ECF-200UP1-20-0022
Revision 0

Calculation of Temporal Trends and Confidence Limits for Chromium and Cyanide in Groundwater at Waste Management Area U

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

CH2MHILL
Plateau Remediation Company

P.O. Box 1600
Richland, Washington 99352

Approved for Public Release;
Further Dissemination Unlimited

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ENVIRONMENTAL CALCULATION COVER PAGE

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Please approve via email, ECF-200UP1-20-0022, Rev. 0, *Calculation of Temporal Trends and Confidence Limits for Chromium and Cyanide in Groundwater at Waste Management Area U*

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Terms

CRAN	Comprehensive R Archive Network
ECF	environmental calculation file
HEIS	Hanford Environmental Information System
LCL	lower confidence limit
MDL	method detection limit
P&T	pump and treat
SST	single-shell tank
UCL	upper confidence limit
WMA	waste management area

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1 Purpose

This environmental calculation file (ECF) presents estimates of concentration trends, mean concentrations, and confidence limits of the mean for total and dissolved/hexavalent chromium in groundwater in the vicinity of Single-Shell Tank (SST) System Waste Management Area (WMA) U. The calculations evaluate the groundwater data collected at WMA U network wells through December 2019 to determine if there is statistically significant evidence of exceedances of established groundwater limits. The calculations will support the final status groundwater monitoring plan for WMA U, which will be modified into the future Revision 9 of WA7890008967, *Hanford Facility Dangerous Waste Permit (Site-Wide Permit)*.

2 Background

WMA U is one of seven inactive WMAs within the SST System unit and is one of the SST farms located in the 200 West Area on the Hanford Site's Central Plateau (Figure 1). In 1989, groundwater monitoring was initiated at each of the seven SST System WMAs based on the requirements for interim status facilities, as defined by the *Resource Conservation and Recovery Act of 1976*, with regulations promulgated by the Washington State Department of Ecology in the *Washington Administrative Code* and the *Code of Federal Regulations* by reference (WAC 173-303-400, "Dangerous Waste Regulations," "Interim Status Facility Standards"; 40 CFR 265, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," Subpart F, "Ground-Water Monitoring"). Indicator parameter monitoring continued until the WMAs were placed into a groundwater quality assessment monitoring program in accordance with 40 CFR 265.93(d), "Preparation, Evaluation, and Response," due to separate, WMA-specific exceedances of critical means.

Under final status, the appropriate groundwater monitoring program (i.e., detection monitoring, compliance monitoring, or corrective action monitoring) is determined using the requirements in WAC 173-303-645(2)(a), "Releases from Regulated Units," "Required Programs." If there is no statistically significant evidence of a release (contamination) at the point of compliance, the unit is monitored under WAC 173-303-645(9), "Detection Monitoring Program." If groundwater monitoring has shown statistically significant evidence of a release (contamination) at the point of compliance, the unit is monitored under WAC 173-303-645(10), "Compliance Monitoring Program." If the groundwater protection standard is exceeded, a corrective action program is implemented and the unit is monitored under WAC 173-303-645(11), "Corrective Action Program."

Additional evaluation of chromium results is performed in this ECF to support the final status groundwater monitoring program determination in compliance with WAC 173-303-806(4)(a)(xx)(G), "Final Facility Permits," "Contents of Part B," and WAC 173-303-645(10). There was only one cyanide sample and no free cyanide data for WMA U from 2012 through 2019, so no cyanide evaluation was performed in this ECF.

Final status groundwater monitoring requires that any potential and/or verified releases be monitored using approved statistical methods. Both compliance and corrective action monitoring rely on the calculation of sample means and the confidence interval of the sample mean to determine exceedance of an established groundwater protection standard.

