently throughout the entire year. The maximum dose received would be 1.30 mrem/year.

This scenario is being presented to demonstrate that regardless of how any future members of the public are to use the land comprising the Hematite site, that the dose contribution from groundwater sources will never exceed the EPA drinking water standard of 4 mrem/year.

4.4.2 Bounding Scenario – Maximum Quarterly Concentration for all HSUs

An additional bounding scenario was also considered when assessing the groundwater dose contribution for compliance with the release criteria. The scenario assumed the maximum quarterly radionuclide result as the concentration in the groundwater, regardless of the HSU from which the result originated. Therefore, for this bounding scenario, the maximum hypothetical result for Tc-99 used originated from the Sand/Gravel HSU, while the maximum hypothetical results from the uranium isotopes originated from the Jefferson City-Cotter HSU.

While this scenario is considered by Westinghouse to be incredible due to 1) the limited extent and thickness of the Sand/Gravel HSU, 2) the State of Missouri regulations regarding placement of potable water wells in formations like the Sand/Gravel HSU, and 3) the future monitoring and control of the facility to accomplish chemical groundwater remediation as approved by the State of Missouri Department of Natural Resources, the results of this scenario supports the conclusion that the dose contribution from groundwater sources, calculated to be 2.186 mrem/year, does not exceed the EPA drinking water standard of 4 mrem/year. The results of this scenario are shown in Table 4-22.

Table 4-20
Calculated Groundwater Dose

Groundwater Formation	Monitoring Period Average Tc-99 (pCi/L)	x	DSR_{GW} (mrem/yr per pCi/L)	=	Dose Contribution from Radionuclide	Monitoring Period Average U233/234 (pCi/L)	x	DSR_{GW} (mrem/yr per pCi/L)	=	Dose Contribution from Radionuclide	Monitoring Period Average U-235/236 (pCi/L)	x	DSR_{GW} (mrem/yr per pCi/L)	=	Dose Contribution from Radionuclide	Monitoring Period Average U-238 (pCi/L)	x	DSR_{GW} (mrem/yr per pCi/L)	=	Dose Contribution from Radionuclide	Calculated Groundwater Dose (mem/year)
Sand/Gravel HSU	5.994	x	9.374 E-04	=	0.0056	0.218	x	0.1532	=	0.0334	0.0124	x	0.1448	=	0.0018	0.165	x	0.1455	=	0.0240	**0.06**
Jefferson City-Cotter HSU	0.131	x	9.374 E-04	=	0.0001	3.825	x	0.1532	=	0.5860	0.0474	x	0.1448	=	0.0069	0.5794	x	0.1455	=	0.0843	**0.68**
Roubidoux HSU	0.0682	x	9.374 E-04	=	0.00006	2.8768	x	0.1532	=	0.4407	0.0252	x	0.1448	=	0.0036	0.3024	x	0.1455	=	0.0440	**0.49**

Table 4-21
Calculated Groundwater Dose – Maximum ~~Average~~Quarterly Concentration Scenario per HSU

Groundwater Formation	Maximum Detected Tc-99 (pCi/L)	x	DSR_{GW} (mrem/yr per pCi/L)	=	Dose Contribution from Radionuclide	Maximum Detected U-233/234 (pCi/L))	x	DSR_{GW} (mrem/yr per pCi/L)	=	Dose Contribution from Radionuclide	Maximum Detected U-235/236 (pCi/L)	x	DSR_{GW} (mrem/yr per pCi/L)	=	Dose Contribution from Radionuclide	Maximum Detected U-238 (pCi/L)	x	DSR_{GW} (mrem/yr per pCi/L)	=	Dose Contribution from Radionuclide	Calculated Groundwater Dose Based on Maximum Concentration (mem/year)
Sand/Gravel HSU	80.3	x	9.374 E-04	=	0.0753	4.5	x	0.1532	=	0.6894	0.121	x	0.1448	=	0.0175	3.56	x	0.1455	=	0.5180	**1.30**
Jefferson City-Cotter HSU	1.19	x	9.374 E-04	=	0.0011	11.7	x	0.1532	=	1.7924	0.149	x	0.1449	=	0.0216	2.04	x	0.1455	=	0.2968	**2.11**
Roubidoux HSU	0.969	x	9.374 E-04	=	0.0009	6.2	x	0.9498	=	0.4407	0.0757	x	0.1448	=	0.0110	0.717	x	0.1455	=	0.1043	**0.56**

Table 4-22

Calculated Groundwater Dose – Maximum Quarterly Concentration Scenario for All HSUs

Radionuclide of Concern	HSU	Maximum Detected Activity (pCi/L)	DSR_{GW} (mrem/yr per pCi/L)	Dose Contribution from Radionuclide (mrem/year)
Tc-99	Sand/Gravel	80.3	9.374 E-04	0.075
U-233/234	Jefferson City-Cotter	11.7	0.1532	1.792
U-235/236	Jefferson City-Cotter	0.149	0.1448	0.022
U-238	Jefferson City-Cotter	2.04	0.1455	0.297
			Sum of Dose Contributions:	**2.186**

4.4.3 Uncertainty Analysis

To evaluate the potential impact of uncertainties associated with the ROC detections, Westinghouse used the data from the maximum quarterly concentration scenario groundwater dose (Table 4-22) and added the uncertainty to the detected value as shown in Table 4-23 below.

Table 4-23

Maximum Quarterly Concentration Scenario for All HSUs with Uncertainty

Radionuclide of Concern	HSU	Maximum Detected Activity (pCi/L)	Uncertainty (pCi/L)	Activity Maximum Detected + Uncertainty (pCi/L)	DSR_{GW} (mrem/yr per pCi/L)	Dose Contribution from Radionuclide (mrem/year)
Tc-99	Sand/Gravel	80.3	8.24	88.54	9.374 E-04	0.083
U-233/234	Jefferson City-Cotter	11.7	1.39	13.09	0.1532	2.005
U-235/236	Jefferson City-Cotter	0.149	0.0804	0.2294	0.1448	0.033
U-238	Jefferson City-Cotter	2.04	0.44	2.48	0.1455	0.361
					Sum of Dose Contributions:	**2.482**

Using this method, the calculated worst-case groundwater dose including sample uncertainty was 2.482 mrem/year, which is below the EPA standard of 4 mrem/year. Westinghouse used this calculation to determine that the effect of uncertainty on the dose calculation would not result in a false negative situation, where the groundwater dose would be incorrectly assumed to be below the EPA standard. Instead, this uncertainty analysis demonstrates that there was not a potential

for a false negative due to uncertainty, as the maximum concentrations plus the error did not result in exceedance of the EPA standard of 4 mrem/year.

4.5 HSU Groundwater Elevation Contour Maps

To evaluate the potential seasonal effects on the groundwater elevation and flow, groundwater elevations were collected from monitoring wells prior to the initiation of sampling. The water levels were collected within a 24 hour period to minimize the potential change in environmental parameters, such as precipitation, infiltration and barometric pressure, on the wells so an accurate temporal representation could be depicted.

The groundwater elevation contour maps for the Jefferson City-Cotter HSU, Roubidoux HSU and the Sand/Gravel HSU for the 4 Quarters of post-remediation groundwater monitoring period are provided in Attachment 3. There were no perceived changes in groundwater flow throughout the annual monitoring.

5.0 Tc– 99 EVALUATION IN SOIL ADJACENT TO HYBRID WELLS

In a response to a Request for Additional Information (RAI) on DP Chapter 3 (HDP-3-Q9), Westinghouse responded in Westinghouse letter HEM-11-56 {ML111260624} that an investigation protocol (Former Process Buildings Investigation Area and Hybrid Well Investigation) would be applied to the abandonment of hybrid wells. This commitment was intended to verify that hybrid wells were not introducing or creating a pathway from the leachate zone (silty/clay aquitard) to the underlying sand/gravel layer.

Westinghouse Technical Report, HDP-RPT-FSS-302, Summary Report of Investigations of Hybrid Wells and Former Process Buildings Investigation Area (Appendix E), describes the actions taken which included conducting borings in the close proximity to four specified wells and collect soil samples to the top of sand/gravel layer for radionuclide analysis to complete the investigations and the analytical results obtained.

The analytical results were used in the planning of remediation of the site and also for determination of the appropriate Conceptual Site Model DCGLs (uniform or Three Stratum) to be used to demonstrate compliance with the unrestricted release criteria.

6.0 ABANDONMENT OF GROUNDWATER MONITORING WELLS

As captured by the NRC in the Safety Evaluation Report {ML112101630}, Westinghouse committed to the abandonment of selected wells.

The first group of monitoring wells to be abandoned were selected hybrid wells identified with leachate impacted with radionuclides. These wells included PL-06, NB-33, EP-20, BD-14, WS-13, NB-31, NB-81, WS-17B, and DM-02. Prior to removal of these wells, a paired well, installed with a well screen solely in the sand/grave was placed adjacent to each well. This paired well analysis is discussed in FSSFR Volume 6, Chapter 1, Revision 1. These wells were removed during the pre-remediation preparations and during the time the SER was being finalized.

Subsequent to the issuance of the SER Westinghouse investigated the hybrid wells in the vicinity of the Former Process Buildings, and the location where Tc-99 was detected in leachate water above the investigation level. Because the wells, BD-01, BD-02, BD-03, BD-04, BD-05, BD-06, BD-08, and BD-13, exceeded the investigation threshold, composite samples of the surrounding soil were collected. The sampling of the soil adjacent to the wells began in July of 2013 and continued through August. The samples were from each 5 foot increment of depth to the top of the screened/filtered interval; from the increment that is equivalent to the top half of the screened/filtered interval; and from the increment that is equivalent to the bottom half of the screened/filtered interval.

Concurrent with the Former Process Building evaluation, hybrid well investigation sampling was performed additional wells that were located in the suspected impacted area and where monitoring well samples exceeded an investigation threshold. These addition wells included BP-17, EP-14, EP-15, EP-16, LF-08, LF-09, PL-06, and WS-32. The results of this investigation were reported in HDP-RPT-FSS-302. The removal of the hybrid wells and surrounding impacted soil in these areas, combined with the FSS, indicate that there is not a threat of cross-communication between the impacted silty clay and the underlying sand/gravel HSU.

There are still existing hybrid wells on site but they are installed at locations that were not found to be impacted by Tc-99 and were remediation of the overburden soil was not required. These well are listed in Table 6.1, Remaining Hybrid Wells. Since there is no residual contamination within the leachate zone at these locations, these wells do not pose a cross-communication threat between the silty clay overburden and the underlying sand/gravel HSU.

Table 6-1
Remaining Hybrid Wells

Well Designation	Location
NB-34	South of Railroad
NB-35	South of Railroad
NB-85	South of Railroad, Western Portion
OB-01	West of Site Near Highway P
OB-02	East of Site, South McKee property
PZ-02	South of Railroad
NB-50	North of Building 110
NB-54	In Parking Lot
NB-57A	In Parking Lot
NB-71	South of Laydown Area
NB-80	East of Former Burial Pits
WS-34	West of Building 231

7.0 CONCLUSIONS

There were no indications of Radionuclides of Concern above the EPA MCLs in any of the HSUs at the Westinghouse Hematite Facility during the post-remediation monitoring period.

Prior to remediation and as summarized in FSSFR Volume 6, Chapter 1, Revision 1, the silty clay unit above the Sand/Gravel HSU contained contamination in the form of leachate which is not usable groundwater. As the source term has been removed during the remediation of the site, an overall upward trend in contamination was not anticipated, and has been shown through the post-remediation monitoring not to be occurring. Therefore, the analytical data for the sampling that was conducted post-remediation of the site supports the conclusion that remediation activities did not impact groundwater

In addition, the estimated dose from groundwater sources has been estimated using the post-remediation monitoring data and has shown the dose contribution from groundwater to be less than 4 mrem/year. Therefore, the dose contribution from groundwater will be reduced from 4 mrem/year, down to 0.68 mrem/year for all LSA SUs. This dose will be reflected in the final site dose summary provided in FSSFR Volume 7, Chapter 1.

8.0 REFERENCES

8.1 DO-08-004, Hematite Decommissioning Plan {ML092330123}

8.2 Westinghouse letter HEM-11-56, *"Evaluation of Technetium-99 Under the Process Buildings"*, dated May 5, 2011 {ML111260624}

8.3 Westinghouse letter HEM-16-6, *Revision to the Physical Security Plan Dated September 11, 2013*, dated January 18, 2016 {ML16020A479}

8.4 U. S. NRC Safety Evaluation Report on Westinghouse Amendment Request for Approval of Hematite Decommissioning Plan and Associated Supporting Documents, October 2011 {ML112101630}

8.5 Mann-Kendall Test for Analysis of Groundwater Contaminant Plume Stability and Evaluation of Sampling Frequency for Long-Term Monitoring – 13233, Jeffrey R. Walker and Toby R. Harrison, Elvado Environmental LLC, 9724 Kingston Pike, Suite 603, Knoxville, TN 37922

9.0 APPENDICES (To Be Provided On Separate Data Disc)

APPENDIX A: Laboratory Data Packages Post-remediation Groundwater Monitoring 1st Quarter Results

APPENDIX B: Laboratory Data Packages Post-remediation Groundwater Monitoring 2nd Quarter Results

APPENDIX C: Laboratory Data Packages Post-remediation Groundwater Monitoring 3rd Quarter Results

APPENDIX D: Laboratory Data Packages Post-remediation Groundwater Monitoring 4th Quarter Results

APPENDIX E: HDP-RPT-FSS-302, Summary Report of Investigations of Hybrid Wells and Former Process Buildings Investigation Area

Attachment 1

Post-remediation Groundwater Monitoring Period Summary of Results

JEFFERSON CITY – COTTER HSU
Tc-99 pCi/L

Well ID	1st Quarter			2nd Quarter			3rd Quarter			4th Quarter			Average	Maximum
	Result	MDC	Error	Result	MDC	Error	Result	MDC	Error	Result	MDC	Error		
BR-04-JC	-1.16	2.11	1.21	-0.266	1.9	1.1	0.528	2.61	1.55	0.306	1.56	0.931	0.2085	0.528
BR-13-JC	-0.695	1.98	1.13	-0.117	1.8	1.05	-0.657	1.96	1.13	0.162	1.65	0.978	0.0405	0.162
BR-14-JC	-1.24	2.19	1.22	-0.126	1.87	1.08	-0.927	2.17	1.24	1.19	1.65	1.02	0.2975	1.19
BR-15-JC	-0.33	2.17	1.26	-0.683	2.38	1.38	-0.471	2.02	1.17	0.919	1.56	0.953	0.22975	0.919
BR-16-JC	-0.767	2.11	1.22	-0.946	2.17	1.24	0.567	1.97	1.18	-1.09	1.97	1.12	0.14175	0.567
BR-17-JC	-0.402	2.6	1.51	-0.307	2.05	1.19	-0.901	2	1.14	-0.718	3.59	2.09	0	-0.307
BR-18-JC	0.0809	1.82	1.07	-0.899	2.01	1.15	0.054	1.98	1.16	-0.358	1.63	0.946	0.033725	0.0809
BR-19-JC	0.276	2.31	1.36	-0.648	1.99	1.14	0.0273	2	1.17	0.0784	1.68	1.02	0.095425	0.276

JEFFERSON CITY – COTTER HSU
U-233/234 pCi/L

Well ID	1st Quarter			2nd Quarter			3rd Quarter			4th Quarter			Average	Maximum
	Result	MDC	Error	Result	MDC	Error	Result	MDC	Error	Result	MDC	Error		
BR-04-JC	2.81	0.0288	0.404	3.32	0.0931	0.516	2.89	0.12	0.498	2.68	0.0551	0.397	2.925	3.32
BR-13-JC	4.02	0.0621	0.522	4.16	0.0504	0.49	4.34	0.136	0.655	4.05	0.0827	0.47	4.1425	4.34
BR-14-JC	3.74	0.0319	0.508	3.56	0.0991	0.476	4.01	0.177	0.741	3.21	0.0788	0.395	3.63	4.01
BR-15-JC	1.38	0.0745	0.26	1.33	0.0859	0.27	1.13	0.116	0.301	1.37	0.0871	0.264	1.3025	1.38
BR-16-JC	1.72	0.11	0.283	4.59	0.0744	0.572	5.4	0.09	0.747	4.18	0.0553	0.479	3.9725	5.4
BR-17-JC	11.7	0.249	1.39	4.91	0.0976	0.609	2.73	0.166	0.479	2.84	0.0451	0.372	5.545	11.7
BR-18-JC	2.64	0.0838	0.406	2.25	0.0862	0.354	2.15	0.0995	0.434	2.08	0.0805	0.285	2.28	2.64
BR-19-JC	6.26	0.0538	0.7	7.02	0.0906	0.783	7.21	0.0537	0.939	6.72	0.0933	0.703	6.8025	7.21

JEFFERSON CITY – COTTER HSU U-235/236														
Well ID	1st Quarter			2nd Quarter			3rd Quarter			4th Quarter			Average	Maximum
	Result	MDC	Error	Result	MDC	Error	Result	MDC	Error	Result	MDC	Error		
BR-04-JC	0.0477	0.0358	0.06	0.0705	0.0529	0.0707	-0.0253	0.149	0.0292	0.0145	0.0815	0.038	0.033175	0.0705
BR-13-JC	0.0168	0.0773	0.02	0.0709	0.0266	0.0505	-0.0087	0.116	0.0176	0.0537	0.0611	0.0473	0.03535	0.0709
BR-14-JC	0.0662	0.0397	0.01	0.0474	0.0355	0.0476	0.112	0.27	0.16	0.0554	0.0238	0.0422	0.07025	0.112
BR-15-JC	0.0241	0.0362	0.05	0.0139	0.0417	0.0278	-0.0183	0.144	0.0259	0.0501	0.0376	0.0503	0.022025	0.0501
BR-16-JC	0.0204	0.0781	0.07	0.0286	0.076	0.0444	0.101	0.0608	0.091	0.0394	0.0236	0.0354	0.04735	0.101
BR-17-JC	0.126	0.192	0.18	0.0221	0.097	0.0491	0.0228	0.128	0.0598	0.0267	0.0267	0.0309	0.0494	0.126
BR-18-JC	0.0187	0.0857	0.03	0.0491	0.0368	0.0492	0.0243	0.314	0.157	0.0279	0.0571	0.0358	0.03	0.0491
BR-19-JC	0.149	0.0318	~~2.8~~0.0804	0.0468	0.0351	0.047	0.0668	0.0668	0.0773	0.104	0.0241	0.0585	0.09165	0.149

JEFFERSON CITY – COTTER HSU U-238 pCi/L														
Well ID	1st Quarter			2nd Quarter			3rd Quarter			4th Quarter			Average	Maximum
	Result	MDC	Error	Result	MDC	Error	Result	MDC	Error	Result	MDC	Error		
BR-04-JC	0.402	0.0287	0.129	0.461	0.0781	0.167	0.394	0.131	0.171	0.262	0.0801	0.109	0.37975	0.461
BR-13-JC	0.59	0.0858	0.164	0.299	0.0213	0.0955	0.29	0.111	0.147	0.361	0.075	0.106	0.385	0.59
BR-14-JC	0.435	0.0318	0.141	0.678	0.06	0.171	0.568	0.176	0.258	0.604	0.0786	0.139	0.57125	0.678
BR-15-JC	0.358	0.029	0.121	0.345	0.0334	0.127	0.194	0.0529	0.118	0.237	0.0555	0.101	0.2835	0.358
BR-16-JC	0.655	0.0627	0.158	0.888	0.029	0.2	0.822	0.0898	0.242	0.77	0.0189	0.154	0.78375	0.888
BR-17-JC	2.04	0.0605	0.44	0.828	0.105	0.201	0.49	0.126	0.186	0.436	0.0623	0.12	0.9485	2.04
BR-18-JC	0.433	0.0837	0.145	0.216	0.0295	0.0941	0.239	0.235	0.173	0.118	0.0804	0.0659	0.2515	0.433
BR-19-JC	1.05	0.0255	0.209	1.11	0.0282	0.224	0.995	0.132	0.283	0.972	0.09	0.183	1.03175	1.11

ROUBIDOUX HSU
Tc-99 pCi/L

Well ID	1st Quarter			2nd Quarter			3rd Quarter			4th Quarter			Average	Maximum
	Result	MDC	Error	Result	MDC	Error	Result	MDC	Error	Result	MDC	Error		
BR-03R-RB	-1.08	2.42	1.4	-1.09	2.07	1.18	-0.207	1.98	1.15	-0.0105	1.83	1.07	0	-0.0105
BR-04-RB	-0.478	2.11	1.23	0.394	2.11	1.26	-0.738	1.97	1.13	-0.962	2.1	1.2	0.0985	0.394
BR-08-RB	-0.937	2.11	1.21	-0.37	3.12	1.83	-0.369	2.01	1.16	-1.13	1.96	1.12	0	-0.369
BR-10-RB	-1.13	2.12	1.22	-0.162	1.8	1.05	-1.13	1.99	1.13	0.969	1.58	0.97	0.24225	0.969
WS-04	-0.11	1.92	1.12	-0.37	2.32	1.35	-0.852	2.01	1.15	-1.77	1.97	1.11	0	-0.11

ROUBIDOUX HSU
U-233/234 pCi/L

Well ID	1st Quarter			2nd Quarter			3rd Quarter			4th Quarter			Average	Maximum
	Result	MDC	Error	Result	MDC	Error	Result	MDC	Error	Result	MDC	Error		
BR-03R-RB	1.9	0.142	0.331	2	0.0869	0.346	2.01	0.121	0.422	1.69	0.0682	0.25	1.9	2.01
BR-04-RB	2.41	0.0265	0.355	2.45	0.0613	0.371	2.58	0.133	0.544	2.43	0.0652	0.329	2.4675	2.58
BR-08-RB	6.2	0.11	0.732	5.21	0.061	0.627	6.01	0.15	0.896	6.09	0.0401	0.645	5.8775	6.2
BR-10-RB	2.91	0.0324	0.431	3.21	0.07	0.404	2.82	0.175	0.526	3.26	0.0629	0.401	3.05	3.26
WS-04	1.05	0.096	0.286	0.936	0.0984	0.271	1.25	0.244	0.339	1.12	0.0945	0.203	1.089	1.25

ROUBIDOUX HSU
U-235/236 pCi/L

Well ID	1st Quarter			2nd Quarter			3rd Quarter			4th Quarter			Average	Maximum
	Result	MDC	Error	Result	MDC	Error	Result	MDC	Error	Result	MDC	Error		
BR-03R-RB	0.0392	0.0392	0.0454	0.0422	0.0422	0.0489	0.0134	0.127	0.0497	0.000953	0.0667	0.0272	0.0239383	0.0422
BR-04-RB	0.00412	0.0695	0.0259	0	0.0362	0.0151	0.0473	0.165	0.0881	0.0168	0.0253	0.0239	0.017055	0.0473
BR-08-RB	0.0757	0.101	0.0737	0.0722	0.0361	0.0592	-0.0472	0.228	0.0473	0.0237	0.0237	0.0275	0.0429	0.0757
BR-10-RB	0.0185	0.0848	0.0416	0.00867	0.026	0.0174	0.0237	0.071	0.0474	0	0.0244	0.0102	0.0127175	0.0237
WS-04	0.0216	0.0648	0.0433	0.0222	0.0665	0.0444	0.0395	0.167	0.0849	0.0347	0.0735	0.0451	0.0295	0.0395

ROUBIDOUX HSU
U-238 pCi/L

Well ID	1st Quarter			2nd Quarter			3rd Quarter			4th Quarter			Average	Maximum
	Result	MDC	Error	Result	MDC	Error	Result	MDC	Error	Result	MDC	Error		
BR-03R-RB	0.169	0.147	0.11	0.158	0.0338	0.0855	0.158	0.102	0.112	0.115	0.047	0.0566	0.15	0.169
BR-04-RB	0.204	0.0771	0.0919	0.281	0.0291	0.107	0.206	0.132	0.146	0.241	0.0519	0.0854	0.233	0.281
BR-08-RB	0.426	0.0667	0.14	0.306	0.0742	0.115	0.503	0.149	0.223	0.381	0.0554	0.106	0.404	0.503
BR-10-RB	0.123	0.068	0.0765	0.125	0.0209	0.0599	0.144	0.105	0.109	0.135	0.0501	0.0632	0.13175	0.144
WS-04	0.607	0.052	0.211	0.508	0.0982	0.197	0.541	0.199	0.221	0.717	0.0426	0.152	0.59325	0.717

SAND/GRAVEL HSU

Tc-99 pCi/L

Well ID	**1st Quarter**			**2nd Quarter**			**3rd Quarter**			**4th Quarter**			**Average**	**Maximum**
	Result	**MDC**	**Error**	**Result**	**MDC**	**Error**	**Result**	**MDC**	**Error**	**Result**	**MDC**	**Error**		
GW-BB	-0.036	1.79	1.05	0.405	1.79	1.07	1.93	1.97	1.24	0.793	1.57	0.952	0.782	1.93
GW-CC	3.6	1.94	1.31	2.66	2.29	1.46	3.95	1.91	1.32	6.12	1.68	1.32	4.0825	6.12
GW-DD	4.82	2.12	1.48	5.06	2.18	1.53	3.91	1.96	1.34	4.23	2.18	1.48	4.505	5.06
GW-EE	1.72	1.81	1.14	1.51	2.08	1.29	1.95	1.94	1.23	1.51	1.73	1.08	1.6725	1.95
GW-FF	3.05	1.84	1.23	3.58	2.08	1.39	1.93	1.96	1.24	1.32	2.53	1.54	2.47	3.58
GW-GG	-0.563	2.34	1.32	-0.0554	2.03	1.19	-0.667	2.88	1.66	1	1.74	1.06	0.25	1
GW-HH	-0.513	1.93	1.11	-0.478	1.81	1.04	-0.234	1.97	1.15	-0.764	1.97	1.13	0	-0.234
GW-II	-0.252	2.09	1.2	-1.27	2.12	1.2	0.0832	2.18	1.28	0.243	1.56	0.928	0.08155	0.243
GW-JJ	5.69	1.98	1.48	4.12	1.91	1.34	3.28	1.98	1.32	6.83	1.71	1.38	4.98	6.83
GW-V	5.12	1.83	1.36	4.88	1.9	1.38	4.68	1.85	1.33	2.65	2.08	1.34	4.3325	5.12
GW-W	1.17	2.25	1.37	0.322	1.95	1.16	0.373	2.09	1.25	0.486	1.56	0.937	0.58775	1.17
GW-X	61.4	1.83	6.43	71	1.8	7.32	80.3	2.01	8.24	75.7	1.97	7.78	72.1	80.3
GW-Y	3.29	2.04	1.36	3.68	1.83	1.26	3.35	1.99	1.33	2.65	2.08	1.34	3.2425	3.68
NB-34	2.27	2.22	1.4	4.5	1.8	1.3	3.46	1.99	1.33	2.17	2.46	1.54	3.1	4.5
NB-35	2.38	2.11	1.35	1.33	2.01	1.23	1.94	2	1.25	3.02	1.64	1.1	2.1675	3.02
NB-71	0.23	2	1.18	-1.03	2.13	1.22	-0.315	1.98	1.15	-0.989	1.97	1.13	0.0575	0.23
NB-80	0.522	1.81	1.08	-0.414	2.08	1.21	-0.153	1.99	1.16	-1.3	1.97	1.12	0.1305	0.522
PZ-02	2.5	2.03	1.31	4.73	1.95	1.4	3.86	1.86	1.28	2.29	2.07	1.31	3.345	4.73

SAND/GRAVEL HSU
U-233/234 pCi/L

Well ID	1st Quarter			2nd Quarter			3rd Quarter			4th Quarter			Average	Maximum
	Result	MDC	Error	Result	MDC	Error	Result	MDC	Error	Result	MDC	Error		
GW-BB	0	0.0472	0.0131	0.0251	0.0966	0.0514	0.0306	0.107	0.057	0.0417	0.0618	0.0419	0.02435	0.0417
GW-CC	0.97	0.12	0.187	0.928	0.0804	0.214	0.746	0.17	0.259	0.709	0.0674	0.182	0.83825	0.97
GW-DD	0.148	0.0817	0.0763	0.0422	0.137	0.0764	0.0378	0.176	0.0906	0.00875	0.0402	0.0197	0.0591875	0.148
GW-EE	0.226	0.0856	0.122	0.0392	0.0733	0.0487	0.0185	0.112	0.0534	0.00657	0.1	0.0458	0.0725675	0.226
GW-FF	0.723	0.0899	0.179	0.366	0.0673	0.13	0.284	0.125	0.148	0.649	0.0561	0.142	0.5055	0.723
GW-GG	0.0868	0.0859	0.0776	0	0.123	0.0566	0.235	0.235	0.272	0.00929	0.279	0.0186	0.0827725	0.235
GW-HH	0.518	0.0278	0.145	1.02	0.0293	0.218	0.3	0.122	0.156	4.5	0.0534	0.518	1.5845	4.5
GW-II	0.127	0.0425	0.0856	0.0406	0.0304	0.0407	0.00902	0.166	0.0725	0.0602	0.0642	0.0532	0.059205	0.127
GW-JJ	0.0371	0.0694	0.0462	0.00882	0.0836	0.0328	-0.0221	0.233	0.0864	-0.0152	0.0756	0.028	0.01148	0.0371
GW-V	0.0833	0.0416	0.0684	0.0645	0.0892	0.0627	0.0458	0.168	0.0902	-0.00312	0.095	0.0392	0.0484	0.0833
GW-W	0.0691	0.0414	0.062	0.0225	0.0867	0.0461	0.0482	0.166	0.0896	-0.00632	0.0764	0.0247	0.03495	0.0691
GW-X	0.00503	0.0969	0.043	0.0188	0.0828	0.0419	0.0496	0.156	0.0866	0.0353	0.0472	0.0344	0.0271825	0.0496
GW-Y	0.33	0.0807	0.143	0.287	0.116	0.115	0.374	0.0916	0.163	0.279	0.0322	0.112	0.3175	0.374
NB-34	0.058	0.198	0.11	0.0621	0.0964	0.0669	0.109	0.103	0.087	0.0777	0.114	0.0758	0.0767	0.109
NB-35	-0.0461	0.167	0.0696	0.0275	0.0731	0.0427	0.131	0.167	0.122	0.04	0.0593	0.0402	0.049625	0.131
NB-71	0.0831	0.0626	0.0612	0.0536	0.0915	0.06	0.0343	0.0514	0.0486	0.0581	0.0194	0.039	0.057275	0.0831
NB-80	-0.00721	0.0729	0.0144	0.118	0.0559	0.0679	-0.00471	0.139	0.0464	0.0269	0.0202	0.027	0.036225	0.118
PZ-02	0.0382	0.132	0.071	0.0247	0.0551	0.0338	0.0893	0.131	0.0902	0.00724	0.0712	0.0307	0.03986	0.0893

SAND/GRAVEL HSU
U-235/236 pCi/L

Well ID	1st Quarter			2nd Quarter			3rd Quarter			4th Quarter			Average	Maximum
	Result	MDC	Error	Result	MDC	Error	Result	MDC	Error	Result	MDC	Error		
GW-BB	0	0.0587	0.0163	0.0125	0.0375	0.025	0	0.0721	0.02	-0.00499	0.0505	0.01	0.003125	0.0125
GW-CC	0.047	0.105	0.0629	0.013	0.0391	0.0261	0.0245	0.0735	0.049	0.0638	0.0383	0.0573	0.037075	0.0638
GW-DD	0.0276	0.0703	0.0412	0.00543	0.0915	0.0342	0.0358	0.125	0.0667	0	0.0238	0.0099	0.0172075	0.0358
GW-EE	0	0.0578	0.0161	0	0.0433	0.0181	-0.0072	0.0955	0.0144	0.0368	0.0368	0.0426	0.0092	0.0368
GW-FF	0.0697	0.0349	0.0572	0.0398	0.0398	0.046	-0.00527	0.155	0.052	0.0459	0.0614	0.0447	0.03885	0.0697
GW-GG	0.0193	0.058	0.0387	-0.1	0.185	0.0563	0	0.293	0.325	0.0116	0.0347	0.0231	0.007725	0.0193
GW-HH	0.0115	0.0346	0.0231	0	0.0364	0.0152	0.0134	0.127	0.05	0.121	0.0259	0.0655	0.036475	0.121
GW-II	0.0176	0.0528	0.0353	0.0126	0.0379	0.0253	-0.00935	0.124	0.0187	-0.00506	0.0672	0.0101	0.00755	0.0176
GW-JJ	0	0.041	0.0171	0	0.0565	0.0157	-0.0075	0.221	0.0739	0.011	0.0504	0.0247	0.00275	0.011
GW-V	0	0.0518	0.0144	0.00211	0.0896	0.033	-0.019	0.15	0.0269	0	0.035	0.00971	0.0005275	0.00211
GW-W	0	0.0516	0.0143	-0.007	0.0707	0.014	0.015	0.142	0.0557	0	0.0354	0.00983	0.00375	0.015
GW-X	0.0125	0.0376	0.0251	0.0134	0.0402	0.0268	0.00668	0.161	0.0658	0.0305	0.0229	0.0306	0.01577	0.0305
GW-Y	0	0.0545	0.0151	0.0227	0.0739	0.0402	0.0412	0.0619	0.0584	0.0134	0.0401	0.0267	0.019325	0.0412
NB-34	0.0176	0.166	0.0757	-0.00677	0.0899	0.0136	0.0102	0.0964	0.0378	-0.0191	0.138	0.0536	0.00695	0.0176
NB-35	-0.0148	0.137	0.0522	0.0054	0.0909	0.034	-0.0322	0.19	0.0372	0.0307	0.023	0.0308	0.009025	0.0307
NB-71	0	0.037	0.0154	-0.00814	0.0823	0.0163	0	0.064	0.0178	0.00301	0.0507	0.0189	0.0007525	0.00301
NB-80	-0.018	0.11	0.0254	-0.00688	0.0696	0.0138	-0.0195	0.154	0.0277	0.00837	0.0251	0.0168	0.0020925	0.00837
PZ-02	0.0204	0.0611	0.0408	-0.00808	0.0686	0.0162	-0.00783	0.104	0.0157	0	0.036	0.01	0.0051	0.0204

SAND/GRAVEL HSU U-238 pCi/L														
Well ID	**1st Quarter**			**2nd Quarter**			**3rd Quarter**			**4th Quarter**			**Average**	**Maximum**
	Result	**MDC**	**Error**	**Result**	**MDC**	**Error**	**Result**	**MDC**	**Error**	**Result**	**MDC**	**Error**		
GW-BB	0.00915	0.0867	0.034	0.0438	0.0632	0.0466	-0.00803	0.107	0.0161	0.0561	0.0493	0.0423	0.0272625	0.0561
GW-CC	0.704	0.0695	0.149	0.606	0.0313	0.167	0.663	0.145	0.241	0.518	0.0566	0.153	0.62275	0.704
GW-DD	0.103	0.0706	0.0631	0.0218	0.121	0.0613	0.101	0.1	0.0905	0.0214	0.0401	0.0267	0.0618	0.103
GW-EE	0.00901	0.0854	0.0335	0.00434	0.0731	0.0273	0.0358	0.0766	0.0494	0.041	0.0647	0.0456	0.0225375	0.041
GW-FF	0.494	0.0279	0.142	0.128	0.0319	0.0744	0.156	0.179	0.13	0.287	0.0492	0.0908	0.26625	0.494
GW-GG	0.0465	0.0465	0.0539	-0.0111	0.103	0.0394	0.261	0.777	0.437	0.0332	0.0512	0.038	0.085175	0.261
GW-HH	0.203	0.0277	0.0883	0.185	0.0292	0.0863	0.0925	0.0555	0.0831	1.1	0.0208	0.198	0.395125	1.1
GW-II	0.0989	0.0424	0.0752	0.0607	0.0304	0.0498	0.018	0.054	0.036	0.0114	0.0641	0.0299	0.04725	0.0989
GW-JJ	0.011	0.0329	0.022	0.0692	0.0835	0.0689	-0.0321	0.244	0.0886	0.0216	0.0405	0.0269	0.02545	0.0692
GW-V	0.0416	0.0416	0.0481	0.0203	0.0305	0.0288	-0.00457	0.135	0.0451	0.00701	0.0689	0.0297	0.0172275	0.0416
GW-W	0.0138	0.0414	0.0276	0.0157	0.069	0.0349	-0.0344	0.166	0.0345	0.0394	0.0622	0.0439	0.017225	0.0394
GW-X	0.0314	0.0878	0.05	0.043	0.0322	0.0431	0.0495	0.156	0.0864	0.0145	0.0387	0.0226	0.0346	0.0495
GW-Y	0.277	0.0437	0.129	0.233	0.101	0.102	0.164	0.143	0.119	0.169	0.079	0.0908	0.21075	0.277
NB-34	0.0334	0.101	0.0565	0.0728	0.0721	0.0651	0.14	0.042	0.0892	0.0865	0.0839	0.0672	0.083175	0.14
NB-35	0.0289	0.0809	0.0461	0.0274	0.0729	0.0426	0.0361	0.152	0.0775	0.0169	0.0473	0.0269	0.027325	0.0361
NB-71	0.0099	0.0297	0.0198	0.0313	0.0313	0.0363	0.00285	0.113	0.0397	0.00644	0.0193	0.0129	0.0126225	0.0313
NB-80	0.0115	0.0346	0.0231	0.0773	0.0679	0.0584	0.011	0.104	0.0407	0.0269	0.0201	0.027	0.031675	0.0773
PZ-02	0.0286	0.121	0.0614	0.0337	0.0681	0.0424	~~3.86~~0.0565	1.~~86~~11	~~1.28~~0.071	0.00161	0.0634	0.0224	~~0.9809775~~0.0301	~~3.86~~0.0565

Attachment 2

Mann-Kendall Analysis and Sample Results Graphs

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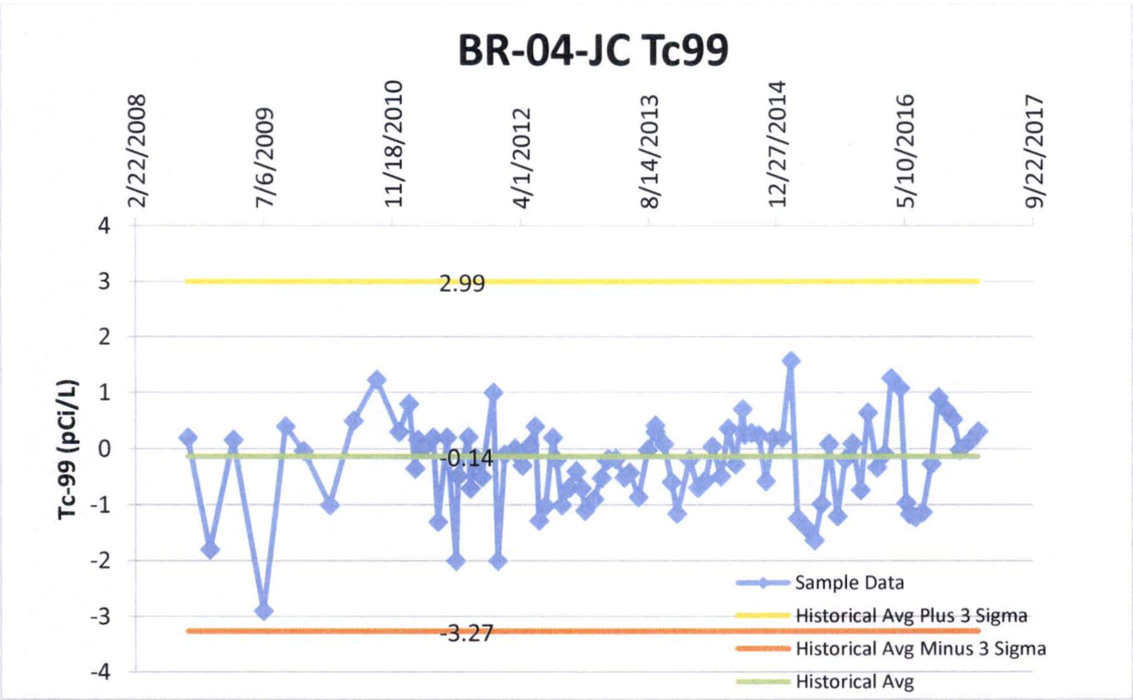
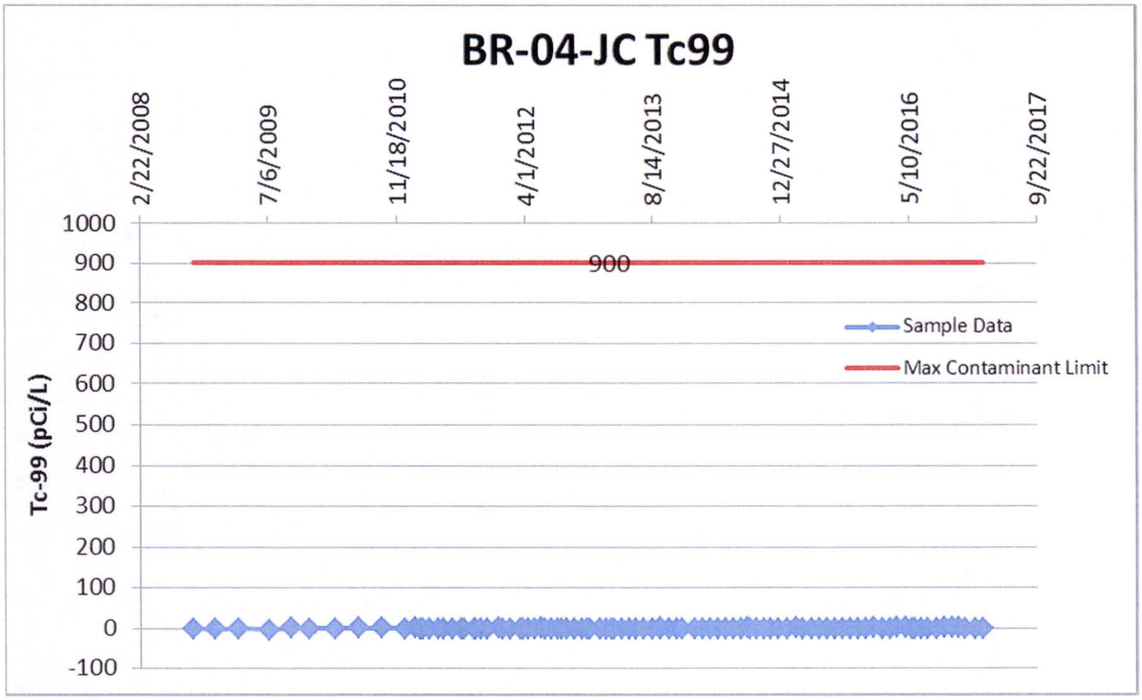
JEFFERSON CITY – COTTER HSU





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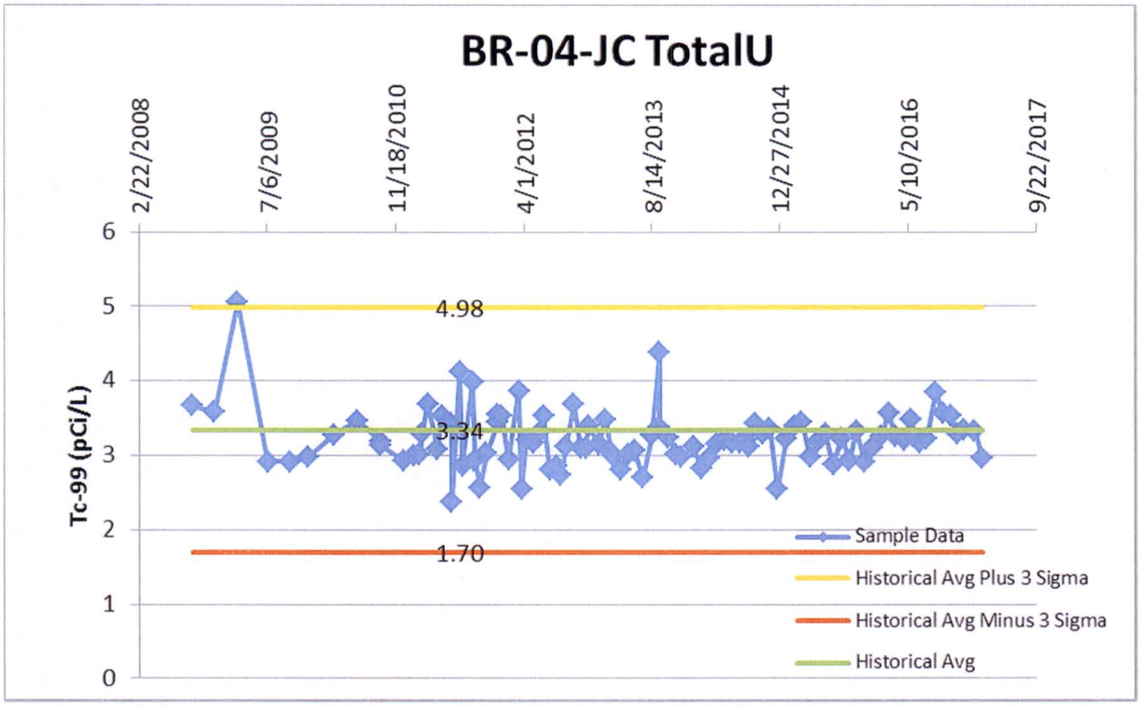

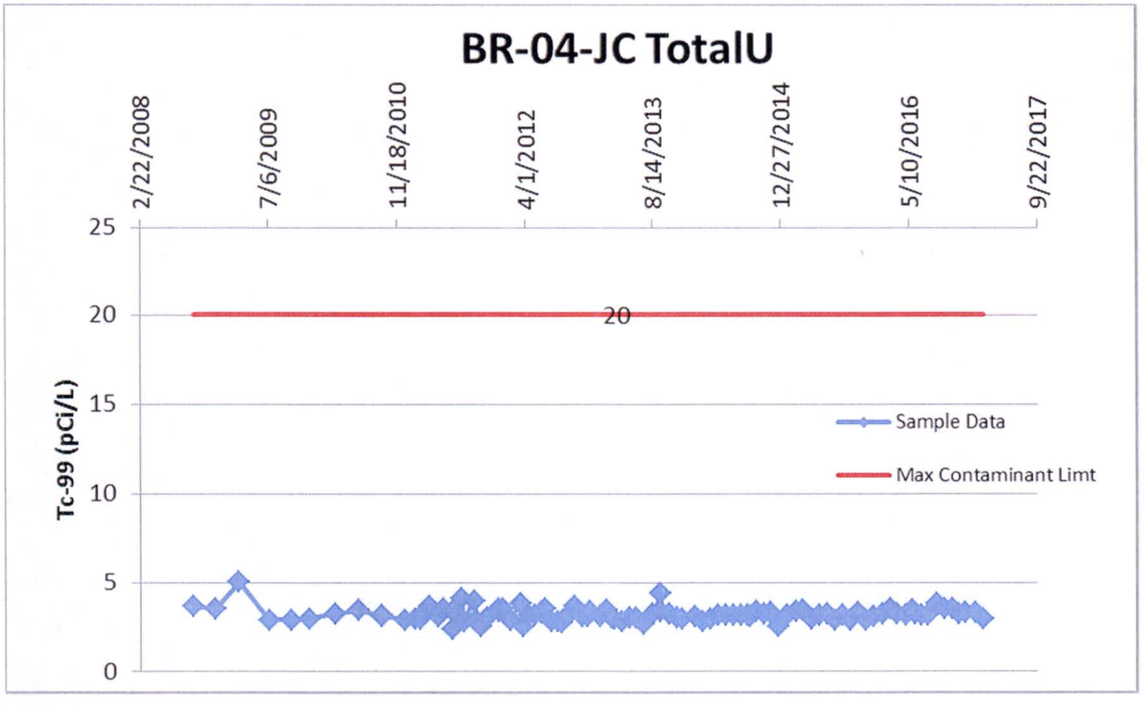

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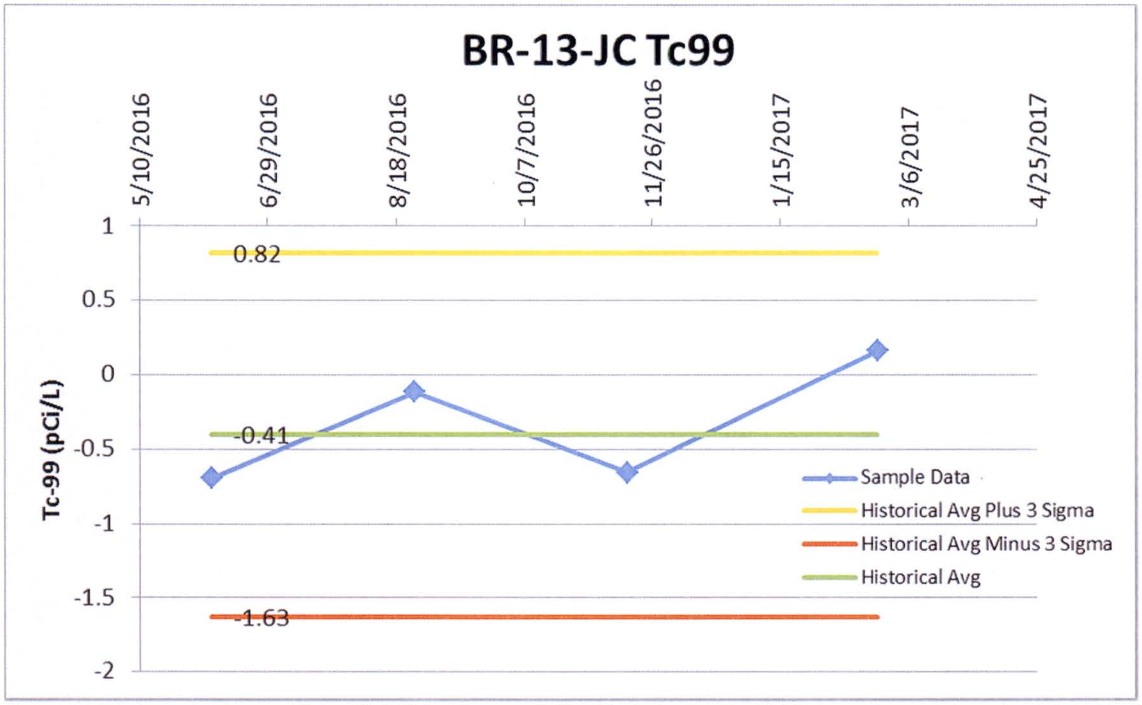