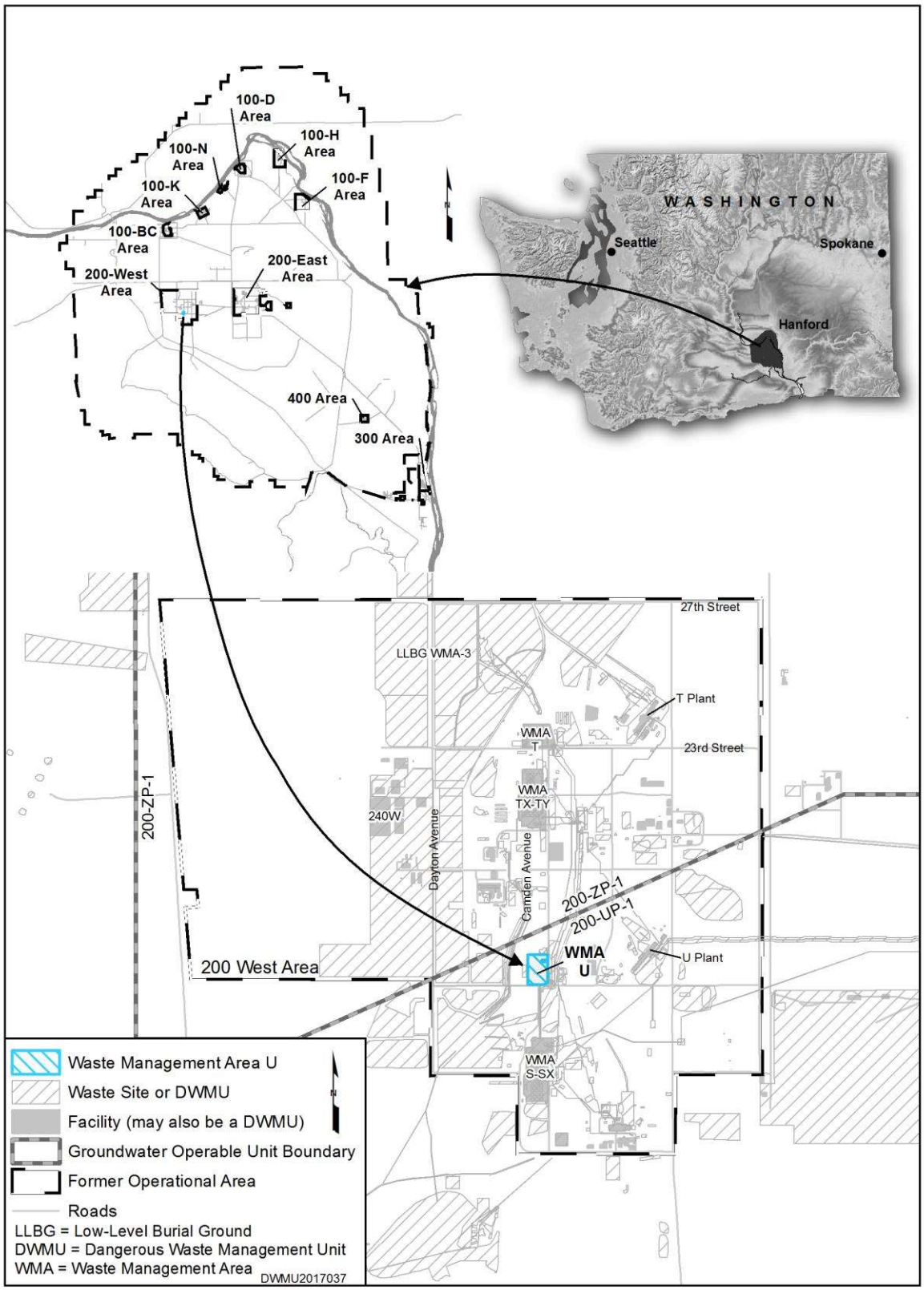

Figure 1. Location Map for WMA U

2.1 Groundwater Flow at WMA U

Groundwater flow at WMA U is affected by the 200 West Area Pump and Treat (P&T) remedy, which began operating in 2012. As a result of the P&T system operations, groundwater flows generally east-northeast beneath WMA U. Prior to 200 West P&T system operations, groundwater flow conditions at WMA U varied greatly over several decades due to changing wastewater disposal in areas near the WMA (Section 3.3.1 in SGW-60578, *Engineering Evaluation Report for Single-Shell Tank Waste Management Area U Groundwater Monitoring*).

2.2 Groundwater Monitoring Network for WMA U

The groundwater monitoring network for WMA U has changed over the years of interim status monitoring. A history of the wells in the network is included as Appendix A to SGW-60578. The final status monitoring network is also presented in SGW-60578 and consists of eight wells, including two upgradient wells (one of which is a proposed well) and six downgradient wells. Figure 2 shows the final status monitoring network wells. The monitoring network is designed to detect significant increases in groundwater contamination that would result from releases from SSTs and liquid handling structures within the regulated unit.

2.3 Monitoring History

In 1989, an interim status indicator parameter groundwater monitoring program was initiated at each of the SST System unit WMAs. The indicator parameter monitoring program continued at WMA U until it was placed into a groundwater quality assessment monitoring program in accordance with 40 CFR 265.93(d), "Interim Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Preparation, Evaluation, and Response," due to an exceedance of the critical mean[1] of an indicator parameter. Discussion of the regulatory basis for the groundwater quality assessment and a detailed history of interim status monitoring at WMA U (including the groundwater monitoring plans and assessment reports that have been issued for the WMA U) are available in Sections 2.2 and 2.4, respectively, of the associated engineering evaluation report (SGW-60578). Chromium and cyanide are evaluated because they have been previously identified in groundwater and attributed to individual WMAs in the SST System unit.

3 Methodology

This chapter discusses the methods used to complete the calculations presented in this document.

3.1 Wells in WMA U Monitoring Network

Table 1 lists the wells that comprise the WMA U monitoring network. Evaluations are conducted only for the downgradient wells in the monitoring network in this ECF. The proposed downgradient well has not yet been installed and therefore is not included in the evaluation.

[1] The critical mean is a statistically determined background value that is calculated as specified under 40 CFR 265.93(b) and is used to determine if indicator parameters exhibit a significant increase (or pH decrease) in downgradient wells.