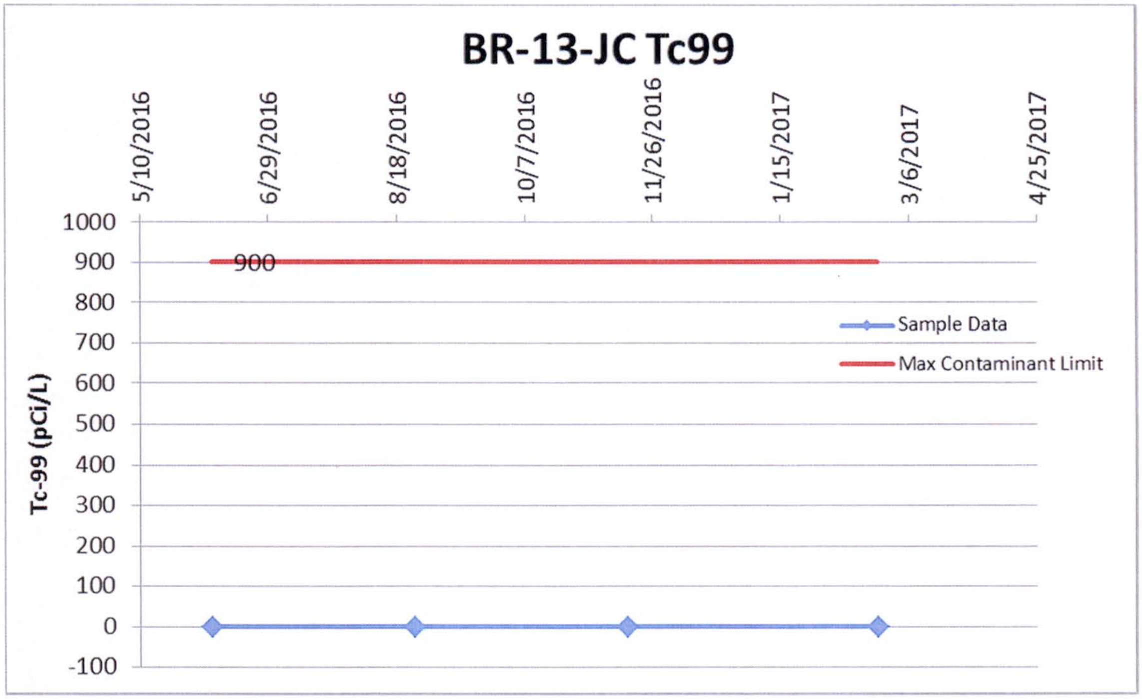

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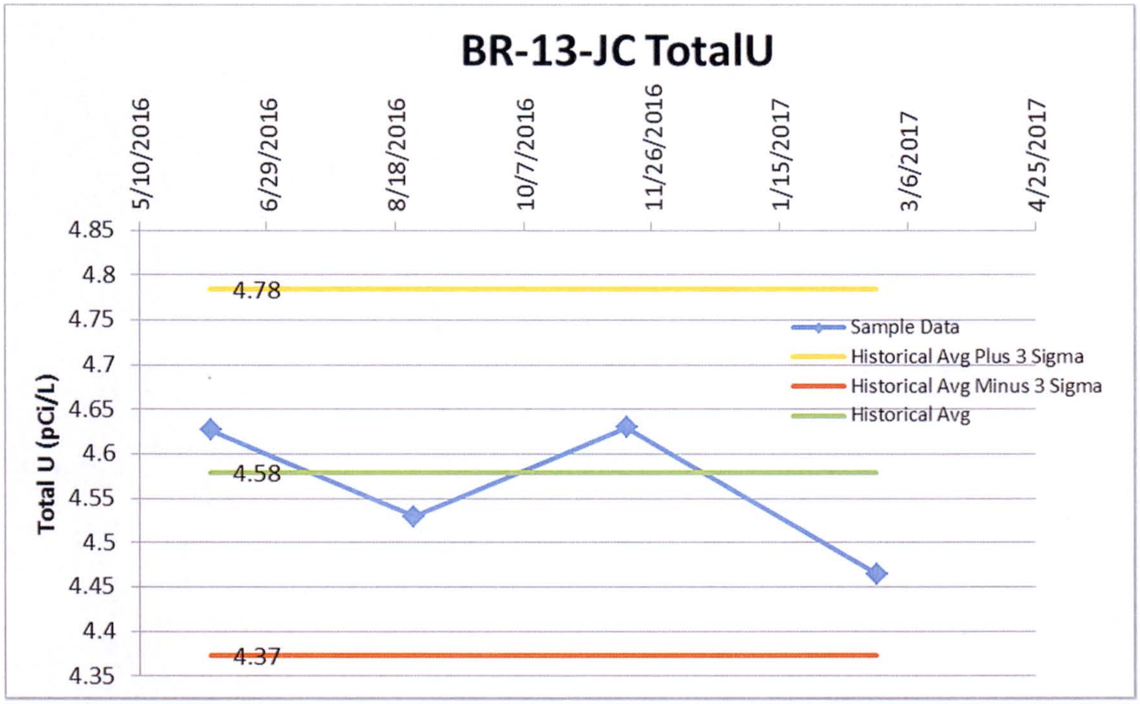

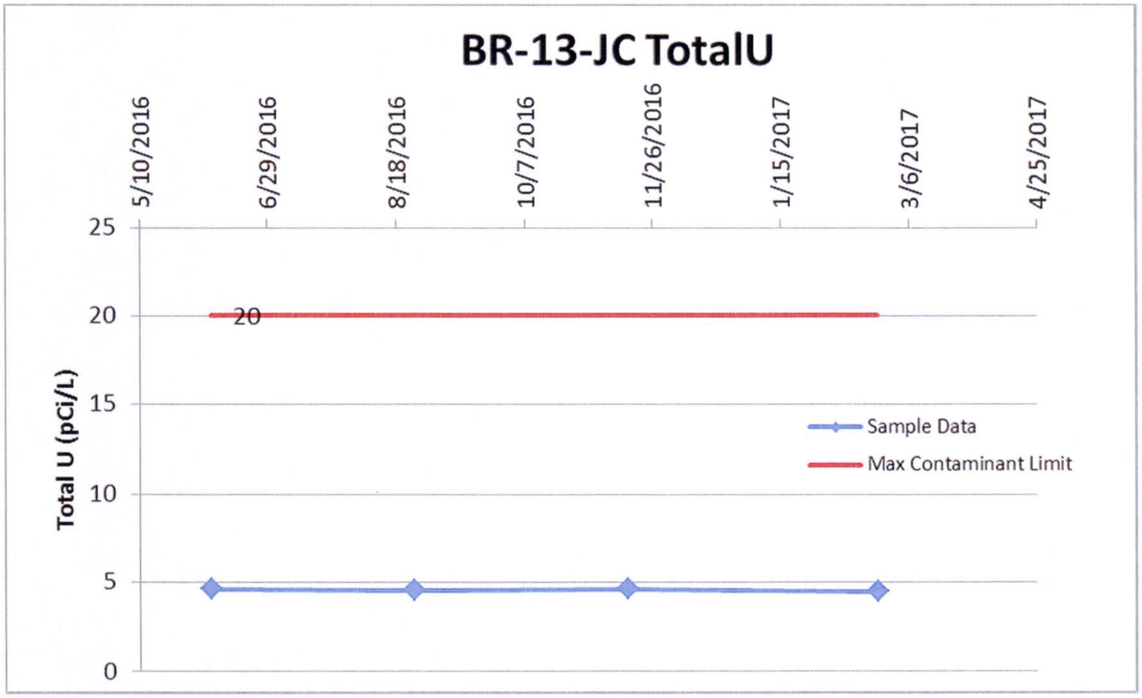

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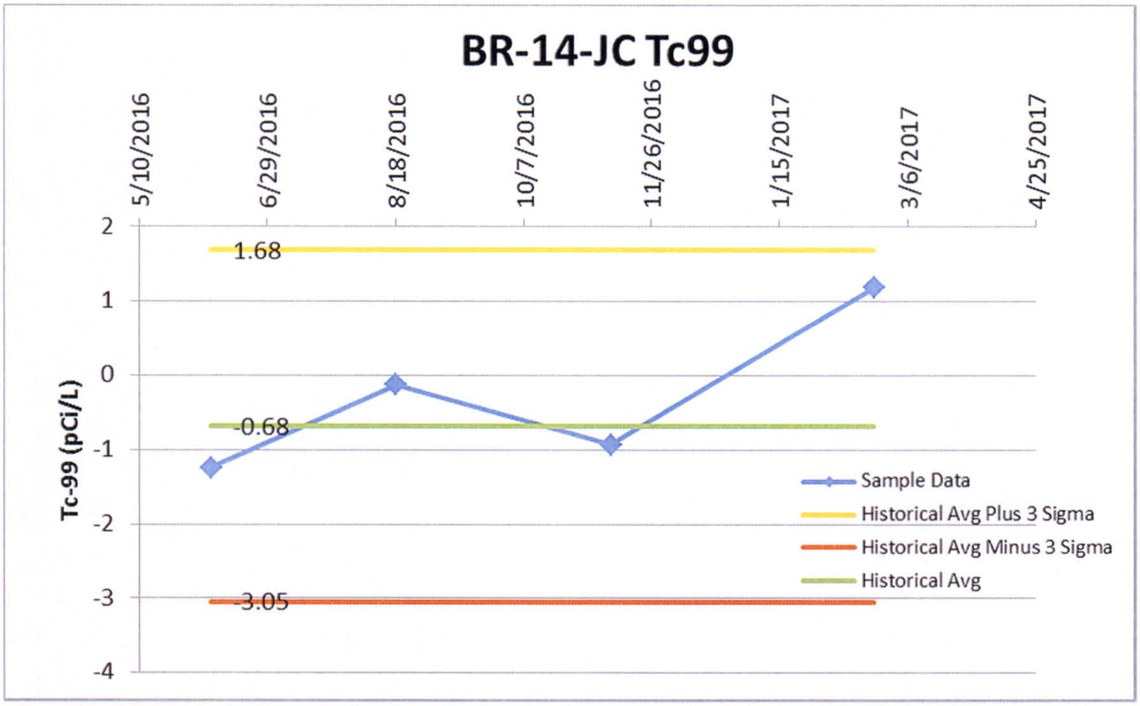

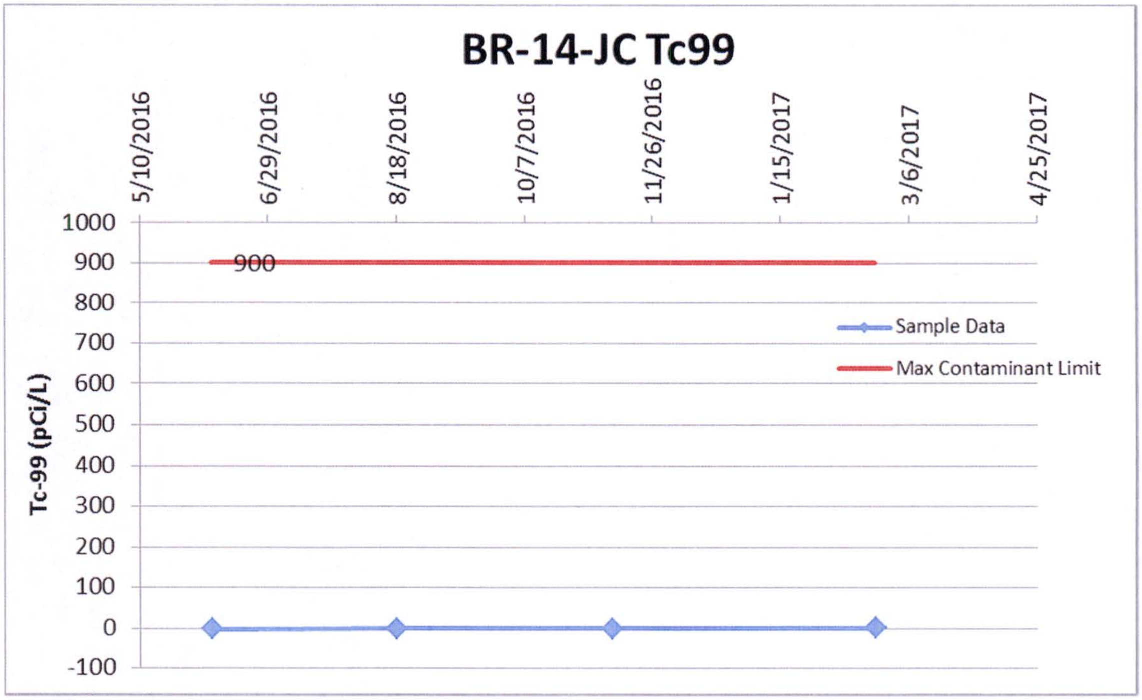

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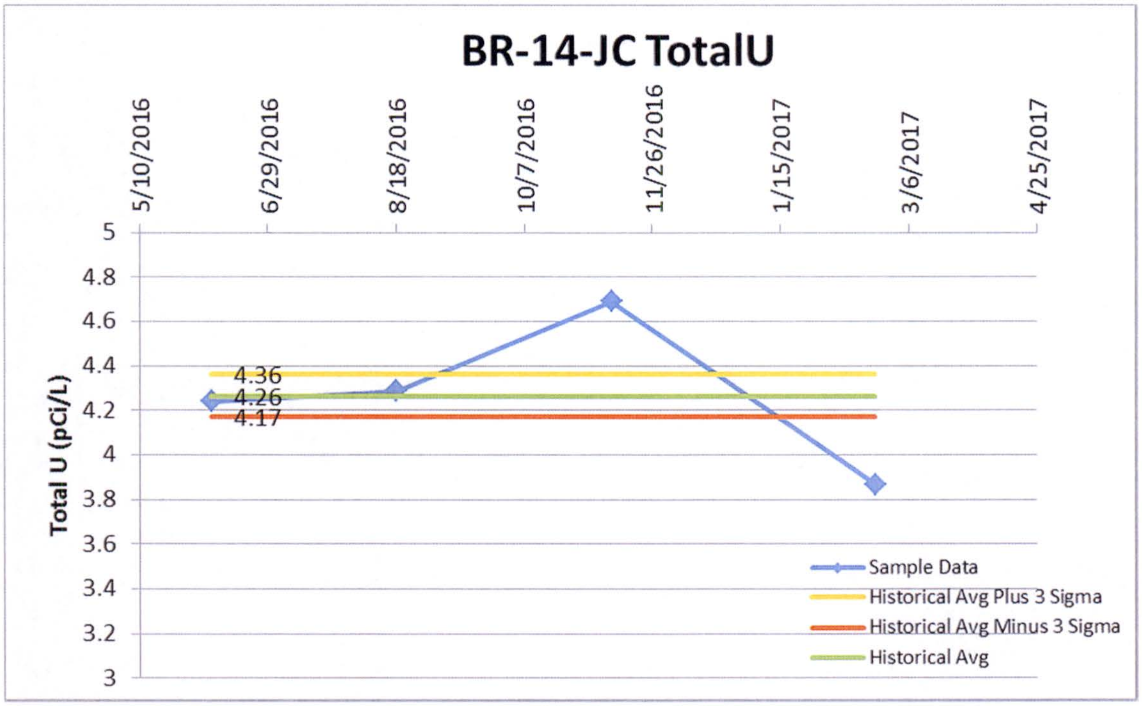

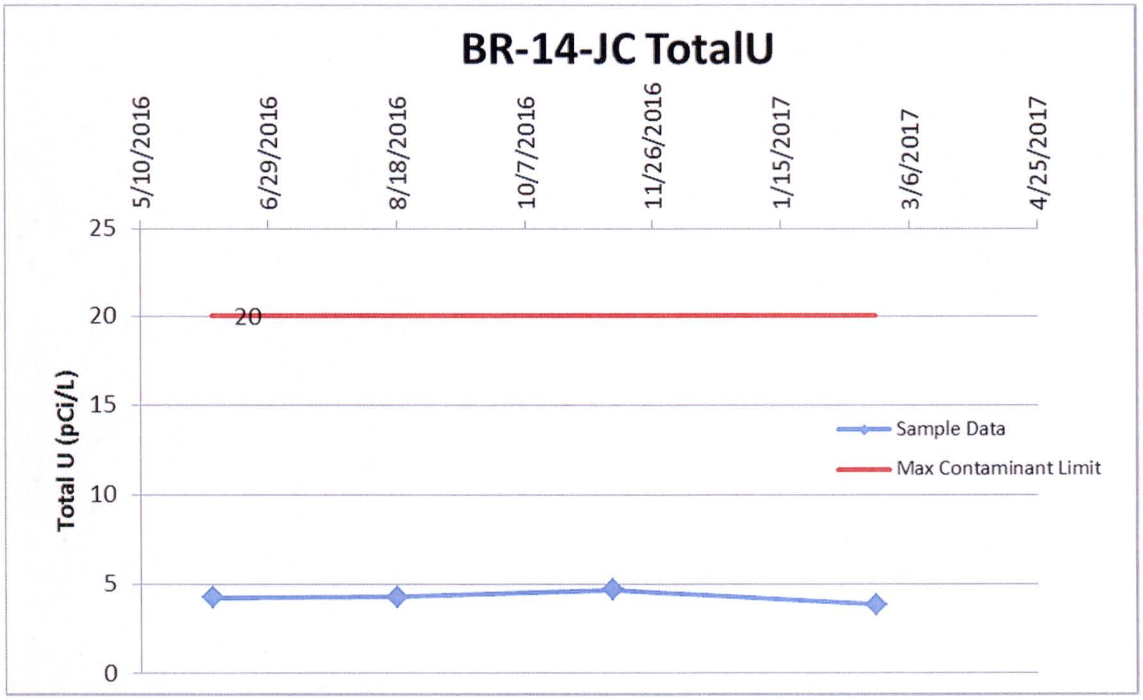

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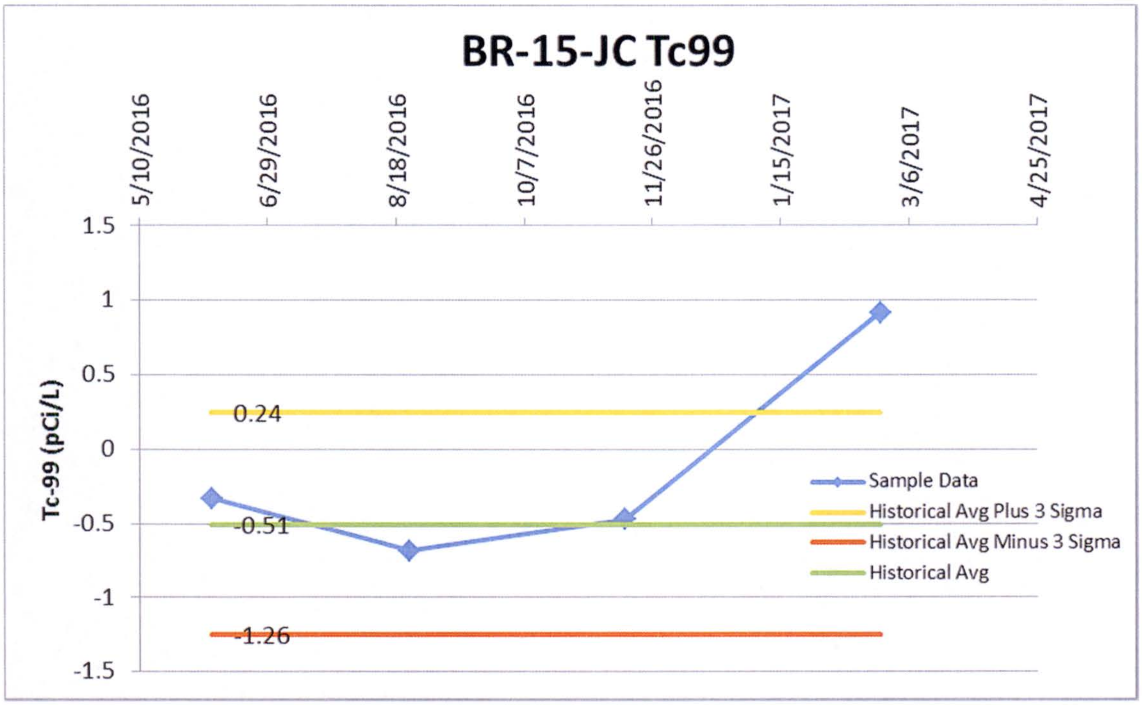

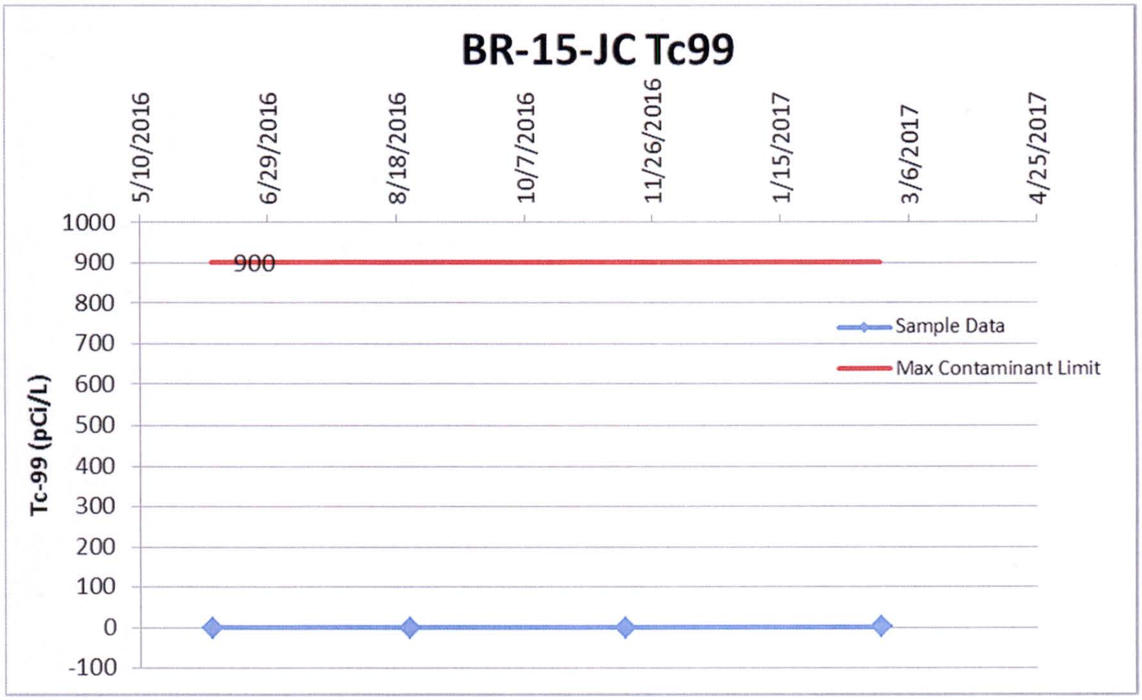

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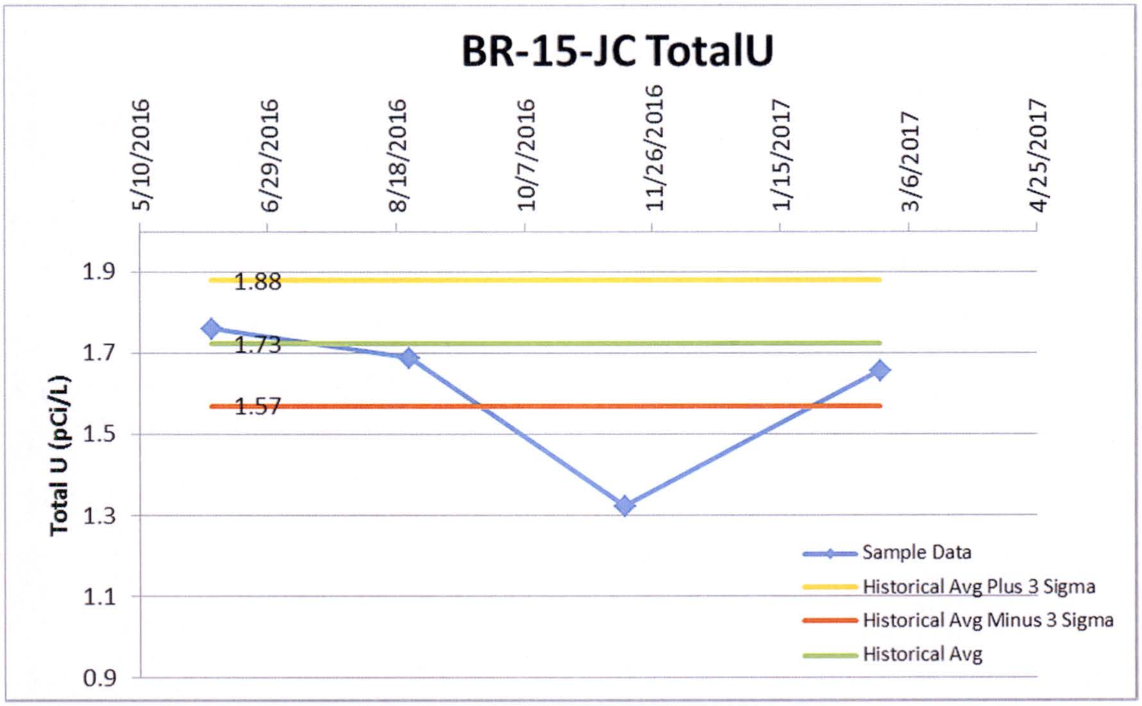

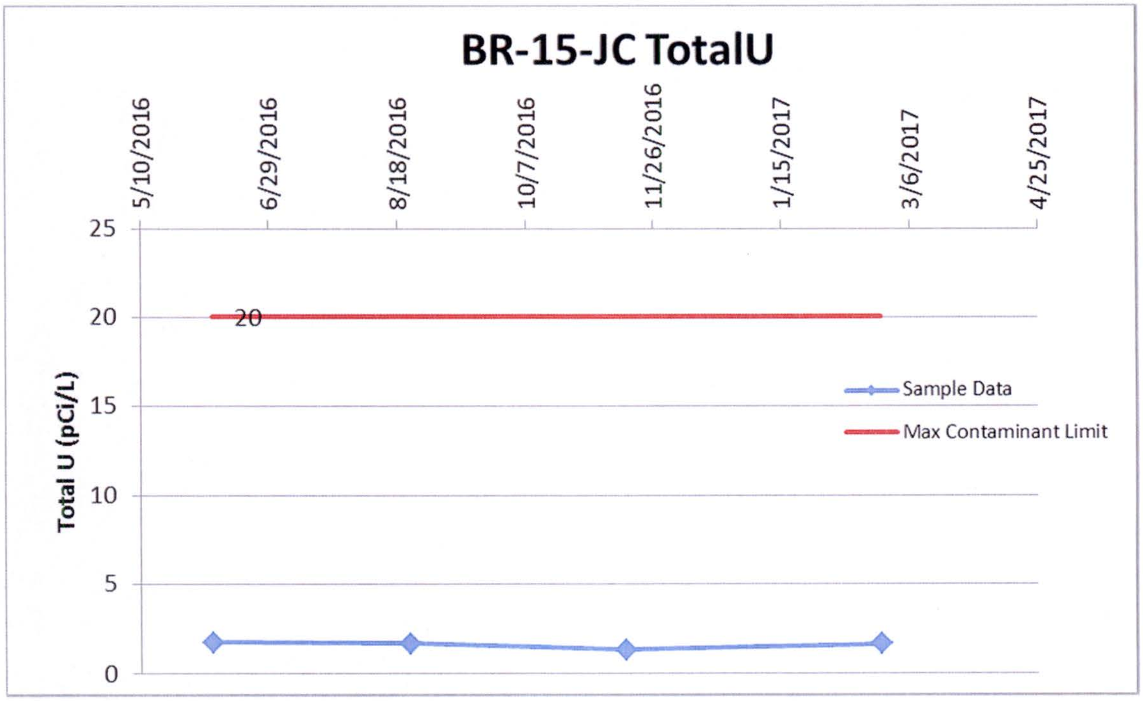

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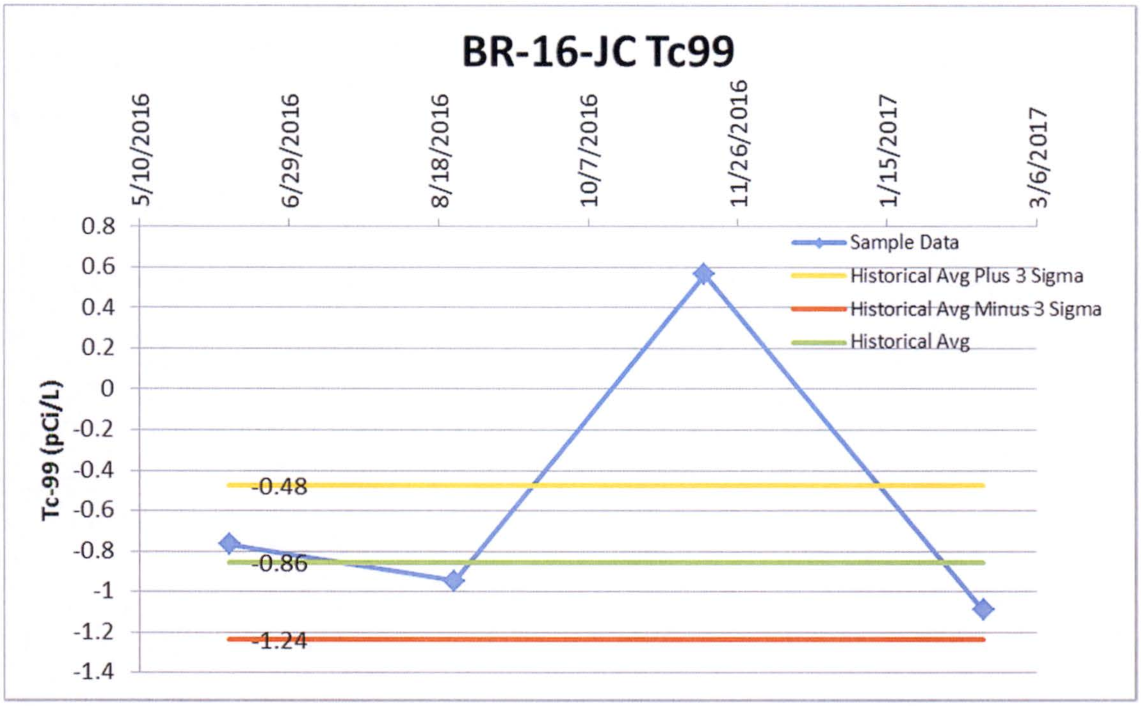

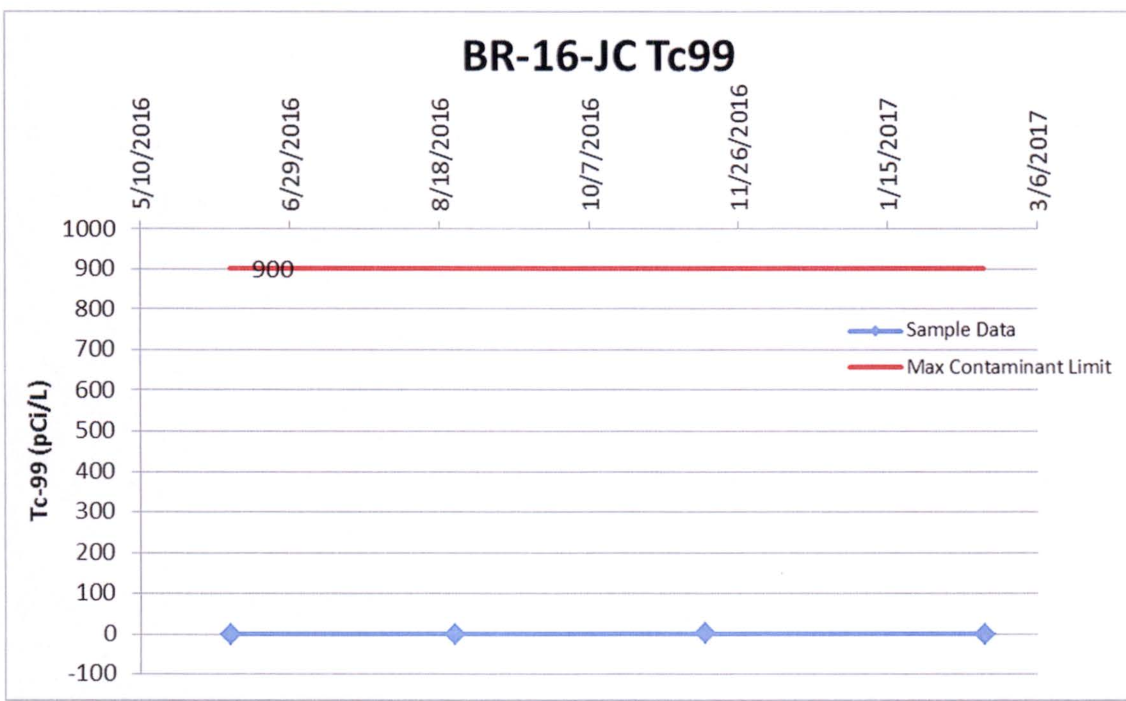

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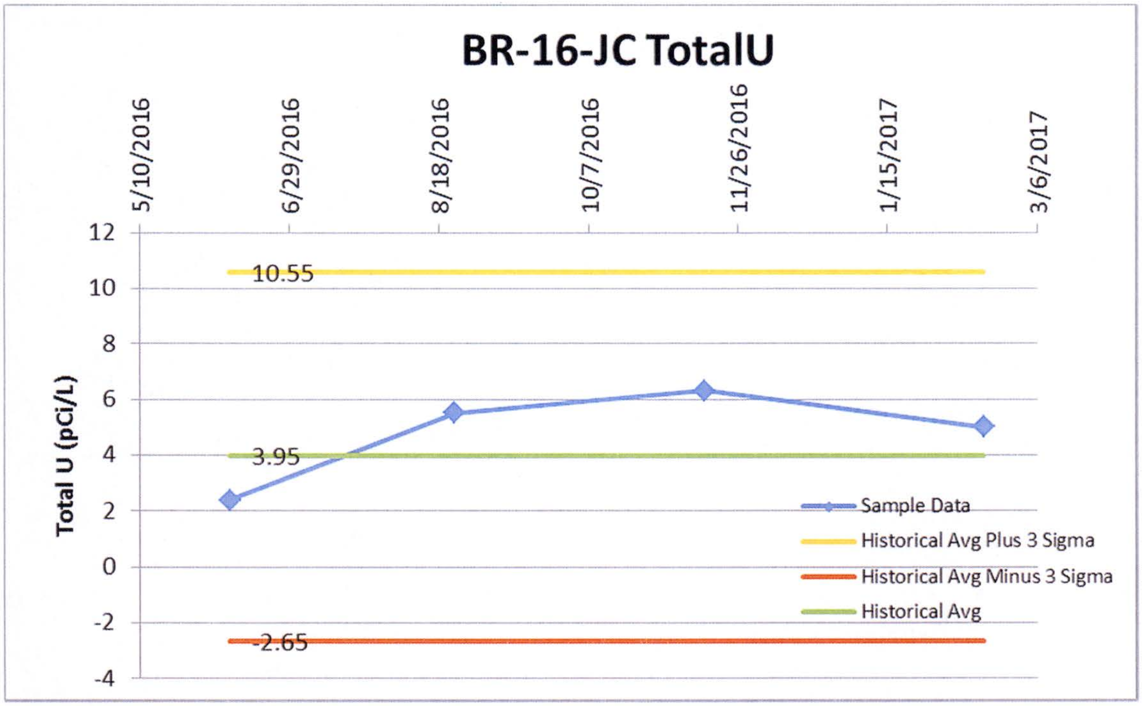

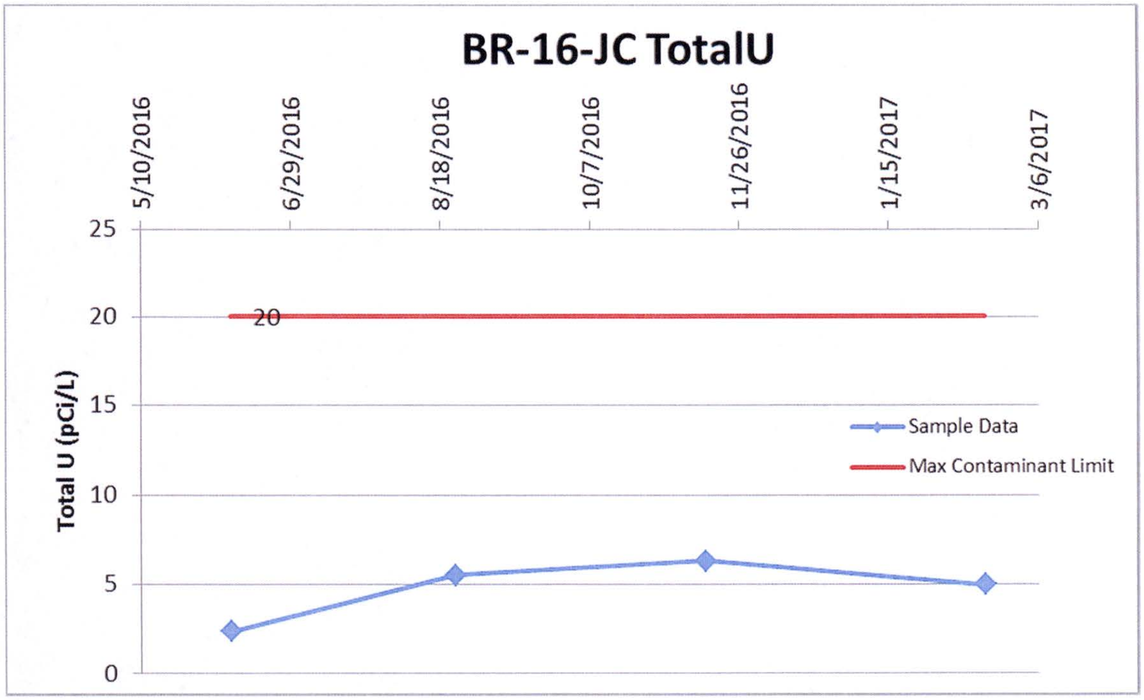

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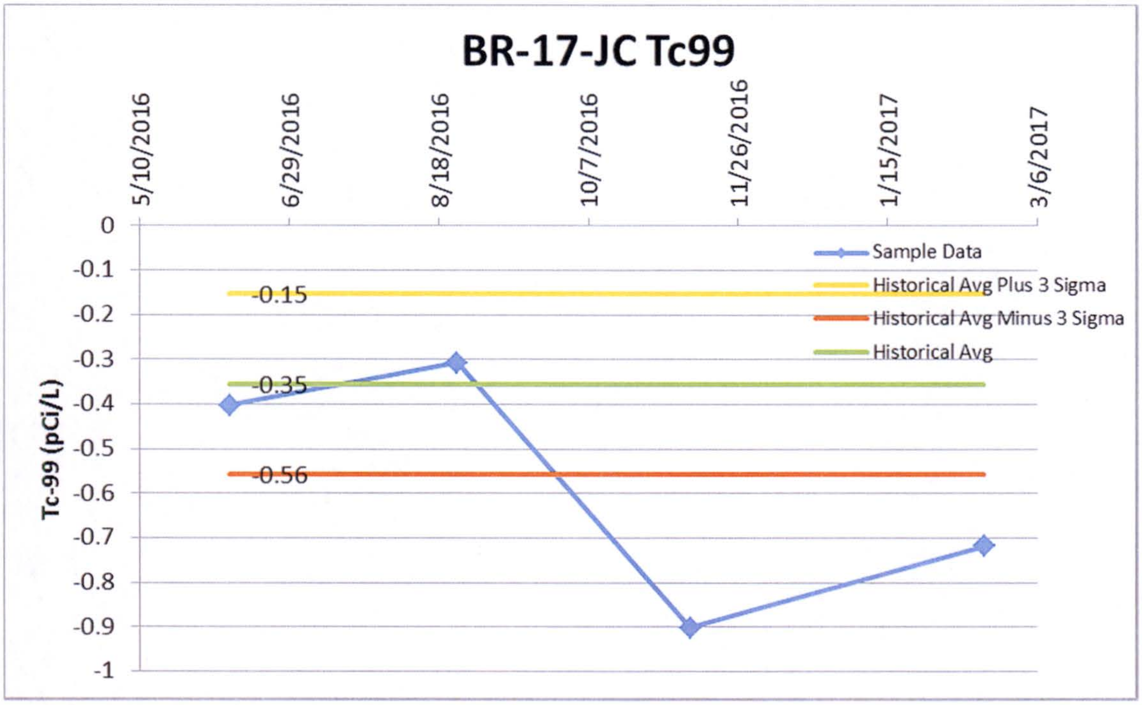

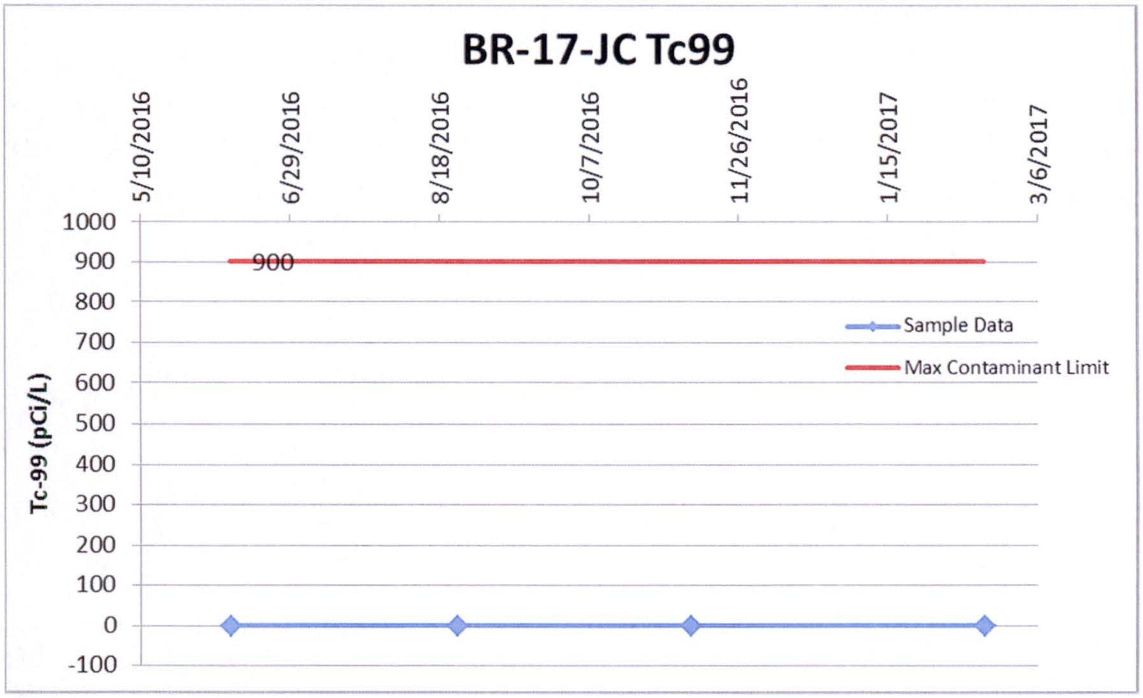

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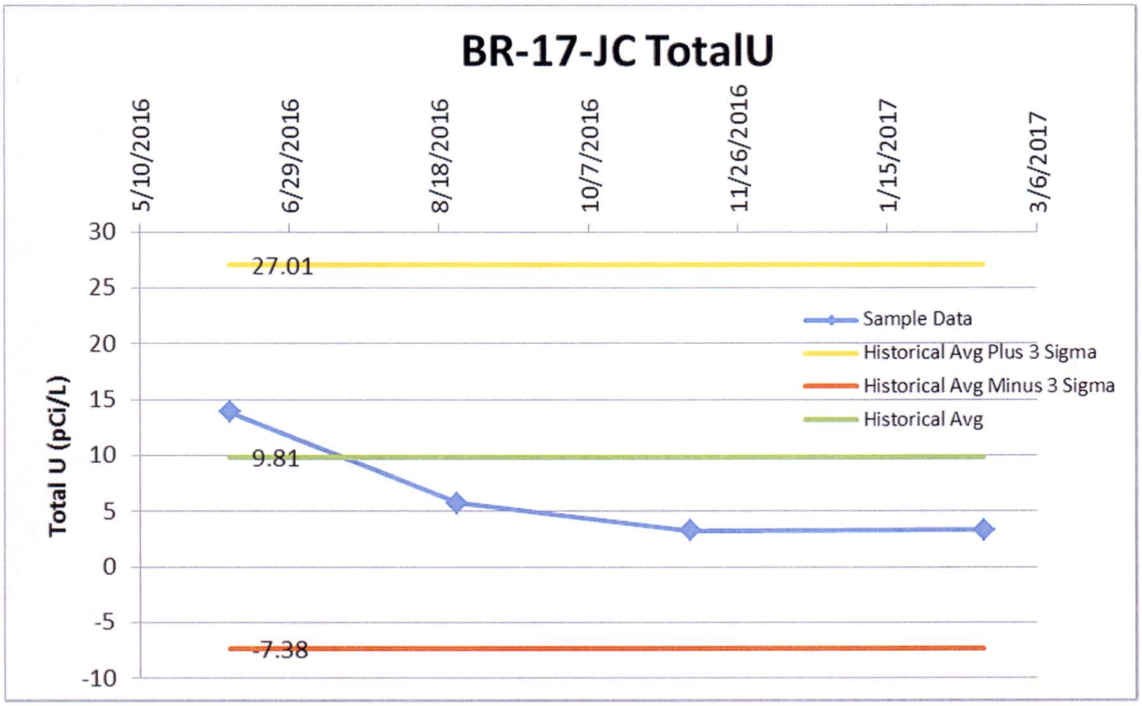

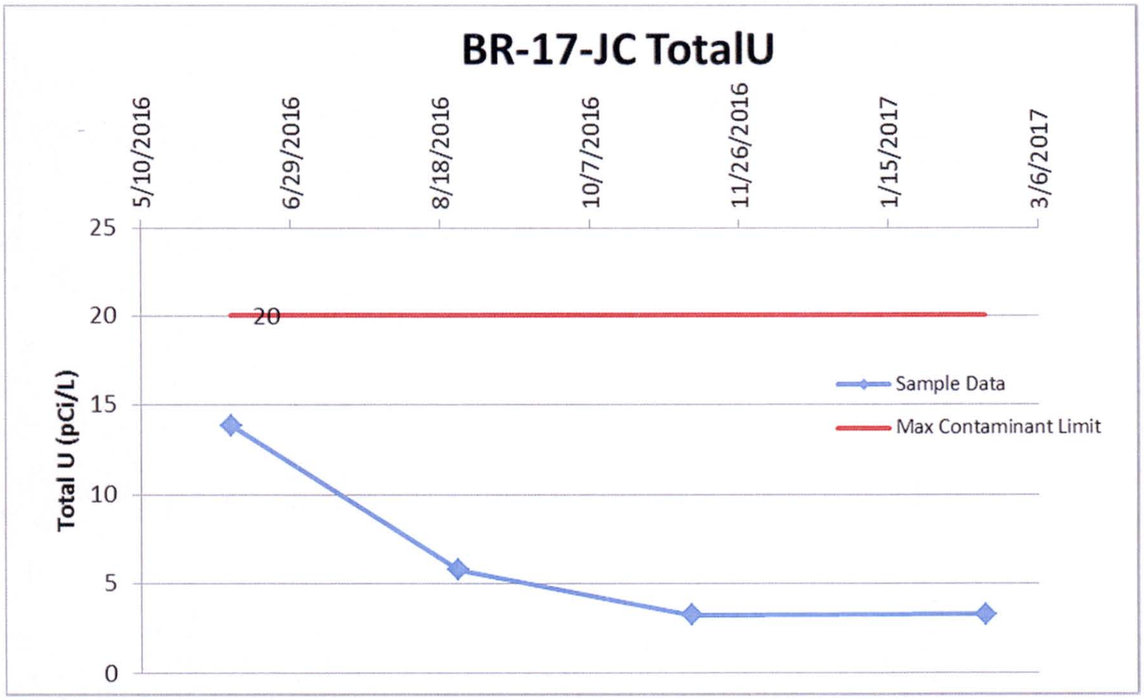

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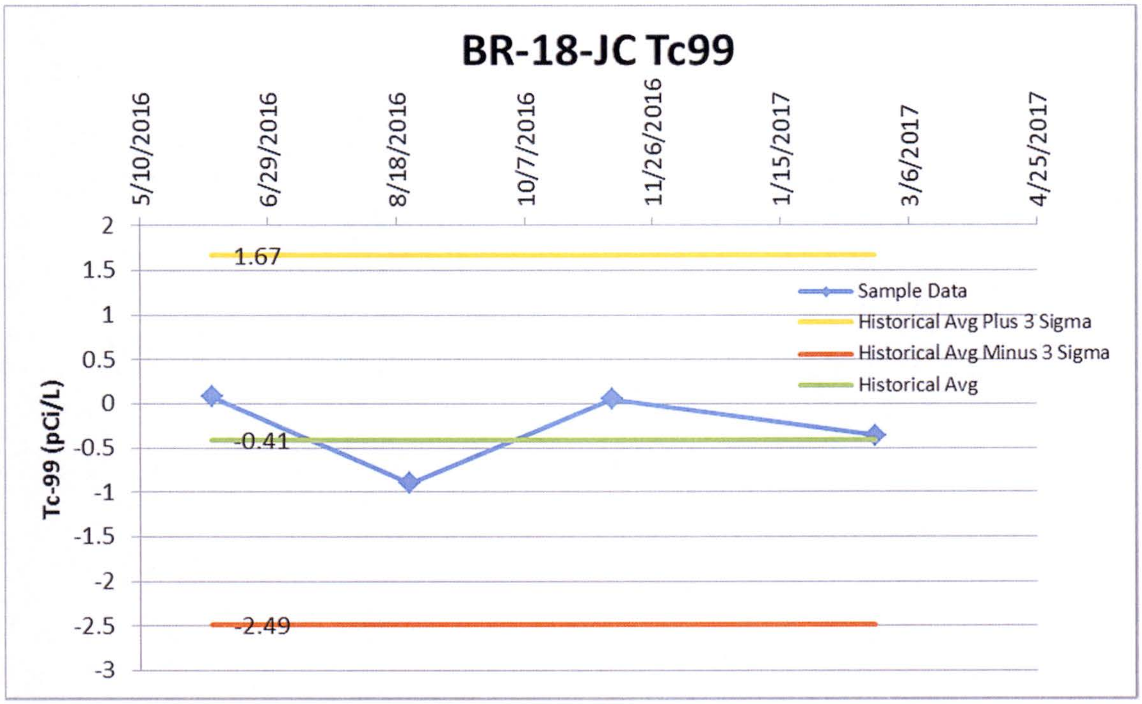

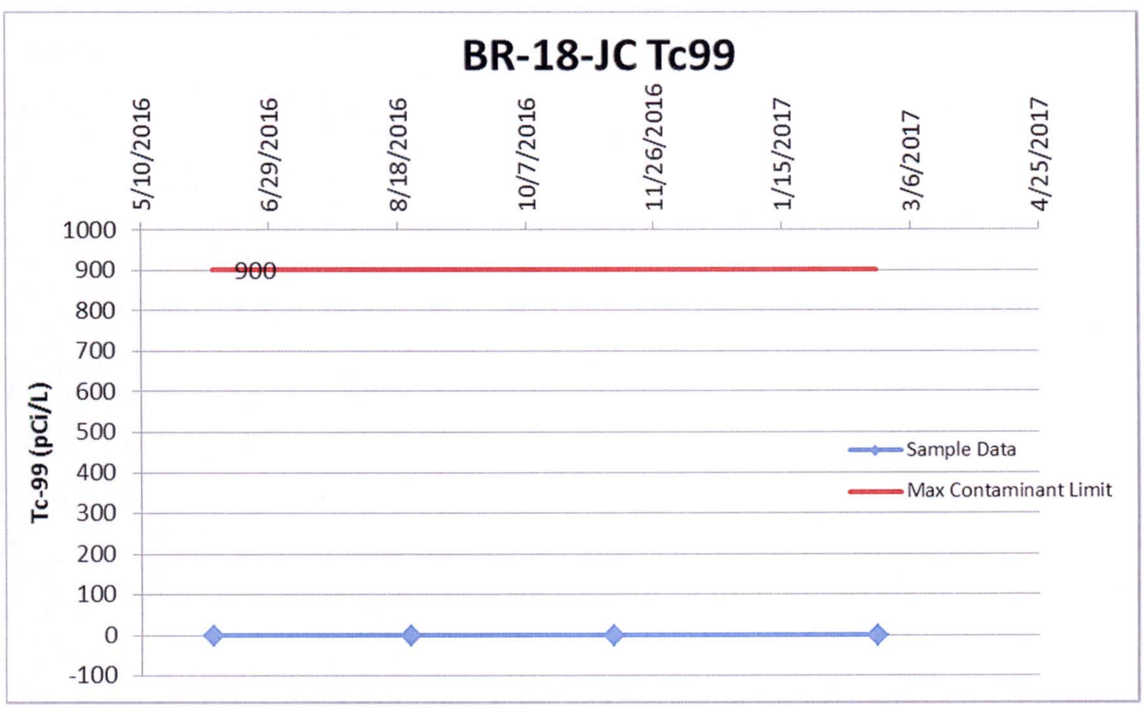

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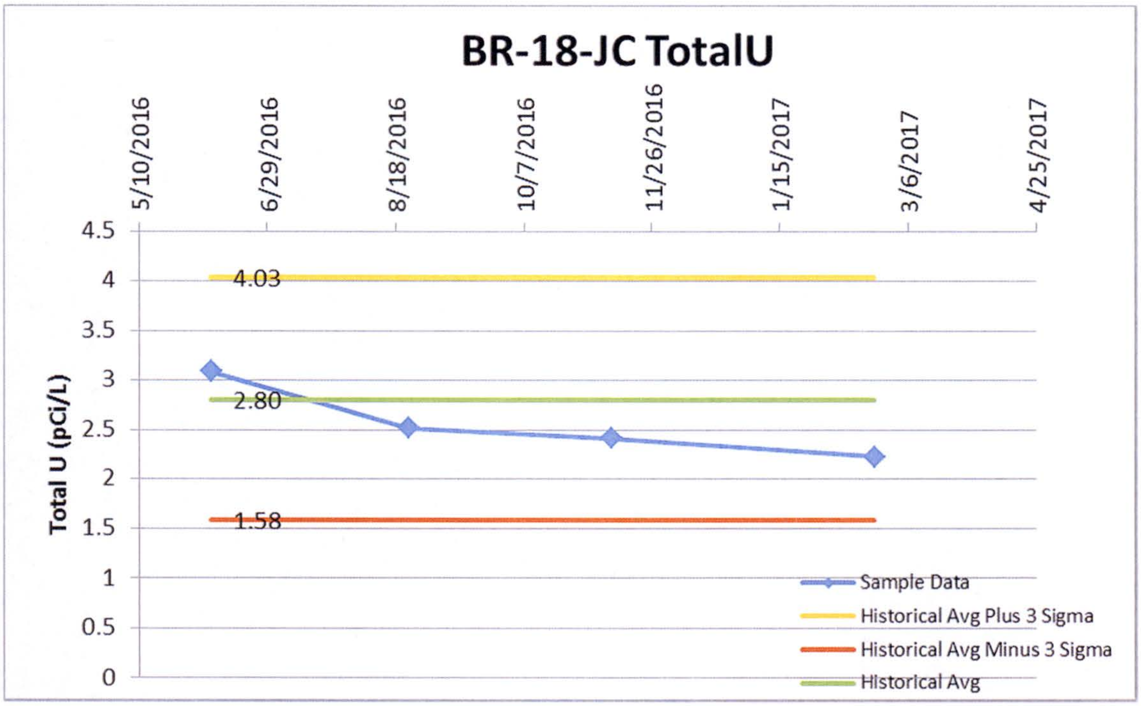

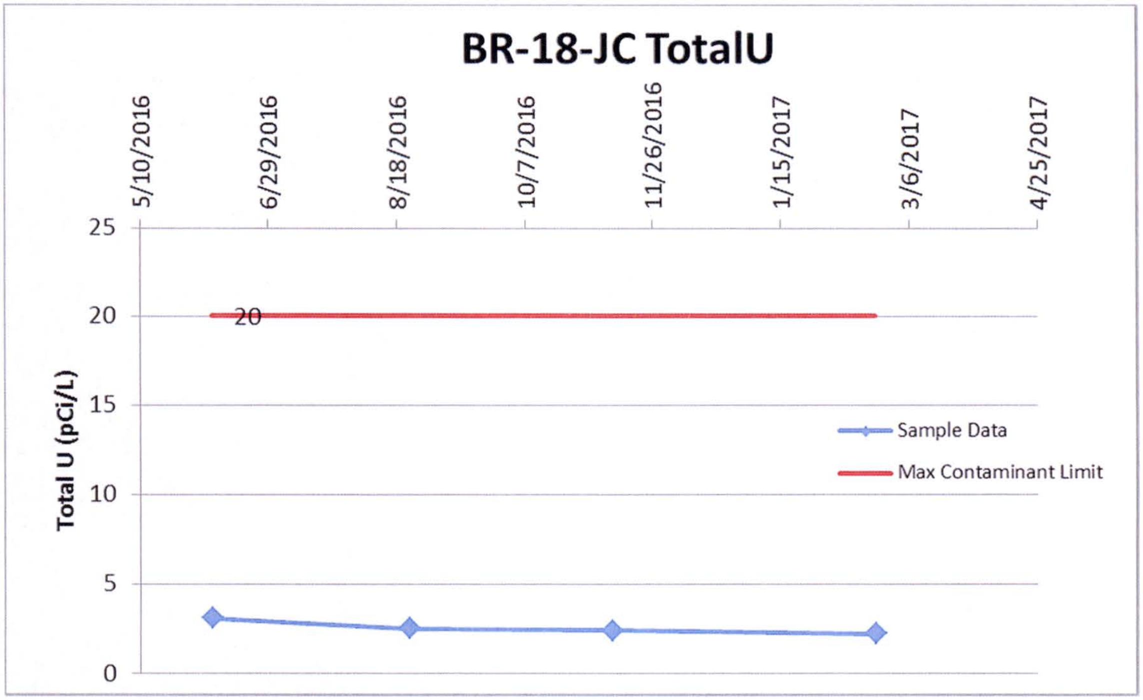

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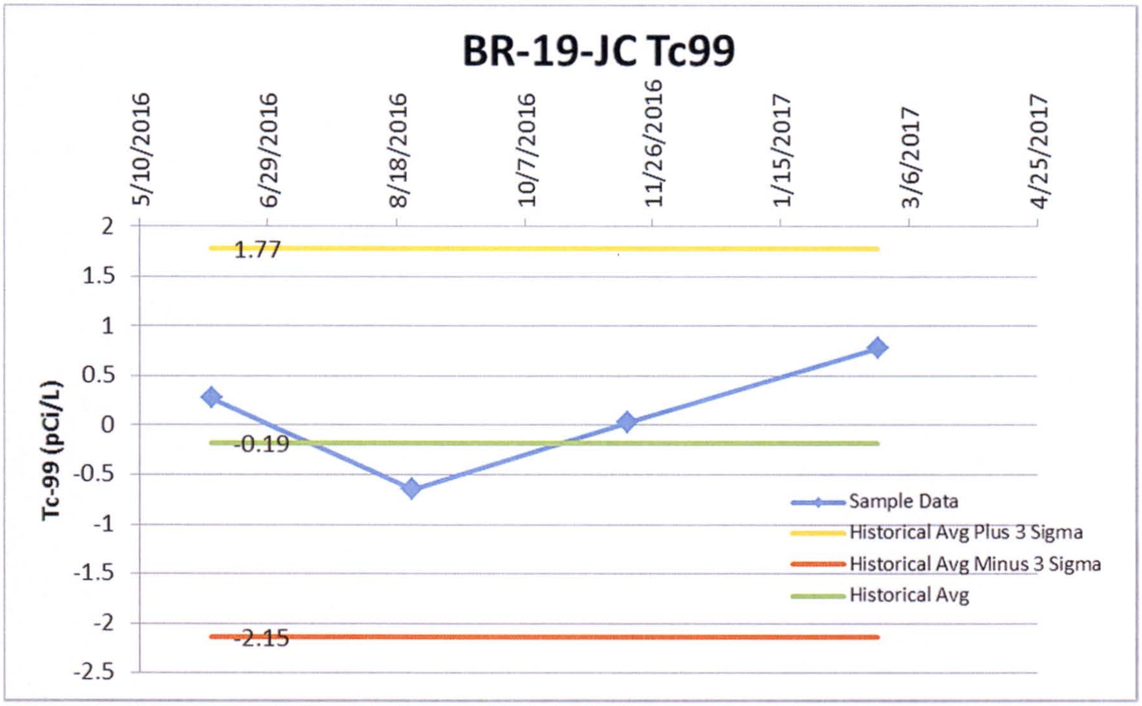

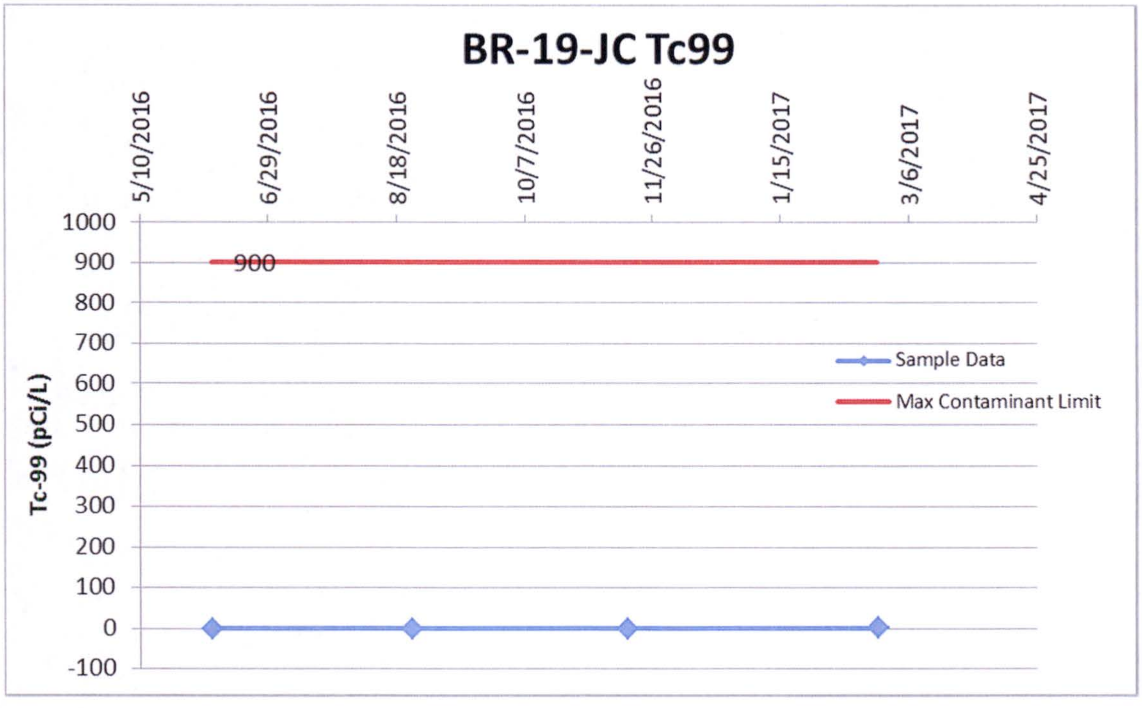

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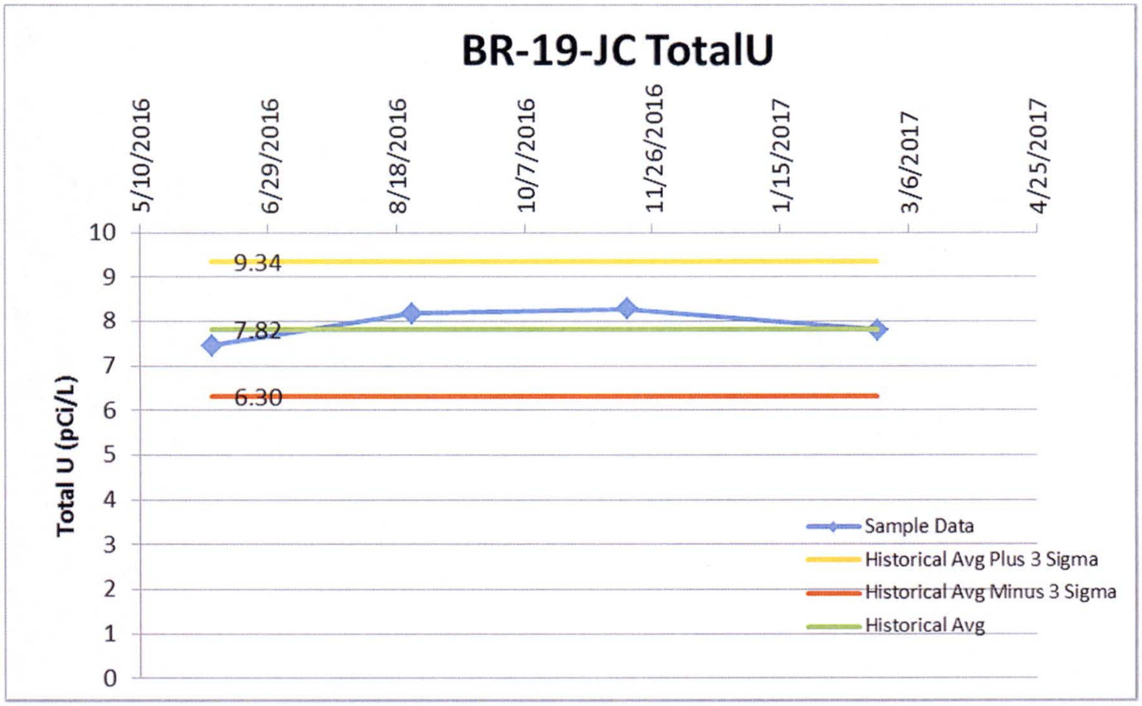

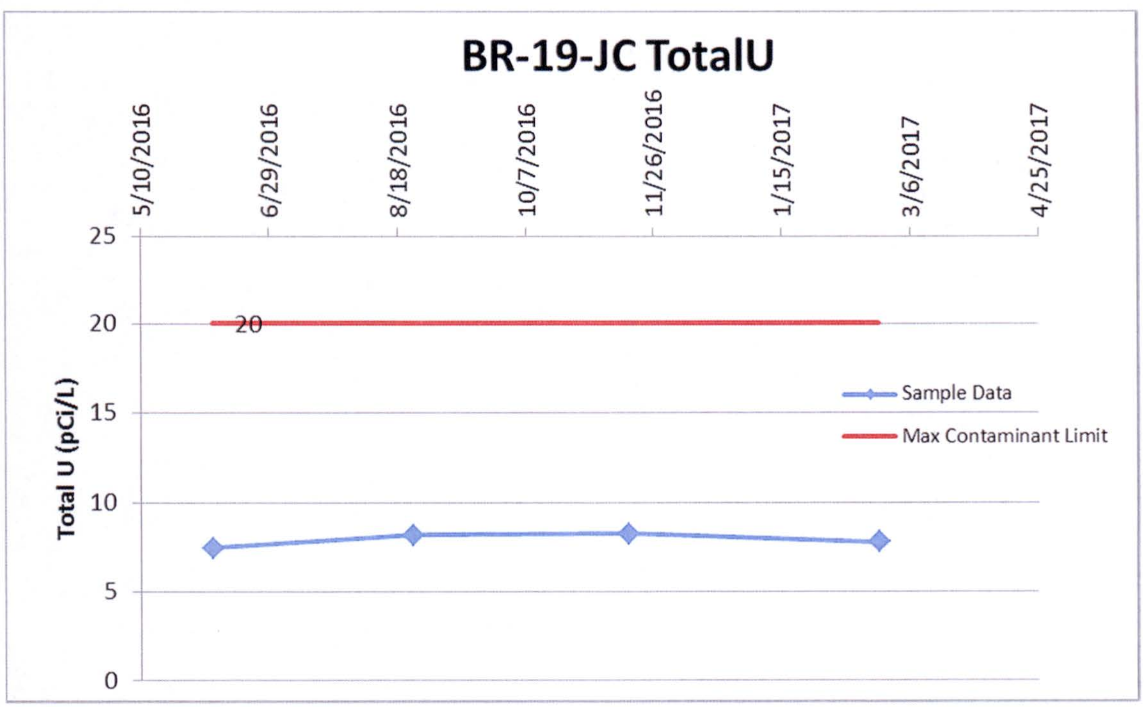

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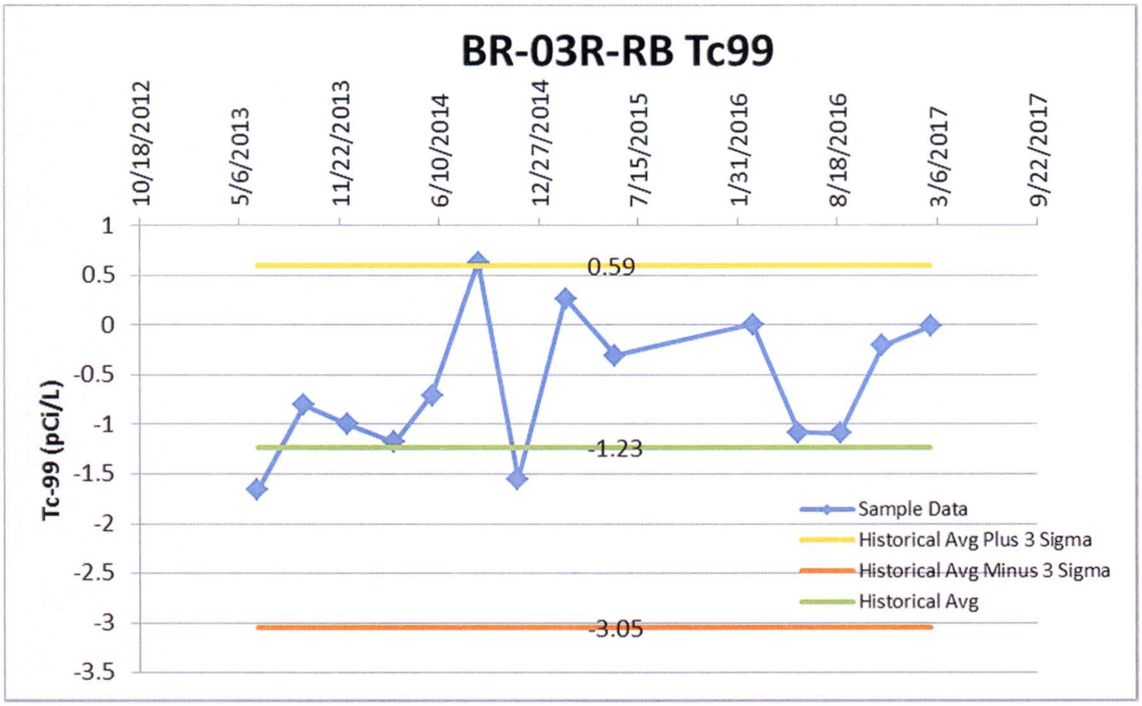
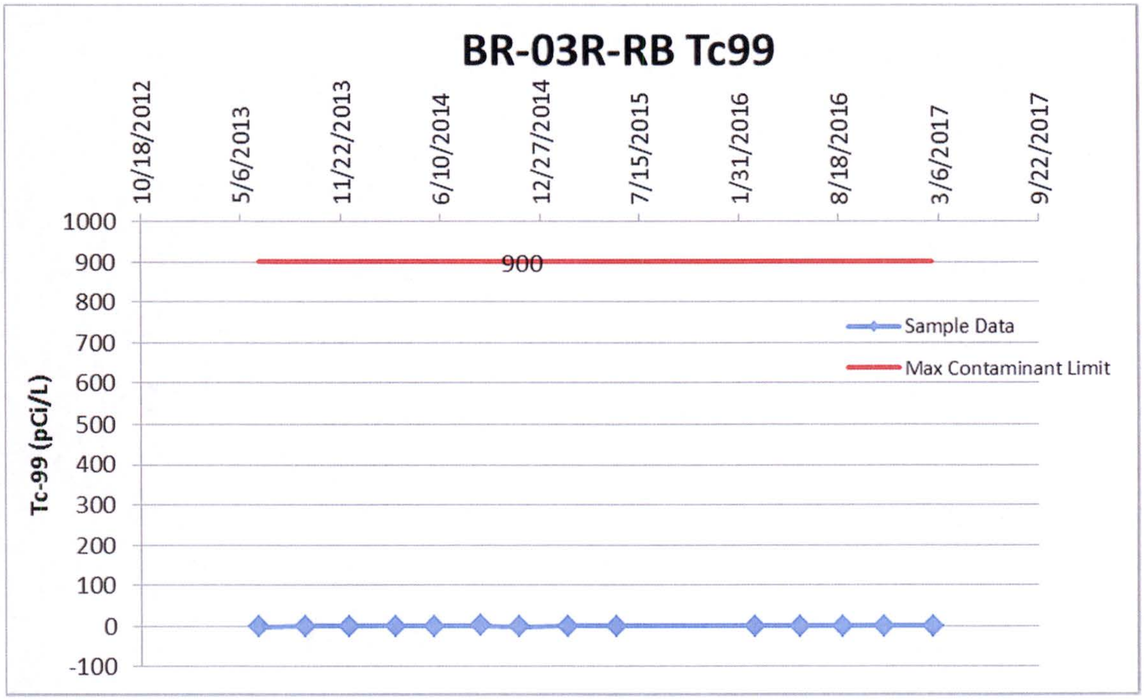
ROUBIDOUX HSU





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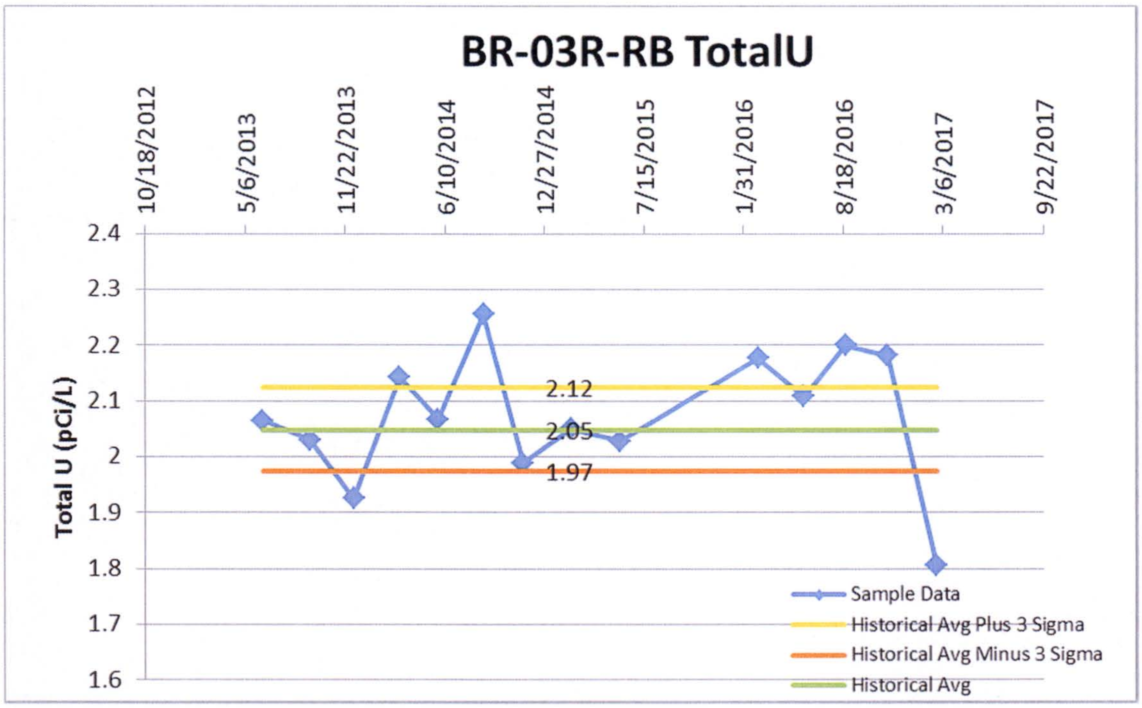

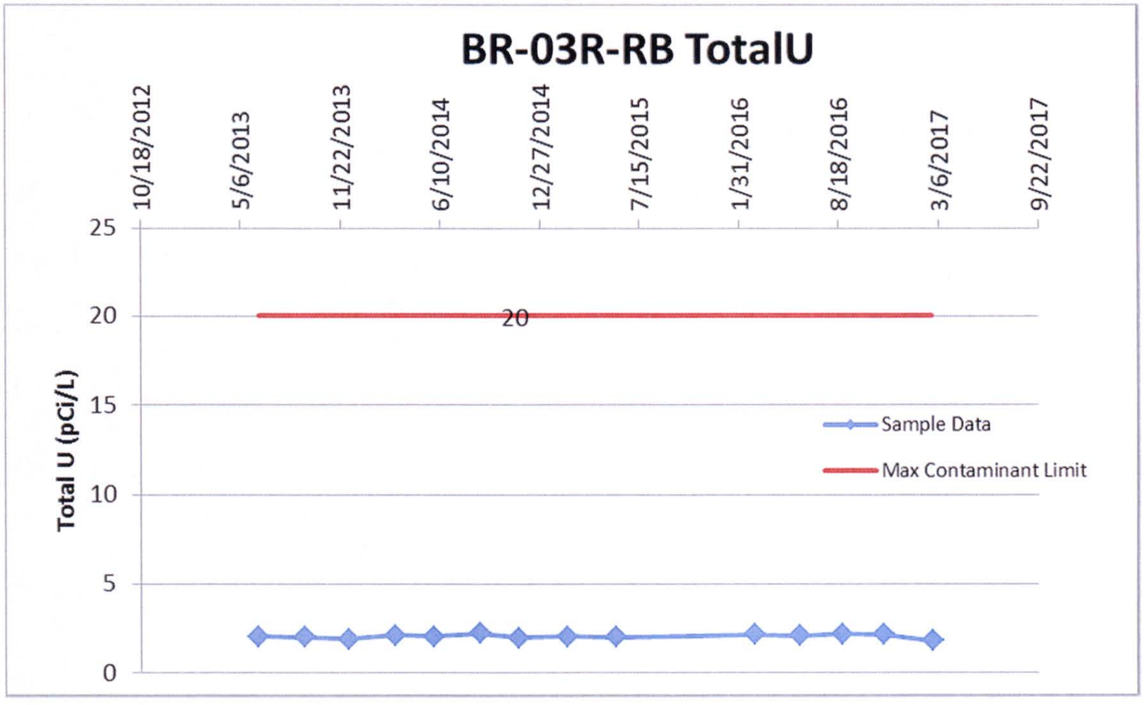

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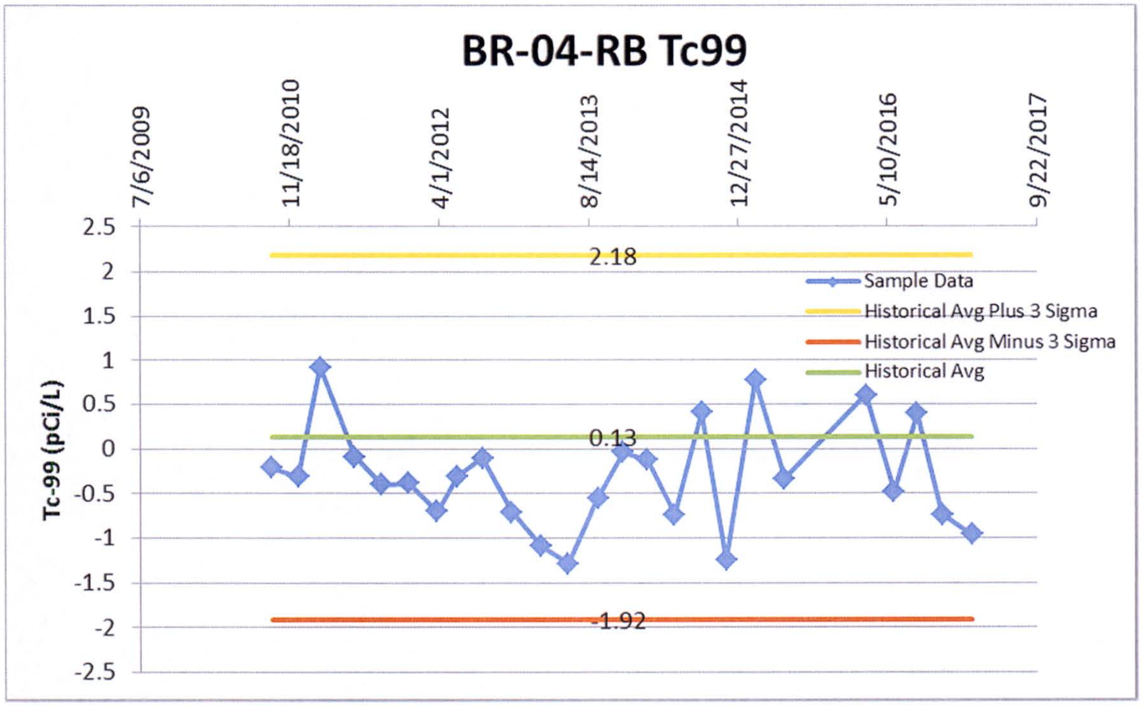

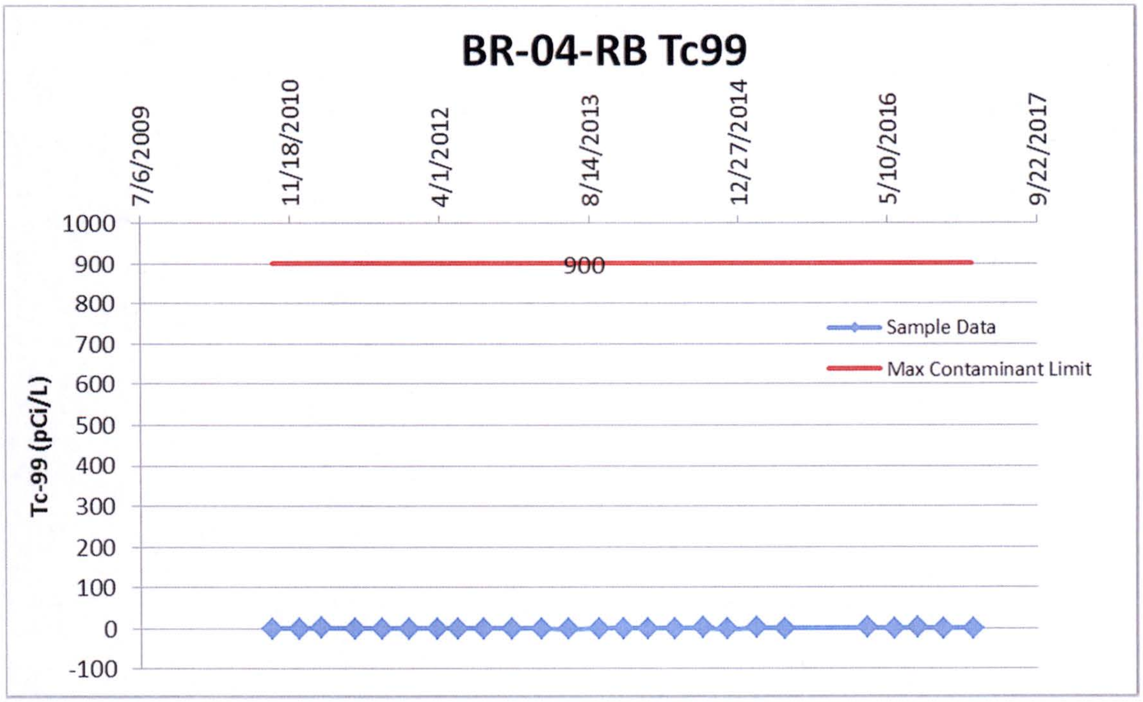

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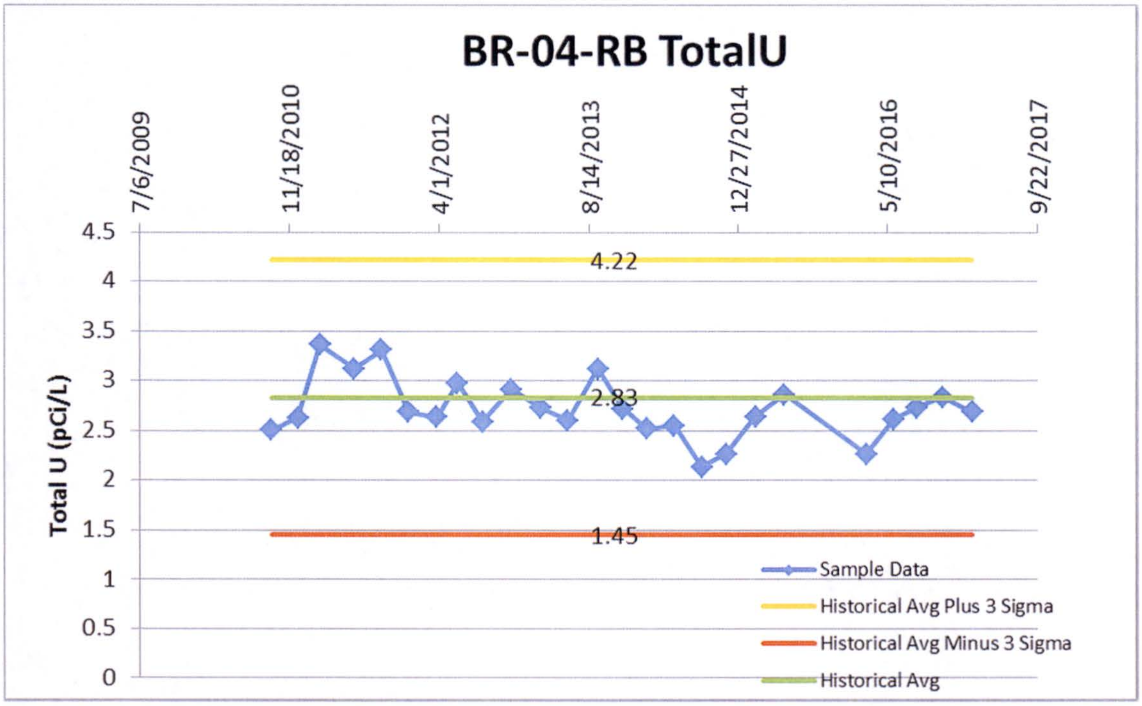

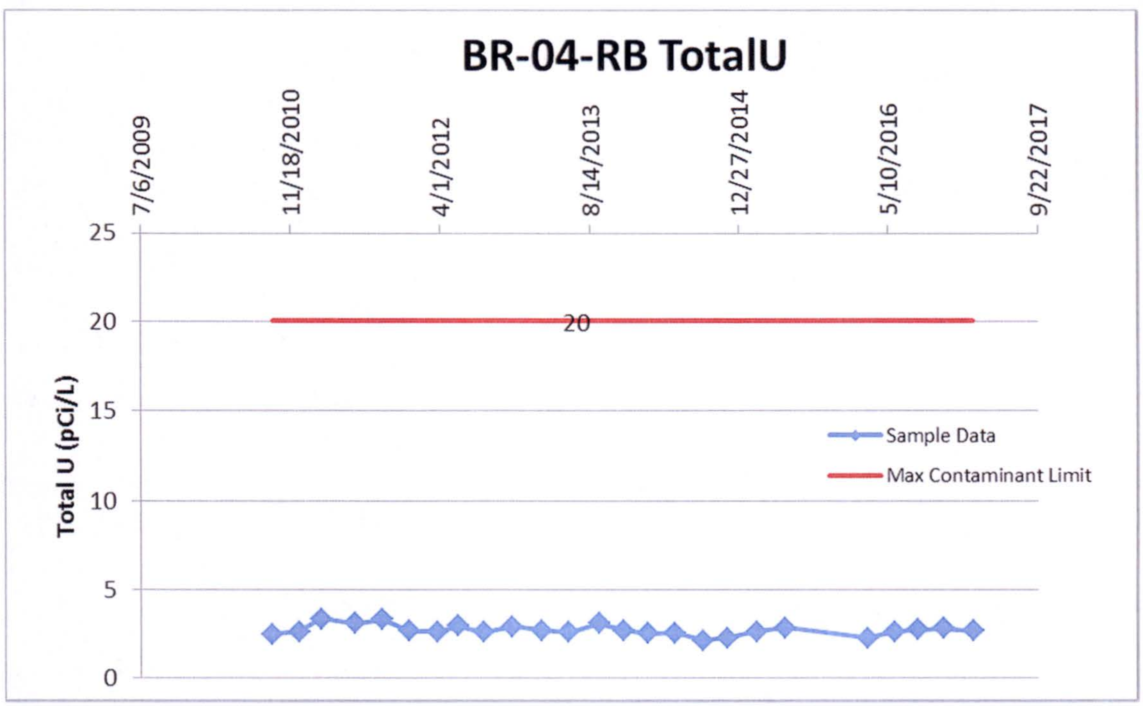

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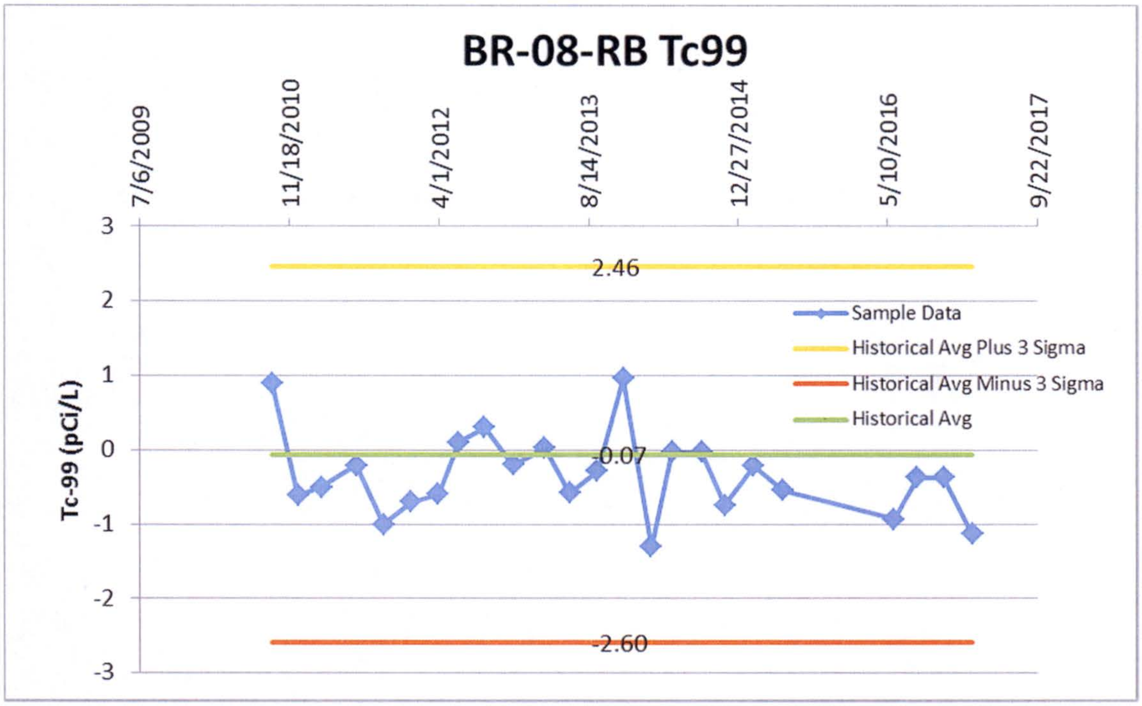

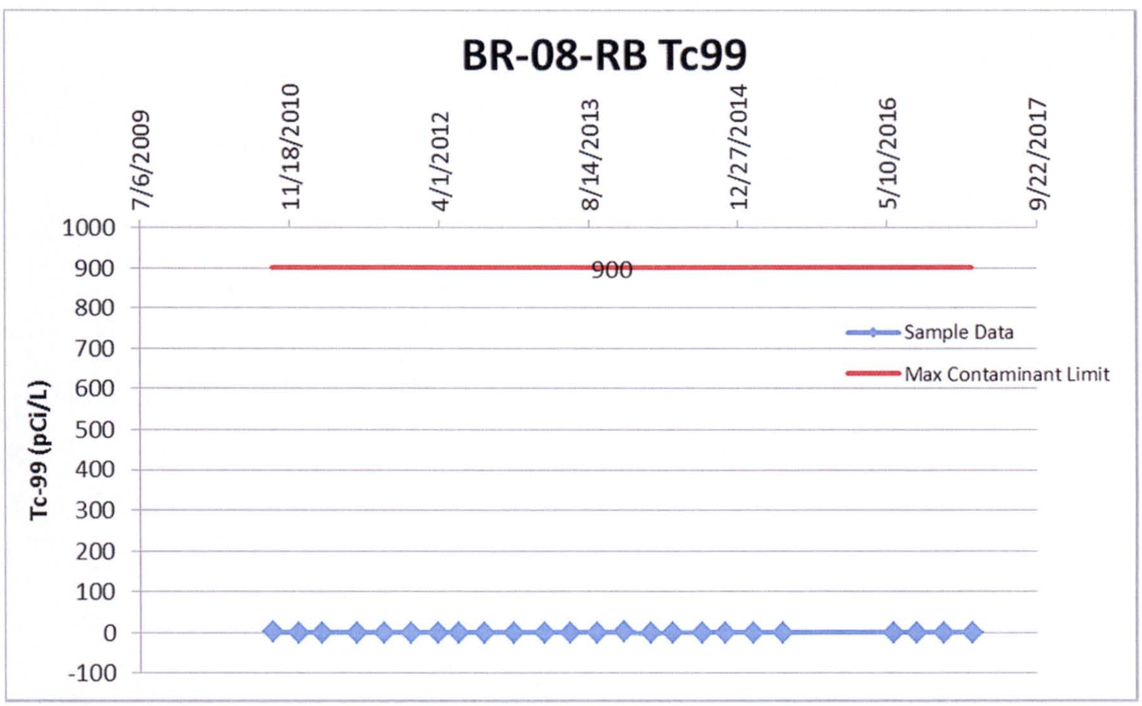

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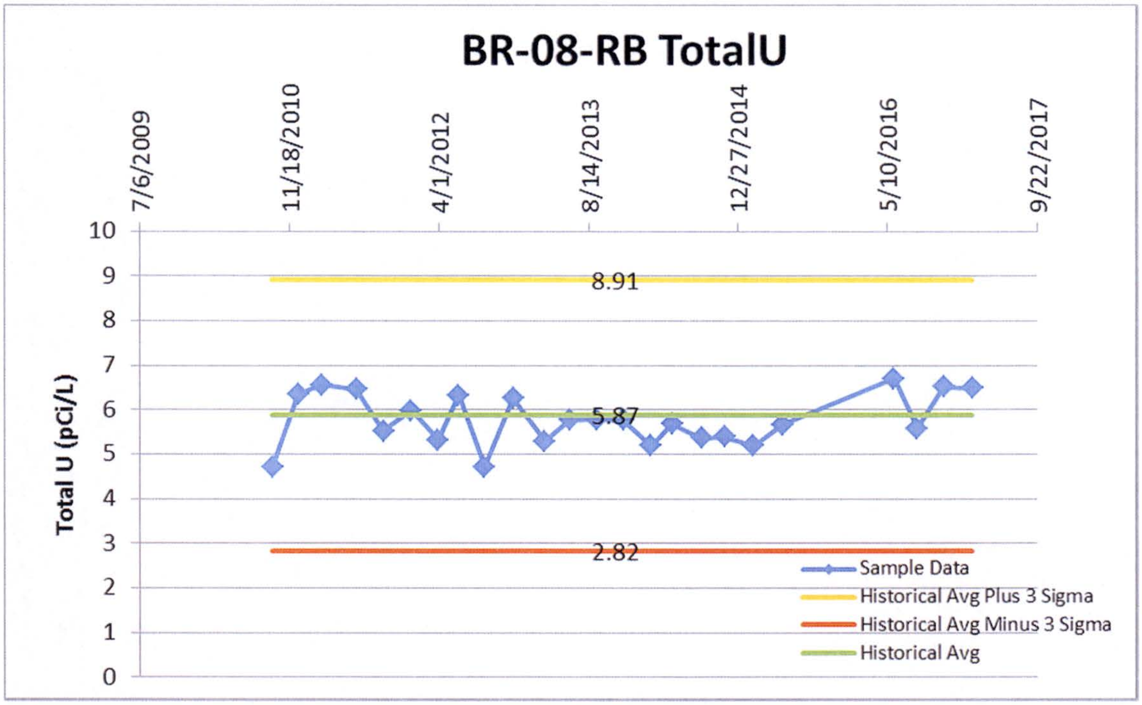

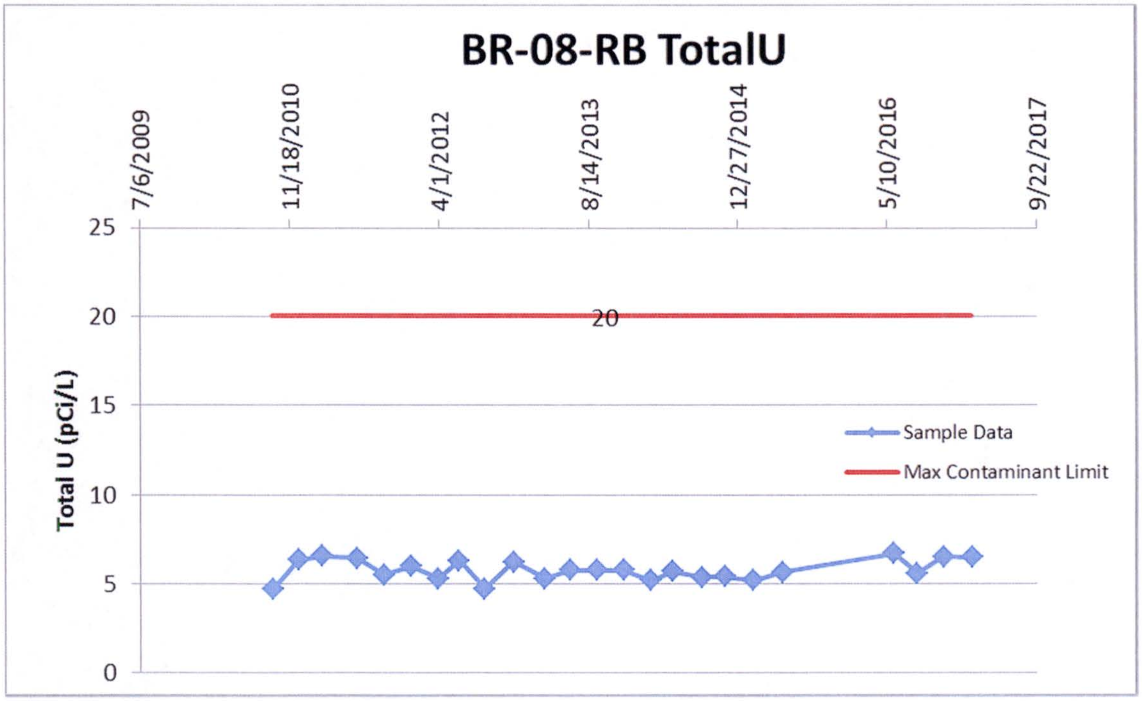

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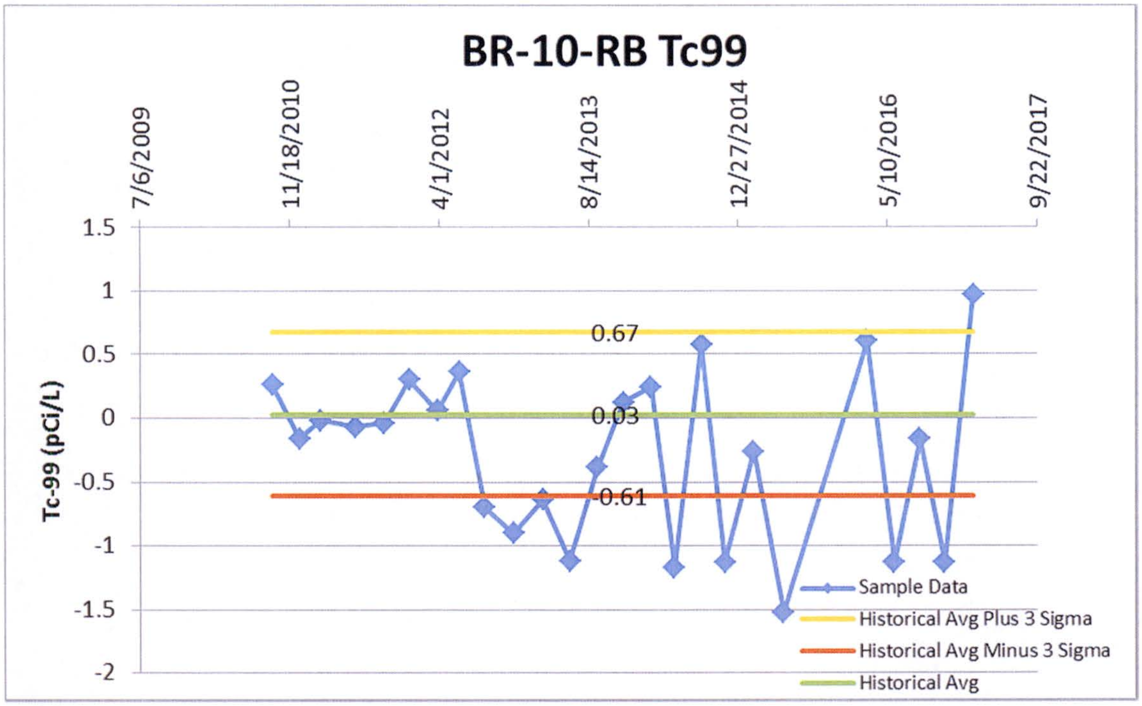