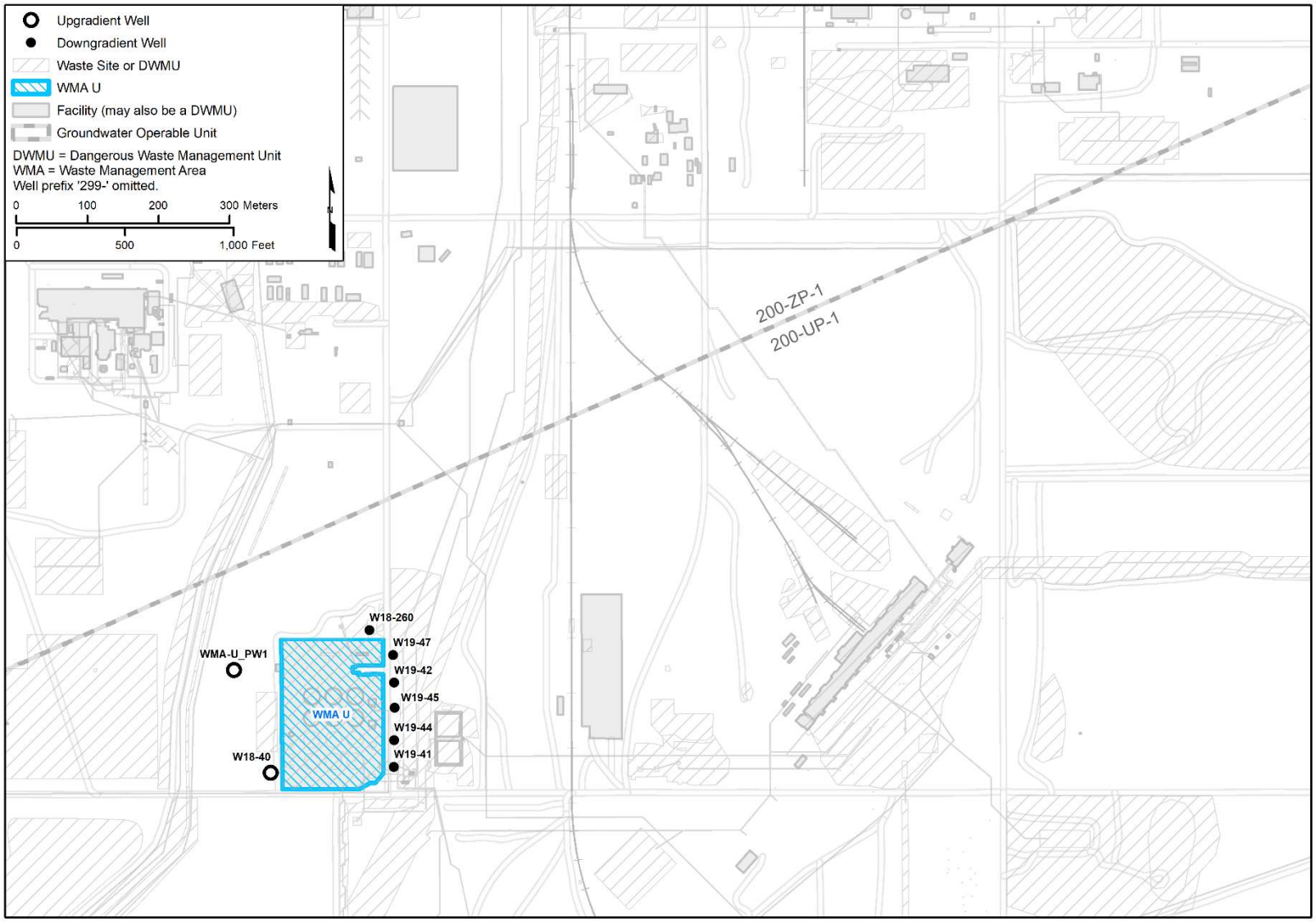

Figure 2. Map Showing Locations of Final Status Monitoring Wells at WMA U

Table 1. WMA U Groundwater Monitoring Network

Well Name	Upgradient/Downgradient
299-W18-40	Upgradient
299-W18-260	Downgradient
299-W19-41	Downgradient
299-W19-42	Downgradient
299-W19-44	Downgradient
299-W19-45	Downgradient
299-W19-47	Downgradient
WMA_U_PW-1*	Ugradient

Reference: Section 9.3 in SGW-60578, *Engineering Evaluation Report for Single-Shell Tank Waste Management Area U Groundwater Monitoring*.

*Proposed well.

3.2 Data Usability

Before performing any statistical analyses, the chromium (total and dissolved/hexavalent) and cyanide (total and free) data were subjected to a data usability evaluation to ensure that only measurements considered to be representative of groundwater quality at WMA U were used in the statistical analyses. Samples were subset into the following three categories:

- Usable data
- Nonrepresentative data, removed from analysis
- Data requiring further evaluation

There was only one cyanide sample and no free cyanide samples for WMA U from 2012 through 2019. All dissolved/hexavalent chromium and total chromium measurements were evaluated based on laboratory qualifiers, review qualifiers, method detection limits (MDLs), and relative percent difference of duplicate samples in the following manner:

1. Review qualifiers: Measurements associated with the data review qualifiers “R” (rejected, do not use), “F” (result is undergoing further review), or “Q” (quality control sample out of limits) were excluded from the statistical analyses.

2. Method detection limits: Reported MDLs (i.e., the numerical values associated with “U” qualified measurements) were compared to the selected groundwater limits (i.e., 48 µg/L) dissolved/hexavalent chromium, 100 µg/L for total chromium). If the reported detection limits were equal to or greater than the groundwater limits, those measurements were identified as inconclusive for the absence of the dangerous waste constituent at the groundwater limit and were not used as representative measurements in the statistical analyses for comparison to limits.

3. Duplicate samples: Measurements that were collected on the same day or reported to be field duplicate pairs were evaluated for measurement precision. If the relative percent difference was greater than 30%, the affected sample pairs were identified as nonrepresentative and were excluded from use in the statistical analyses, even if one of the duplicate samples appeared to be within the concentration range of the usable data.

Total chromium measurement data were also evaluated for the presence of stainless steel alloy metals at concentrations that would indicate apparent corrosion of stainless steel well components. This evaluation was performed by inspecting the data to identify sample events for which the four major metals in 304 stainless steel alloys (i.e., total iron, total chromium, total nickel, and total manganese) were present in quantified measurements. The ratios of concentrations of each metal in each sample were evaluated using ternary plots where they could be compared to the ratios present in reference 304, 304L, and 316 (or 316L) stainless steel alloys. If the observed alloy metal ratios in a sample appeared similar to those of the reference alloy, the sample was identified as potentially being "corrosion affected." The measured chromium concentration in "corrosion-affected" samples were subsequently identified as not representative of formation groundwater for the purposes of statistical analyses of the dataset.

3.3 Daily Averaging

For trend analysis, a daily average was calculated for chemistry data possessing multiple measurements on the same day. When all measurements on the same day were nondetect, the highest detection limit was used for the daily value. For daily duplicates where only one of the samples was nondetect, the detected value was used for the daily value.

3.4 Trend Analysis

A censored regression (Tobit) model was used to estimate the statistical parameters when a statistically significant trend was present (the basis for use of the Tobit censored regression method is detailed in SGW-58883, *Methodology for the Calculation of Concentration Trends, Means, and Confidence Limits for Performance and Attainment Monitoring*). The Tobit model estimates linear relationships when there are left-censored data (nondetects are left-censored data) in the dependent variable. When all data are quantified, the Tobit model yields the same parameter estimates as ordinary least squares regression. The standard errors of the parameter estimates that it produces tend to be slightly smaller than the ordinary least square standard errors; this difference in standard errors diminishes as the amount of data increases. The Tobit regression model allows for the inclusion of multiple covariates (e.g., time and river stage) to explain the observed water levels or concentrations. A brief summary of the trend analysis methodology follows, and a more detailed description is provided in subsequent sections. Trends were tested for statistical significance and yearly means and both lower confidence limits (LCLs) and upper confidence limits (UCLs) of the mean were calculated from the trends.

3.4.1 Tobit Regression Model

The relationship between groundwater chemistry and time is defined as follows in Equation 1 (SGW-58883 provides more detail on the basis for this calculation):

$$ln(C_i) = \alpha_i - \beta_i t \qquad \textbf{(Equation 1)}$$

where:

C_i	=	a fitted concentration (µg/L) for analyte *i*
t	=	the time (day)
α and β	=	parameters corresponding to the equation intercept and date coefficient, respectively; they are assumed to be constant and are estimated using regression.

3.4.2 Determination of Sufficient Data for Trend Analysis

Trends over time were evaluated for each well/dangerous waste constituent pair that possessed a minimum of six samples and less than 50% (i.e., half) reported nondetects.

3.4.3 Evaluation of Overall Trend Significance

The significance of the overall trend was evaluated using the log-likelihood ratio test. The log-likelihood ratio test is a statistical test that compares the goodness of fit between two models: the null model (a model where there is no relationship between the dependent variable and the covariates) and an alternative model (the Tobit regression model). The log-likelihood ratio statistic is defined as follows in Equation 2:

$$LRT = 2(logL_A) - 2(logL_{NULL}) \quad \textbf{(Equation 2)}$$

where:

LRT = the log-likelihood ratio statistic

$logL_A$ = the log-likelihood of the alternative model

$logL_{NULL}$ = the log-likelihood of the null model.

The null probability distribution of the log-likelihood ratio statistic is approximated by the chi-square distribution with degrees of freedom equal to the number of additional covariates used in the alternative model. The significance of the alternative is assessed by comparing the p-value (determined from the chi-square distribution) to the level of significance (α), in this case 0.05[2]. When the p-value is less than α, the alternative model is statistically significant.

3.5 Mean and Upper and Lower Confidence Limit Concentrations

The statistical approach used to calculate the LCL/UCL was determined based on the outcome of the trend analysis. If there was no statistically significant trend in the data or if there were insufficient data for trend analysis, the 95% LCL/UCL of the mean was determined using ProUCL. The presence of a trend in the data resulted in the 95% LCL/UCL of the mean being calculated based on the trend.

3.5.1 Calculation of Confidence Limits Using ProUCL

For well/dangerous waste constituent pairs with no statistically significant trend or insufficient data for trend analysis, the last eight measured data were imported into ProUCL. ProUCL only provides results for the mean and UCL of the mean. The LCL of the mean was calculated using Equation 3:

$$LCL = C_{mean} - (UCL - C_{mean}) \quad \textbf{(Equation 3)}$$

where C_{mean} is the arithmetic mean concentration (µg/L).

[2] The level of significance of 0.05 represents a 5% probability of rejecting the null hypothesis (in this case, the null hypothesis is that the trend is significant) when it is true.

3.5.2 Calculation of Confidence Limits Based on Trend Analysis

The first step in calculating the 95% LCL/UCL of the mean based on the trend is to calculate fitted concentrations. Fitted concentrations were determined by applying the Tobit regression described in Section 3.4.1. Yearly mean concentrations (C_{mean}) were estimated from the fitted concentrations in Equation 4 as follows:

$$ln\big(C_{mean}(t_0, t_1)\big) = \frac{1}{t_1 - t_0}\int_{t_0}^{t_1}(\alpha - \beta t)dt \qquad \textbf{(Equation 4)}$$

where:

C_{mean}	=	the yearly geometric mean concentration
t_0	=	the first day (start) of the year
t_1	=	the last day (end) of the year.

UCLs and LCLs were calculated by calculating the mean concentration for the year (C_{mean}). The UCL and LCL were then calculated as shown in Equations 5a and 5b:

$$UCL = exp^{\left(\ln(C_{mean}) - (t_{df,\alpha/2})(\sigma)\right)} \qquad \textbf{(Equation 5a)}$$

$$LCL = exp^{\left(\ln(C_{mean}) + (t_{df,\alpha/2})(\sigma)\right)} \qquad \textbf{(Equation 5b)}$$

where:

C_{mean}	=	the calculated yearly mean concentration (µg/L)
$t_{df,\alpha}$	=	the lower 100% – α quantile of Student's t distribution with df degrees of freedom
α	=	the significance level based on a confidence limit of 95% (0.05)
df	=	the number of data points minus the number of covariates
σ	=	estimate of the standard deviation of the concentration calculated using the variance-covariance matrix of the regression coefficients.

3.6 Comparison to Groundwater Limits

Groundwater limits for comparison of groundwater monitoring measurements were identified from established regulatory limits. The values selected for comparison are provided in Table 2. A well is determined to be out of compliance with the concentration limit if the 95% LCL of the mean is above the established groundwater limits provided in Table 2.

Table 2. Groundwater Concentration Limits

Dangerous Waste Constituent	Groundwater Limit (µg/L)	Source
Dissolved/hexavalent chromium	48	CLARC[a] (May 2019)
Total chromium	100	MCL[b]

a. CLARC Method B noncancer (Ecology, 2019, *Cleanup Levels and Risk Calculation (CLARC)*) (WAC 173-340, "Model Toxics Control Act—Cleanup.")

b. MCL per 40 CFR 141.62(b), "National Primary Drinking Water Regulations," "Maximum Contaminant Levels for Inorganic Contaminants."

CLARC = Cleanup Levels and Risk Calculation

MCL = maximum contaminant level

4 Assumptions and Inputs

This chapter outlines the assumptions and inputs that underlie the calculations presented in this ECF.

4.1 Assumptions

The following is a summary of assumptions made in this analysis:

- The MDLs are independent of concentration.
- Concentrations observed at a well are affected by the same activities at the site for the selected time periods over which calculations of the mean and LCL/UCL are made.

The results presented in this ECF are based on the application of statistical methods to sample datasets of varying size, degree of censoring, and historical coverage, among other factors. Assessments made on the basis of these calculations should be interpreted in light of the number of sample results, the level of censoring (i.e., number of nondetect results), the historical period for which data are available, and the historical period over which the Tobit regression was applied.

4.2 Inputs

This section discusses the acquisition of the input data used in this analysis.

4.2.1 Chemistry Data

Groundwater chemistry data were downloaded from the Hanford Environmental Information System (HEIS) database (maintained by CH2M HILL Plateau Remediation Company) and exported into a Microsoft® Access® database (named HEIS_CHEM_20200115.accdb). The data for this analysis were downloaded from the HEIS database on January 15, 2020. The HEIS database has one table (HEIS_ADM_PNLGW_STD_RESULT_MV_2) that contains information on groundwater samples, including laboratory and review data qualifiers, sample medium, sample collection purpose, analytical method, and reporting limits. Table 3 presents the fields extracted from the HEIS database for use in calculations described in this document. Appendix A includes the data used in the evaluation.

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Table 3. HEIS Database Fields for Chemistry Data

Field Extracted[a]	Definition
WELL_NAME	Location Identification
SAMP_DATE_TIME	Sampling Date
STD_CON_LONG_NAME	Analyte Name
STD_VALUE_RPTD	Reported Concentration
STD_ANAL_UNITS_RPTD	Units for Concentration Measurement
LAB_QUALIFIER	Laboratory Data Qualifier
REVIEW_QUALIFIER	Review Data Qualifier[b]
COLLECTION_PURPOSE	Primary Reason for Sample Collection
VALIDATION_QUALIFIER	Validation Qualifier

a. Field codes are defined in HNF-38155, *HEIS Sample, Result, and Sampling Site Data Dictionary*.

b. F = The result is undergoing further review; G = Record has been reviewed and determined to be correct, or the record has been corrected with laboratory confirmation or other supporting information; H = Laboratory holding time exceeded before the sample was analyzed; P = Potential problem. Collection/analysis circumstances makes value questionable; Q = Associated quality control sample is out of limits; R = Do not use. Further review indicates the result is not valid; Y = Result suspect. Review provided insufficient evidence to show result valid or invalid; Z = Miscellaneous circumstances exist. Additional information may be found in the RESULT_COMMENT field for this record.