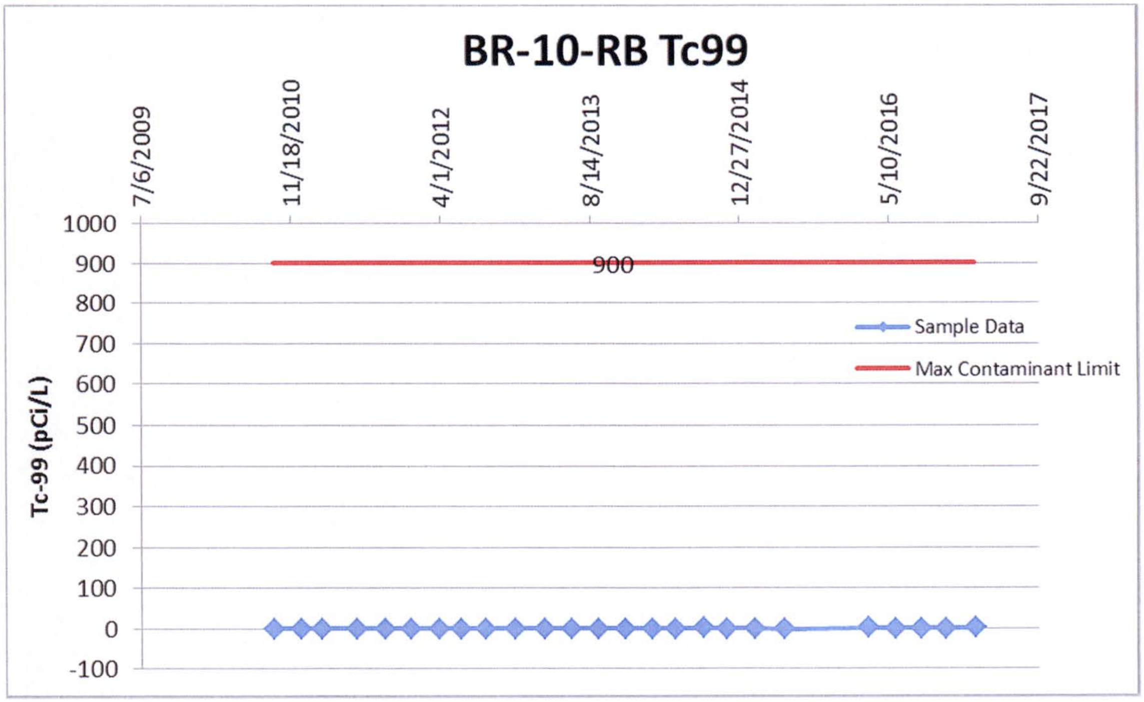

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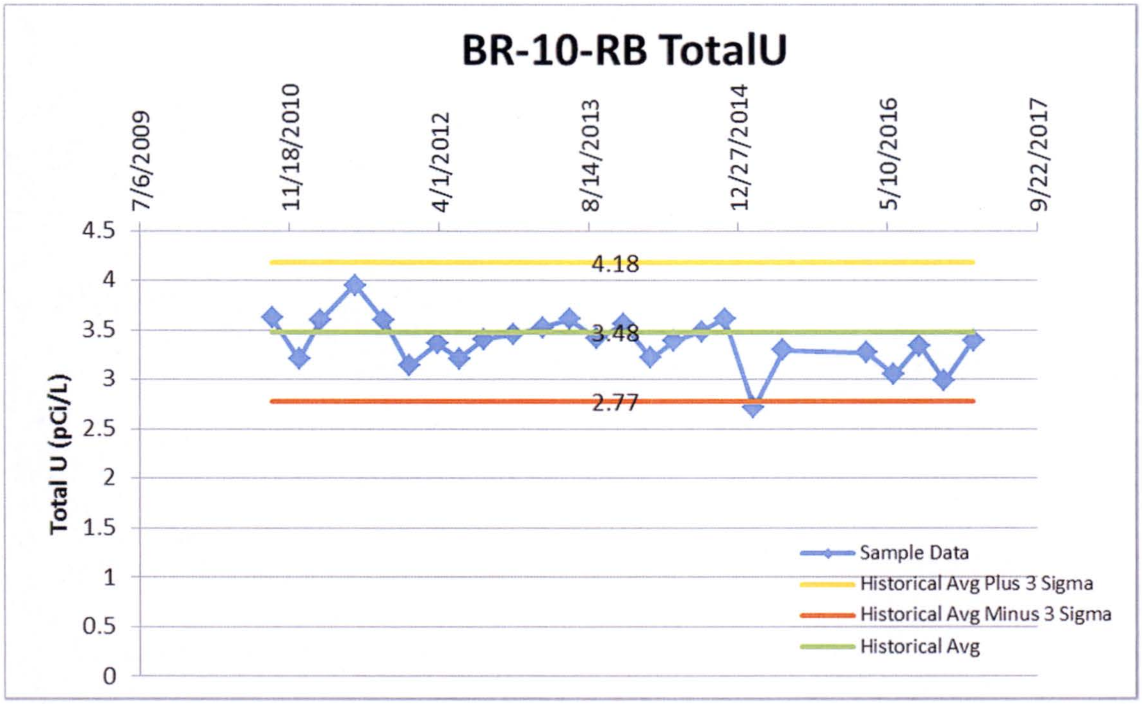

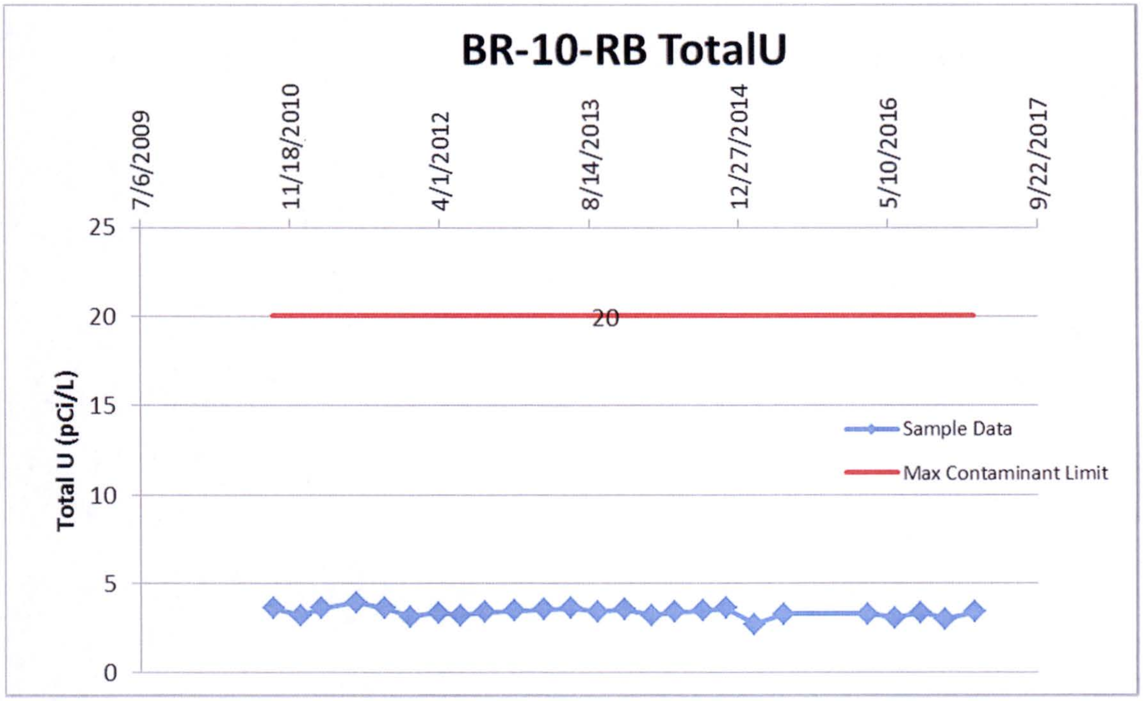

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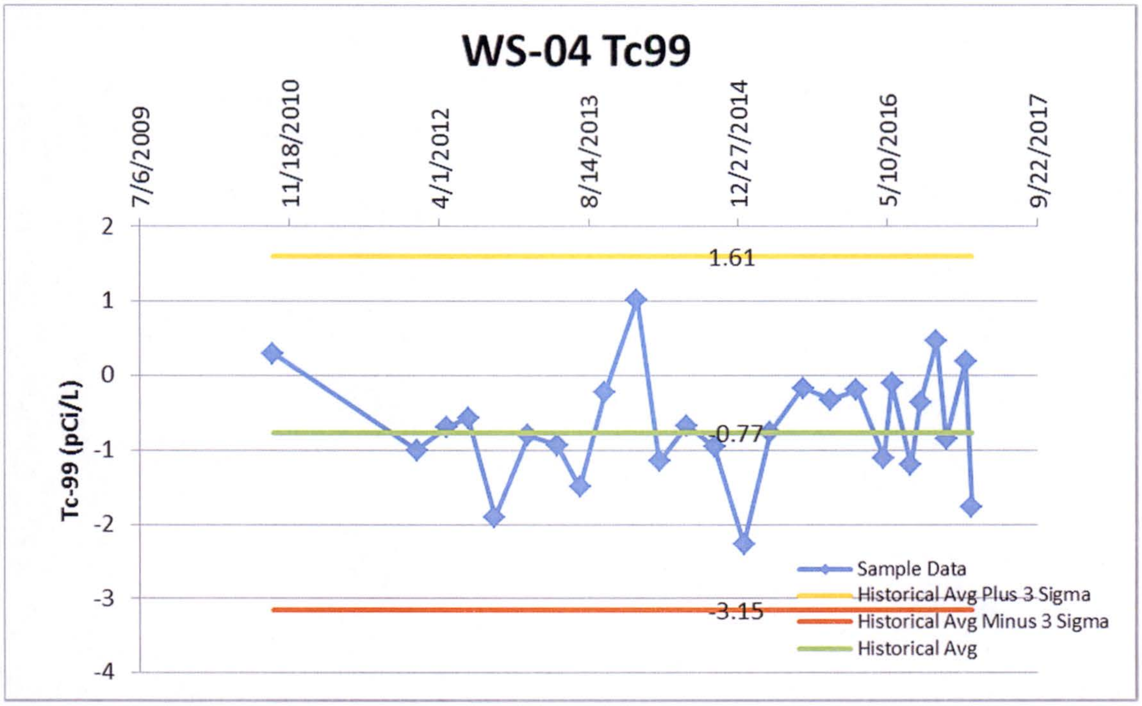

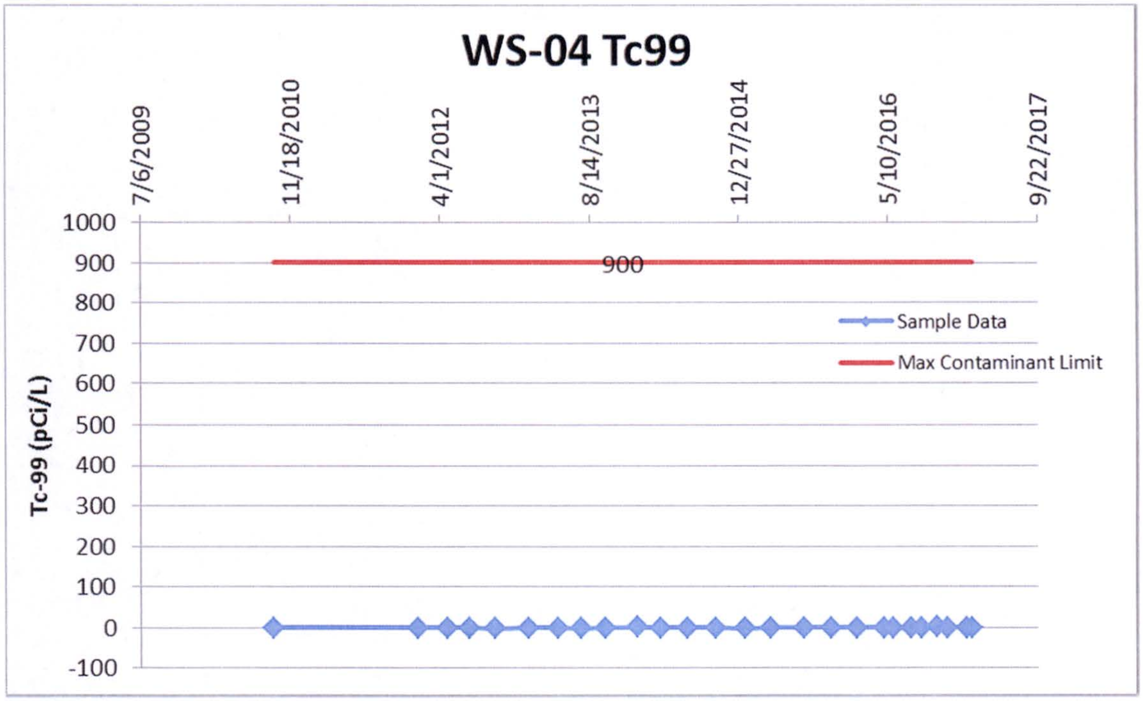

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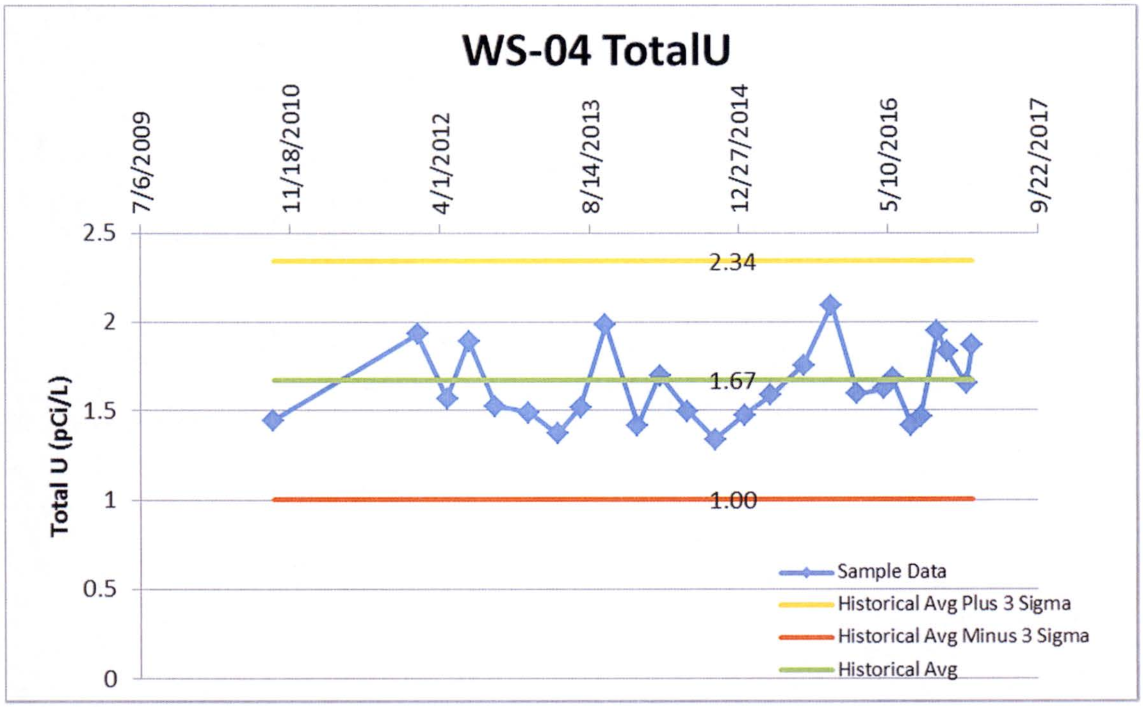

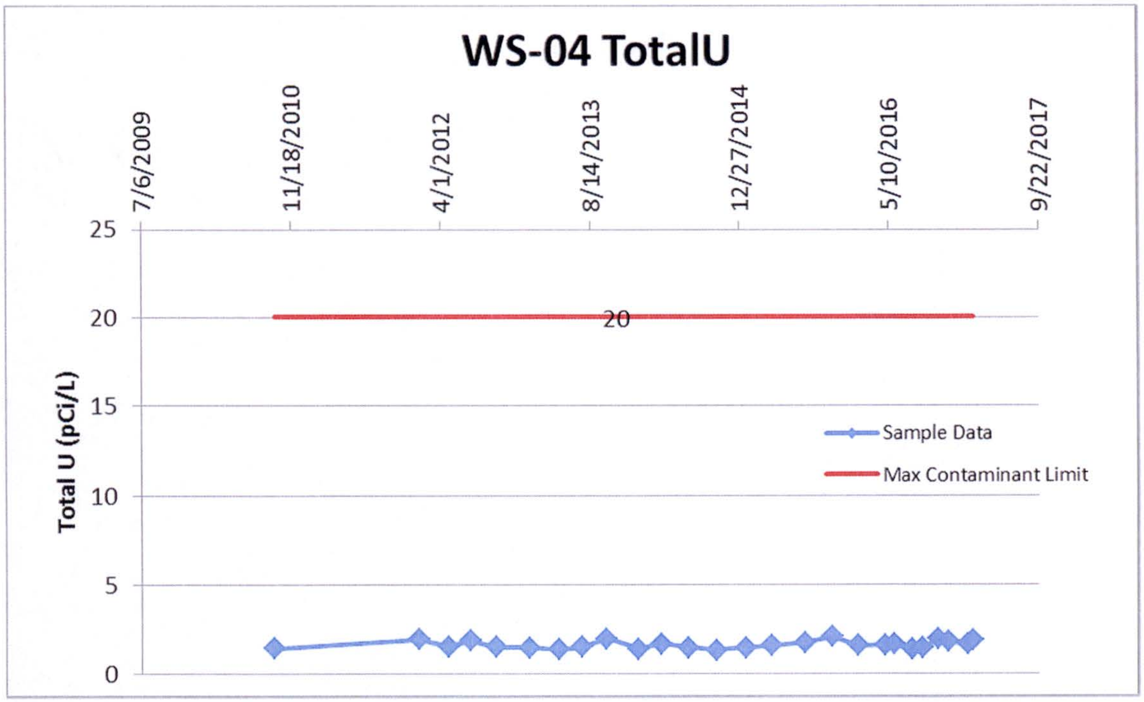

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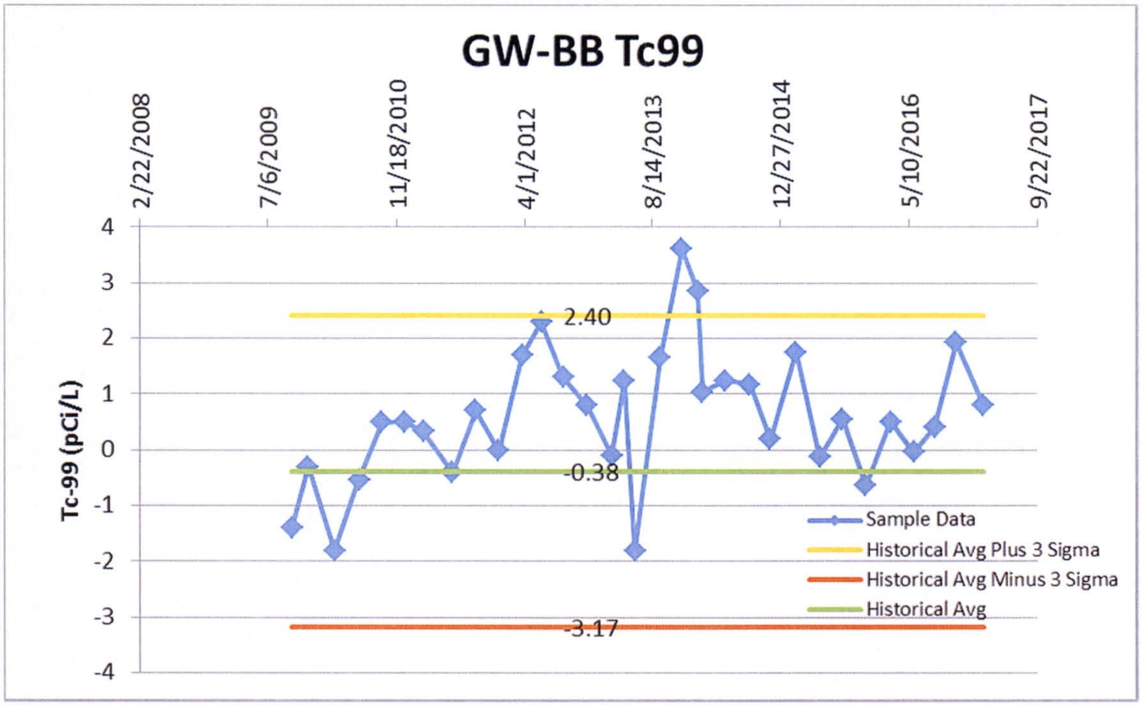
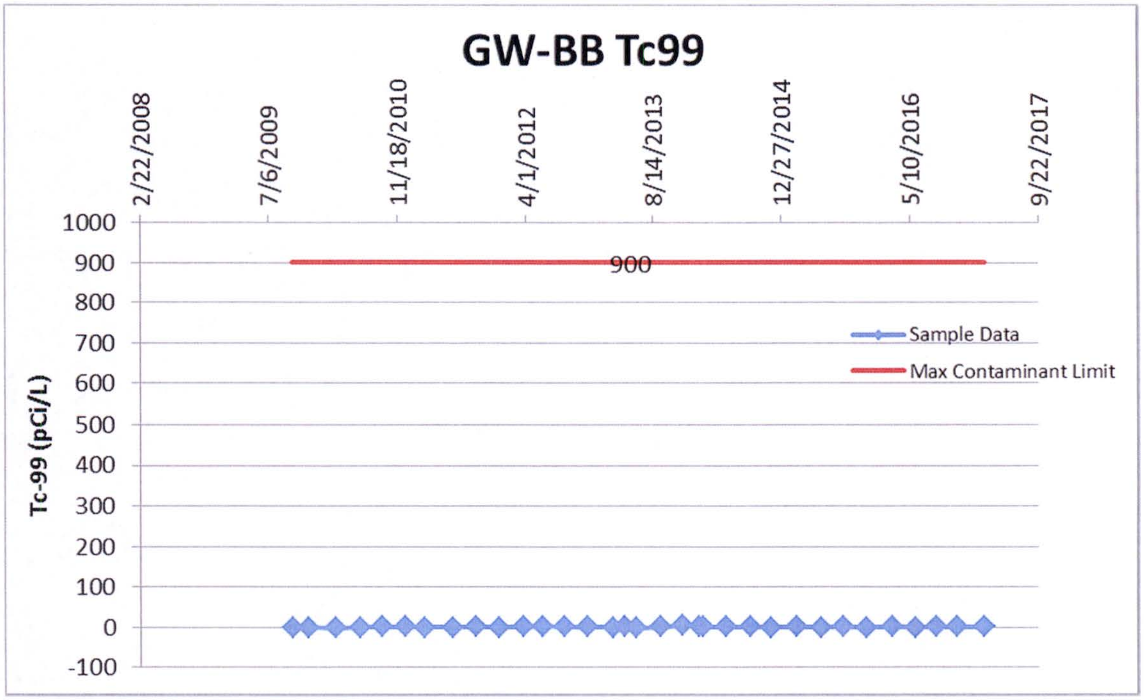
SAND/GRAVEL HSU





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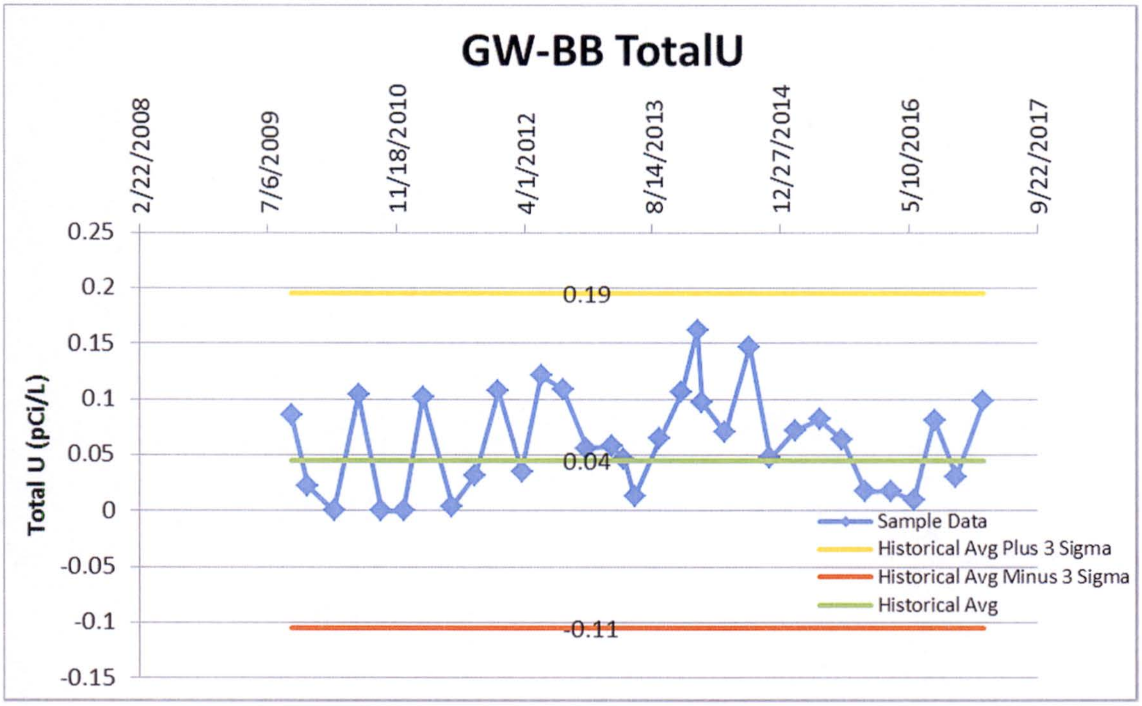

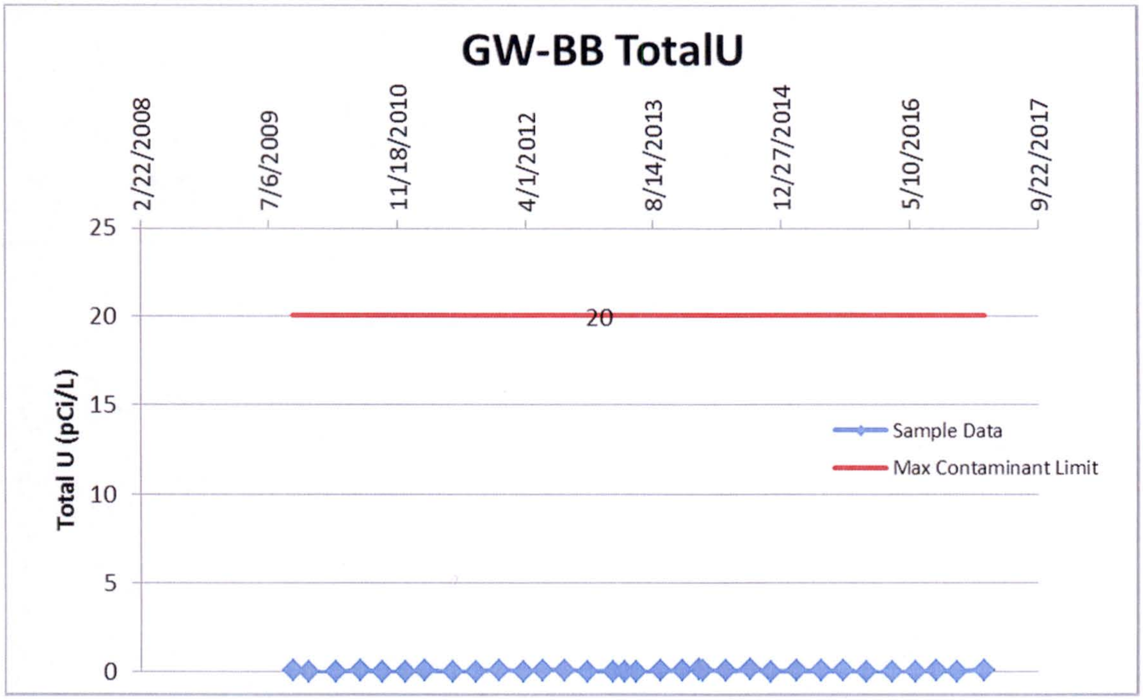

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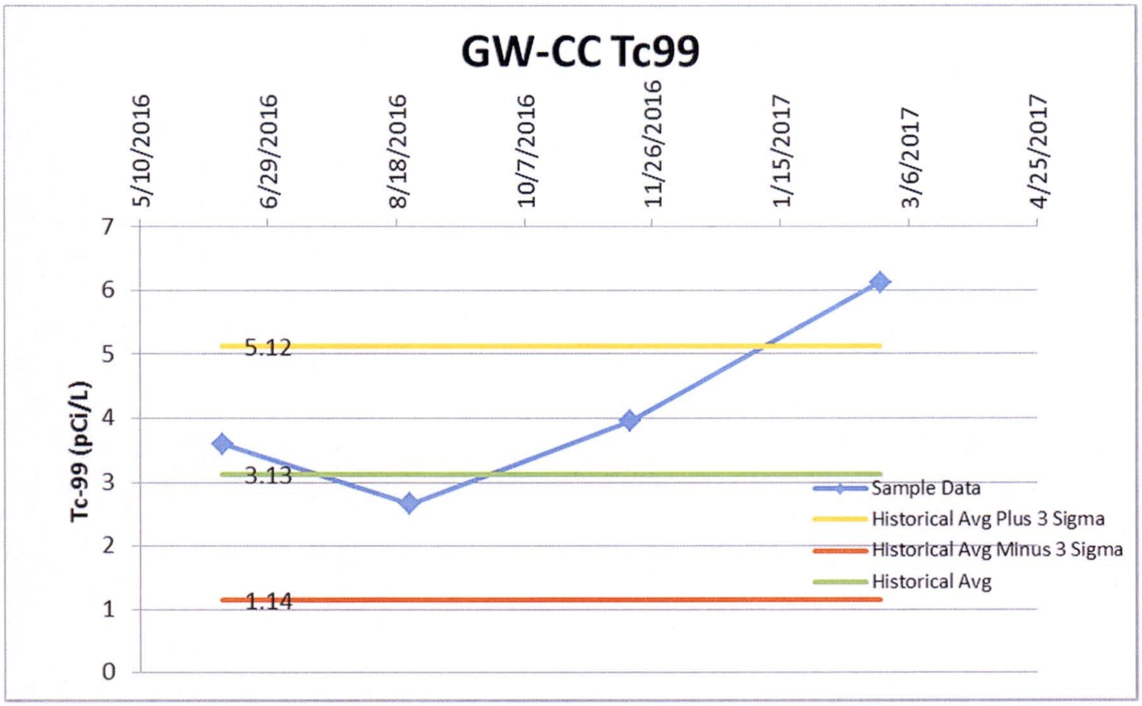

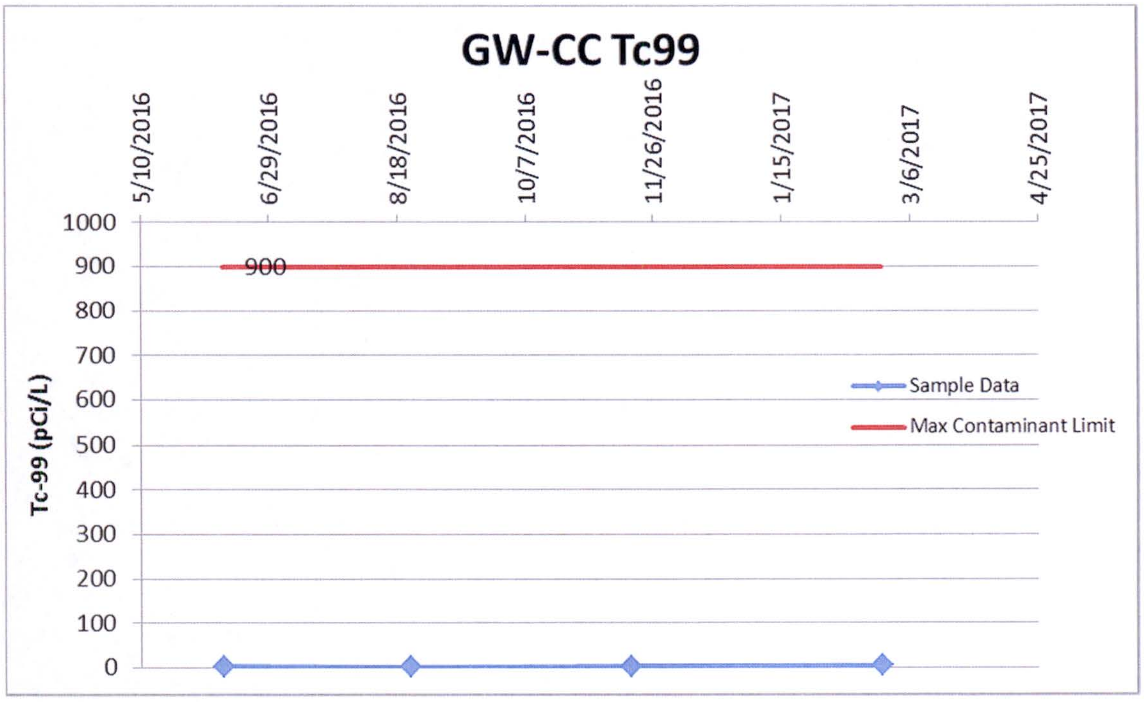

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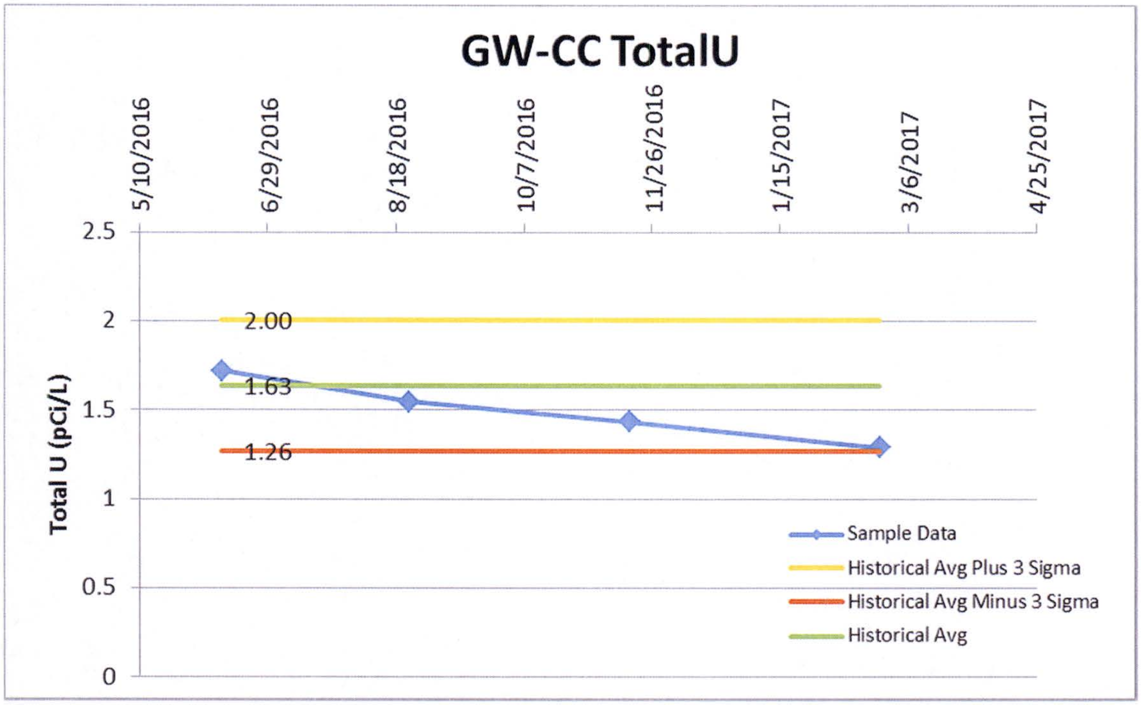

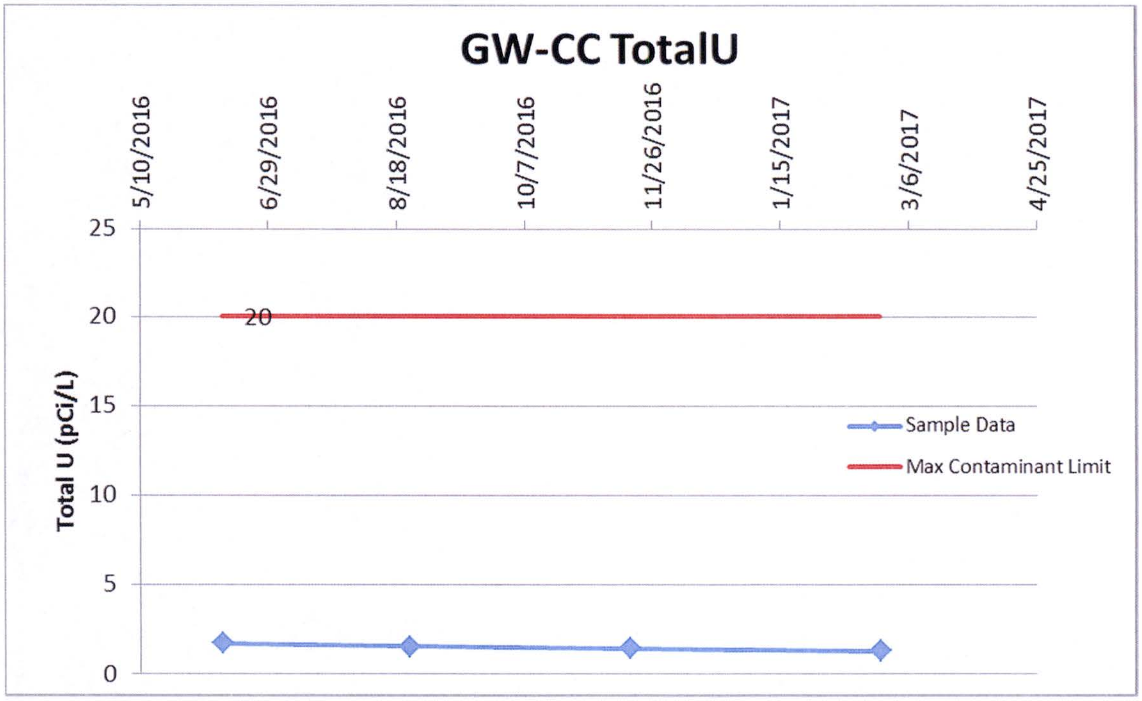

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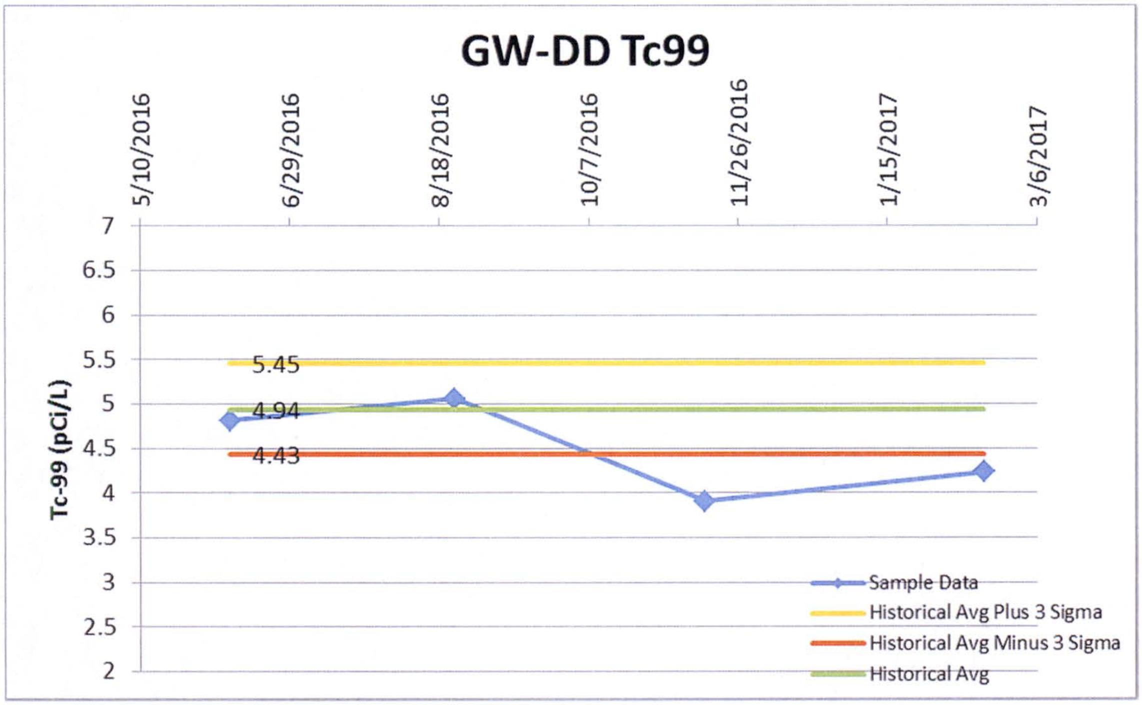

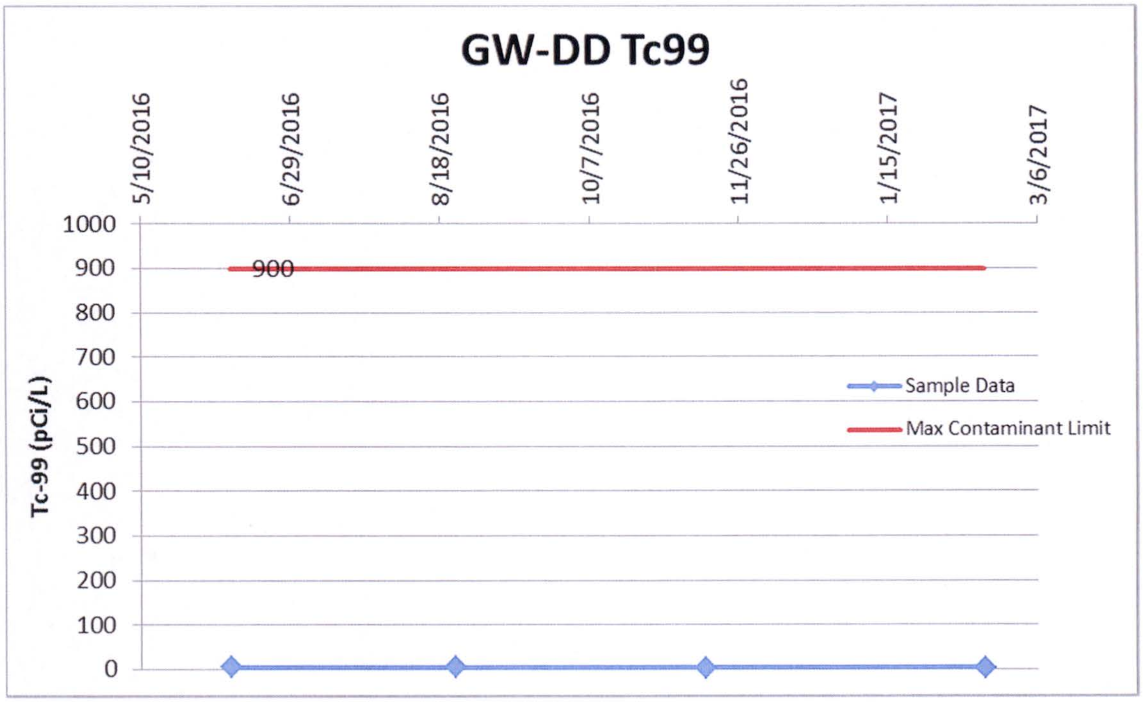

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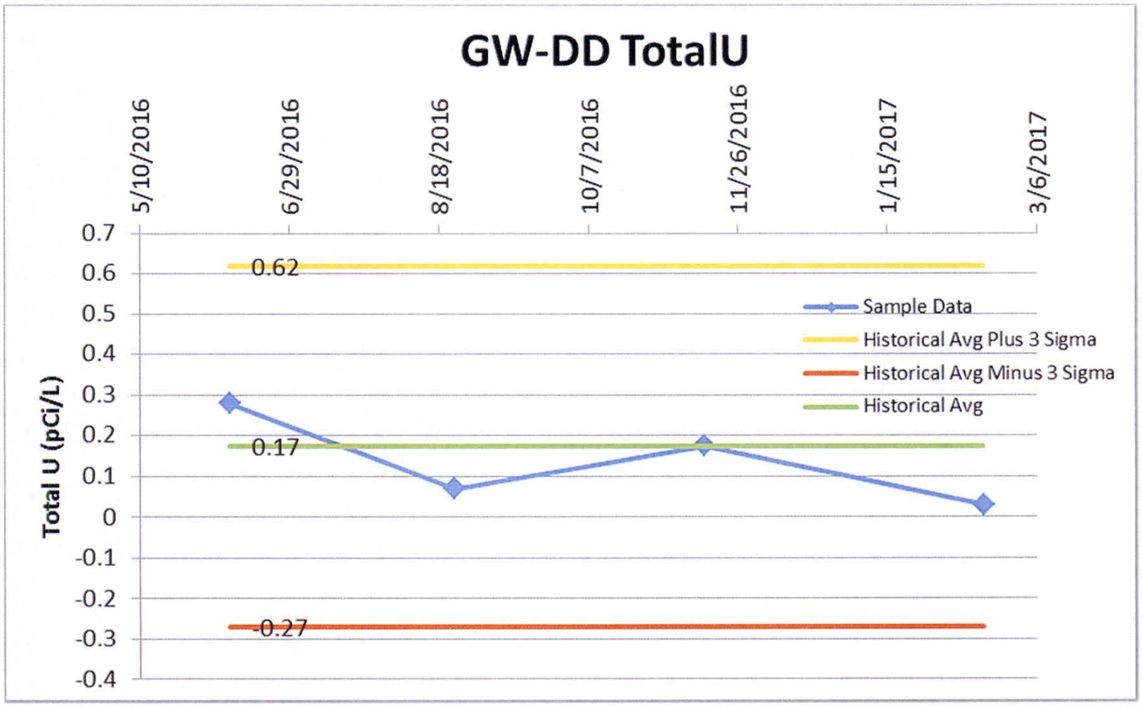

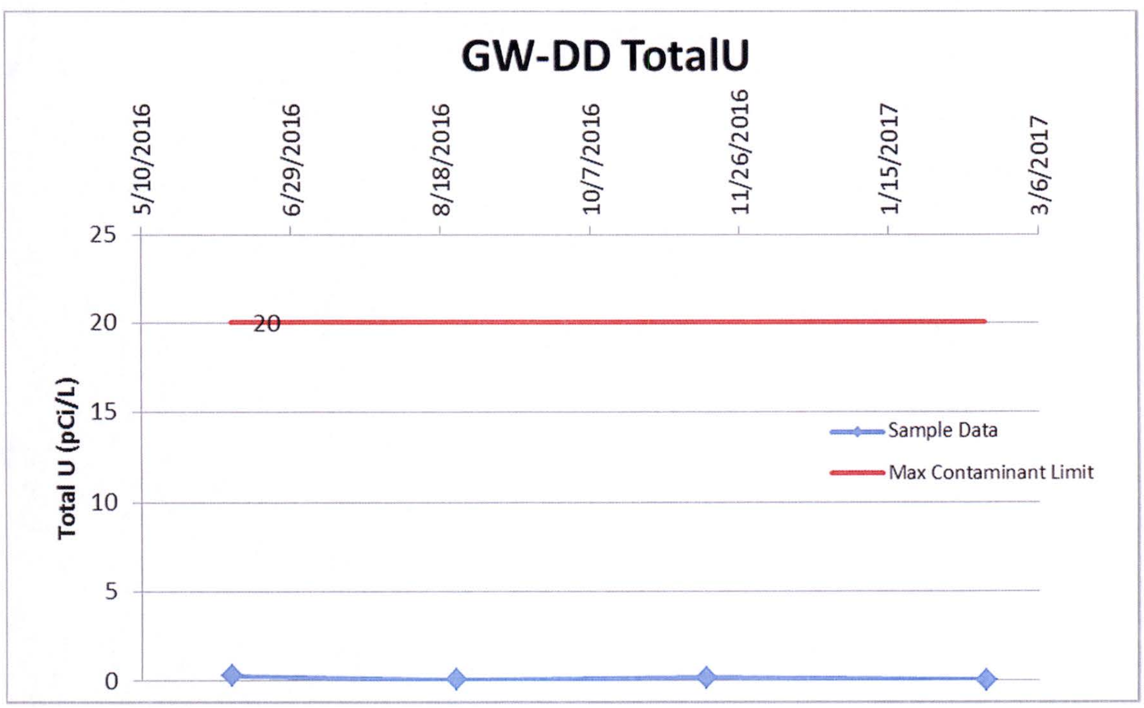

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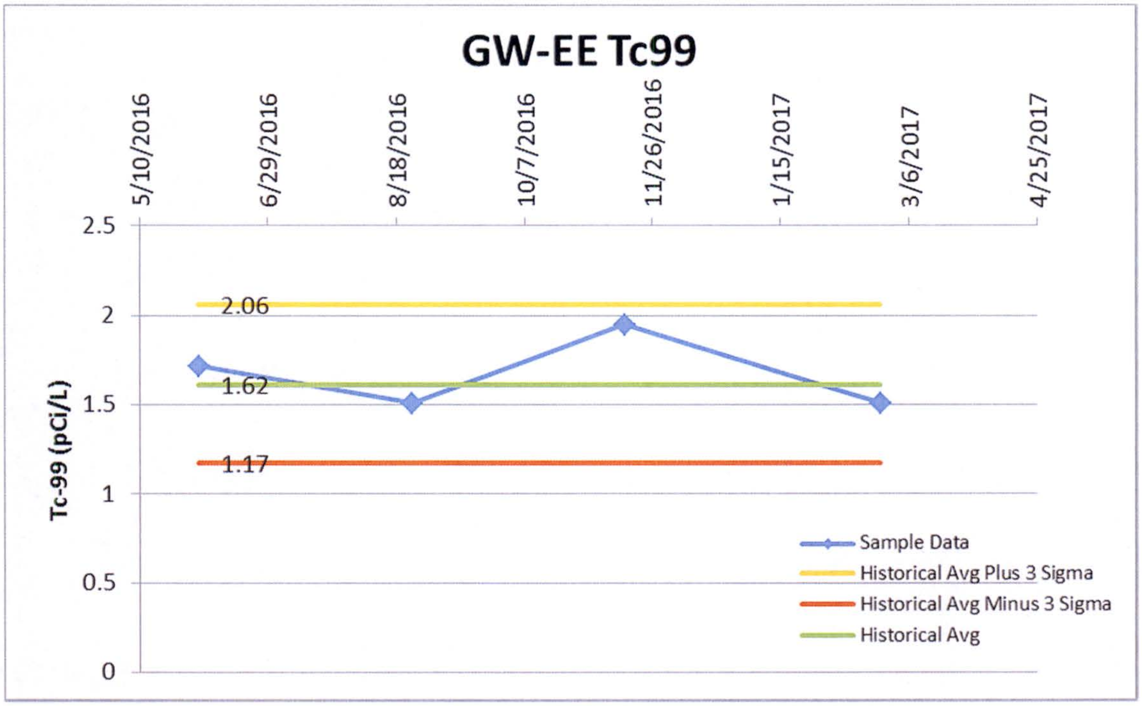

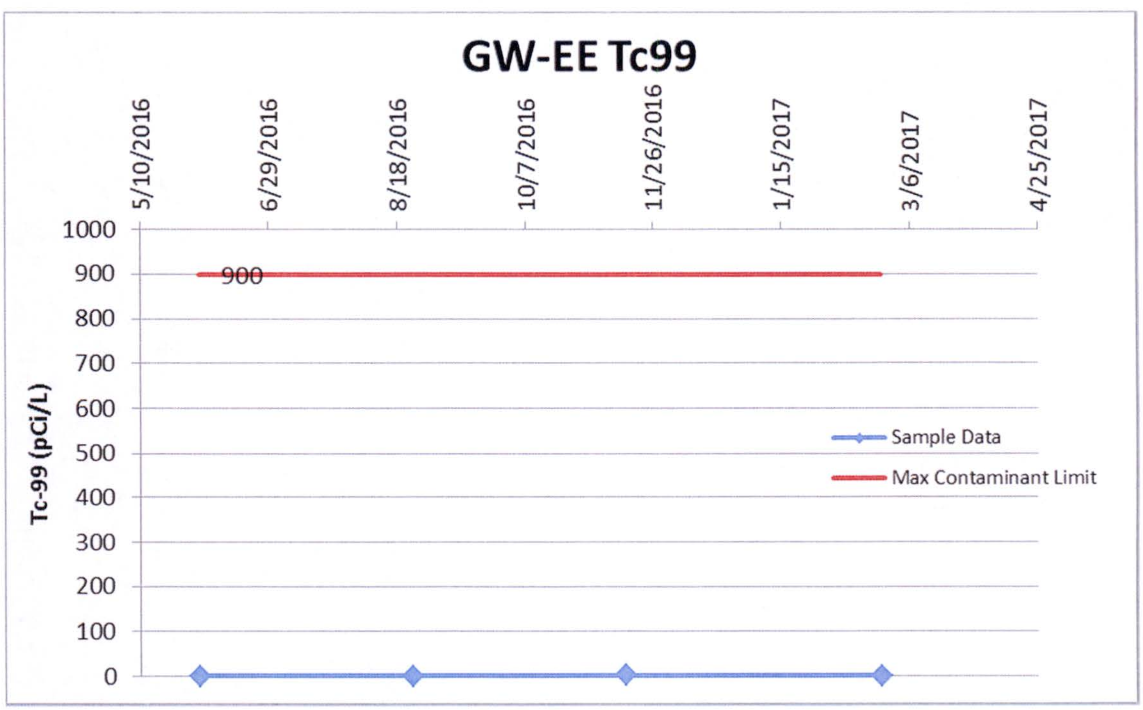

Attachment 2
Mann-Kendall Analysis and Sample Results Graphs

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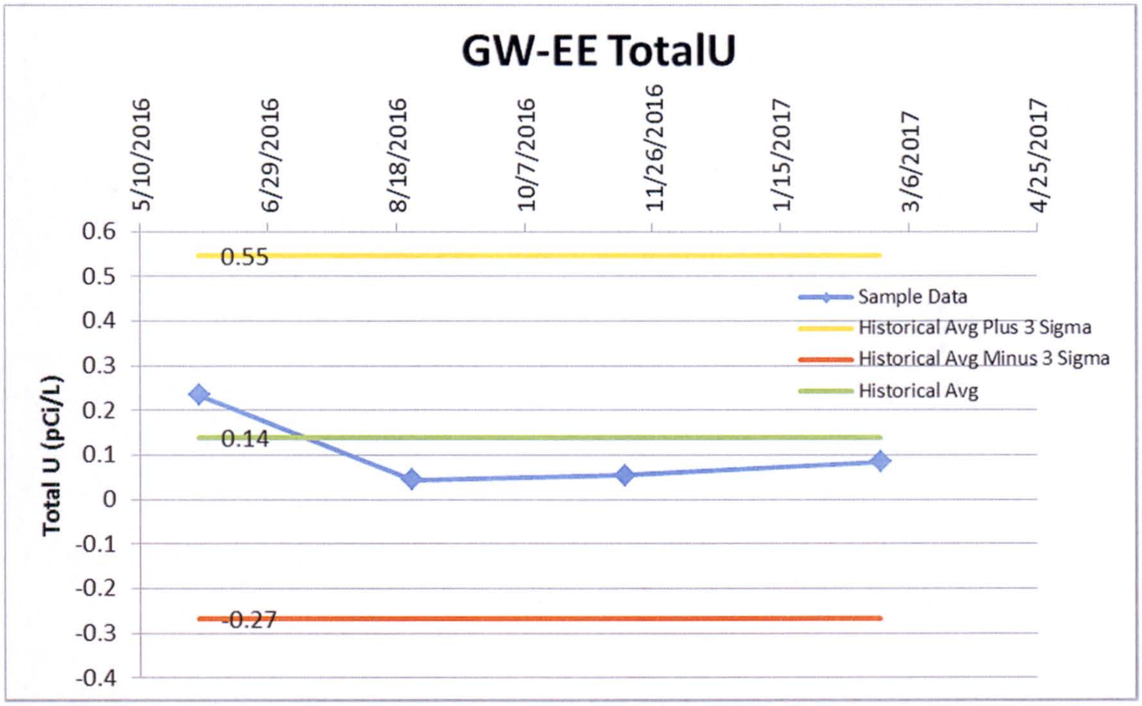