HEIS = Hanford Environmental Information System

4.2.2 Compilation of the Dissolved/Hexavalent Chromium Dataset

The dissolved/hexavalent chromium dataset was compiled from both hexavalent chromium and filtered total chromium samples.

5 Software Applications

The statistical software package ProUCL Version 5.1 was used to calculate the 95% LCL/UCL of the mean, in accordance with the groundwater monitoring plan. ProUCL is available through the U.S. Environmental Protection Agency and provides statistical methods and graphical tools that are commonly used in environmental assessments. ProUCL is capable of working with datasets where nondetects, samples with concentrations less than the reporting limit, are present. There are several methods available in ProUCL for calculating 95% LCLs/UCLs of the mean. These methods account for the underlying distribution of the data and the presence of nondetects. For datasets with nondetects, ProUCL uses the Kaplan-Meier method, a nonparametric method, for calculating the mean and standard deviation. ProUCL highlights a recommended method in its output file. However, it is important to assess all the methods available and independently verify the most appropriate method through visual inspection of the data, evaluation of the number of available data points, and the data distribution.

Trend analysis was performed using the public domain computing platform R (Version 3.5.1 [published July 2, 2018]). The R platform provides data manipulation, calculation, and graphical display capabilities to support data analysis (Venables et al., 2015, *An Introduction to R Notes on R: A Programming Environment for Data Analysis and Graphics*). The platform is freely available to the public and can be compiled and run on a variety of media. The base installation of R contains statistical and plotting functions. Many more functions are available for download through the Comprehensive R Archive Network (CRAN). The R routines described previously were independently checked and verified by evaluation of sample datasets as part of the preparation of this calculation.

Several R packages used for this analysis that were downloaded from CRAN are listed in Table 4. In addition to the CRAN packages listed in Table 4, several functions specific to the calculations performed in this document were incorporated into a user-defined R package called "sspaTrendAnalysis."

Table 4. R Packages Used for Calculations

R Package	Package Description	Version
censReg*	Censored Regression (Tobit) Models	0.5-26
chron	Chronological objects which can handle dates and times	2.3-45
data.table	Extension of data.frame	1.9.4
EnvStats	Package for Environmental Statistics, Including US EPA Guidance	2.10
extraDistr	Additional Univariate and Multivariate Distributions	1.8.8
grid	The Grid Graphics Package	3.1.3
gridBase	Integration of base and grid graphics	2.2.1
gridExtra	Miscellaneous Functions for "Grid" Graphics	0.4-7
gtable	Arrange grobs in tables	0.1.2
lattice	Lattice Graphics	0.20-27
magrittr	A Forward-Pipe Operator for R	1.5
maxLik	Maximum Likelihood Estimation	1.5
mblm	Median-Based Linear Models	0.12
miscTools	Miscellaneous Tools and Utilities	0.6-16
plyr	Tools for Splitting, Applying, and Combining Data	1.8.1
raster	raster: Geographic data analysis and modeling	2.2-12
Rcpp	Seamless R and C++ Integration	0.12.2
reshape2	Restructure and Aggregate Data	1.4
Rgdal	Bindings for the Geospatial Data Abstraction Library	0.9-1
rgeos	Interface to Geometry Engine – Open Source (GEOS)	0.3-4
rJava	Low-level R tro Java interface	0.9-6
sandwich	Robust Covariance Matrix Estimators	2.3-2
sp	Classes and methods for spatio-temporal data	1.0-17
stringi	Character String Processing Facilities	1.0.0

Table 4. R Packages Used for Calculations

R Package	Package Description	Version
stringr	Make It Easier to Work with Strings	1.0.0
tools	Tools for Package Development	3.1.3
trend	Non-Parametric Trend Tests and Change-Point Detection	1.1.0
XLConnect	Excel Connector for R	0.2-7
yaml	Methods to convert data to YANL and back	2.1.13
zoo	S3 Infrastructure for Regular and Irregular Time Series (Z's Ordered Observations)	1.7-11

*Modified to allow for multiple detection limits.

The calculations were performed with the following series of R scripts:

- Data Usability Scripts:
  - 01_ImportData.R
  - 02_DataUasbility.R
- Trend Analysis Scripts:
  - 01_PrepTrendData.R
  - 02_TobitAnalysis_Chemistry.R
  - 03_ReportFigures.R
- ProUCL Scripts:
  - 01_ProUCLData.R
- Well Corrosion Scripts:
  - 01_ImportCorrosionData.R
  - 02_TrilinearPlots.R

6 Calculation

The following input file was used in the implementation of this analysis:

- *qryChemHeis1.txt* and *qryChemHeis2.txt*: Concentration data from the HEIS database

The calculations were performed with a series of R scripts (listed in Chapter 5). The scripts import the concentration, and well/dangerous waste constituent pairs data, subset the data by well/dangerous waste constituent pairs, remove data based on review qualifiers, identify nondetects, compute the daily average concentration when necessary, calculate trends based on the Tobit regression model, produce plots for evaluating chemistry trends with time, and calculate 95% LCLs/UCLs of the yearly mean.

When no statistically significant trend was present, datasets were imported into the ProUCL software and 95% LCLs/UCLs were calculated based on the last eight measurements, using all available methods and accounting for the presence of nondetects. The reported 95% LCL/UCL was selected based on the ProUCL results, including evaluation of the data distribution and sample size.

7 Results

This chapter presents outputs from the trend analysis and comparison of LCLs to groundwater limits.

7.1 Data Usability

As described in Section 3.2, before performing any statistical analyses, the data were subjected to a data usability evaluation to ensure that only measurements considered to be representative of groundwater quality at WMA U were used in the statistical analyses. The results of that analysis are presented below.

There are a total of 149 total chromium and 164 dissolved/hexavalent chromium measurements from WMA U downgradient monitoring wells over the time period of January 2012 through December 2019. A total of nine total chromium (6% of the dataset) and five dissolved/hexavalent chromium (3% of the dataset) samples were removed from the dataset due to data usability issues.

Total chromium data removed based on the data usability methodology are presented in Table 5.