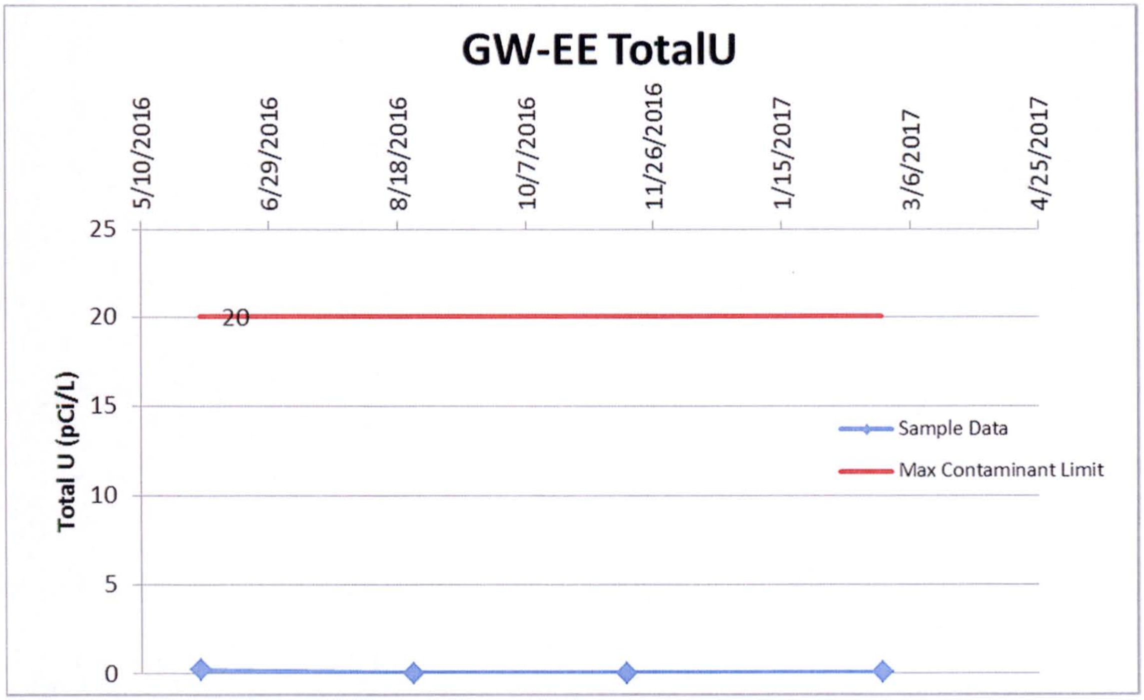

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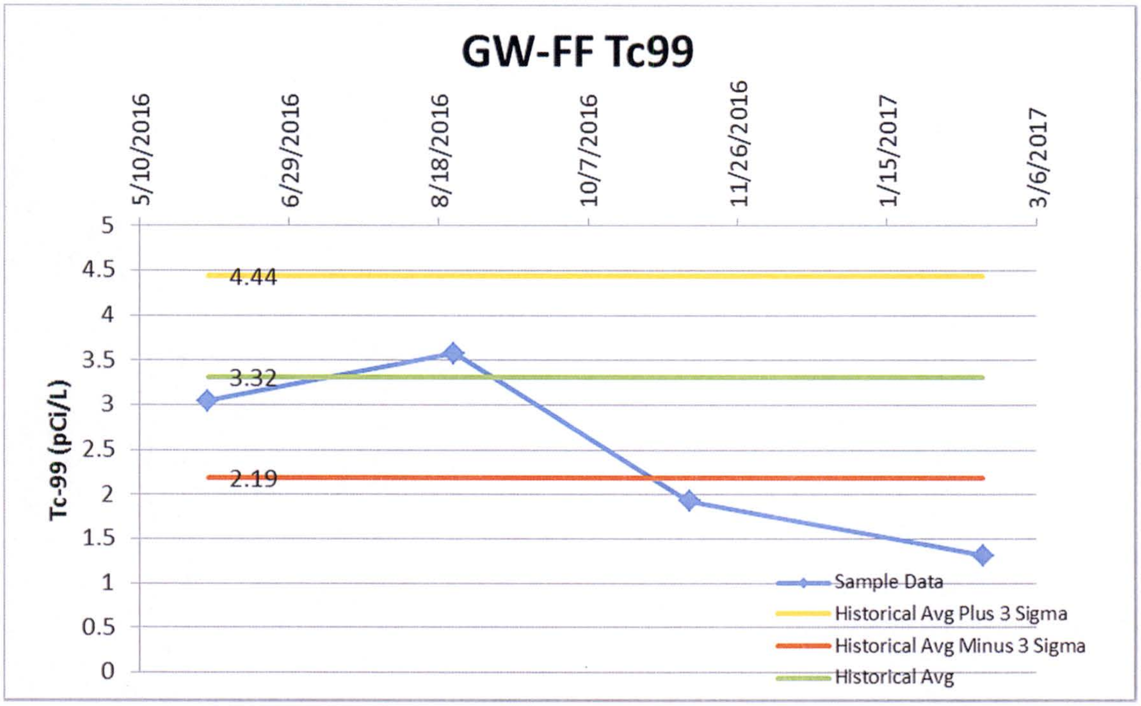

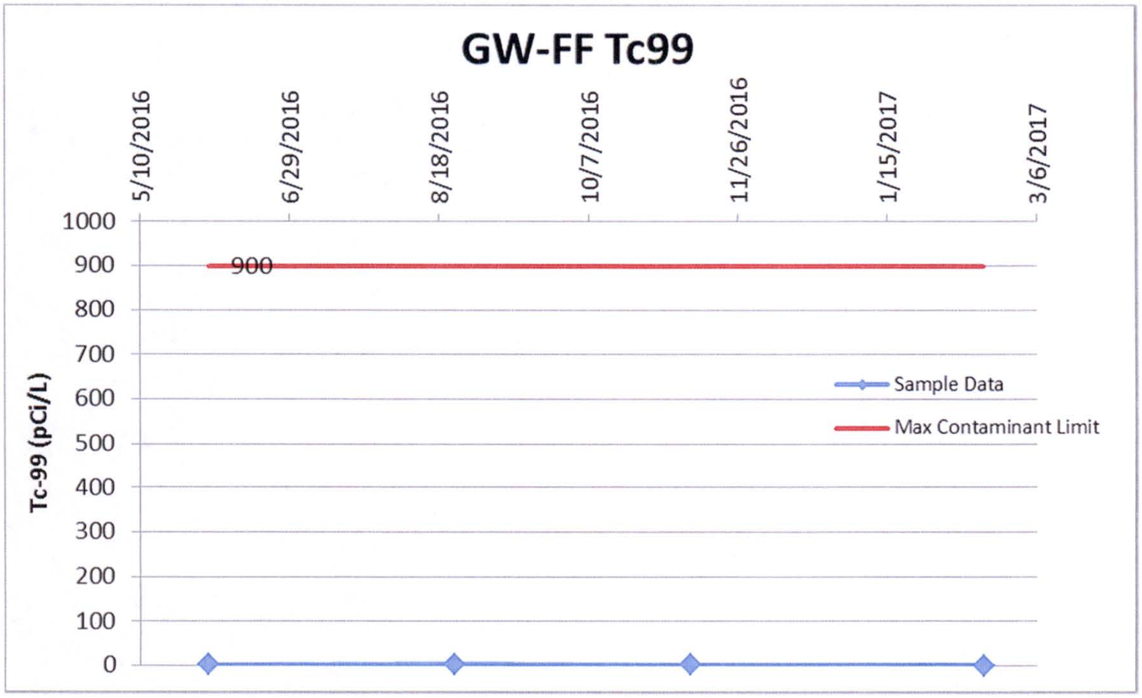

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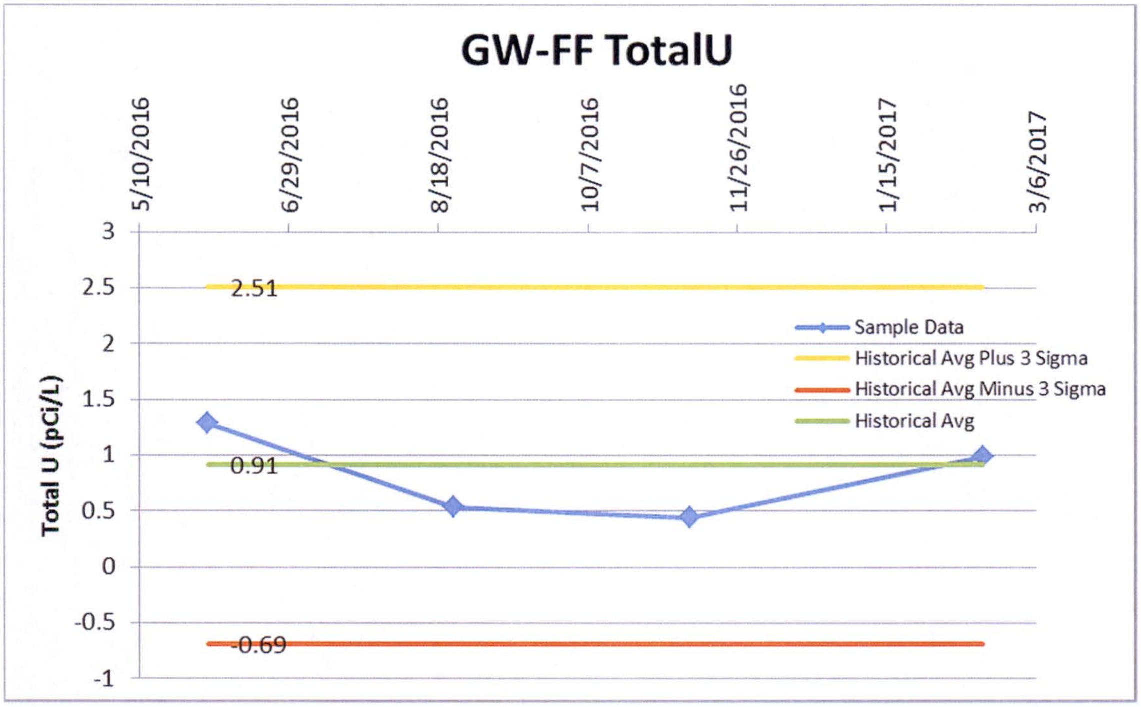

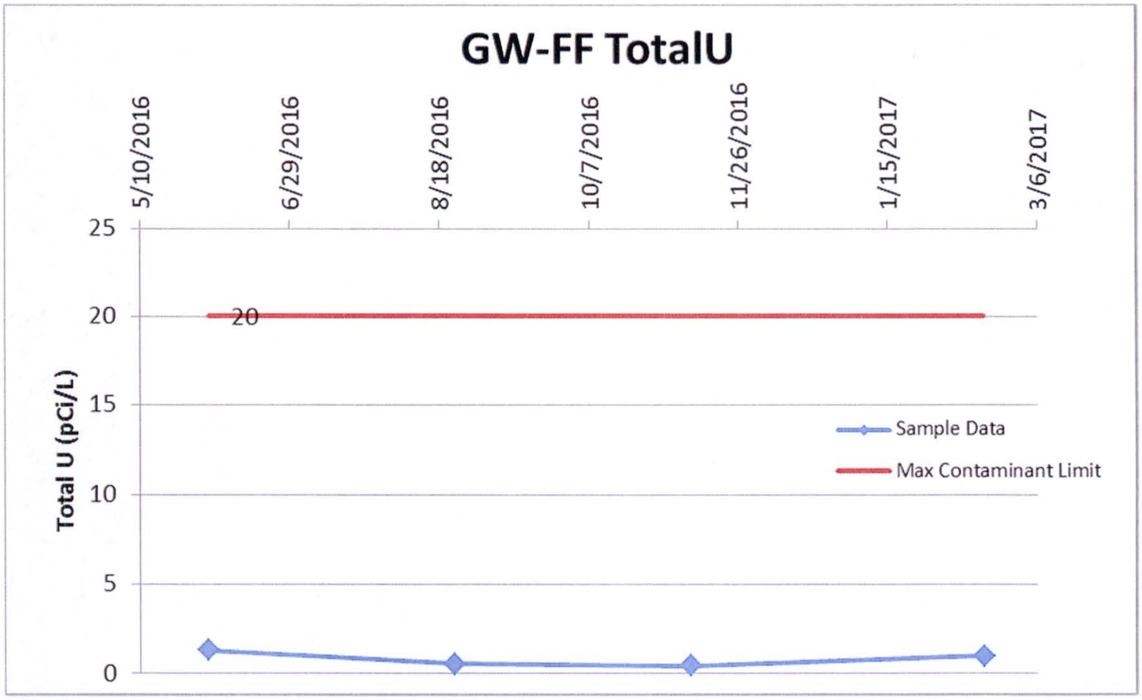

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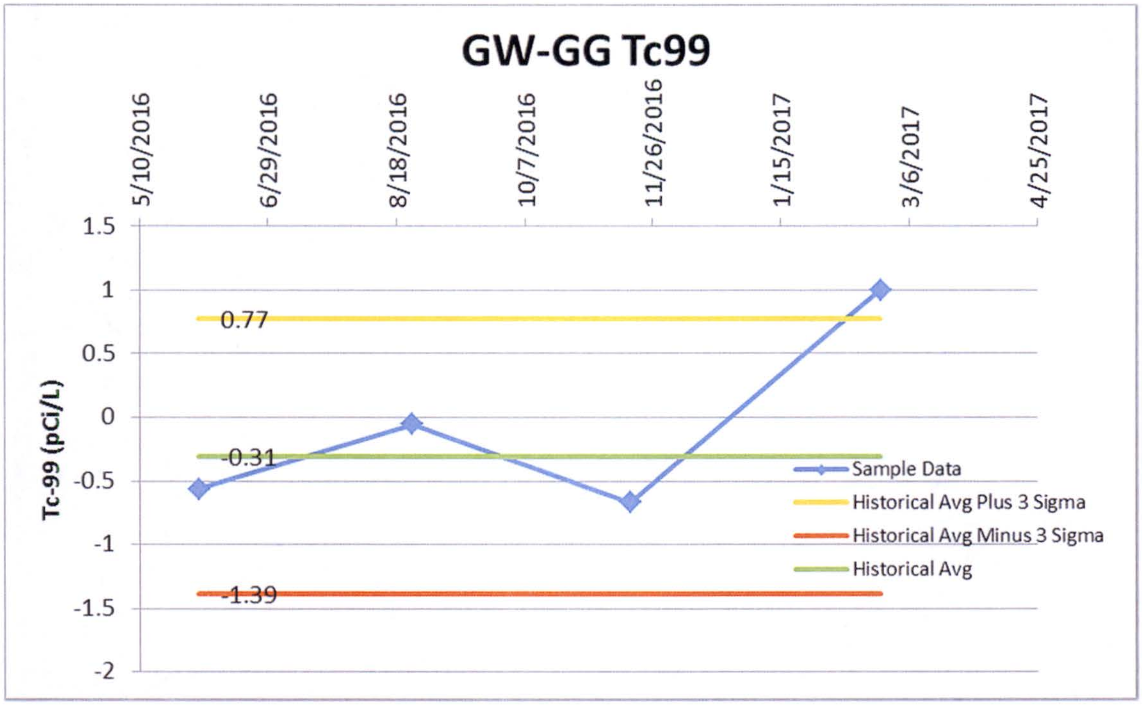

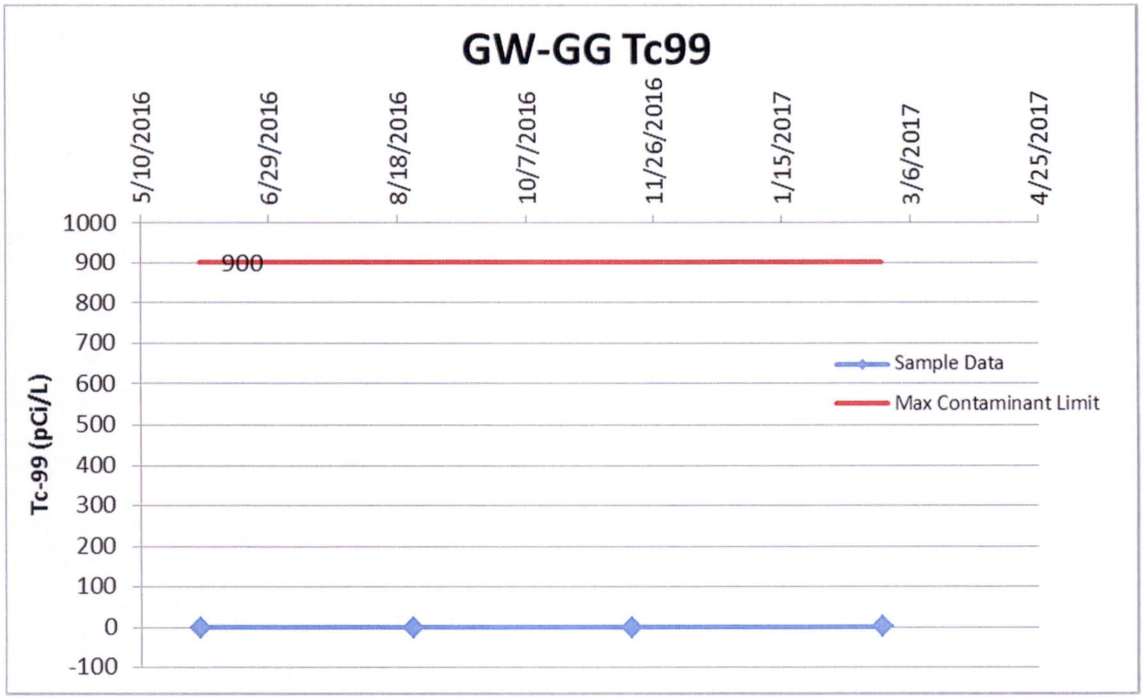

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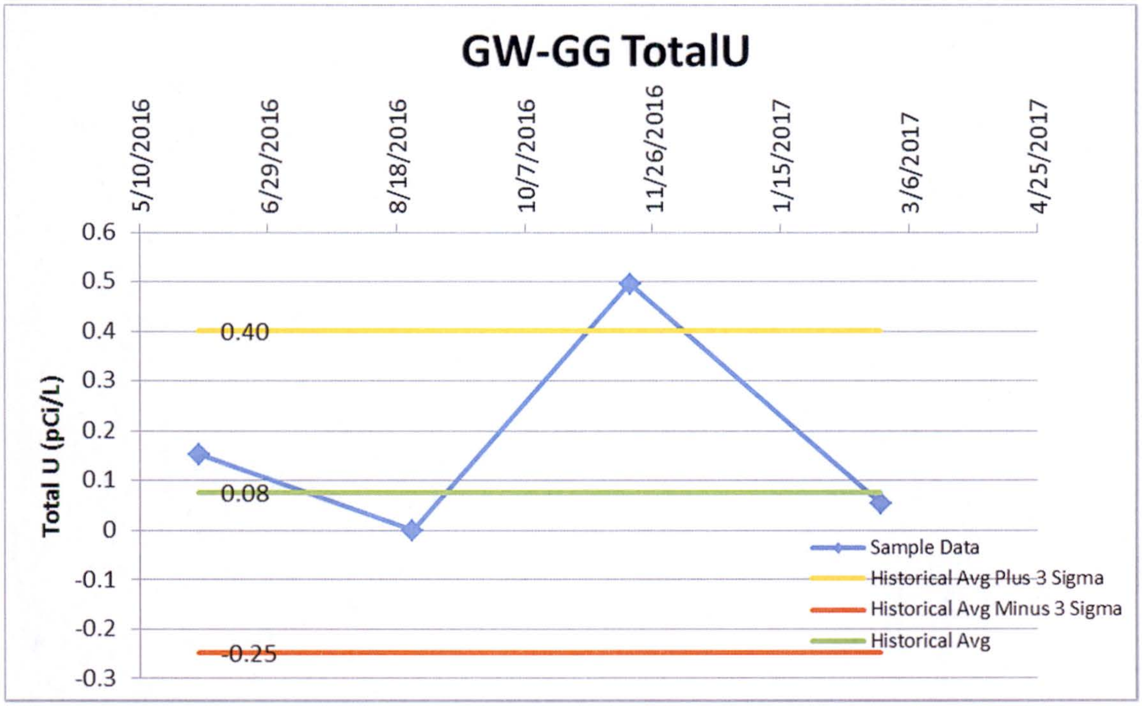

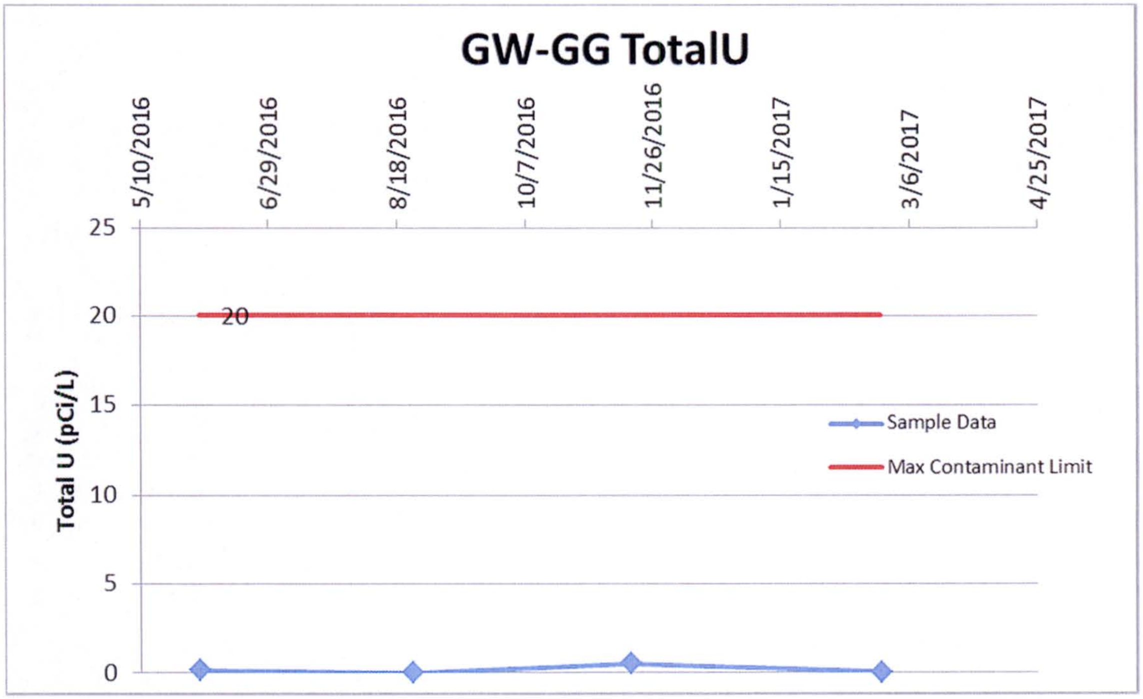

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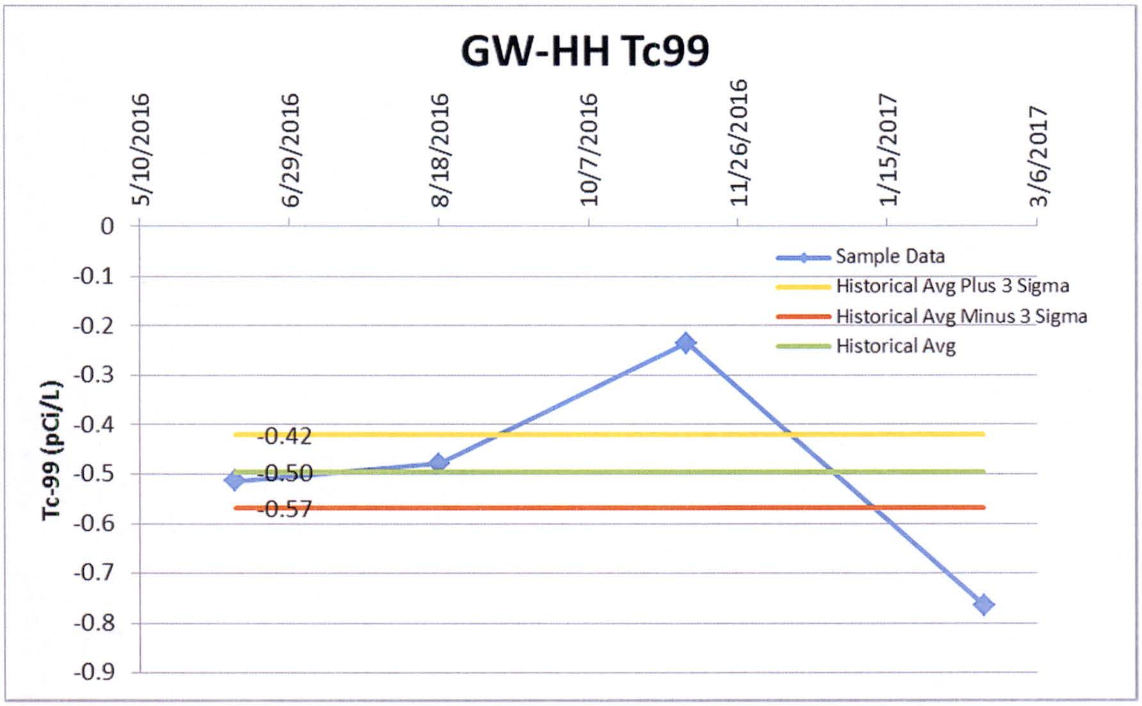

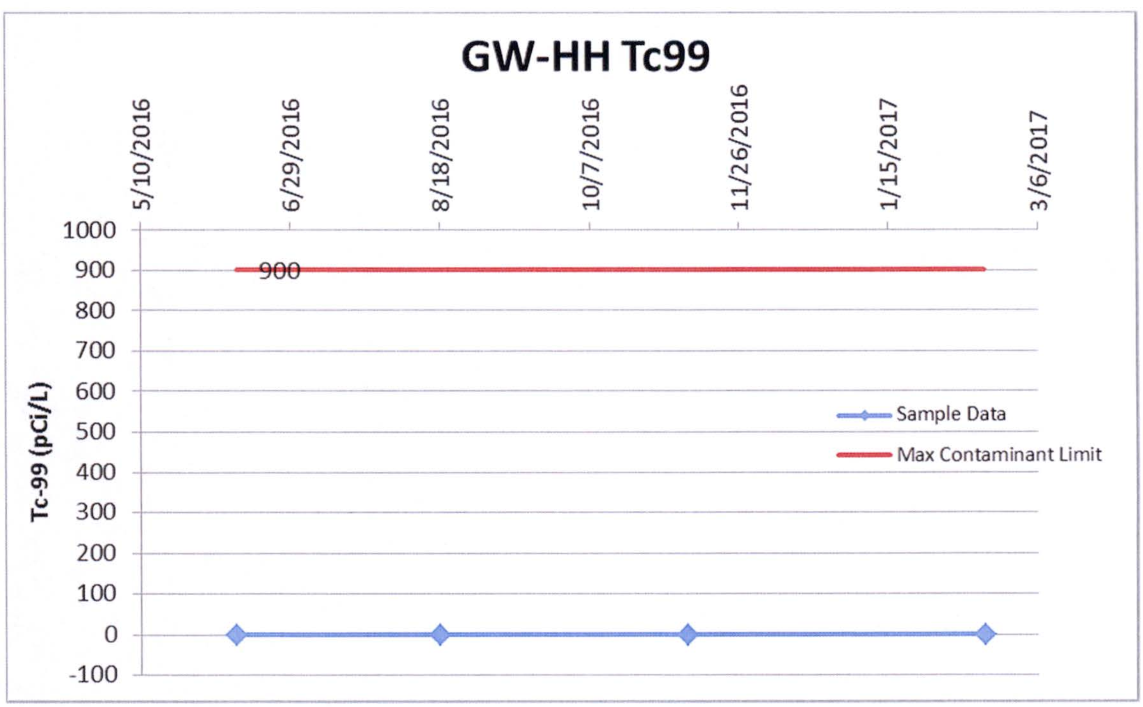

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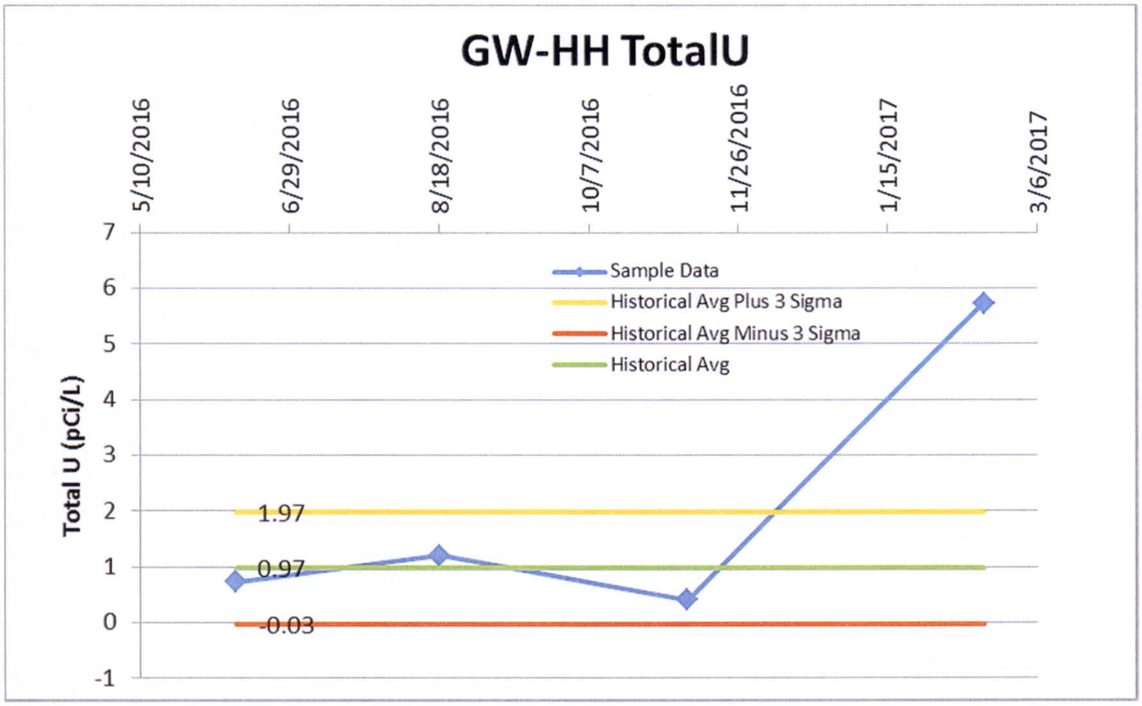

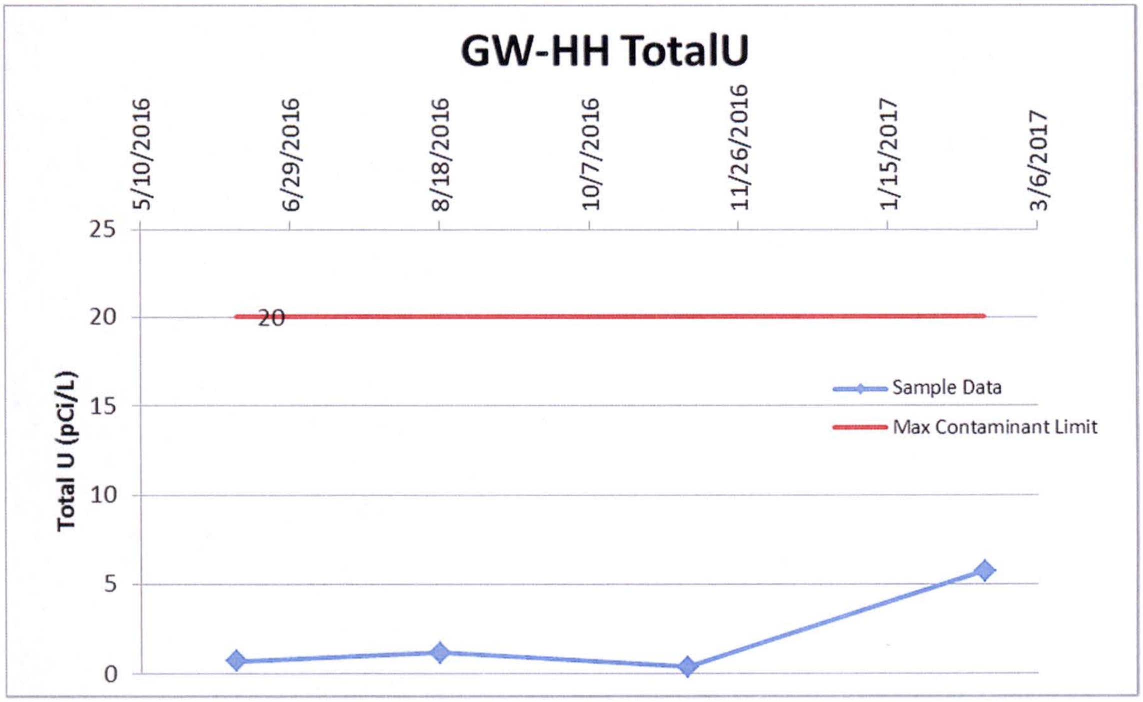

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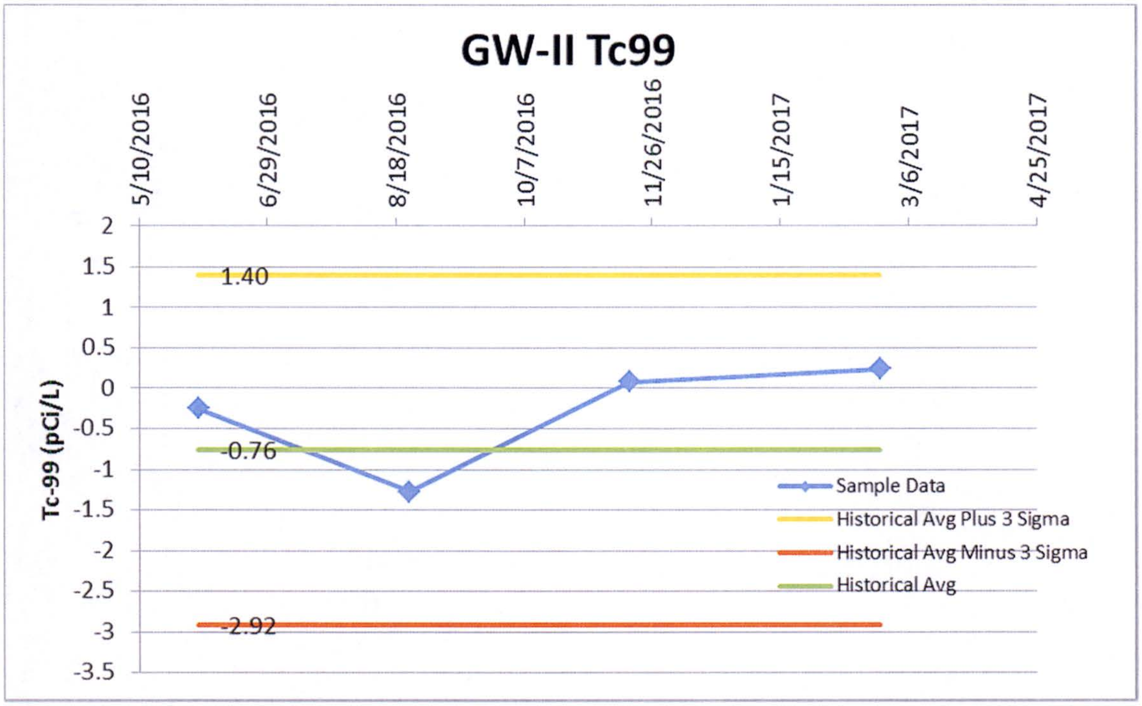

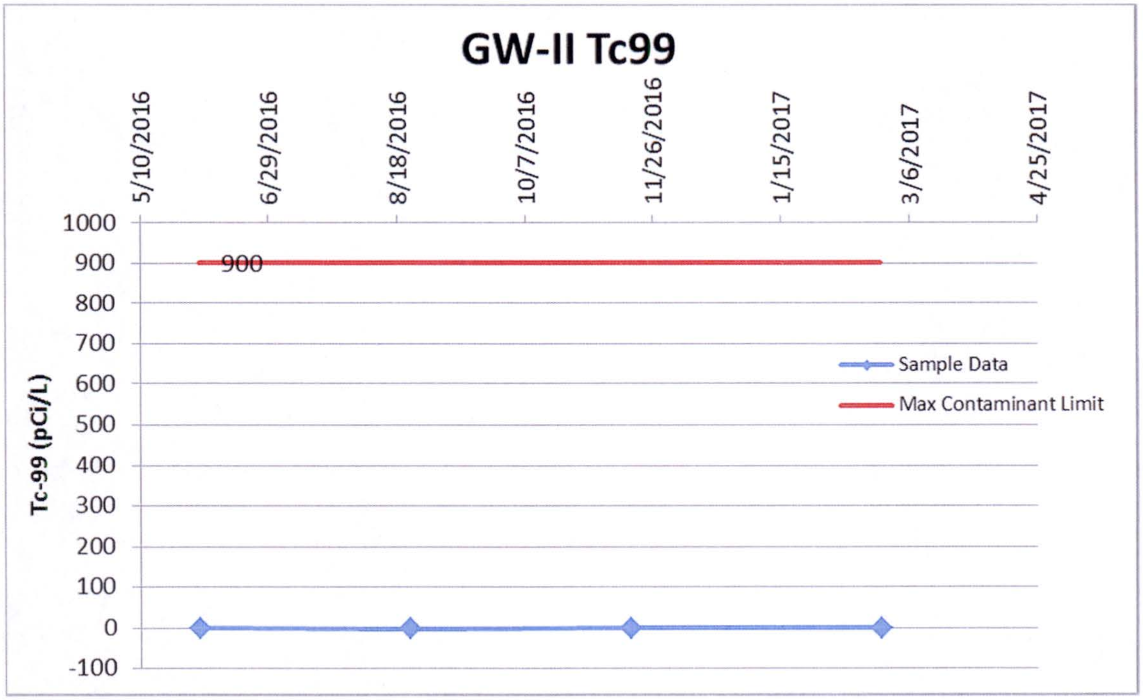

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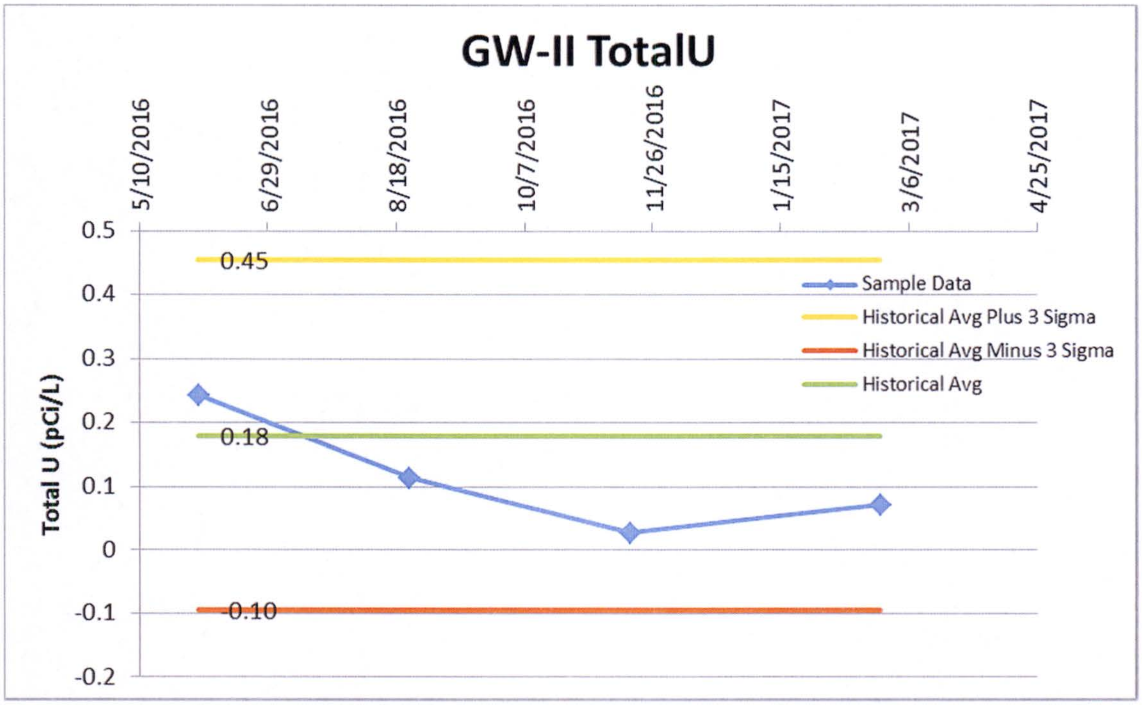

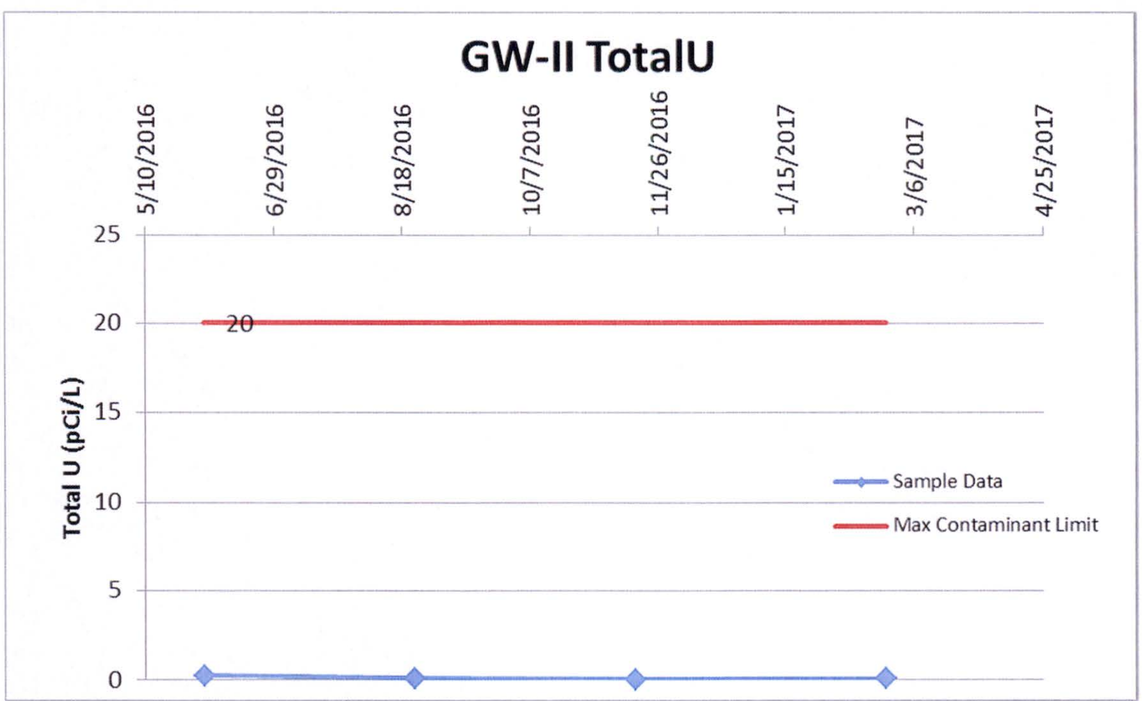

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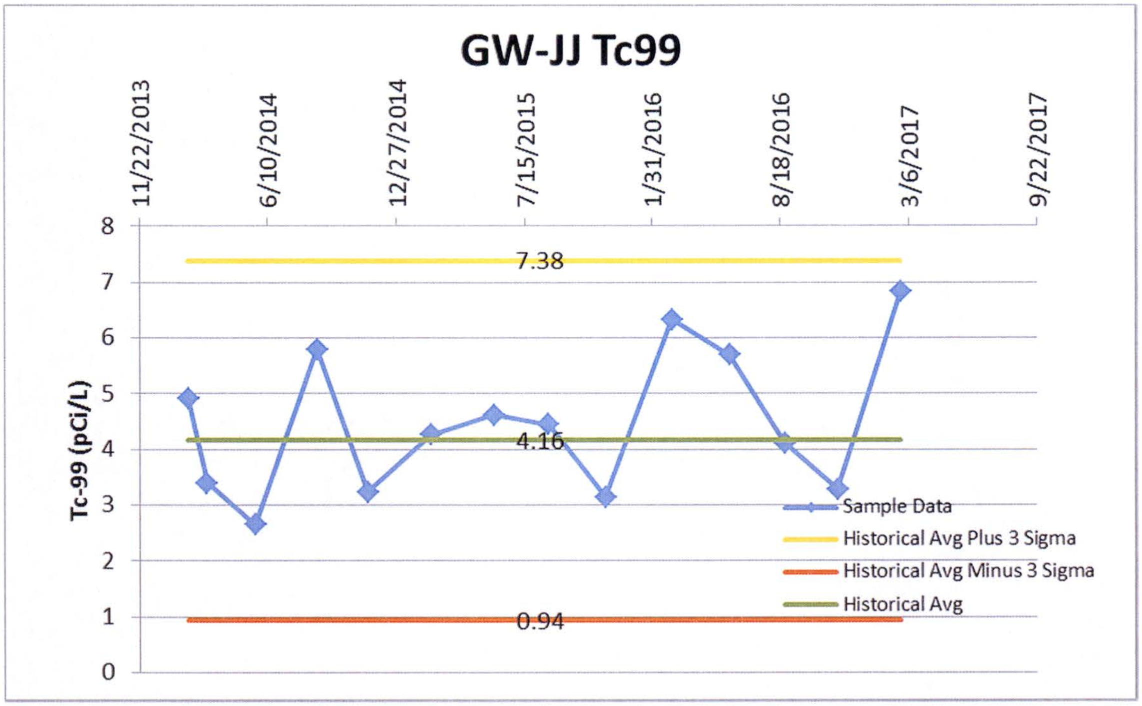

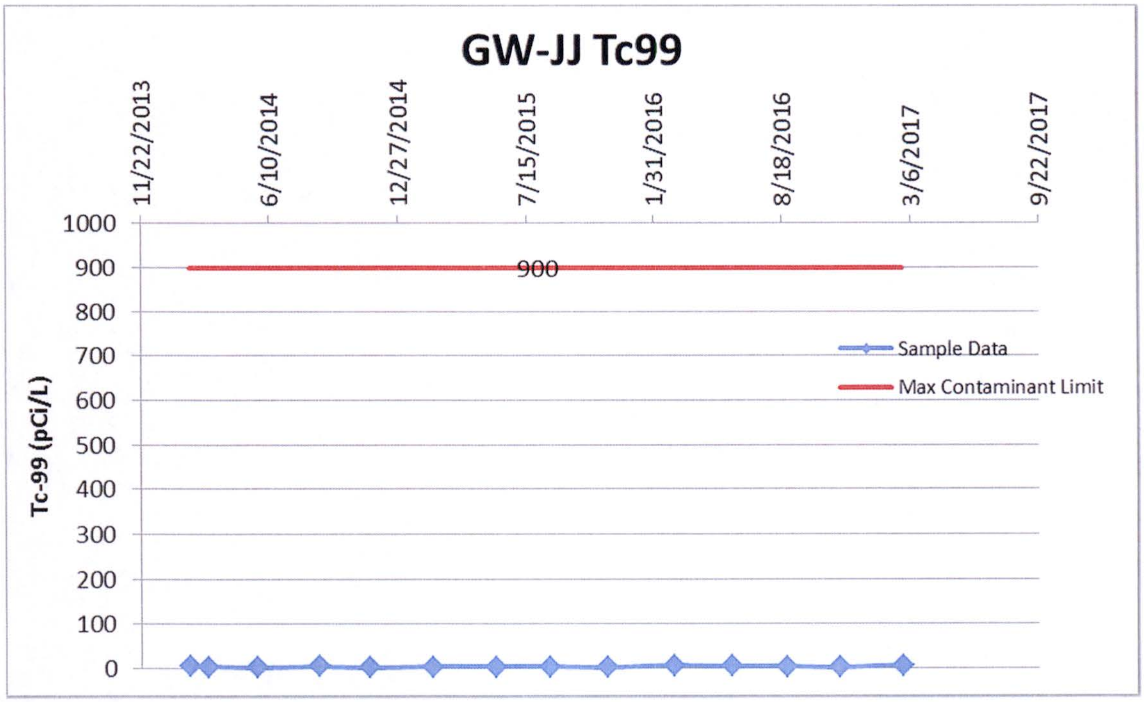

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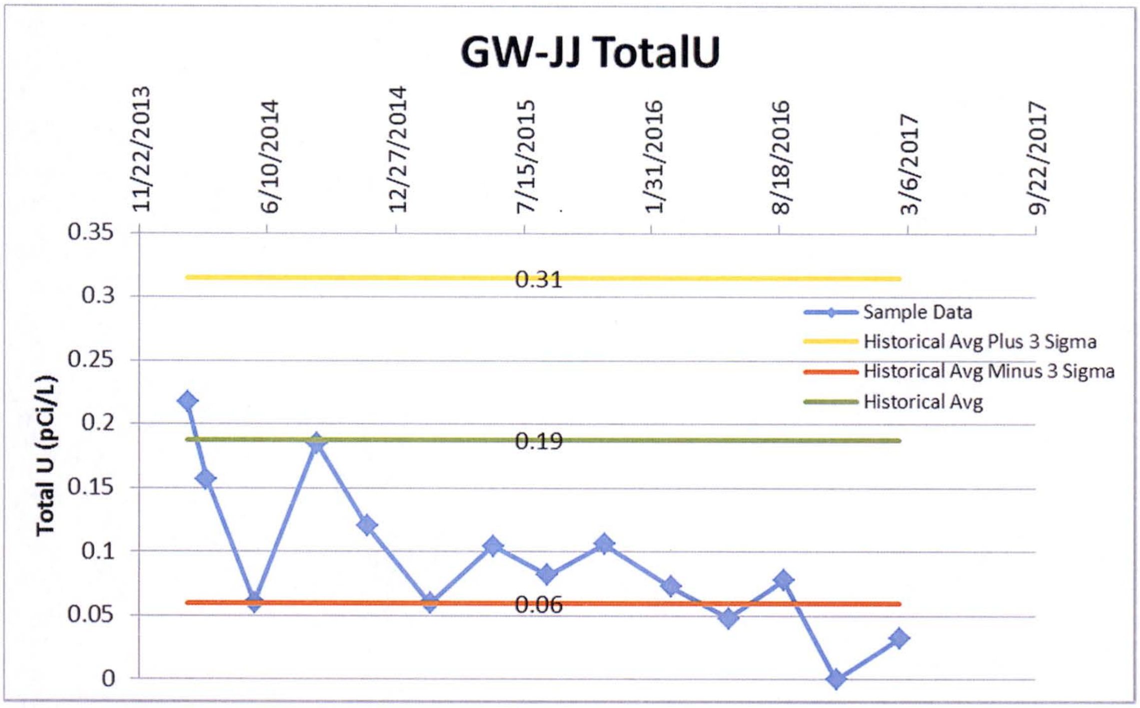

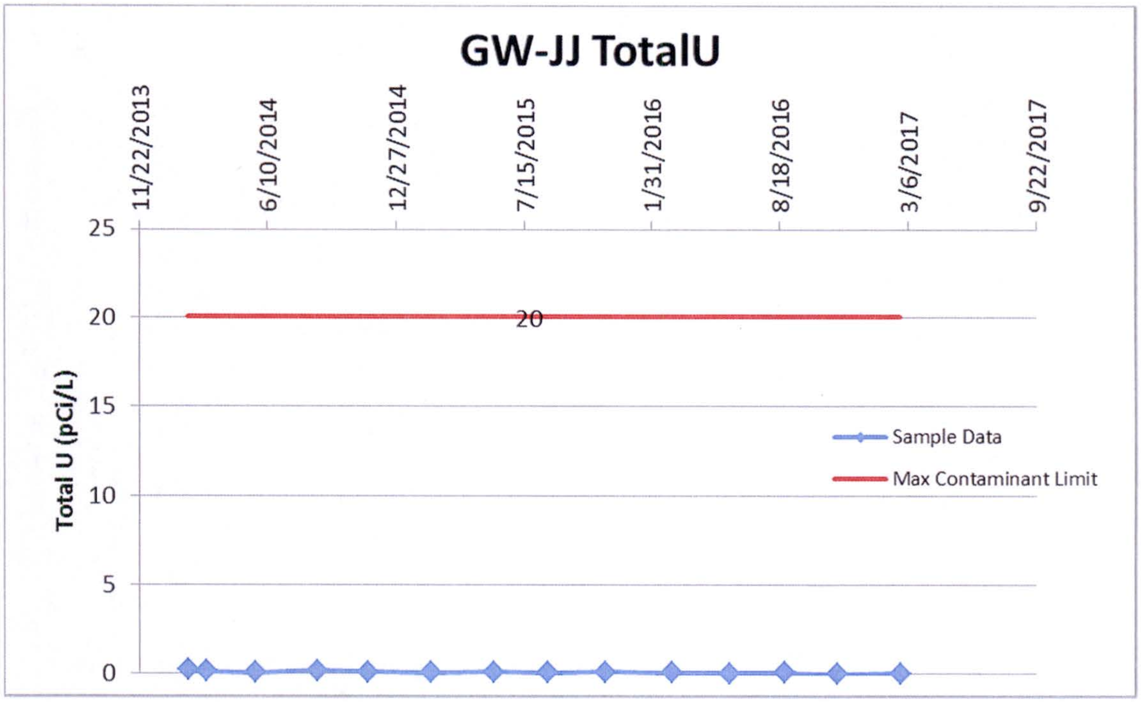

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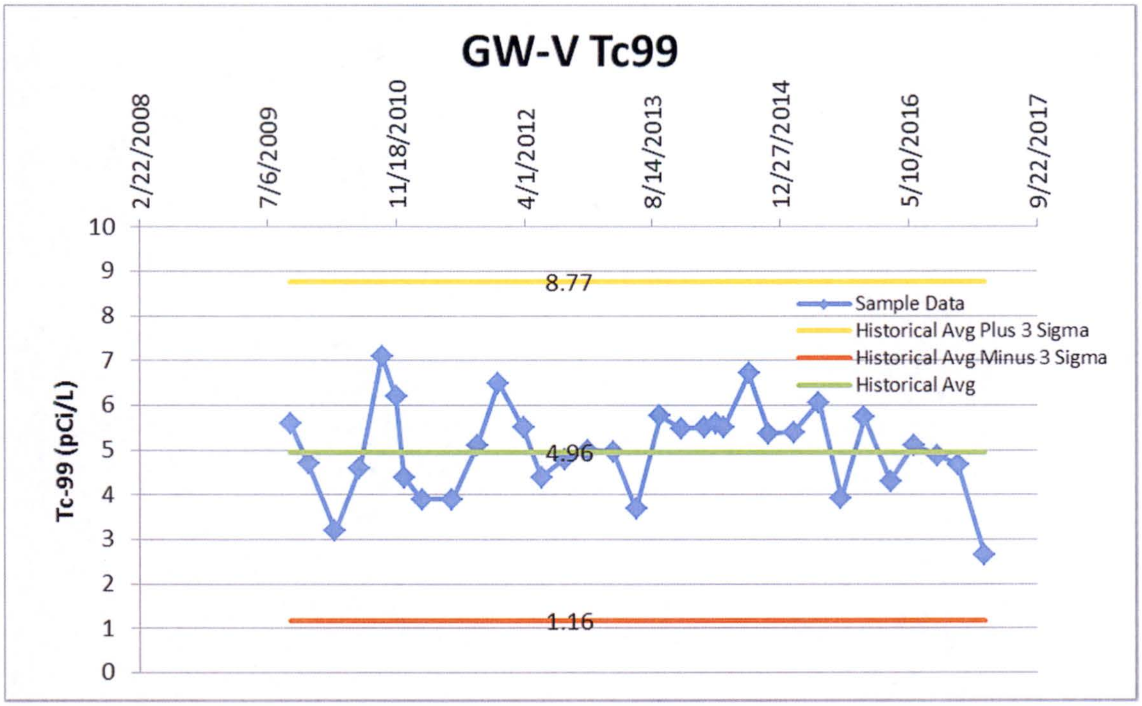

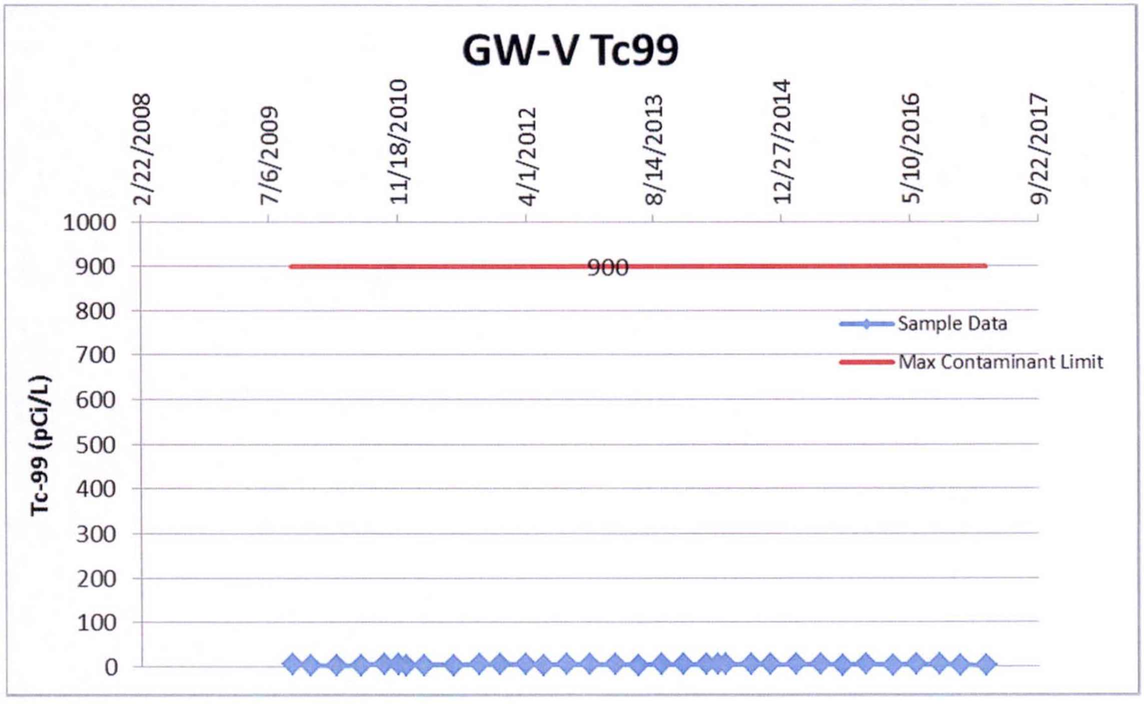

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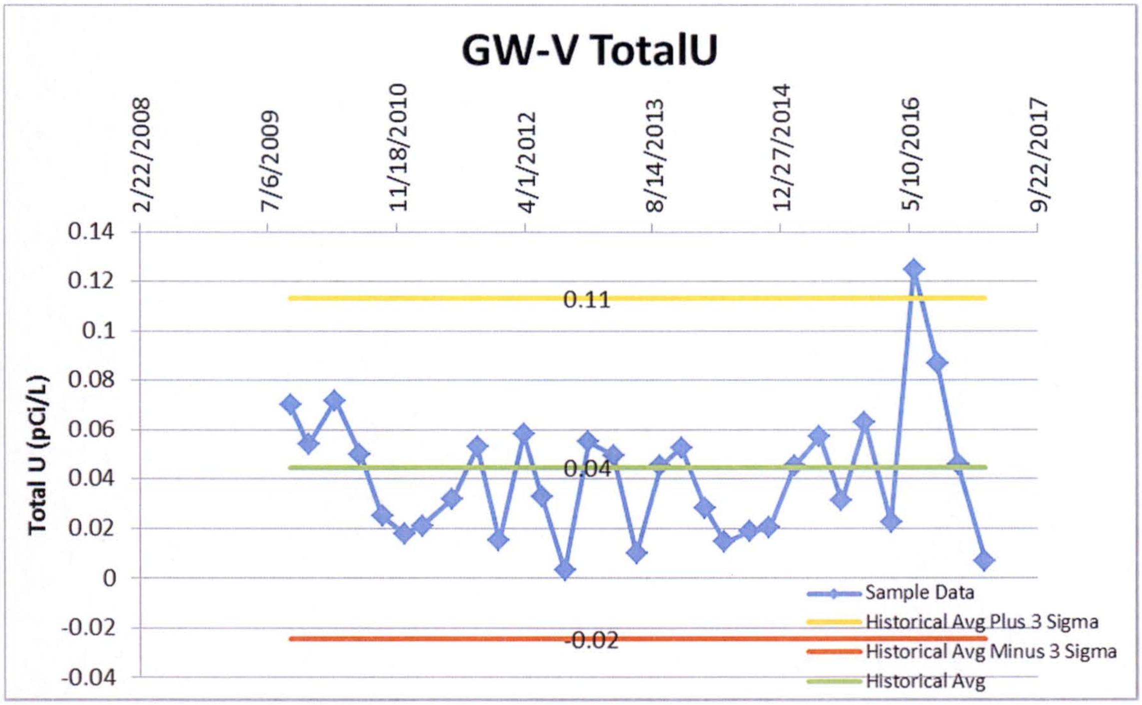

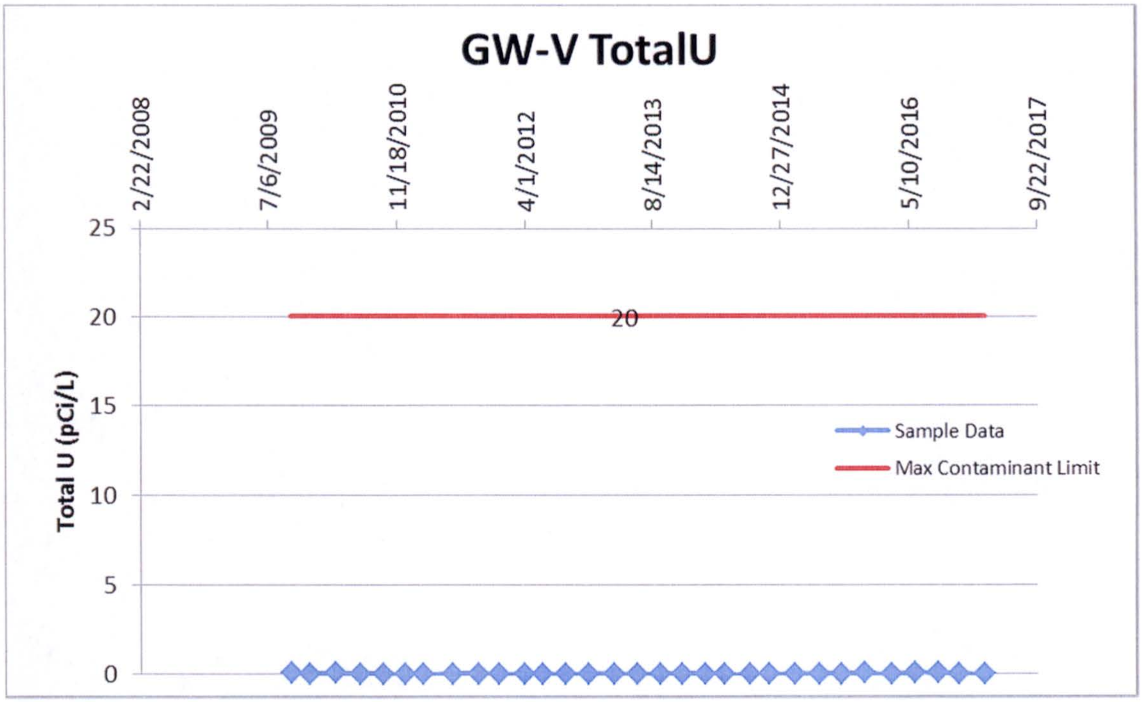

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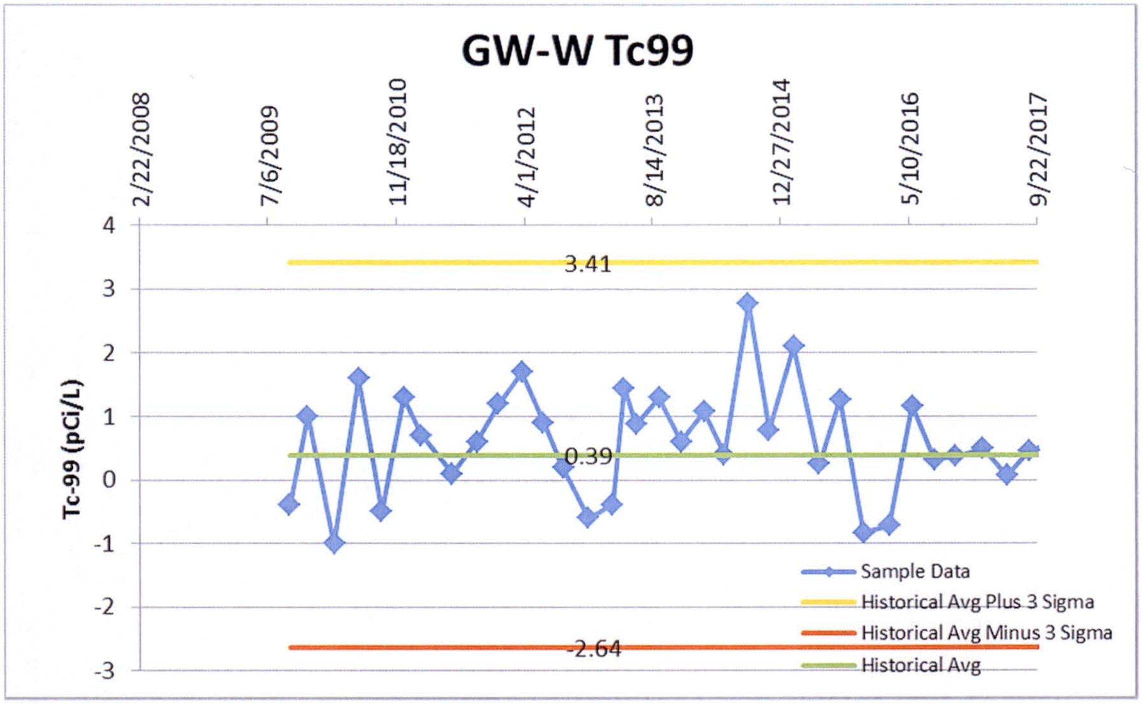

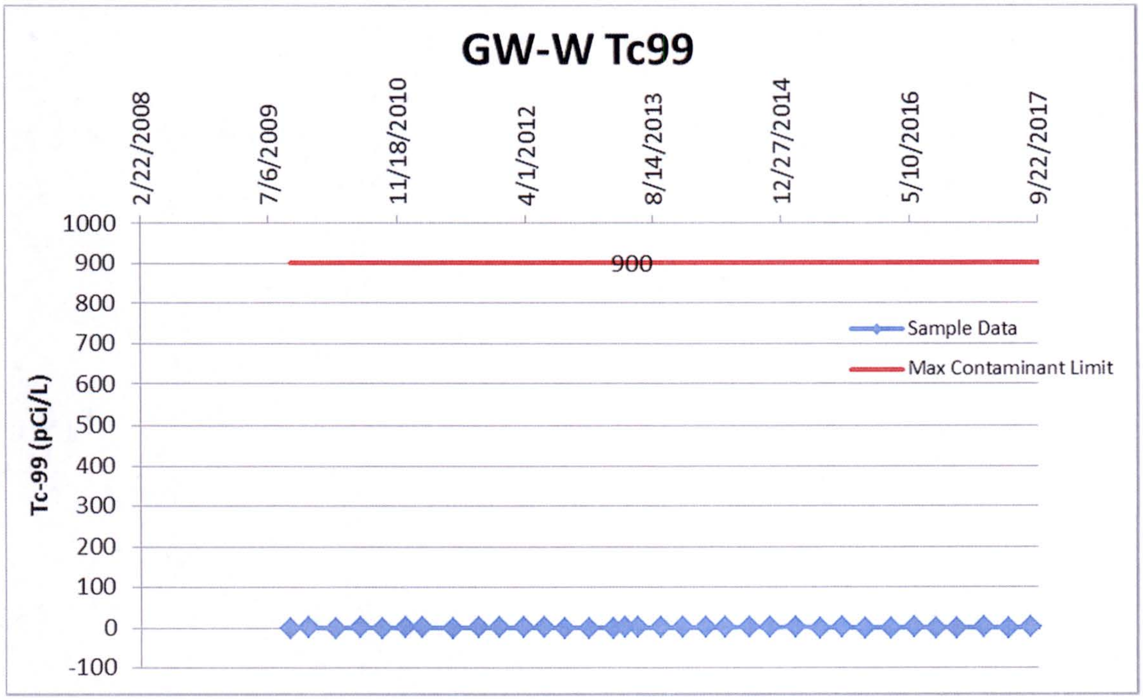

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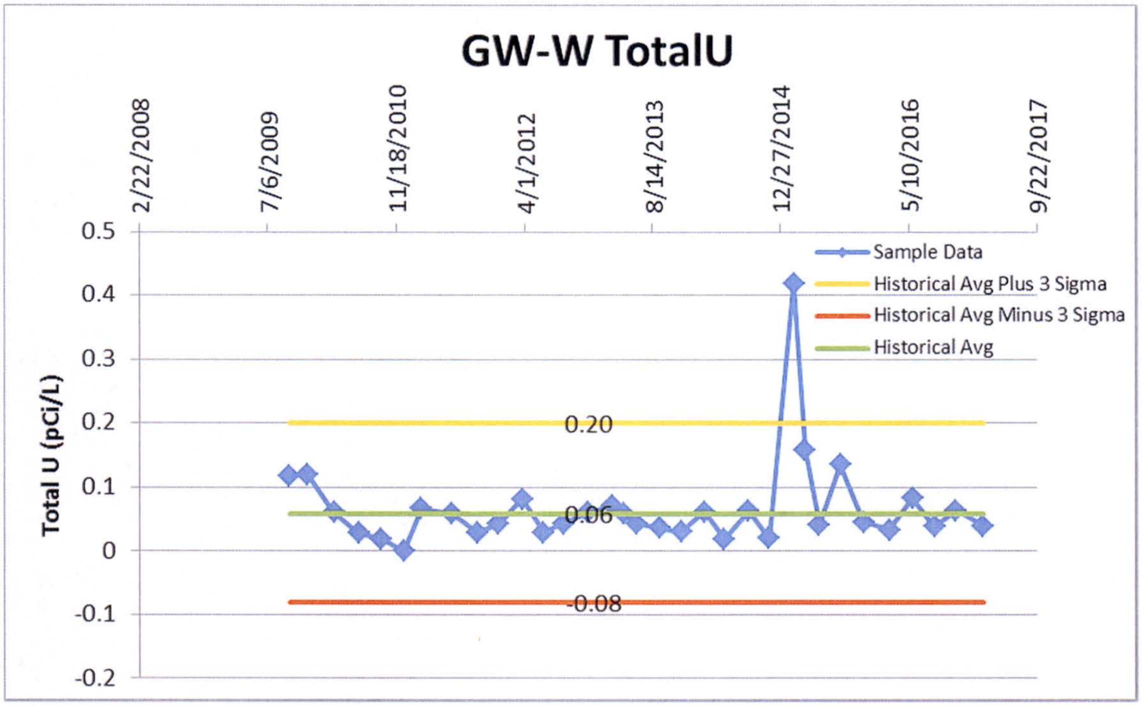

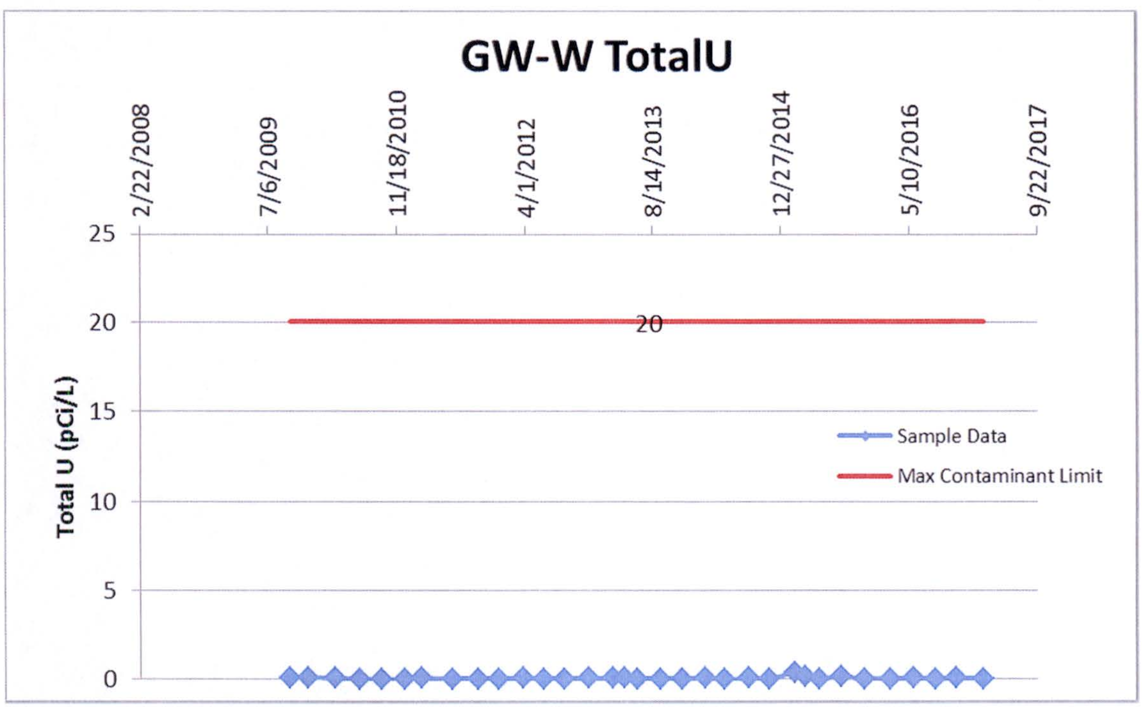

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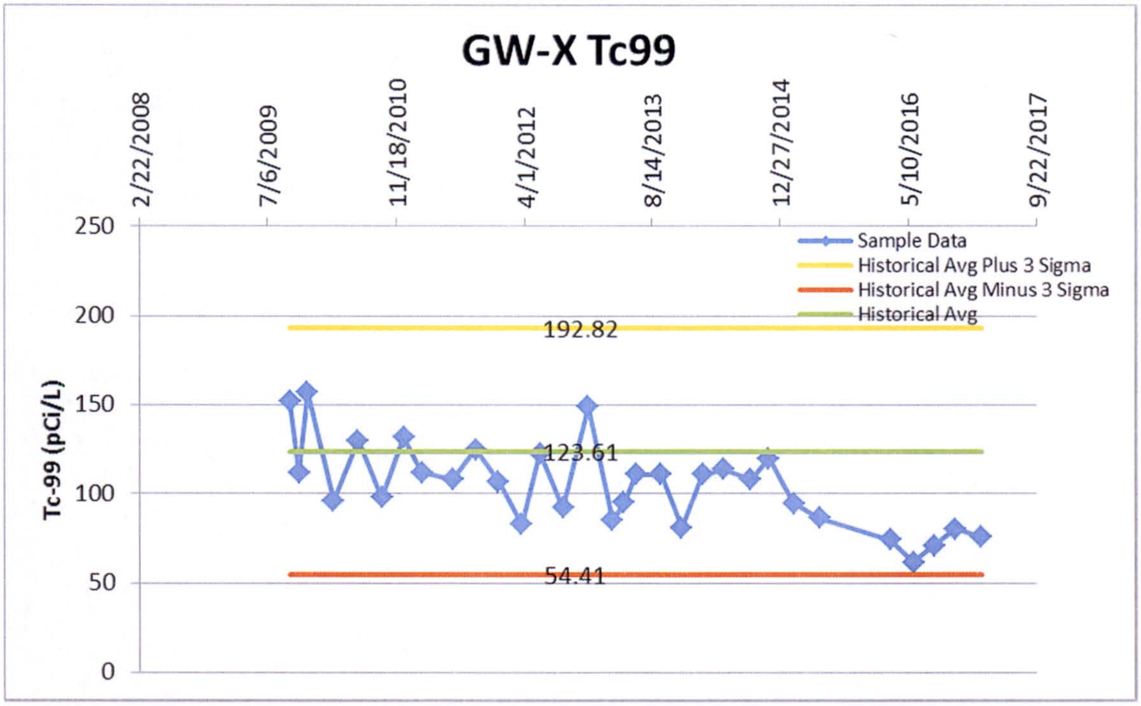

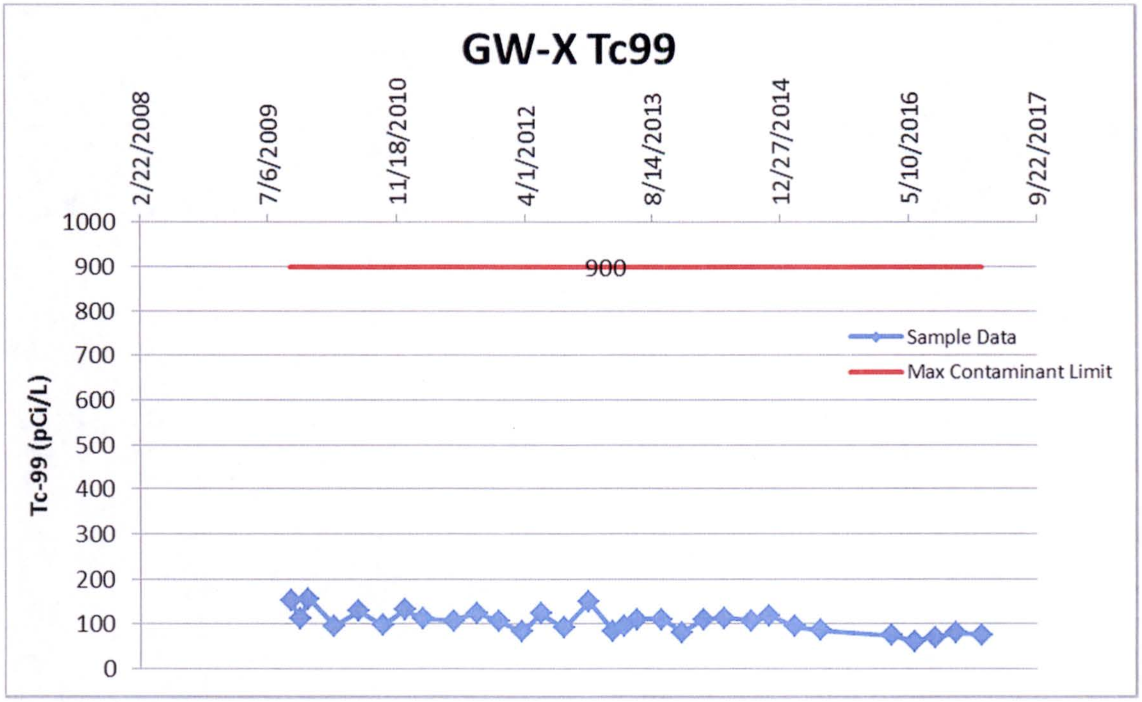

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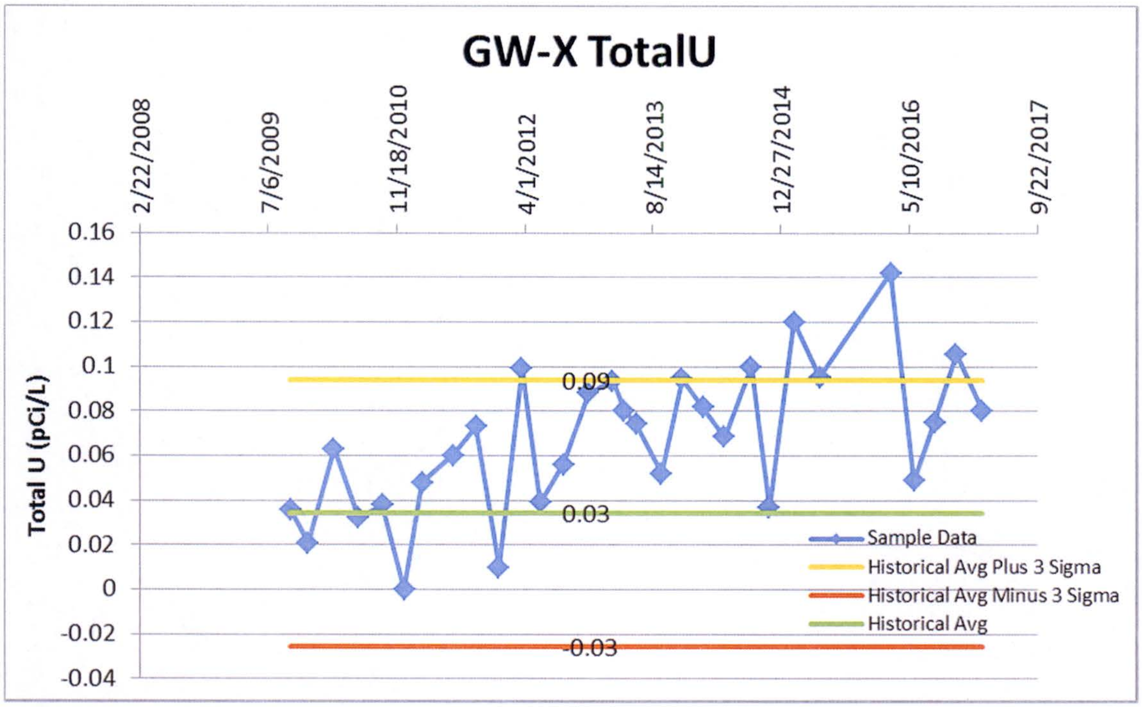

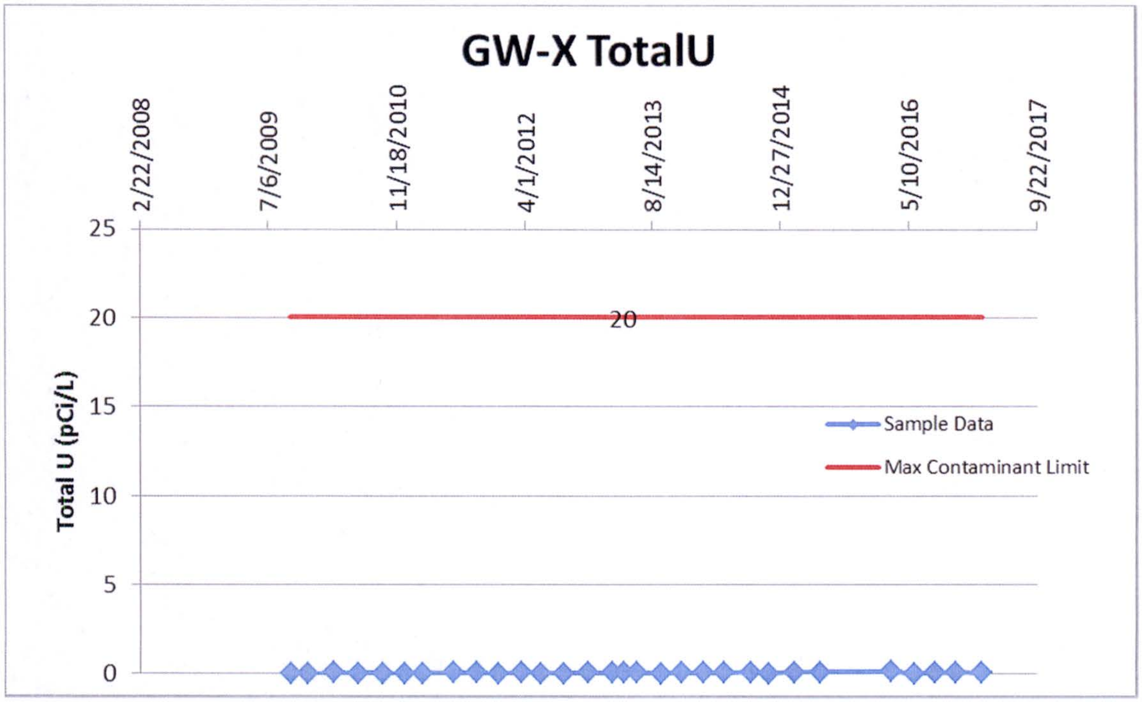

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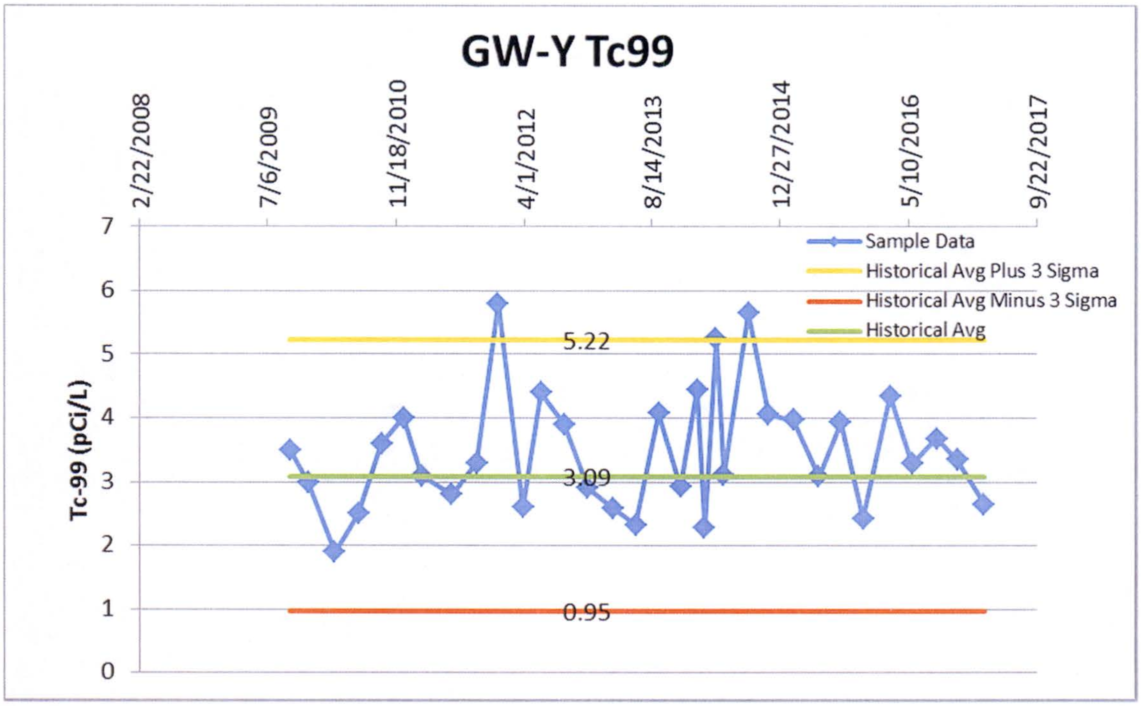

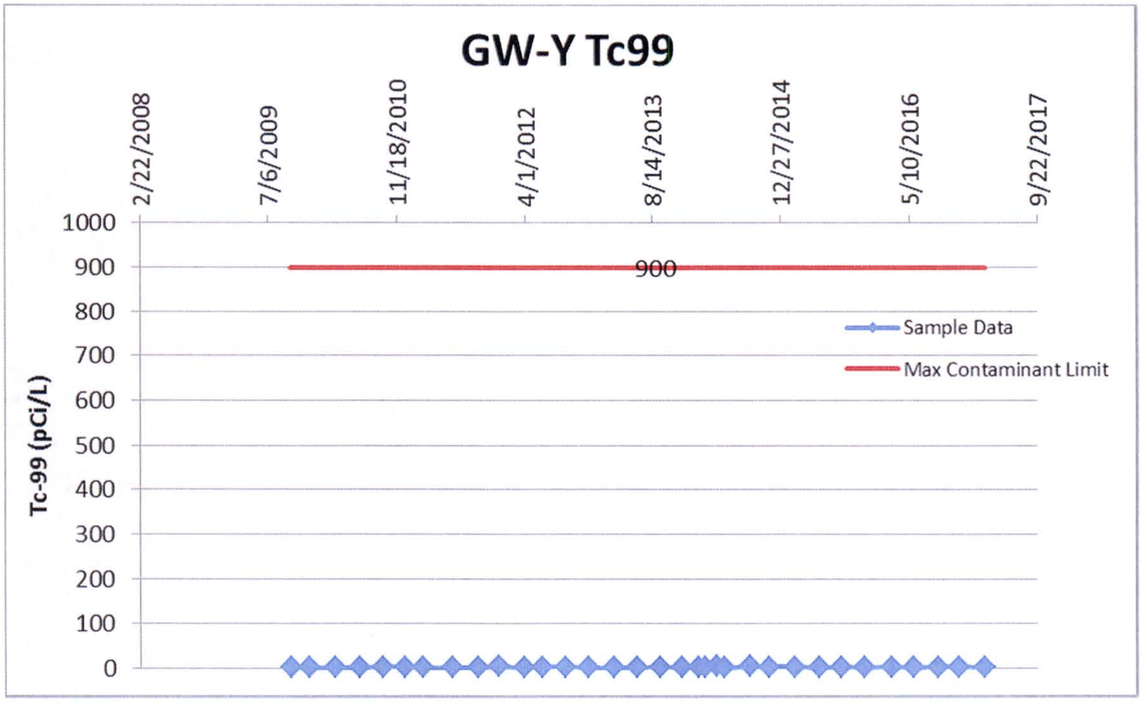

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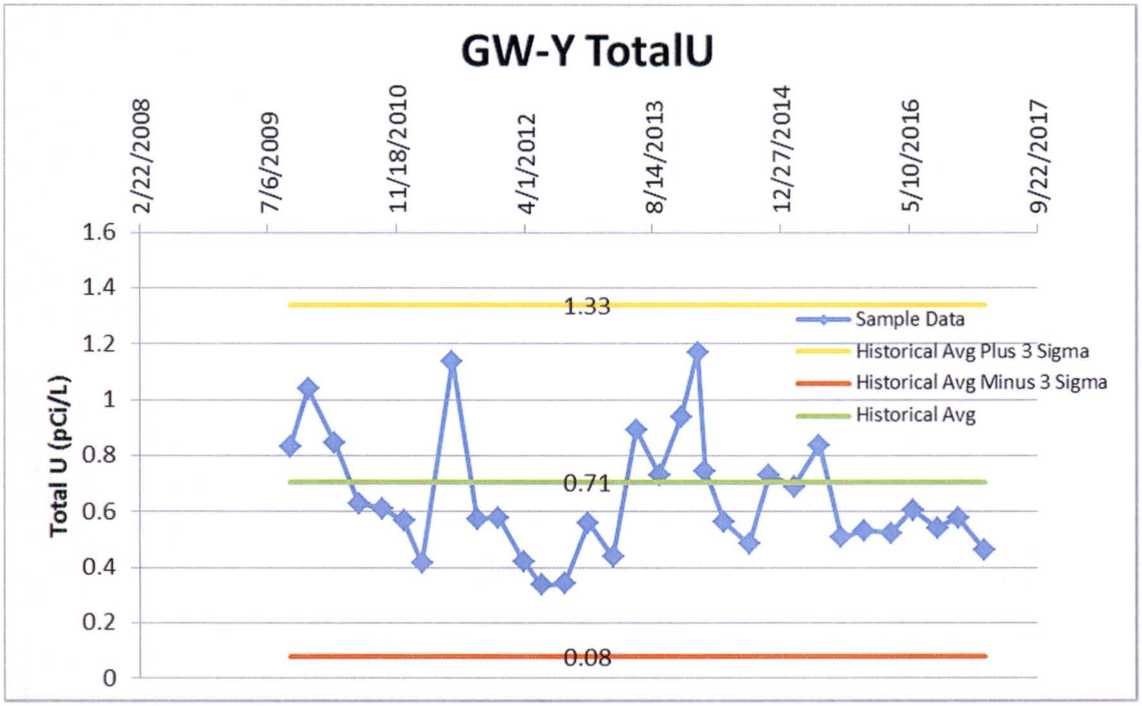

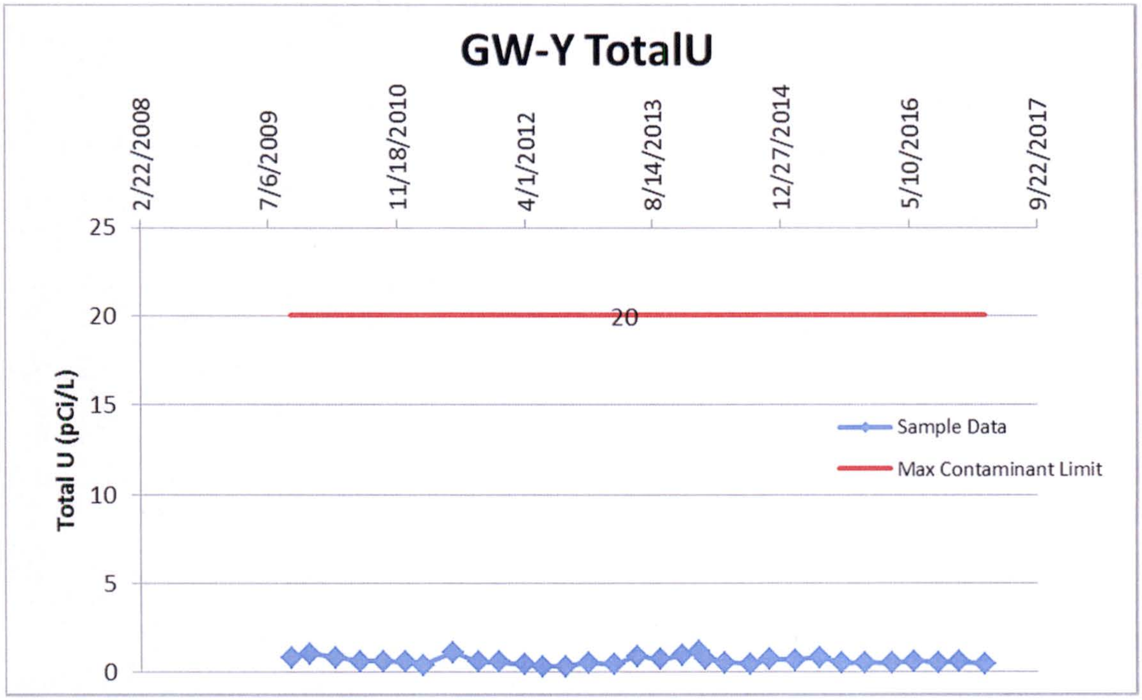

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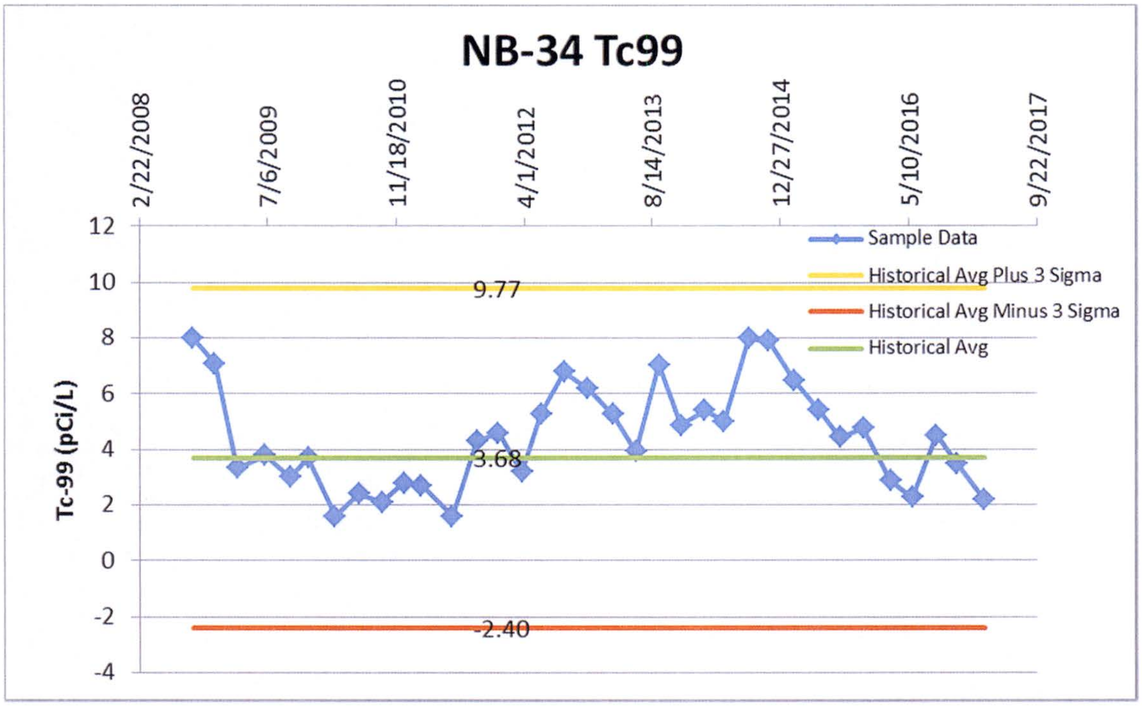

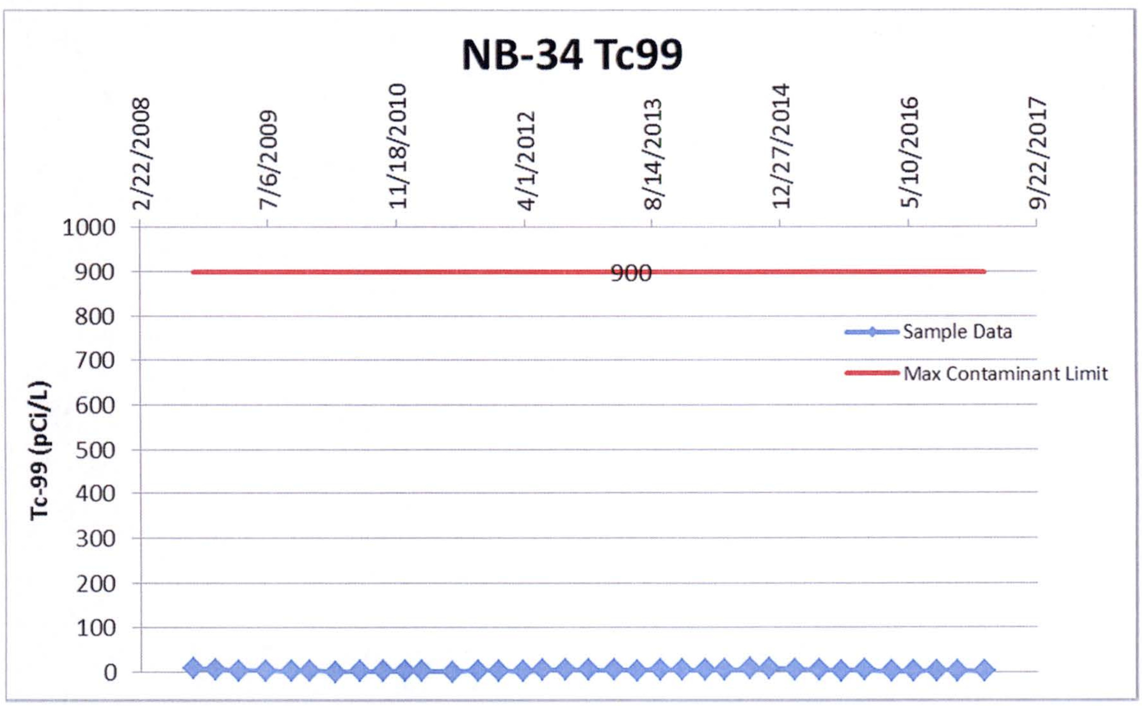

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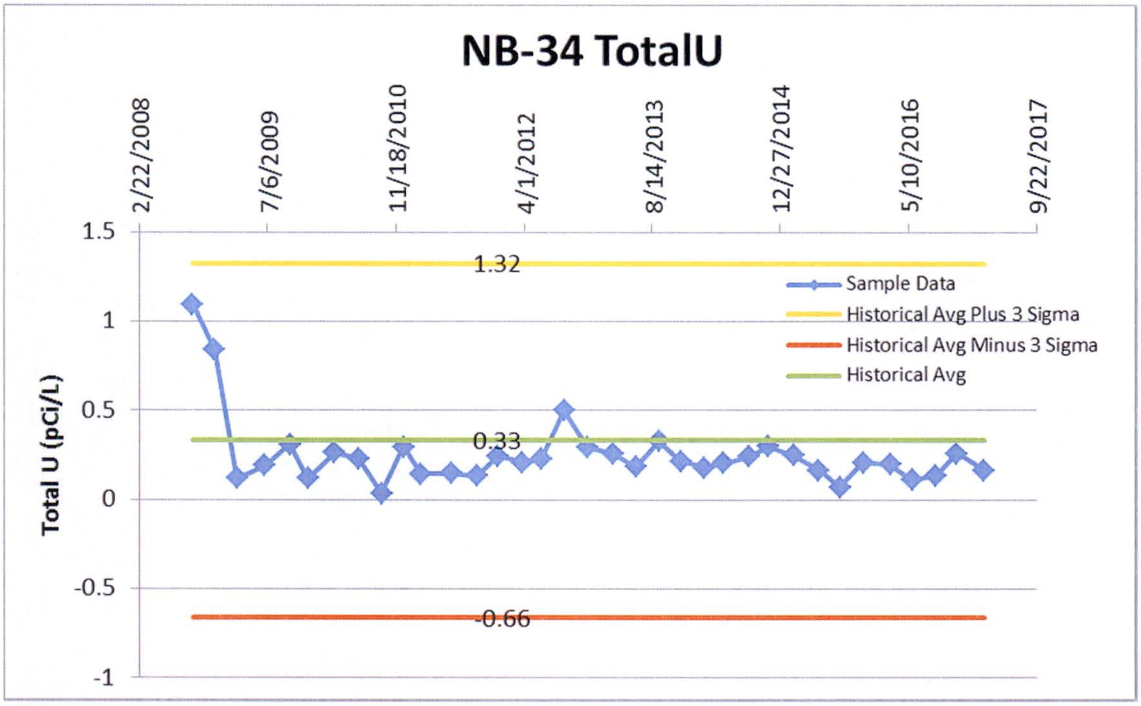