Table 5. Total Chromium in Groundwater Measurements Excluded From WMA U Statistical Analyses

Well Name[a]	Sample Date	Filtered Aliquot?	Groundwater Limit (µg/L)	Concentration[b] (µg/L)	Reason for Exclusion
W19-41	7/11/2012	No	100	12.1 (B)	Duplicate pair, poor precision
W19-41	7/11/2012	No	100	8.54 (D)	Duplicate pair, poor precision
W19-41	10/1/2015	No	100	33.2 [Q]	QC sample out of limits
W19-41	10/1/2015	No	100	18.9 [Q]	QC sample out of limits
W19-47	7/11/2012	No	100	4.94 (D)	Duplicate pair, poor precision
W19-47	7/11/2012	No	100	5.23 (D)	Duplicate pair, poor precision
W19-47	7/11/2012	No	100	8 (B)	Duplicate pair, poor precision
W19-47	7/11/2012	No	100	9.1 (B)	Duplicate pair, poor precision
W19-47	4/12/2019	No	100	11.7 [Q]	QC sample out of limits

a. The prefix "299-" was removed from well names for the purposes of reporting.

b. Bracketed values are review qualifiers, while values in parentheses are laboratory qualifiers.

QC = quality control

Laboratory qualifiers:

B = The analyte was detected at a value less than the contract required detection limit but greater than or equal to the instrument detection limit/method detection limit (as appropriate).

D = The analyte was reported at a secondary dilution factor, typically greater than one (i.e., the primary preparation required dilution to either bring the analyte within the calibration range or to minimize interference).

Review qualifier:

Q = Associated quality control sample is out of limits.

Dissolved/hexavalent chromium data removed based on the data usability methodology are presented in Table 6.

Table 6. Dissolved/Hexavalent Chromium in Groundwater Measurements Excluded From WMA U Statistical Analyses

Well Name[a]	Sample Date	Filtered Aliquot?	Groundwater Limit (µg/L)	Concentration[b] (µg/L)	Reason for Exclusion
W18-260	4/12/2019	Yes	48	11.8 [Q]	QC sample out of limits
W19-41	7/18/2019	Yes	48	10	Duplicate pair, poor precision
W19-41	7/18/2019	Yes	48	6.13 (X)	Duplicate pair, poor precision
W19-42	4/12/2019	Yes	48	11.1 [Q]	QC sample out of limits
W19-47	4/12/2019	Yes	48	11.2 [Q]	QC sample out of limits

a. The prefix "299-" was removed from well names for the purposes of reporting.

b. Bracketed values are review qualifiers, while values in parentheses are laboratory qualifiers.

QC = quality control

Laboratory qualifier:

X = Result-specific qualifier.

Review qualifier:

Q = Associated quality control sample is out of limits.

7.1.1 Well Corrosion

To evaluate corrosion in wells, ternary plots of the ratios of chromium, iron, nickel, and manganese were prepared for the downgradient final network wells. Figure 3 shows an example ternary plot evaluation for well 299-W19-41. Ternary plots for the downgradient wells are included in Appendix B[3]. As shown in Figure 3, the ratios of the metals is similar to the reference material ratios (for the stainless steel alloys) indicating the well is potentially corrosion affected.

Two of the downgradient wells exhibited apparent corrosion effects during some portion of the monitoring time period. Time-series and pie plots of chromium, iron, nickel, and manganese were prepared to evaluate the time periods when corrosion was present in each of these two wells. Figure 4 shows the time-series plot for well 299-W19-41, while detailed corrosion evaluation information is provided in Appendix B. As shown in Figure 4, the ratios of the metals are similar to the reference material ratios, and the metals follow similar trends during the periods potentially affected by corrosion. The results of the evaluation are summarized in Table 7. Total chromium measurement data from unfiltered aliquots during time periods apparently affected by well corrosion were suspected of being nonrepresentative of formation groundwater and were not used in subsequent statistical analysis of total chromium concentration.

[3] The chemical compositions of the stainless steel standards were published by National Electronic Alloys (http://www.nealloys.com/300_series_alloy.php).

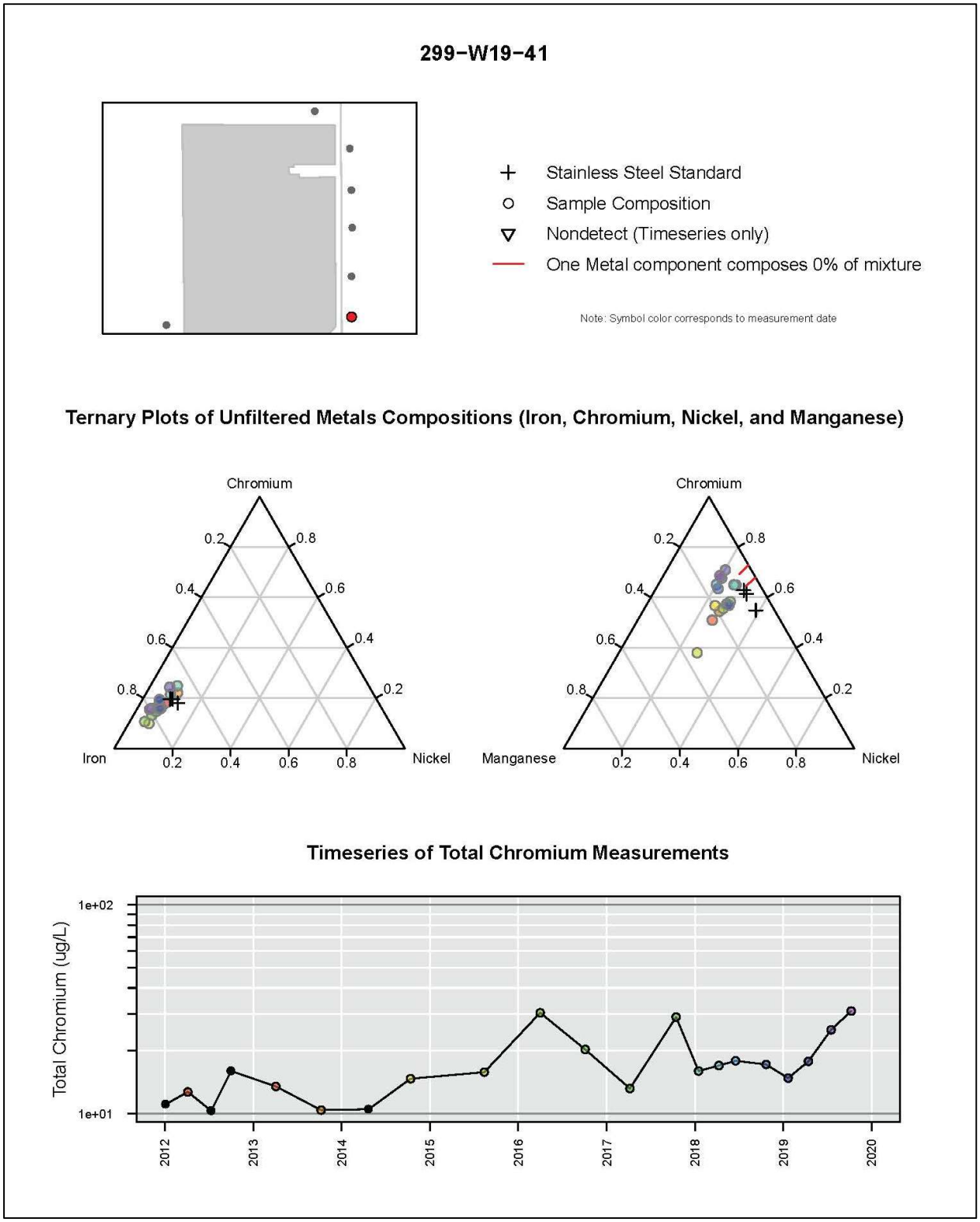

Figure 3. Well Corrosion Analysis Result for Well 299-W19-41

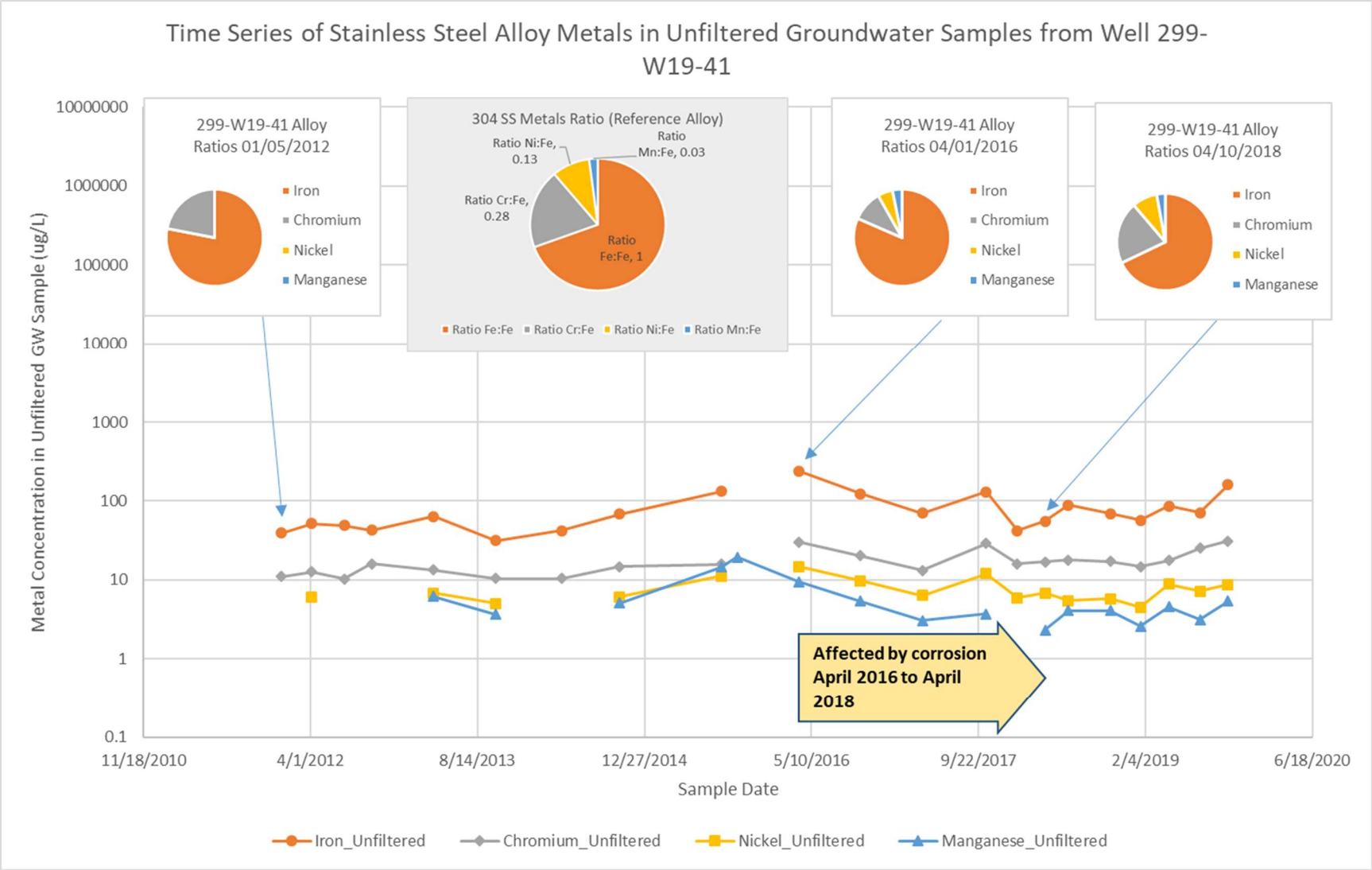

Figure 4. Secondary Well Corrosion Analysis Result for Well 299-W19-41

Table 7. Summary of Corrosion Evaluation of Downgradient Wells at WMA U

Well Name*	Corrosion Present?	Period Indicating Corrosion	Period Not Indicating Corrosion	Comment
W18-260	No	None	N/A	Total chromium measurements used
W19-41	Yes	April 2016 to April 2018	March 2012 April 2016 and April 2018 to present	Total chromium measurements not used April 2016 to April 2018
W19-42	Yes	October 2014 to June 2018	March 2012 to October 2014 and June 2018 to present	Total chromium measurements not sued from October 2014 to June 2018
W19-44	No	None	N/A	Total chromium measurements used
W19-45	No			
W19-47	No			

*The prefix "299-" was removed from well names for the purposes of reporting.

N/A = not applicable, no corrosion impacts were identified

7.2 Trend Analysis

After the data in Tables 5 and 6 were excluded and the total chromium data for corrosion-affected time periods were removed from the dataset included in Appendix A, trends over time were evaluated for each well/dangerous waste constituent pair. Trends were evaluated only for downgradient wells in the WMA U groundwater monitoring network (Table 1) using data since 2012, which corresponds to the startup of the 200 West P&T remedy.