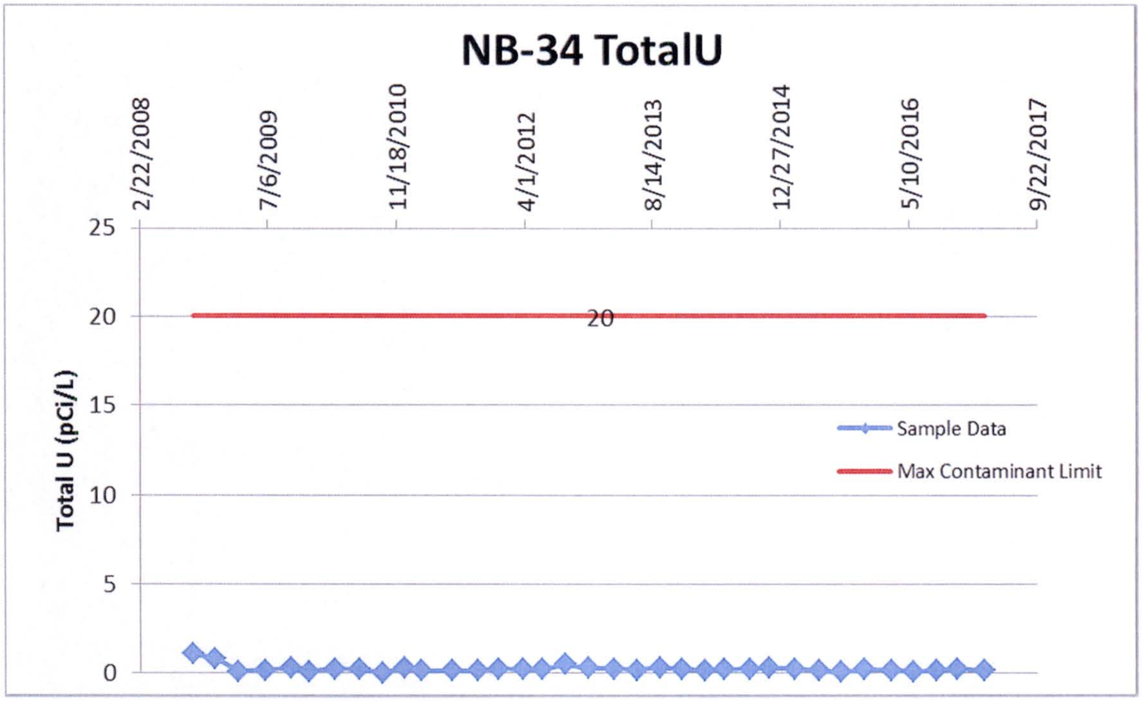

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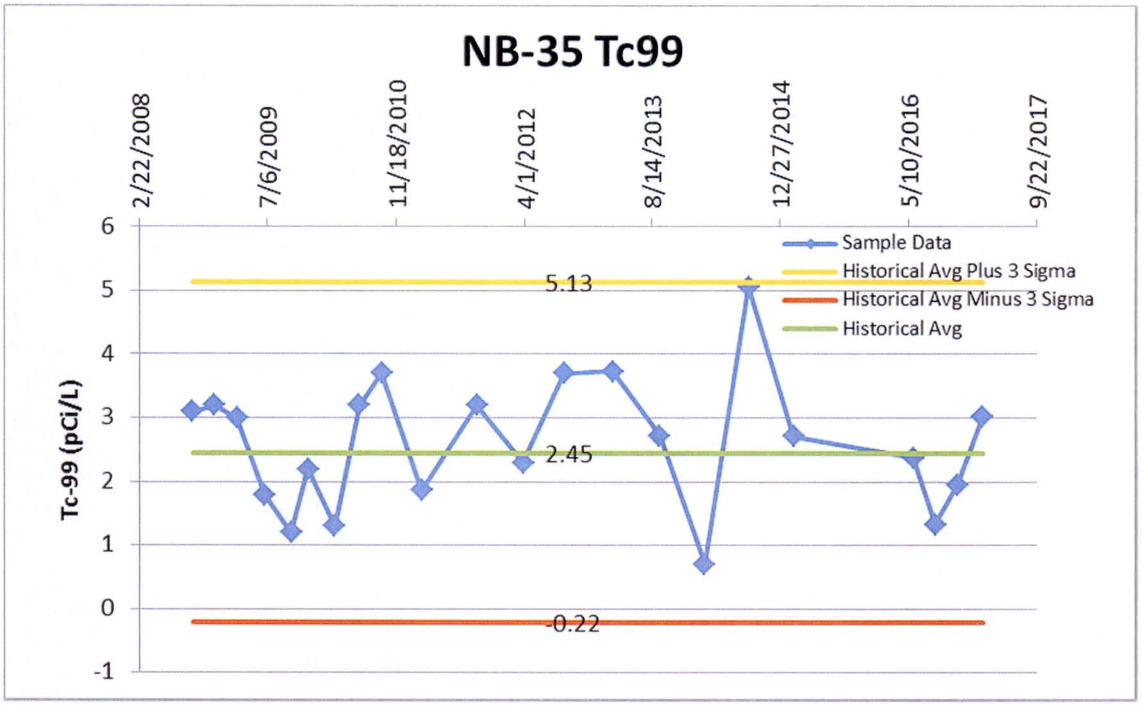

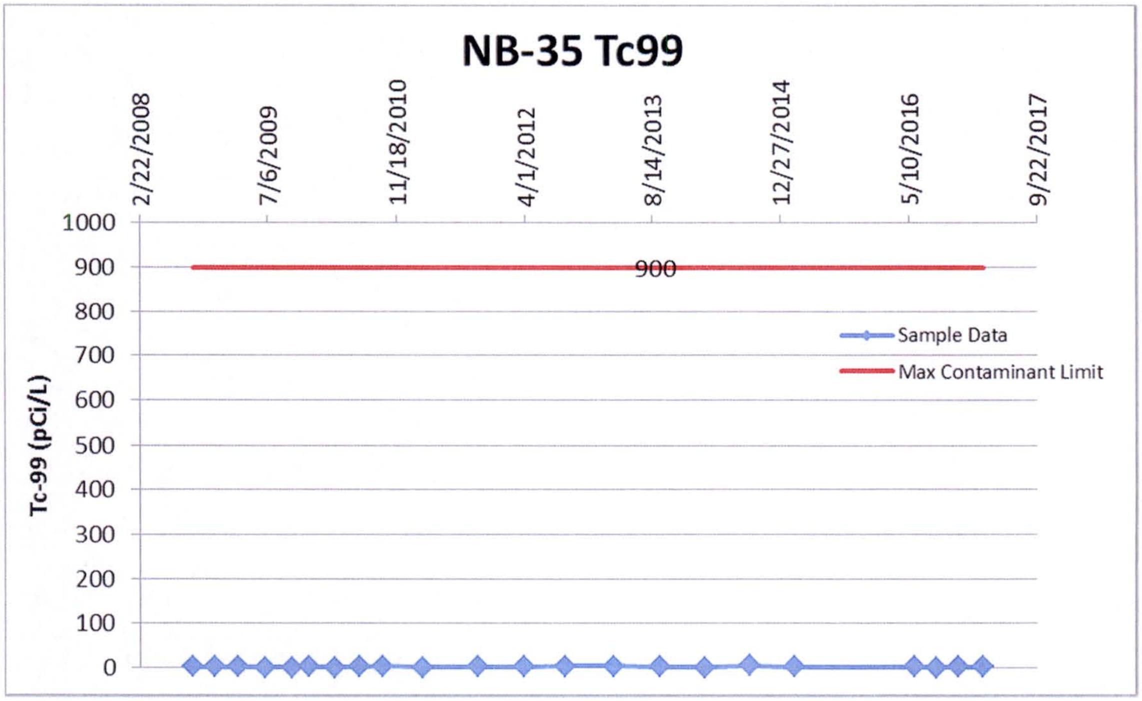

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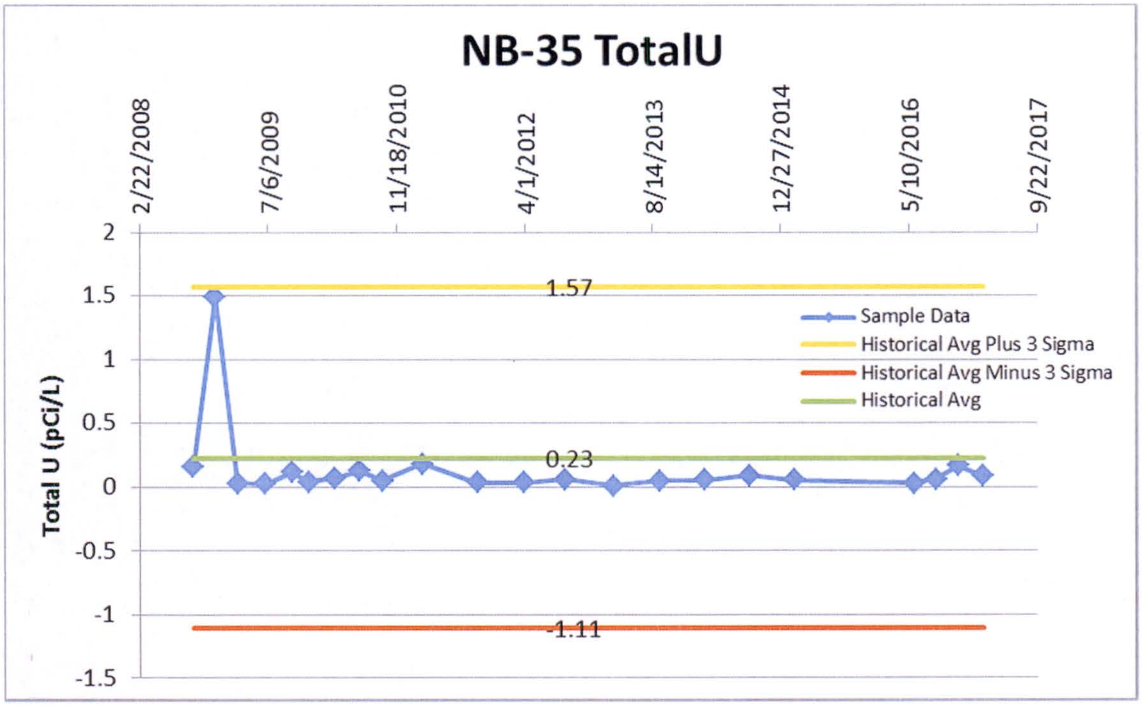

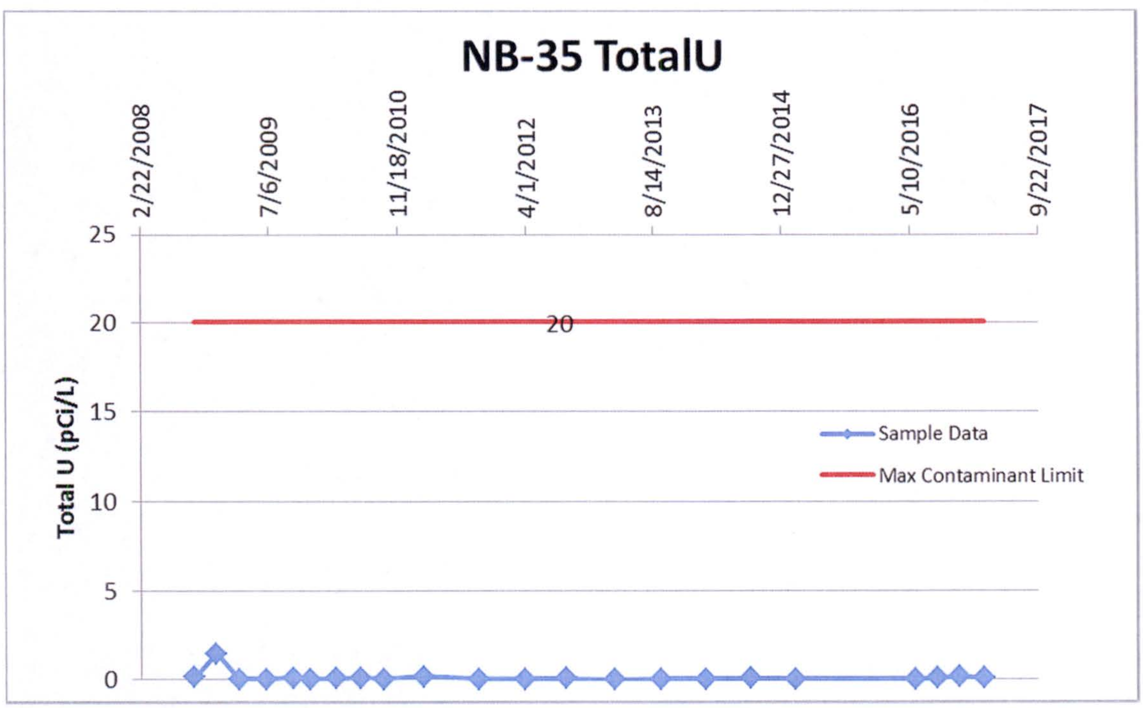

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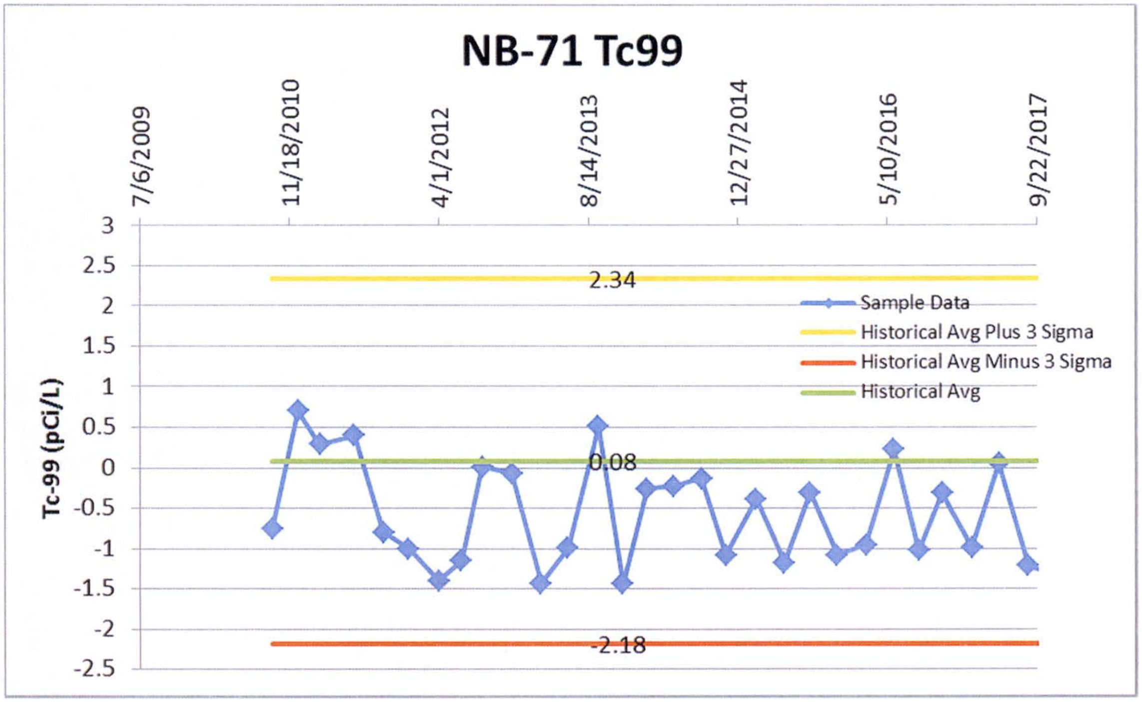

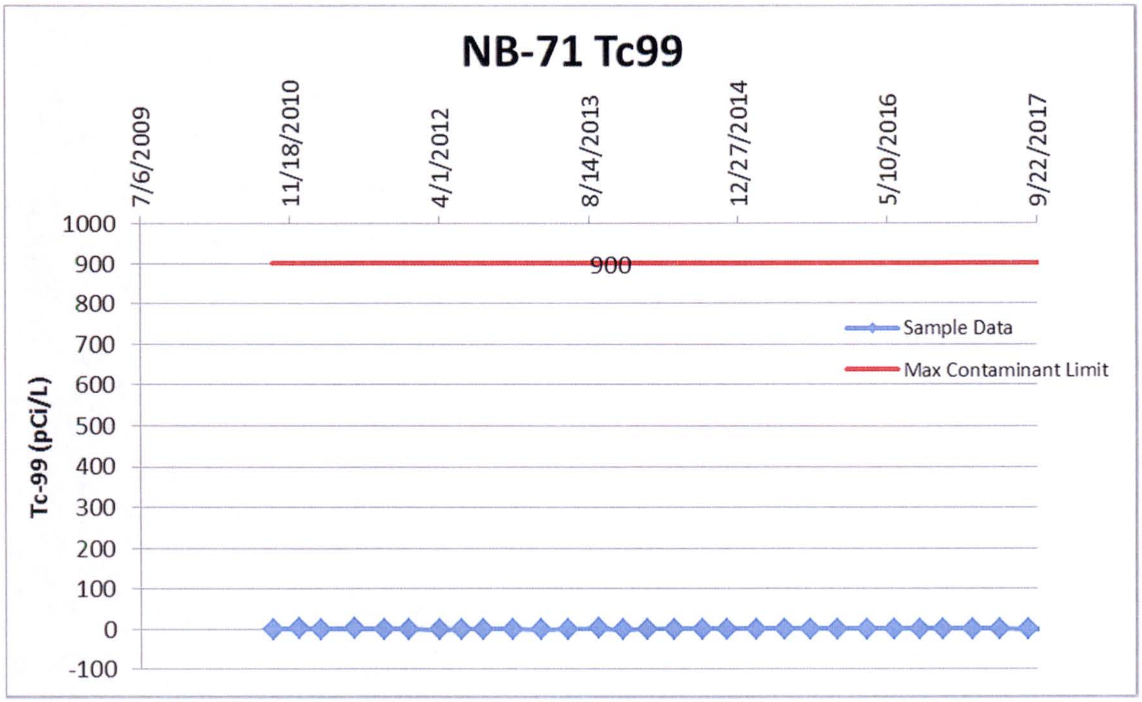

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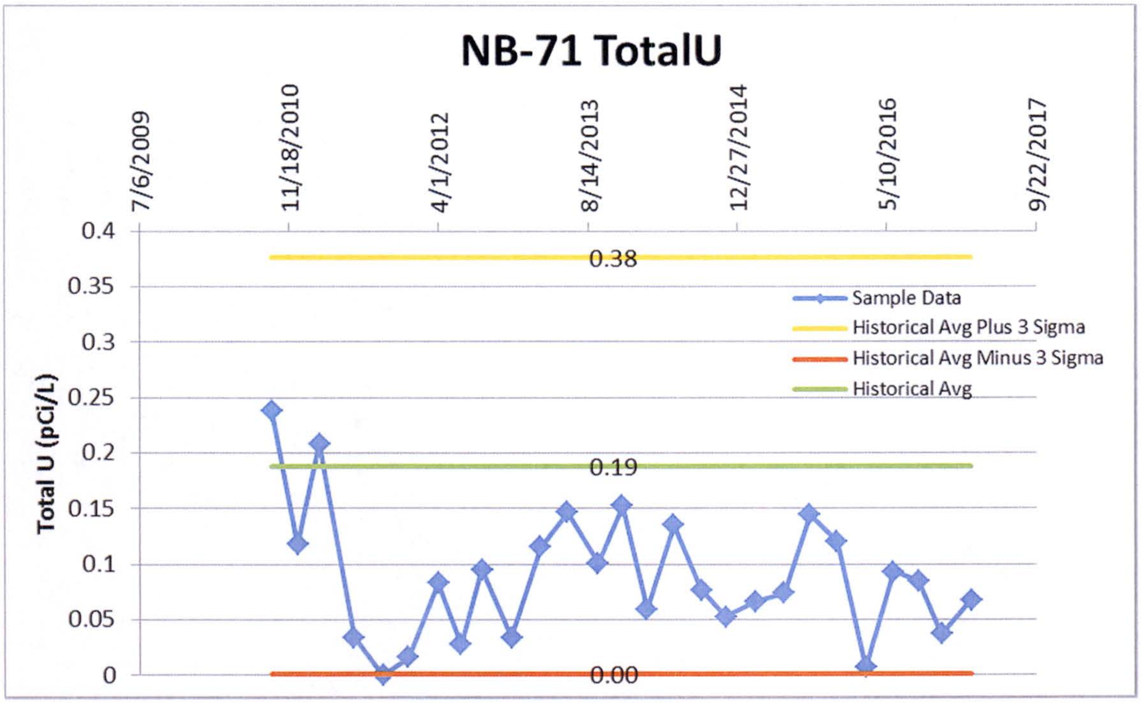

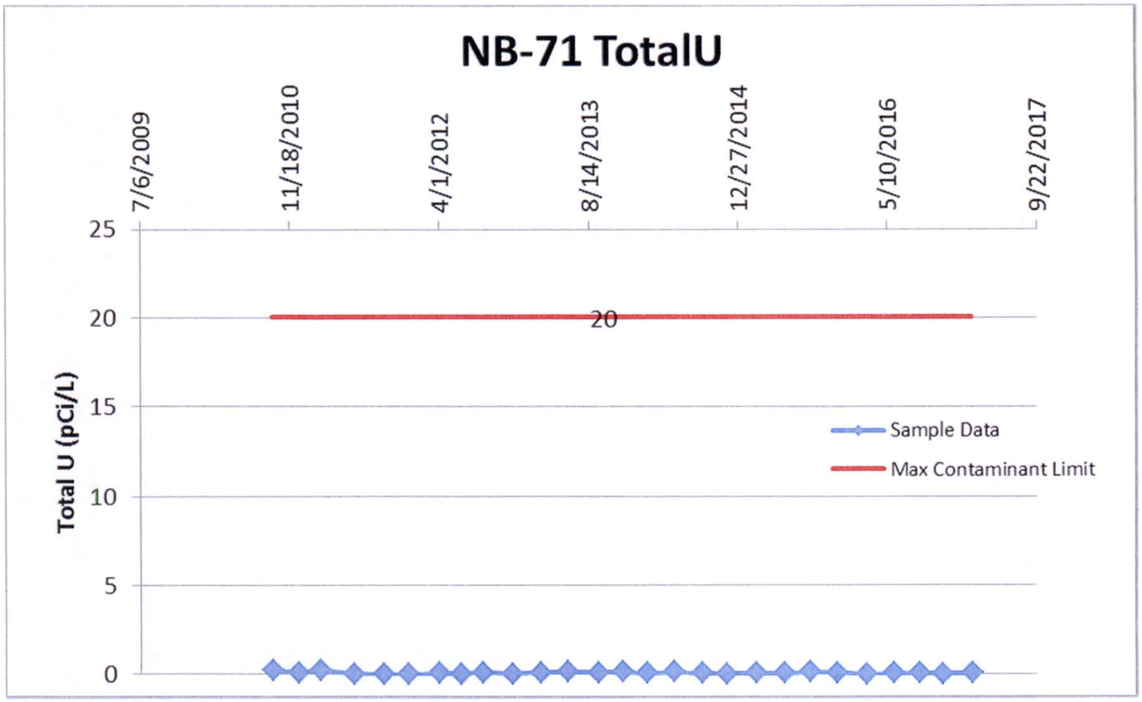

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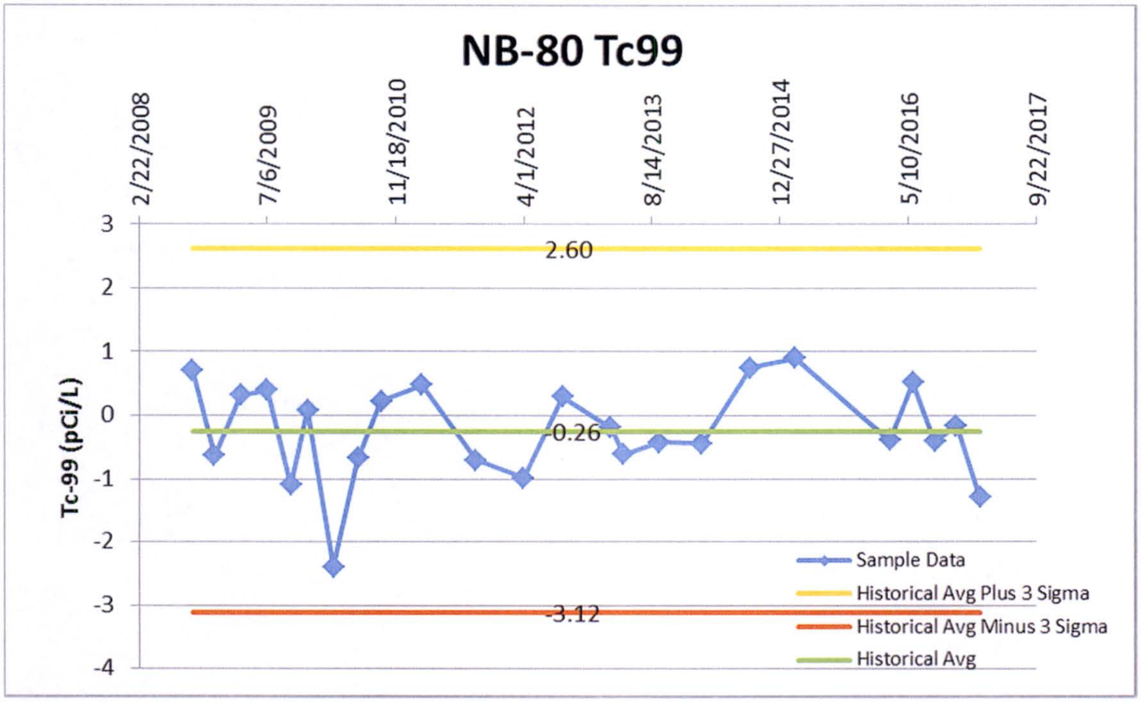

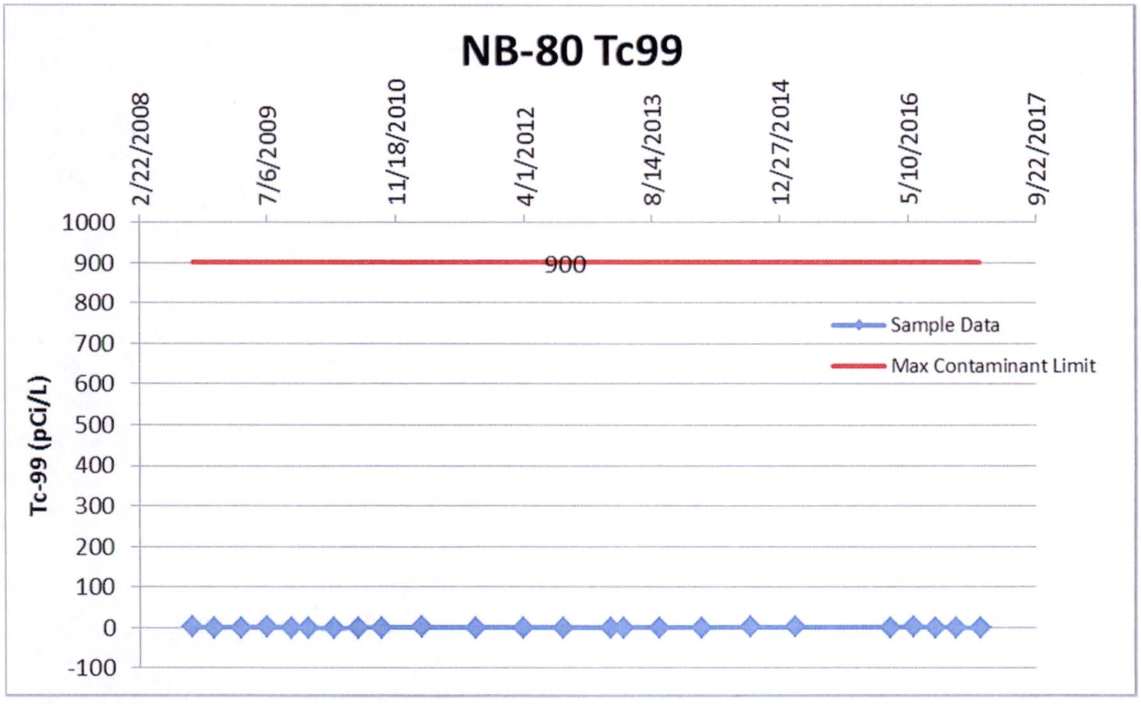

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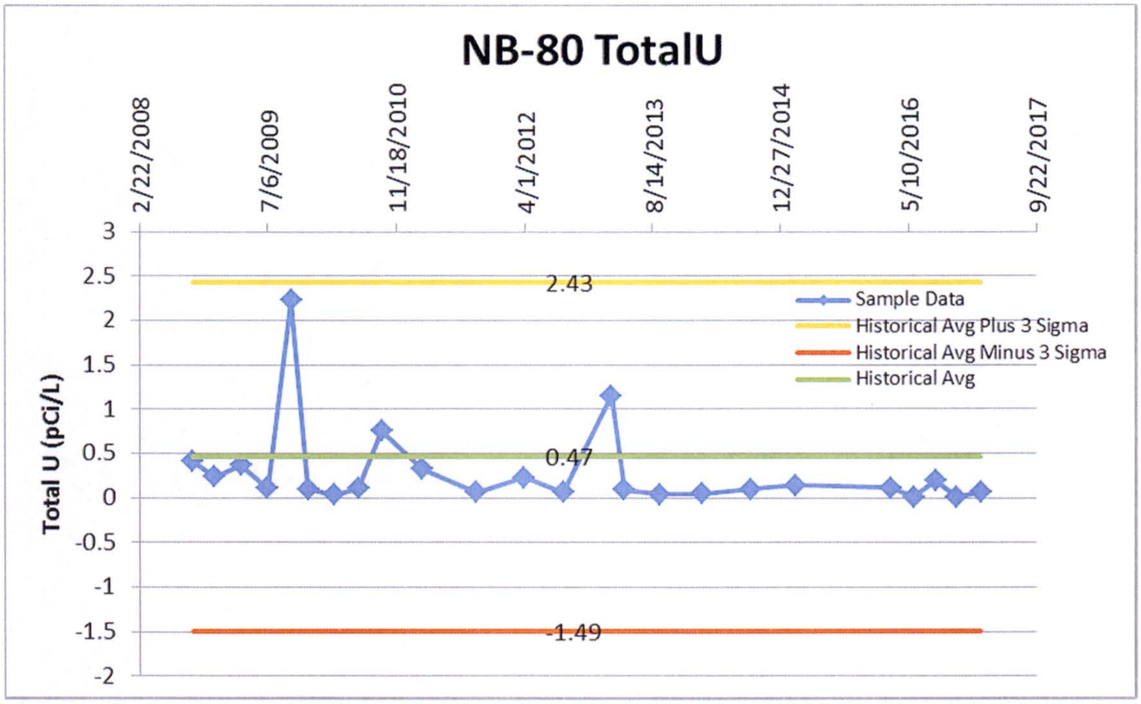

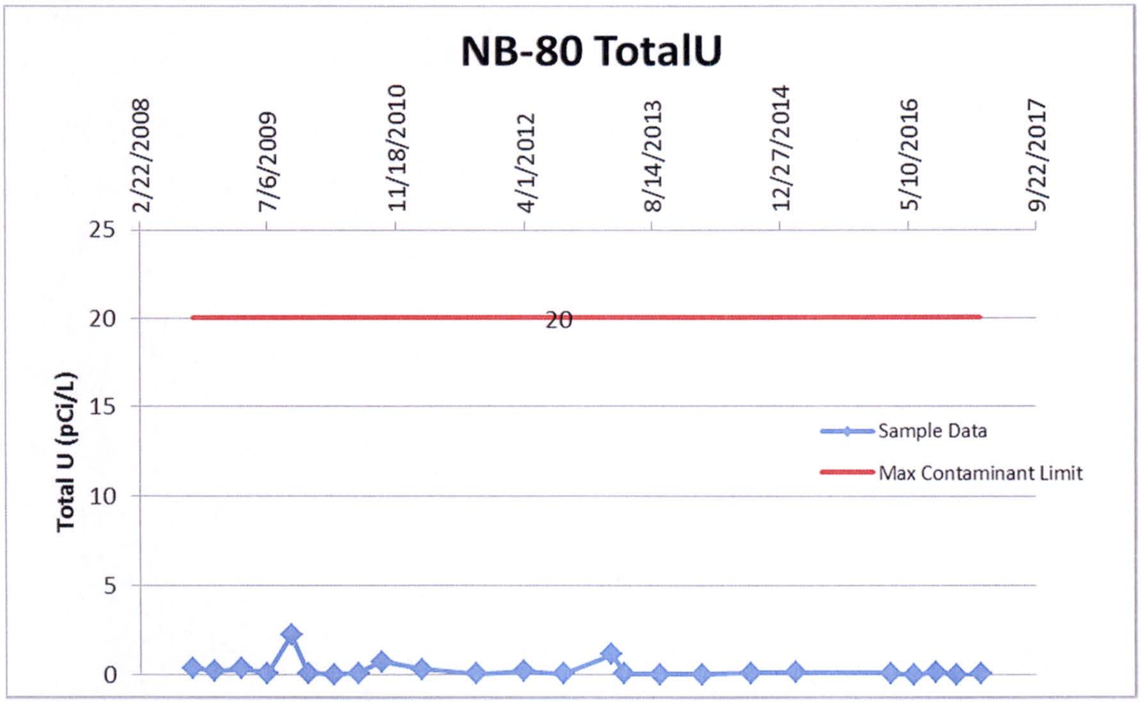

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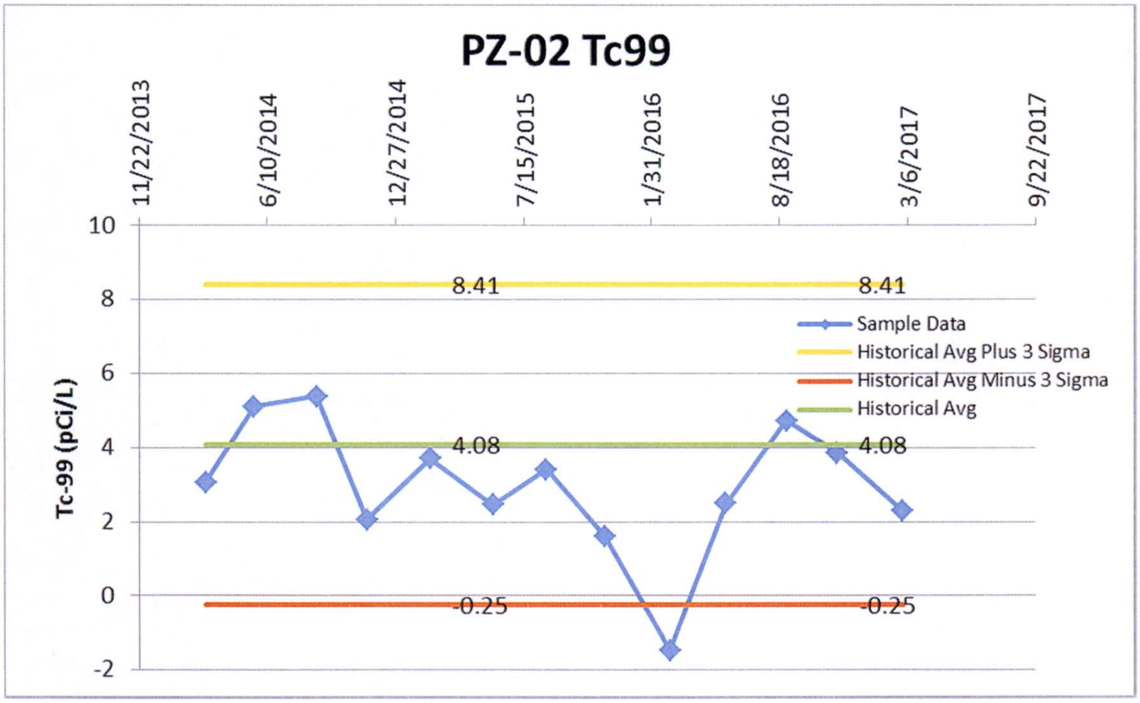

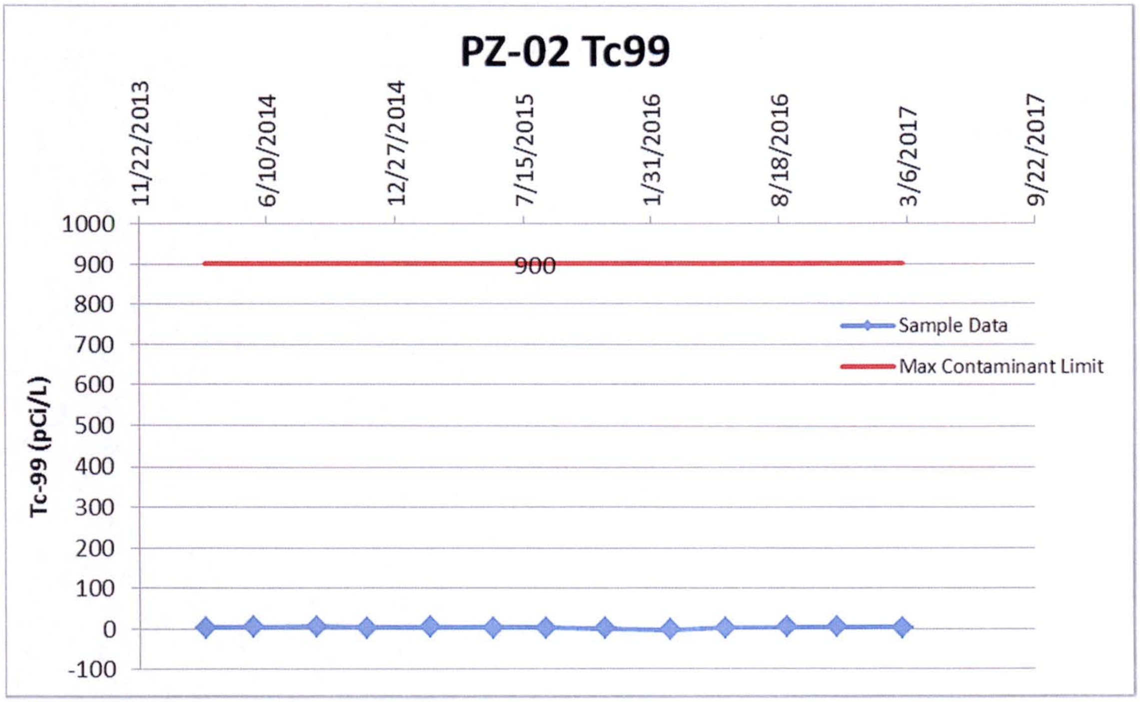

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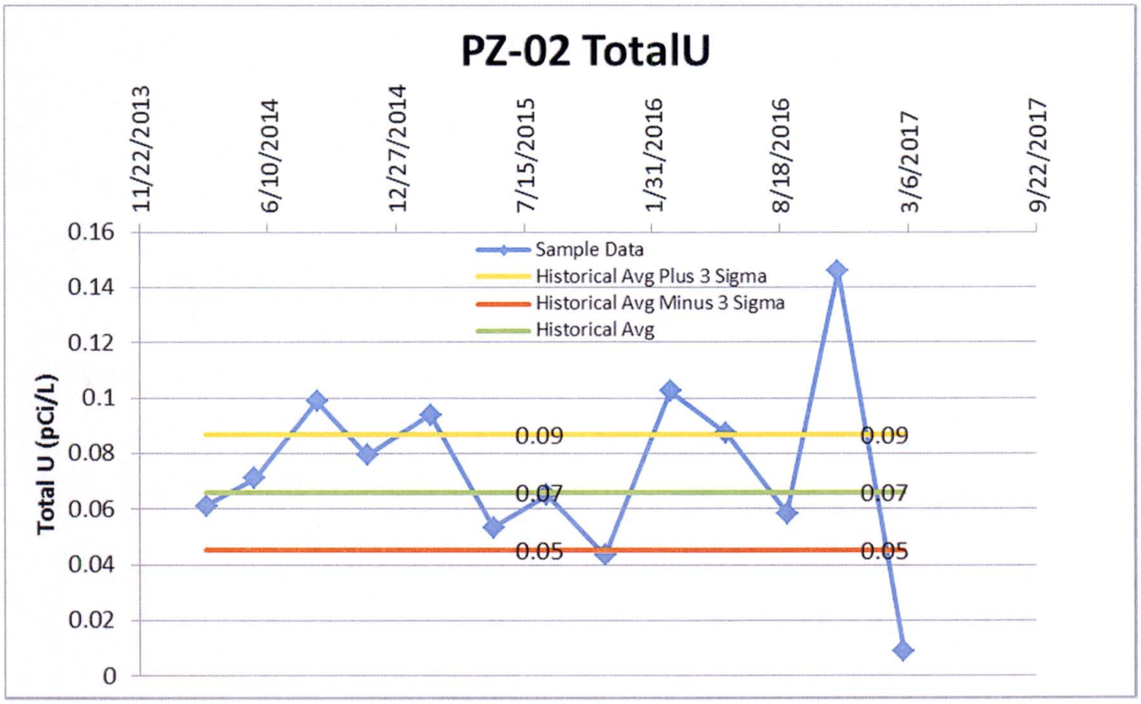
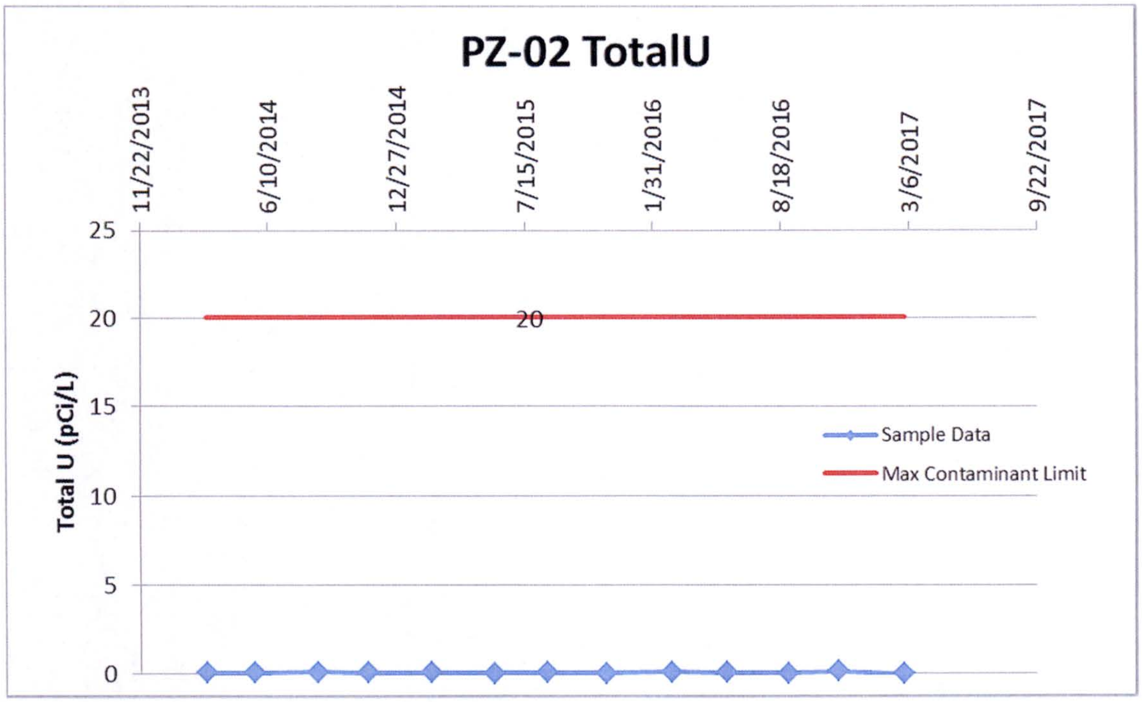


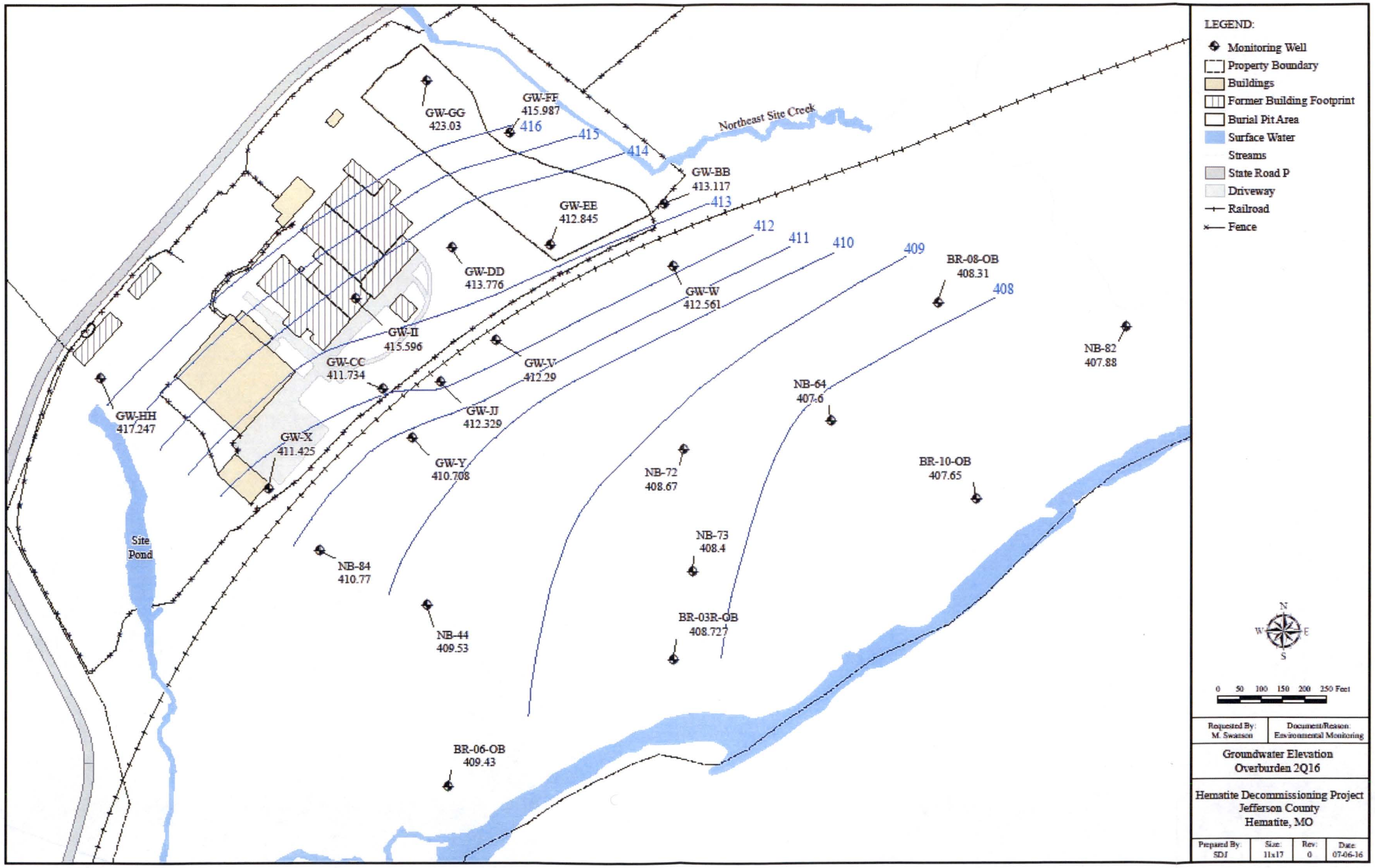


Attachment 3

Quarterly Groundwater Elevation Contour Maps

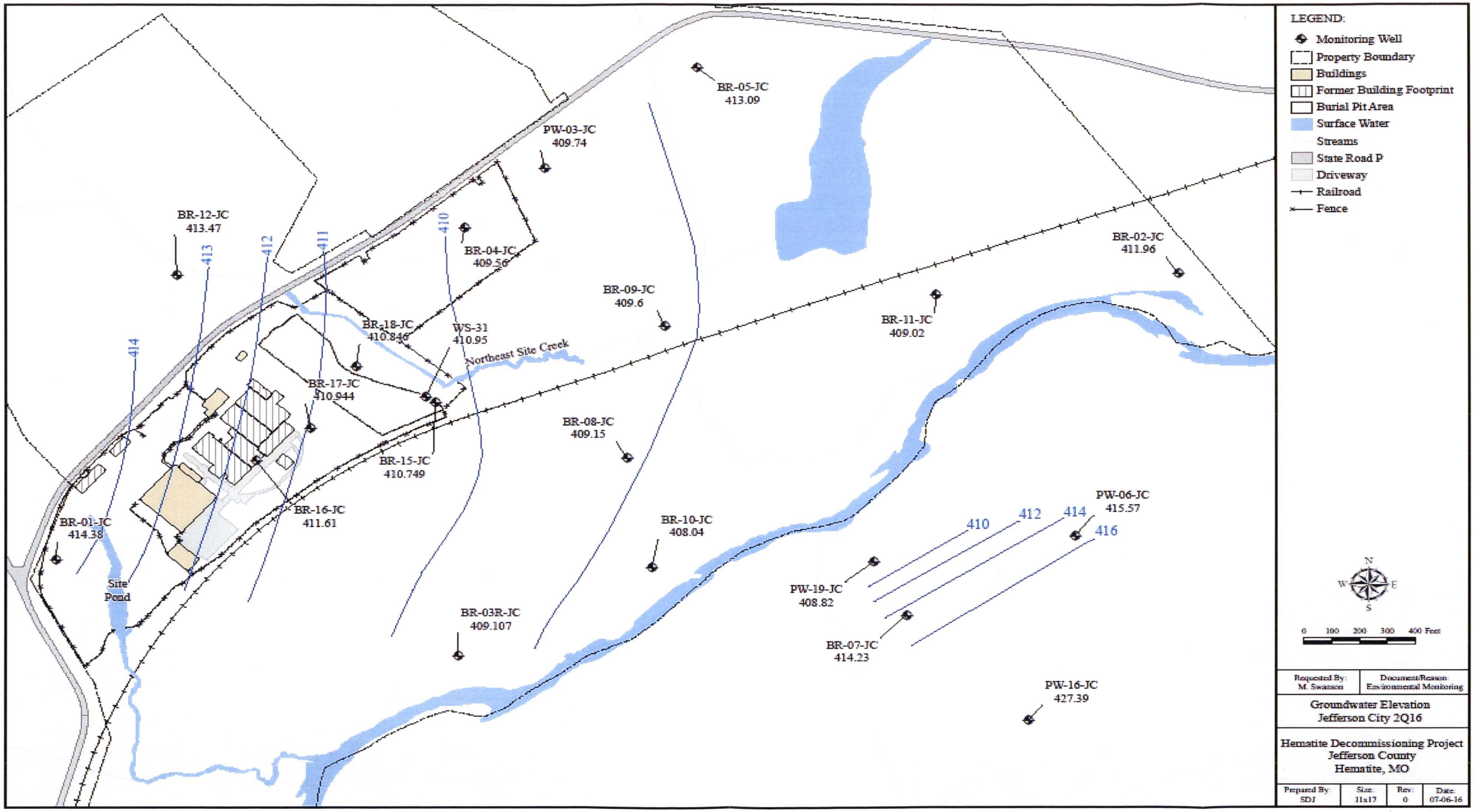
1st Quarter Post-remediation Groundwater Elevation Contour Map

SAND/GRAVEL HSU



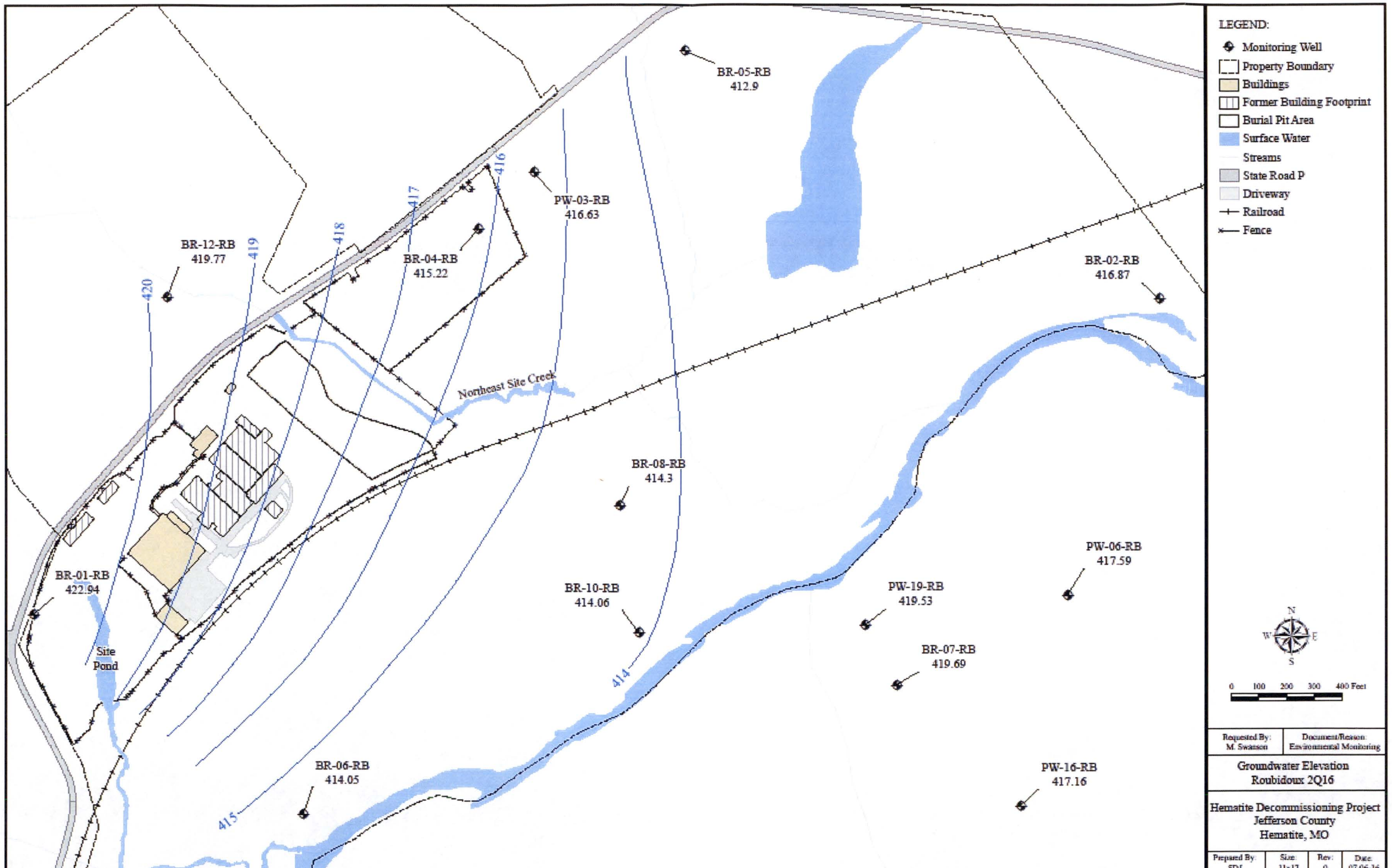
1st Quarter Post-remediation Groundwater Elevation Contour Map

JEFFERSON CITY – COTTER HSU



1st Quarter Post-remediation Groundwater Elevation Contour Map

ROUBIDOUX HSU



2nd Quarter Post-remediation Groundwater Elevation Contour Map

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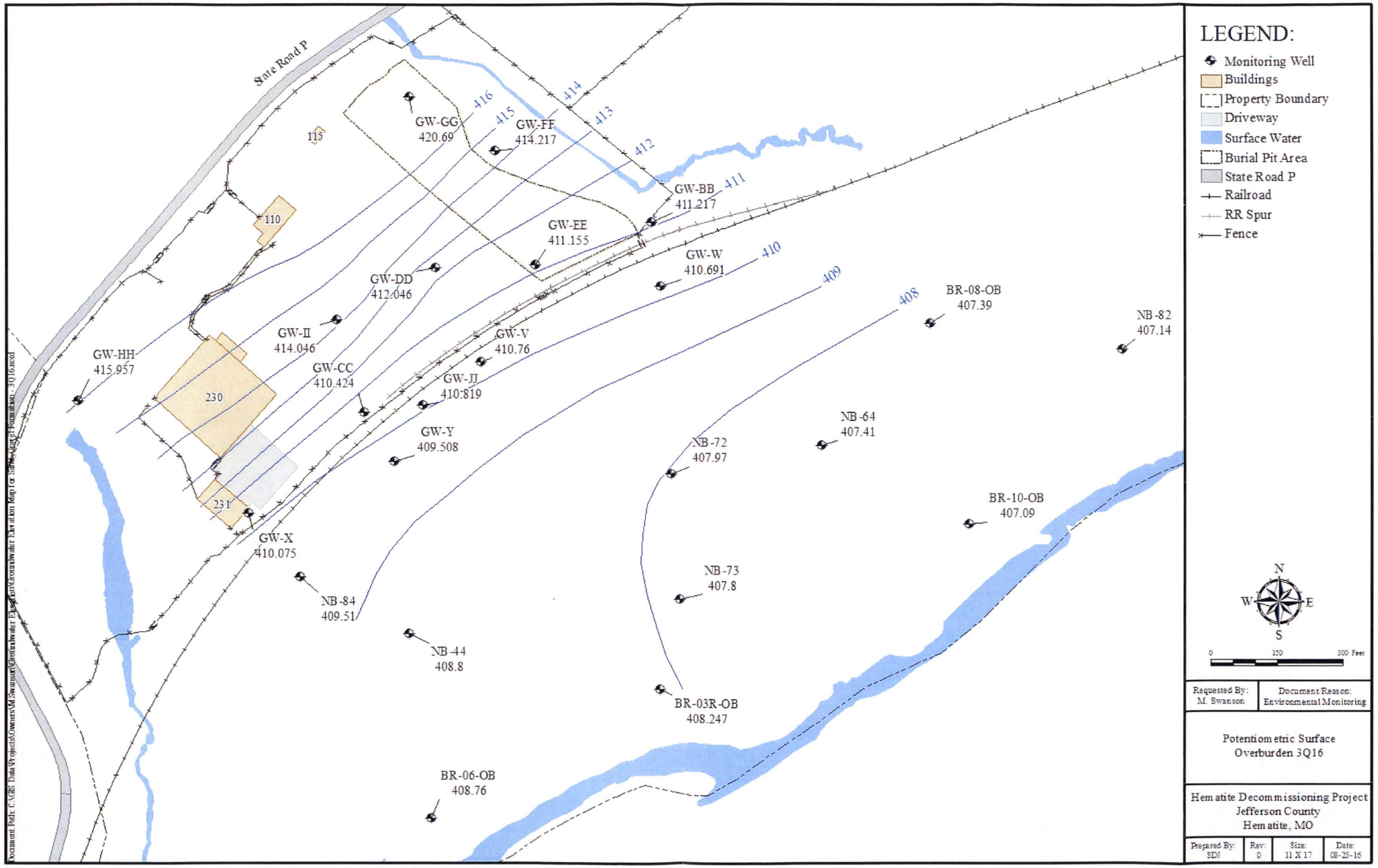
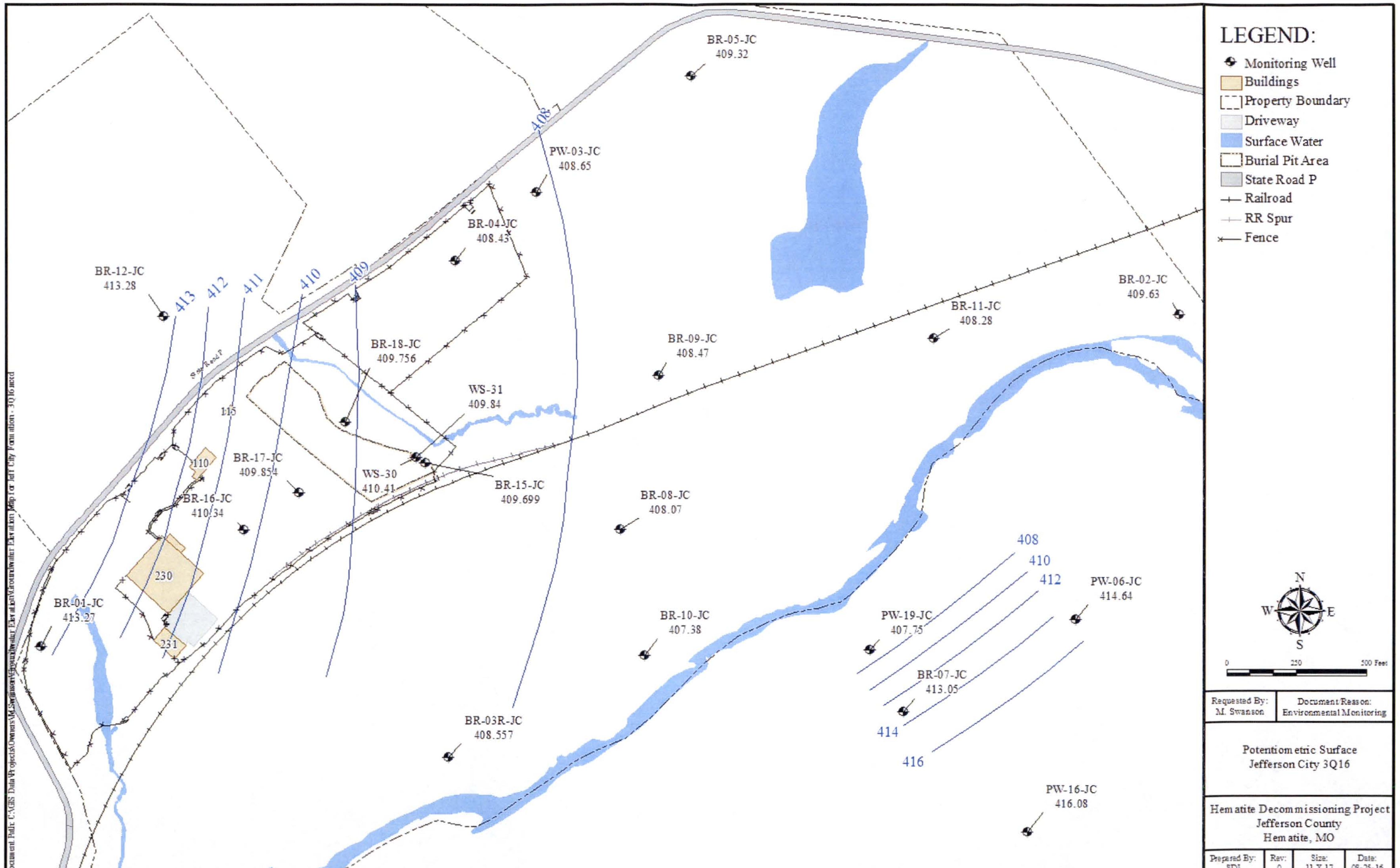


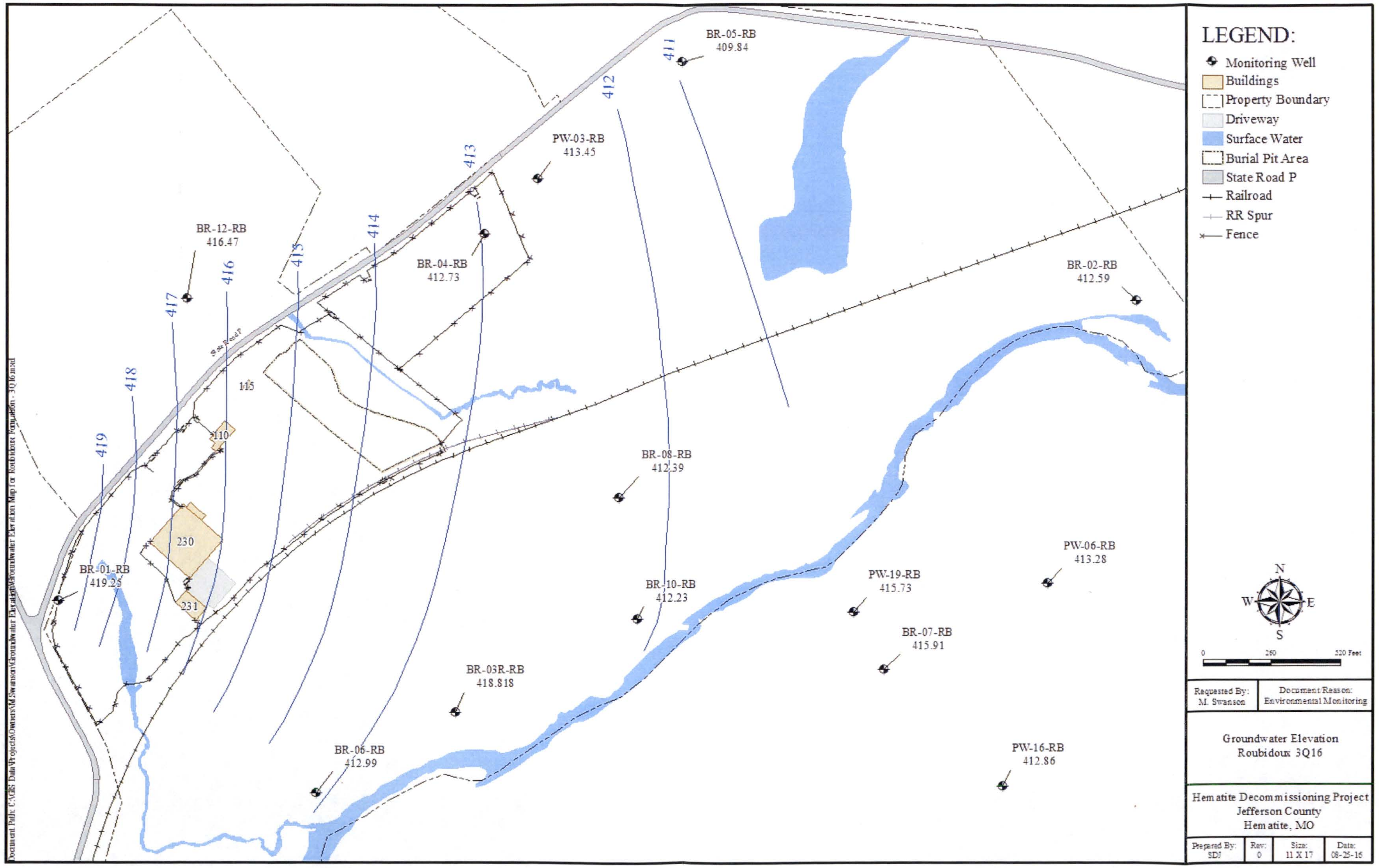
2nd Quarter Post-remediation Groundwater Elevation Contour Map

JEFFERSON CITY – COTTER HSU



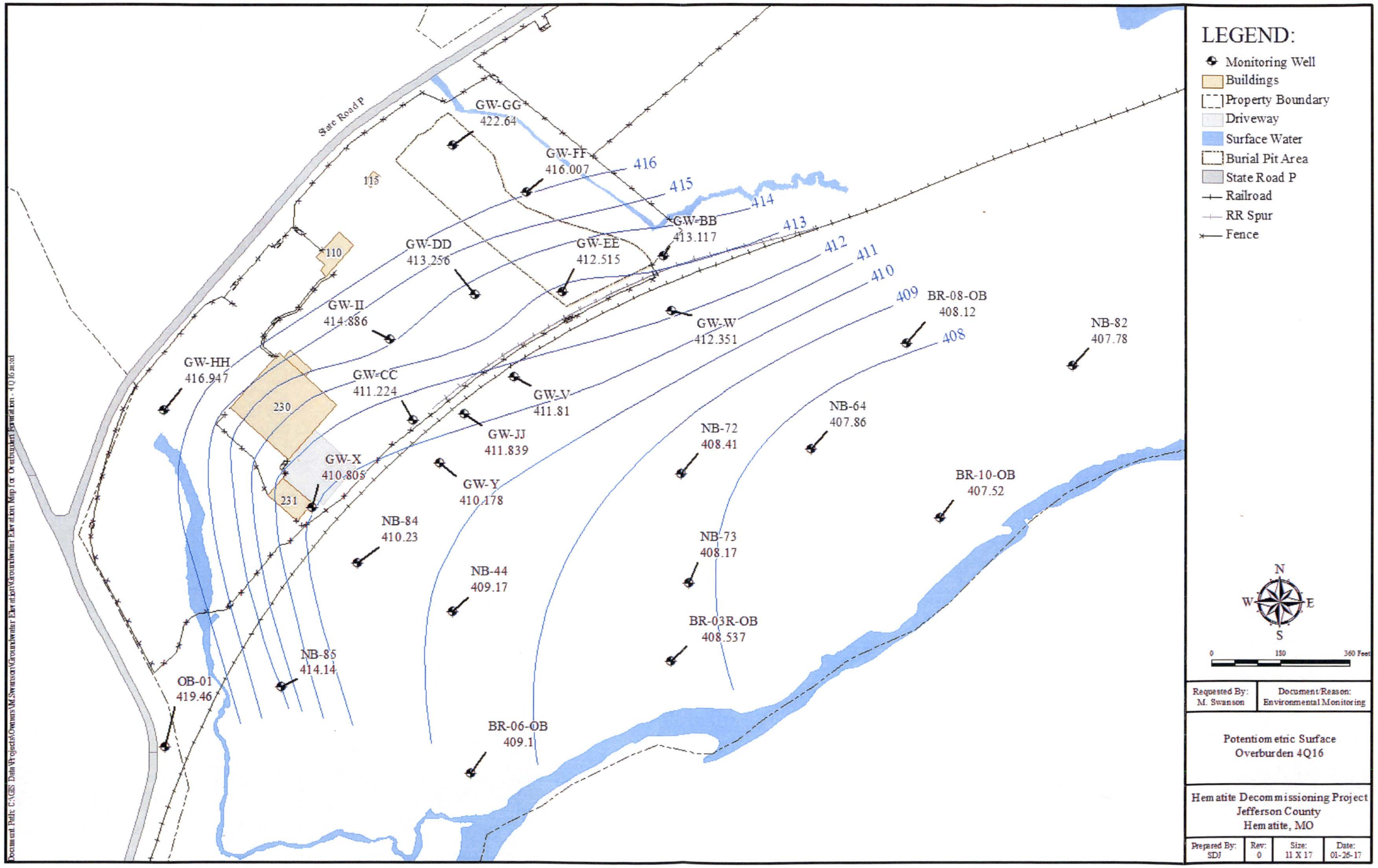
2nd Quarter Post-remediation Groundwater Elevation Contour Map

ROUBIDOUX HSU



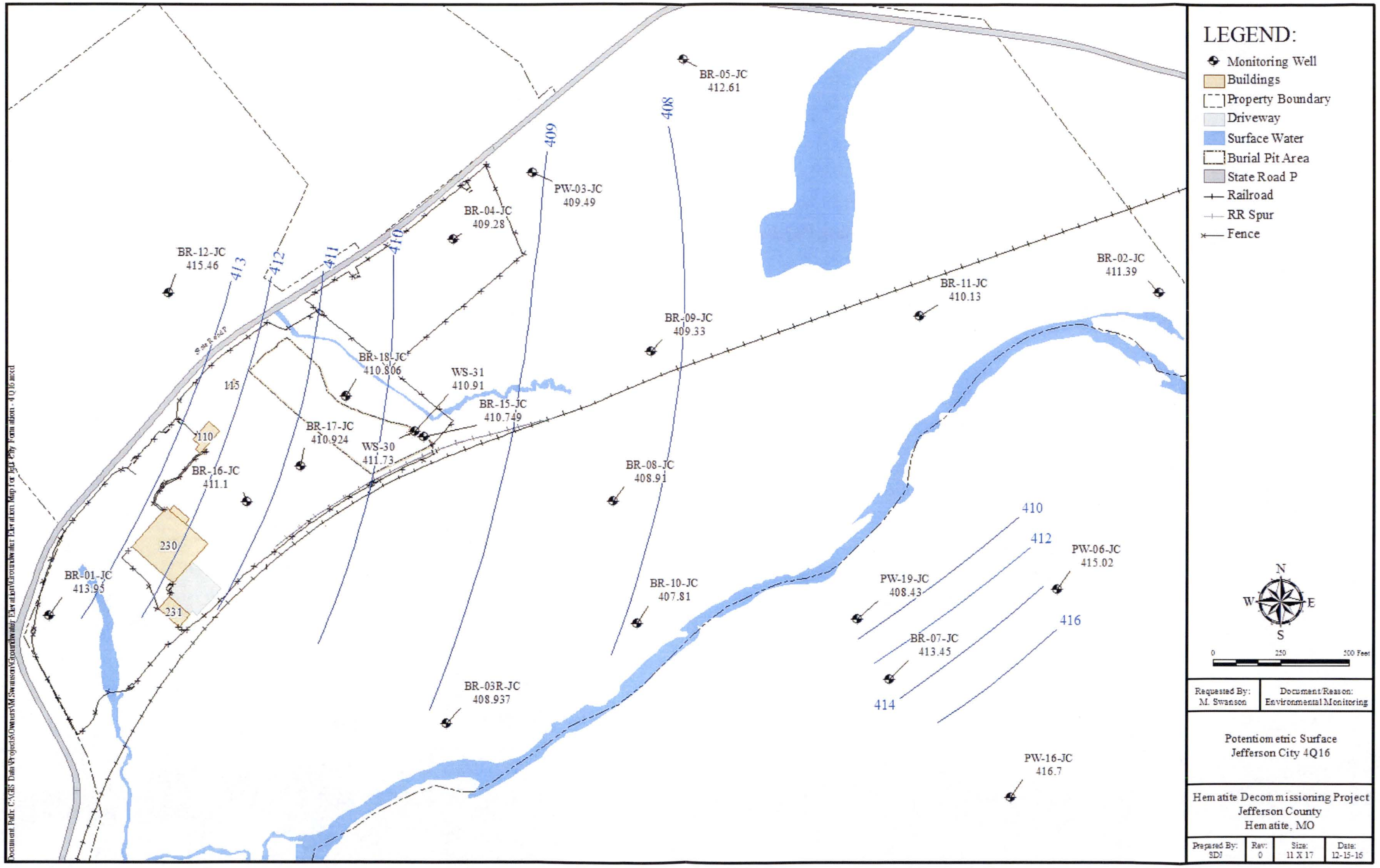
3rd Quarter Post-remediation Groundwater Elevation Contour Map

SAND/GRAVEL HSU



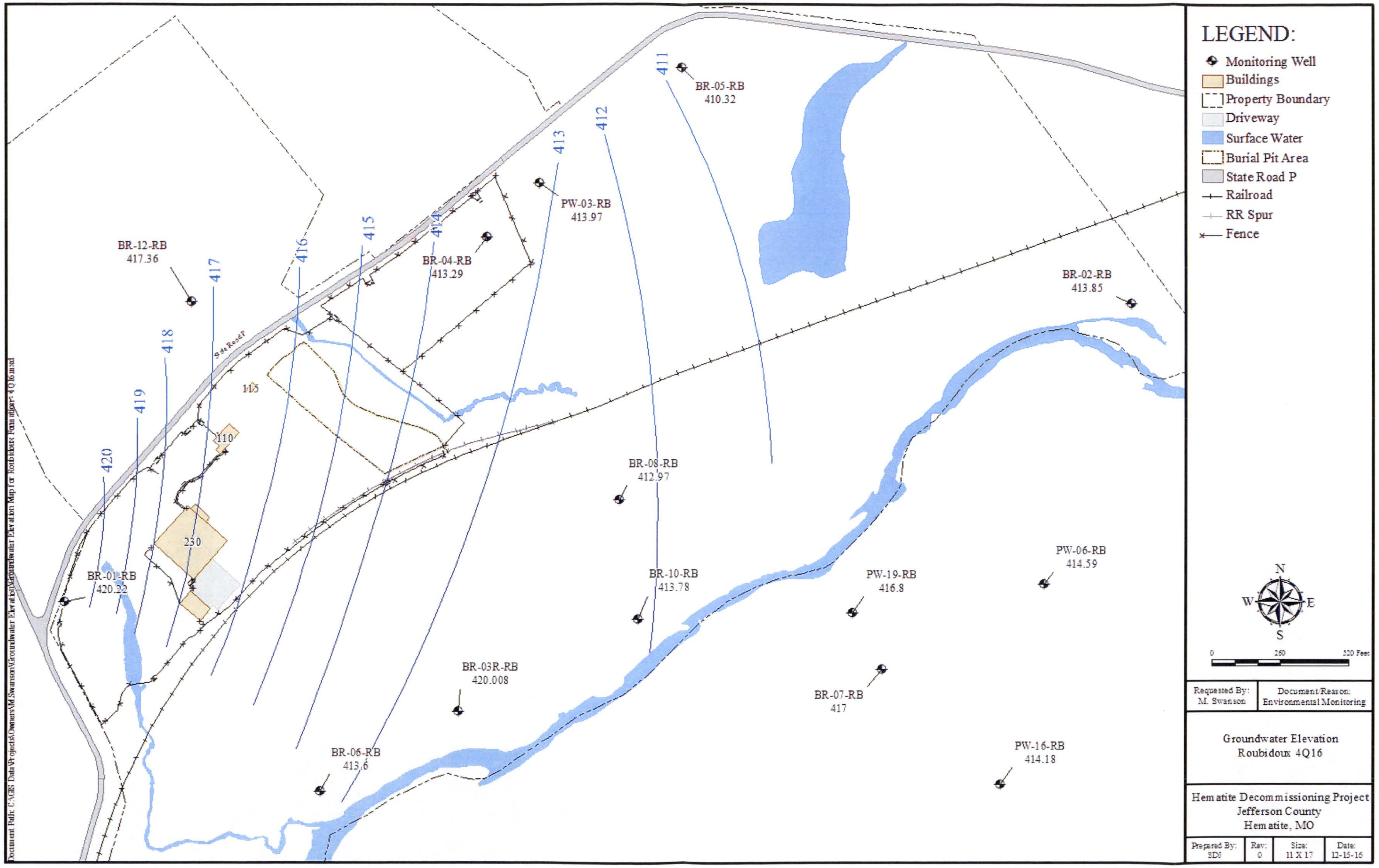
3rd Quarter Post-remediation Groundwater Elevation Contour Map

JEFFERSON CITY – COTTER HSU



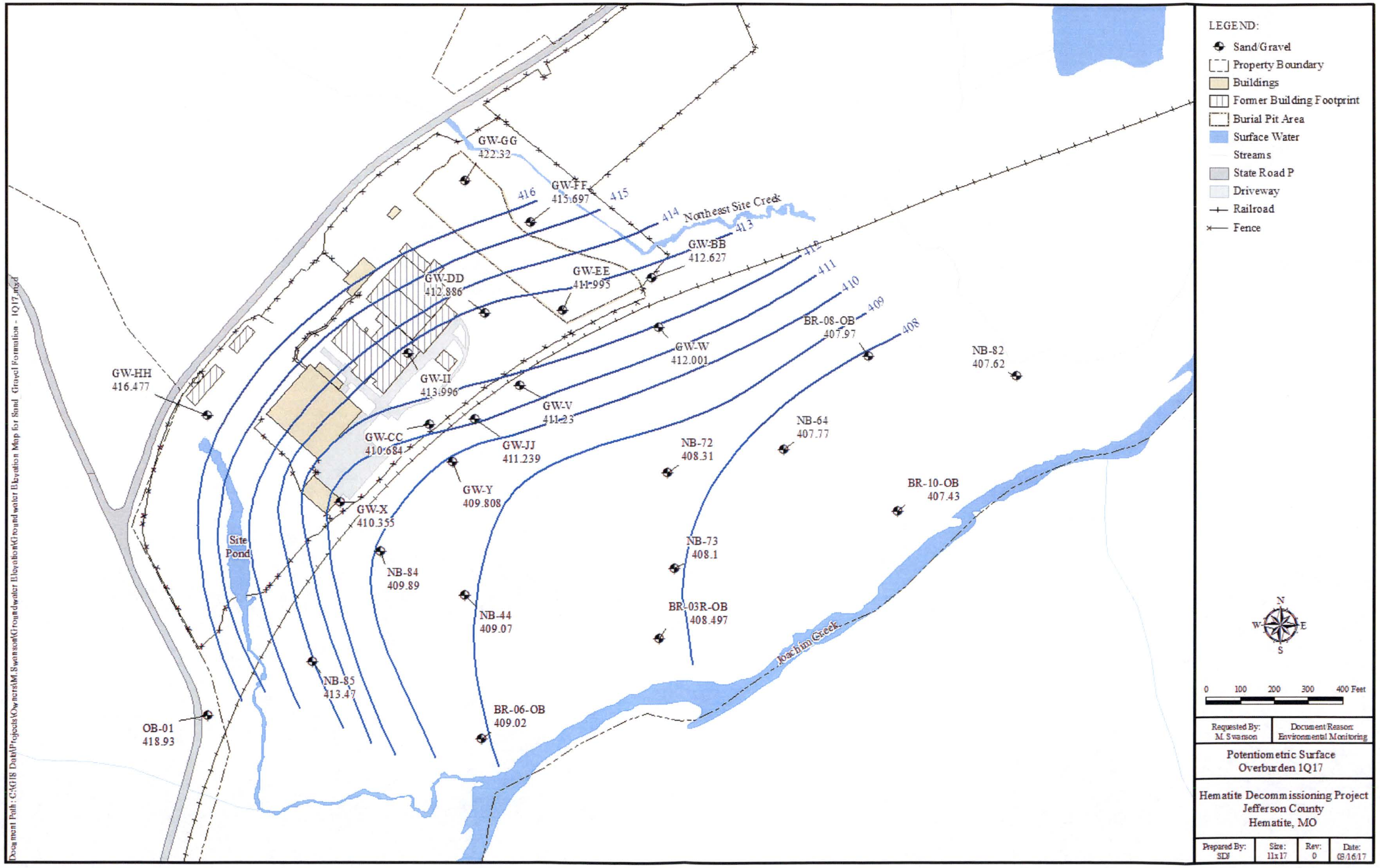
3rd Quarter Post-remediation Groundwater Elevation Contour Map

ROUBIDOUX HSU



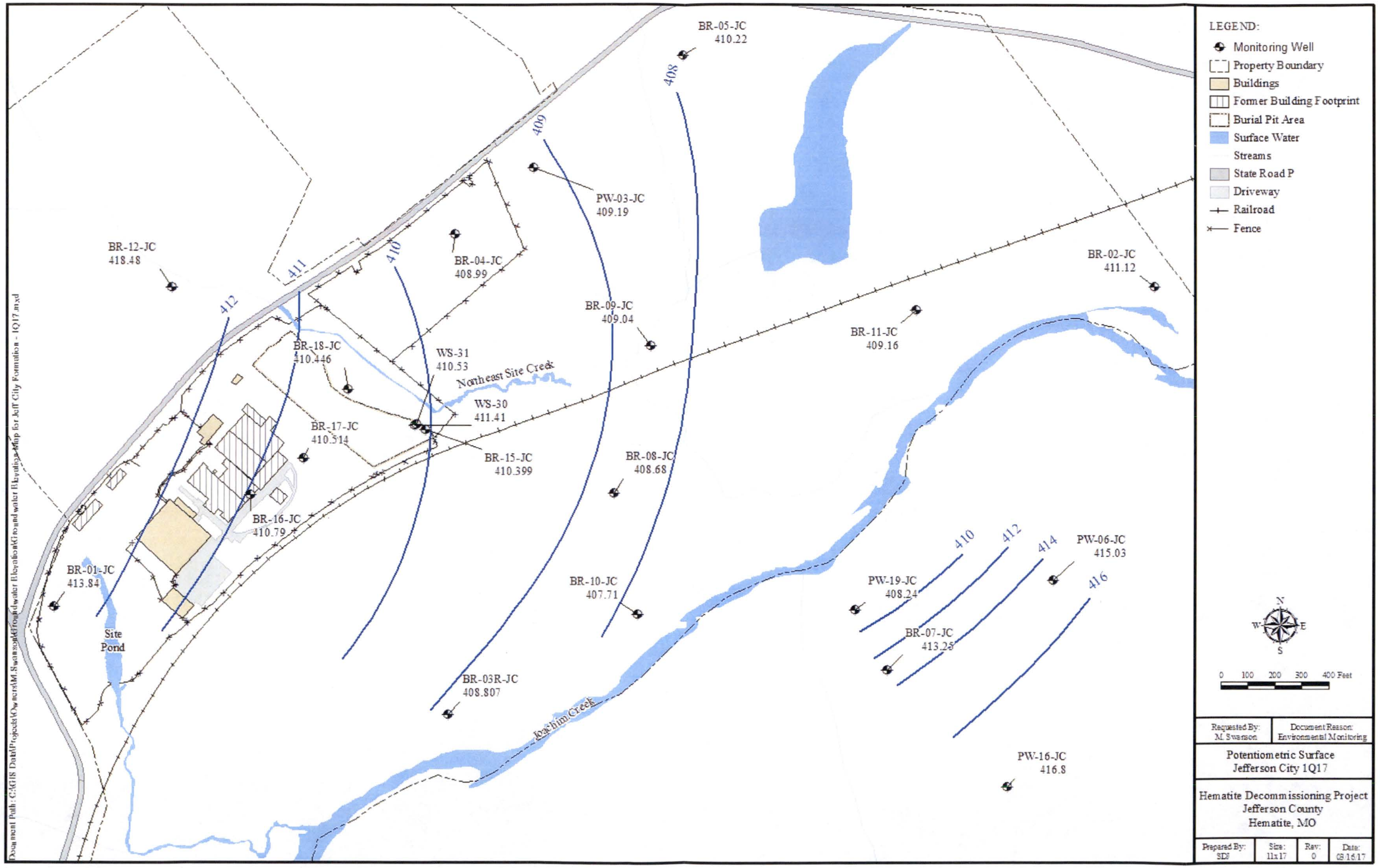
4th Quarter Post-remediation Groundwater Elevation Contour Map

SAND/GRAVEL HSU



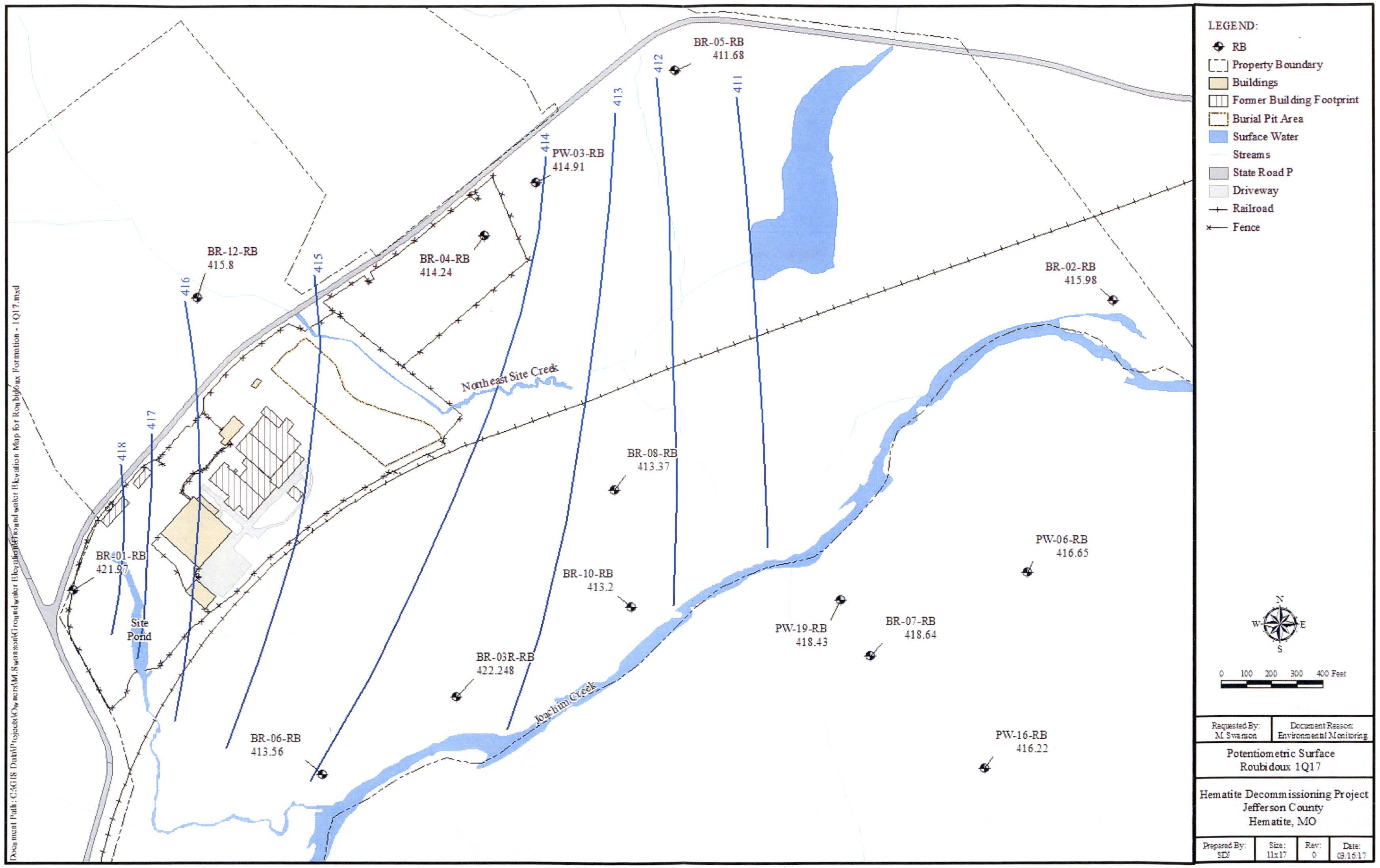
4th Quarter Post-remediation Groundwater Elevation Contour Map

JEFFERSON CITY – COTTER HSU



4th Quarter Post-remediation Groundwater Elevation Contour Map

ROUBIDOUX HSU



Attachment 3

Final Status Survey Final Report Volume 6, Chapter 7, Revision 1

Revision Matrix

Westinghouse Electric Company LLC, Hematite Decommissioning Project

REVISION MATRIX FOR FSSFR VOLUME 6, CHAPTER 7, REVISION 1
Post-remediation Groundwater Monitoring Summary

The NRC provided feedback during a recurring weekly publicly noticed teleconference with a subsequent written follow-up in regards to comments on FSSFR Volume 6, Chapter 7, Post-remediation Groundwater monitoring Summary. During a subsequent publicly noticed teleconference Westinghouse and the NRC discussed the path forward and resolution of the NRC comments. At that time Westinghouse agreed to revise FSSFR Volume 6, Chapter 7. This revision to FSSFR Volume 6, Chapter 7, implements the resolution discussed during the weekly publicly noticed teleconference.

SECTION	REVISION	REASON
4.1 Table 4-5	Corrected uncertainty value.	Agreed upon path forward NRC comment #2.
4.3 Table 4-16	Corrected data for monitoring well PZ-02.	Agreed upon path forward NRC comment #1.
4.3 Table 4-17	Corrected Uranium-238 data.	A typographical error incorrectly listed the U-238 value for well PZ-02. The U-238 value has been corrected for PZ-02, which makes the correct maximum U-238 sample result well GW-HH is now provided.
4.4	Added text providing addition basis for using the average radionuclide concentration.	Agreed upon path forward NRC Comment #1.
New 4.4.1 Header	Added header.	Header added to support addition of new section 4.4.2.
New 4.4.2	Added new section.	Agreed upon path forward NRC comment #1.
New 4.4.3	Added new section.	Agreed upon path forward NRC comment #2.
8.5	Added reference.	Agreed upon path forward NRC comment #5.
Attachment 1 Page 35 BR-19JC U235/236	Corrected uncertainty value.	Agreed upon path forward NRC comment #2.
Attachment 1 Page 41 PZ-02 U238	Corrected values.	Agreed upon path forward NRC comment #1.
Attachment 2 All Graphs	Added legend	Agreed upon path forward NRC comment #4.

Attachment 4

Westinghouse Response and Path Forward for FSSFR Volume 6, Chapter 7, Revision 1, dated February 19, 2018

Westinghouse Electric Company LLC, Hematite Decommissioning Project

NRC Staff's Preliminary Comments on the Post-remediation Groundwater Monitoring Summary, FSS Final Report Volume 6, Chapter 7

Westinghouse proposed path forward February 19, 2018.

1. The GW dose evaluation described in the FSS is based on the averages of averaged activities of ROC in the individual HSU over the entire site for all monitoring periods. The default groundwater dose contribution assigned to each LSA survey unit is 0.68 mrem/year, which is calculated for the Jefferson city-Cotter HSU.

   This approach may underestimate the GW dose contribution to the overall dose or risk in those survey units located in the former buildings, evaporation pond, and burial pit, where the higher activities of radionuclides of concern (ROC) are detected in the groundwater (e.g., BR-14-JC, BR-17-JC, and BR-19-JC). It's reasonable to use the dose calculated in Jefferson City-Cotter HSU to represent site dose from the groundwater pathway. The Sand/gravel HSU and Jefferson City-Cotter HSU are hydraulically connected, and Jefferson City-Cotter HSU is major source of drinking water aquifer in the area. The maximum detected activities of U-233/234, and U-235/236 are in the Jefferson City-Cotter HSU. But the maximum detected activities of Tc-99 and U-238 are found in the Sand/gravel aquifer. It may be argued that the Sand/gravel HSU may be relatively unimportant in the northern part of the site as it is almost absent or very thin. There should be a discussion the implication of averaging ROC activities on the dose calculation in the report, and provide an analysis on the maximum possible groundwater dose contribution by taking the max Tc-99 and U-238 from the sand/gravel and combine it with the max of the U-233/234 and U-235/236 in the Jefferson-City-Cotter HSU, which result in a total of 2.4 mrem/year that is less than the 4 mrem of EPA drinking water standard (Note: Leah Parks did the calculation).

Discussion - Groundwater Worst Case Scenario

During the Westinghouse assessment of the site FSS data in the development and generation of survey area release records Westinghouse completed a theoretical worst case groundwater dose scenario for bounding purposes for internal use. The dose calculated from the groundwater worst case dose scenario was then considered when reviewing the dose contributions for all Land Survey Area survey units.

The groundwater worst case scenario assumed the maximum individual quarterly result, regardless of the aquifer from which the result originated, would be representative of the potable groundwater, even though the Sand/Gravel HSU has insufficient quantities of water to sustain feasible and economic production based on its limited extent and thickness. Therefore, the maximum hypothetical activities for Tc-99 used for this scenario originated from the Sand/Gravel HSU, while the maximum hypothetical activities for the uranium isotopes originated from the Jefferson City-Cotter HSU.

NOTE: When preparing this response during data review it was identified that the U-238 value for Monitoring Well PZ-02 of 3.86 pCi/L was incorrect (correct value 0.0556), and was in fact a

duplicate of the Tc-99 result for Monitoring Well PZ-02 that was collected during the same quarter. As such the maximum U-238 identified was actually from a Jefferson City-Cotter HSU monitoring well (BR-17-JC) collected during the first quarter post-remediation sampling event, with a result of 2.04 pCi/L. The maximum activities for U-233/234 and U-235/236 were also from the Jefferson City-Cotter HSU. The maximum activity for Tc-99 was from the Sand/Gravel HSU. No maximum activities were detected within the Roubidoux HSU, therefore, none of the detections for the hypothetical worst case scenario came from that HSU. The hypothetical maximum activities used are shown in the Table below. Under this scenario, the maximum dose contribution by groundwater was calculated to be 2.186 mrem/year.

Calculated Groundwater Dose – Hypothetical Worst Case

Radionuclide of Concern	HSU	Maximum Detected Activity (pCi/L)	DSR_{GW} (mrem/yr per pCi/L)	Dose Contribution from Radionuclide (mrem/year)
Tc-99	Sand/Gravel	80.3	9.374 E-04	0.075
U-233/234	Jefferson City-Cotter	11.7	0.1532	1.792
U-235/236	Jefferson City-Cotter	0.149	0.1448	0.022
U-238	Jefferson City-Cotter	2.04	0.1455	0.297
			Sum of Dose Contributions:	**2.186**

While this scenario is considered by Westinghouse to be incredible due the limited extent and thickness of the Sand/Gravel HSU, the State of Missouri regulations regarding placement of potable water wells in formations like the Sand/Gravel HSU, and the future monitoring and control of the facility to accomplish chemical groundwater remediation as approved by the State of Missouri Department of Natural Resources, this scenario supports the conclusion that the dose contribution from groundwater sources will never exceed the EPA drinking water standard of 4 mrem/year.

<u>Discussion – Utilizing Average Activity versus a Single Maximum Activity</u>

To be consistent with the MARSSIM approach when determining the dose contribution for soil in a survey unit by reporting the survey unit average dose utilizing the same MARSSIM approach the site staff opted to not include a hypothetical worst case (Maximum Activity) determination when reporting the groundwater dose contribution within FSSFR Volume 6, Chapter 7. Rather the average groundwater dose from the highest dose contribution HSU was reported.

Averaging of the ROC activities is considered to be reasonable and a representative estimation of the groundwater dose contribution as it considers the seasonal effects the entire year, rather than from one season or quarter.

Regarding the use of only the Jefferson City-Cotter HSU radiological data for determination of the average dose contribution as noted by the NRC as stated above: "The Sand/gravel HSU and Jefferson City-Cotter HSU are hydraulically connected, and Jefferson City-Cotter HSU is major source of drinking water aquifer in the area". Acknowledging the premise that the Sand/gravel HSU and Jefferson City-Cotter HSU are hydraulically connected to a certain extent, it is also acknowledged that the samples collected from the Jefferson City-Cotter HSU are representative of the inclusion of the contribution from the Sand/gravel HSU into the Jefferson City-Cotter HSU. Therefore, Westinghouse still considers that using the average concentrations from the Jefferson City-Cotter HSU to determine a dose impact of 0.68 mrem/year is still the most representative and appropriate dose estimation for determining if the site meets the unrestricted release criteria.

Proposed Path Forward

Westinghouse proposes that a discussion of the hypothetical groundwater worst case scenario and the rationale for using the average of the ROC activities be included in a revised FSSFR Volume 6, Chapter 7, along with a correction to the typographical error as noted above.

2. The impact of uncertainties associated with the ROC detection on the groundwater dose contribution are not address in the FSS report. Alternatively, the upper bound on the maximum detected activities as shown, e.g., in Table 4-17 for calculating the Maximum Concentration Dose in the Sand/Gravel HSU.

Discussion

In order to evaluate the potential impact of uncertainties associated with the ROC detections, Westinghouse used the data from the hypothetical worst case groundwater dose (as calculated in the response to Comment #1) and added the uncertainty to the detected value as shown in the table below.

NOTE: The uncertainty reported for Uranium 235/236 in table 4-5 was also found to be in error, and has been replaced with the correct value from the laboratory reports.

Calculated Groundwater Dose with Uncertainty – Hypothetical Worst Case

Radionuclide of Concern	HSU	Maximum Detected Activity (pCi/L)	Uncertainty (pCi/L)	Activity Maximum Detected + Uncertainty (Pci/L)	DSR_{GW} (mrem/yr per pCi/L)	Dose Contribution from Radionuclide (mrem/yr)
Tc-99	Sand/Gravel	80.3	8.24	88.54	9.374 E-04	0.083
U-233/234	Jefferson City-Cotter	11.7	1.39	13.09	0.1532	2.005
U-235/236	Jefferson City-Cotter	0.149	0.0804	0.2294	0.1448	0.033
U-238	Jefferson City-Cotter	2.04	0.44	2.48	0.1455	0.361
					Sum of Dose Contributions:	**2.482**

Using this method, the calculated worst case groundwater dose including sample uncertainty was 2.482 mrem/year, which is below the EPA standard of 4 mrem/year. Westinghouse used this calculation to evaluate the effect of uncertainty on the dose calculation.

Proposed Path Forward

Westinghouse proposes that a discussion of the impact of uncertainties associated with the ROC detection on the groundwater dose contribution be included in a revised FSSFR Volume 6, Chapter 7, along with a correction to the typographical error as noted above.

3. Some tables listing the quarterly groundwater monitoring ROC data in Section 4 contain negative activities. Spot checking indicates that these negative numbers appear to be counted as zero in the calculation of averages. Clarify that this is consistent in obtaining the averages in all related tables.

Discussion

Negative results for the laboratory reported activities were treated as a zero result when calculating the average activities for each of the isotopes in all tables contained in FSSFR Volume 6, Chapter 7. This approach was considered to be conservative, as using negative values (as reported by the laboratory) will result in a lower average activity.

4. Some of the legends are not provided for the figures in Attachment 2. The lines indicating the MCLs, for example are labeled, while other lines are not.

Proposed Path Forward

Attachment 2 provides a series of graphs, four in total, for each well on two pages. The first two graphs presented are the trending of Technetium-99 results and the samples results for Technetium-99, while the next two graphs are the trending of Total Uranium and the sample results for Total Uranium. The green line included on the trending graphs represents the historical average activity for that well, with the upper red line indicating the historical average plus 3 standard deviations, and the lower red line indicating the historical average minus 3 standard deviations.

Westinghouse proposes to include labeling lines of the graphs as indicated above for clarity, as well as labeling the blue line as the sample data-trend line in the proposed revision to FSSFR Volume 6, Chapter 7.

5. Provide the reference on Mann-Kendall analysis by DOE presented at the February 2013 Waste management Conference, including the author and title.

Proposed Path Forward

The article was presented at the 2013 Waste Management Conference, Phoenix, Arizona, which took place February 24 through 28. The reference is provided below:

> **Mann-Kendall Test for Analysis of Groundwater Contaminant Plume Stability and Evaluation of Sampling Frequency for Long-Term Monitoring – 13233,** Jeffrey R. Walker and Toby R. Harrison, Elvado Environmental LLC, 9724 Kingston Pike, Suite 603, Knoxville, TN 37922

Westinghouse proposes to add the reference to the proposed revision to FSSFR Volume 6, Chapter 7.