Temporal trends were evaluated using Tobit regression analysis to determine if there were statistically significant trends. The trend analysis used log-transformed data. Results of the trend analyses are included as Appendix C and are summarized in Table 8. To be evaluated, each well/dangerous waste constituent pair required a minimum of six samples and less than 50% (i.e., half) reported nondetects.

Table 8. Results of Trend Analysis

Well Name*	Analyte	Trend	Comment
W18-260	Total chromium	Increasing	
	Dissolved/hexavalent chromium	Increasing	
W19-41	Total chromium	Increasing	
	Dissolved/hexavalent chromium	Not significant	
W19-42	Total chromium	Increasing	
	Dissolved/hexavalent chromium	Increasing	

Table 8. Results of Trend Analysis

Well Name*	Analyte	Trend	Comment
W19-44	Total chromium	Increasing	
	Dissolved/hexavalent chromium	Not significant	
W19-45	Total chromium	Increasing	
	Dissolved/hexavalent chromium	Increasing	
W19-47	Total chromium	Not significant	
	Dissolved/hexavalent chromium	Not significant	

*The prefix "299-" was removed from all well names for the purposes of reporting.

7.3 Calculation of Upper and Lower Confidence Limits and Comparison to Groundwater Limits

The statistical approach used to calculate the LCL/UCL was determined based on the outcome of the trend analysis. The presence of a statistically significant trend in the data resulted in the 95% LCL/UCL of the mean being calculated based on the trend. When no statistically significant trend was present, datasets were imported into the ProUCL software and 95% LCLs/UCLs were calculated based on the last eight measurements, using all available methods and accounting for the presence of nondetects. Table 9 presents the calculated LCLs/UCLs for each well, along with the selected groundwater limit.

Table 9. Calculated LCL/UCLs

Well Name[a]	Analyte	GW Limit (µg/L)	Mean (µg/L)	UCL (µg/L)	LCL (µg/L)	Assessment
W18-260	Total chromium[b]	100	14.14	18.16	11.01	LCL below GW limit
	Dissolved/hexavalent chromium[b]	48	13.89	16.45	11.72	LCL below GW limit
W19-41	Total chromium[b]	100	21.16	25.99	17.23	LCL below GW limit
	Dissolved/hexavalent chromium[c]	48	8.25	8.95	7.55	LCL below GW limit

Table 9. Calculated LCL/UCLs

Well Name[a]	Analyte	GW Limit (µg/L)	Mean (µg/L)	UCL (µg/L)	LCL (µg/L)	Assessment
W19-42	Total chromium[b]	100	14.67	17.01	12.64	LCL below GW limit
	Dissolved/hexavalent chromium[b]	48	9.08	10.4	7.93	LCL below GW limit
W19-44	Total chromium[b]	100	19.36	29.93	12.52	LCL below GW limit
	Dissolved/hexavalent chromium[c]	48	12.49	15.95	9.03	LCL below GW limit
W19-45	Total chromium[b]	100	19.66	22.05	17.53	LCL below GW limit
	Dissolved/hexavalent chromium[b]	48	19.18	21.95	16.75	LCL below GW limit
W19-47	Total chromium[c]	100	9.06	10.62	7.51	LCL below GW limit
	Dissolved/hexavalent chromium[c]	48	8.77	10.73	6.82	LCL below GW limit

a. The prefix "299-" was removed from all well names for the purposes of reporting.

b. Mean and LCL/UCL of the mean calculated based on trend analysis.

c. LCL/UCL of the mean calculated using ProUCL based on 95% Student's-t method.

GW = groundwater

LCL = lower confidence limit

UCL = upper confidence limit

8 References

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Appendix A

Waste Management Area U
Hanford Environmental Information System Data Used

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Table A-1. HEIS Data Used for WMA U Evaluation

Well Name	Sample Date	Analyte	Filtered	Reported Value	Laboratory Qualifier	Review Qualifier	Units	Usable?
299-W18-260	8/10/2015	Dissolved/hexavalent chromium	Y	3.99	B	A	µg/L	Yes
299-W18-260	10/1/2015	Dissolved/hexavalent chromium	Y	4.64	B		µg/L	Yes
299-W18-260	4/1/2016	Dissolved/hexavalent chromium	Y	5.15			µg/L	Yes
299-W18-260	10/4/2016	Dissolved/hexavalent chromium	Y	6.88			µg/L	Yes
299-W18-260	10/4/2016	Dissolved/hexavalent chromium	Y	6.69			µg/L	Yes
299-W18-260	4/7/2017	Dissolved/hexavalent chromium	Y	7.1	B		µg/L	Yes
299-W18-260	10/15/2017	Dissolved/hexavalent chromium	Y	8.9	B		µg/L	Yes
299-W18-260	1/16/2018	Dissolved/hexavalent chromium	Y	8.1	B		µg/L	Yes
299-W18-260	4/10/2018	Dissolved/hexavalent chromium	Y	9.09			µg/L	Yes
299-W18-260	6/20/2018	Dissolved/hexavalent chromium	Y	10			µg/L	Yes
299-W18-260	10/19/2018	Dissolved/hexavalent chromium	Y	16.5			µg/L	Yes
299-W18-260	1/22/2019	Dissolved/hexavalent chromium	Y	15.8			µg/L	Yes
299-W18-260	4/12/2019	Dissolved/hexavalent chromium	Y	11.8		Q	µg/L	No
299-W18-260	7/19/2019	Dissolved/hexavalent chromium	Y	12.2	D		µg/L	Yes
299-W18-260	7/19/2019	Dissolved/hexavalent chromium	Y	13.4	X		µg/L	Yes
299-W18-260	10/10/2019	Dissolved/hexavalent chromium	Y	10.3			µg/L	Yes
299-W18-260	10/10/2019	Dissolved/hexavalent chromium	Y	11	D		µg/L	Yes
299-W18-260	10/10/2019	Dissolved/hexavalent chromium	Y	11			µg/L	Yes
299-W19-41	1/5/2012	Dissolved/hexavalent chromium	Y	6.9	B		µg/L	Yes
299-W19-41	4/5/2012	Dissolved/hexavalent chromium	Y	15.4	B		µg/L	Yes
299-W19-41	7/11/2012	Dissolved/hexavalent chromium	Y	7.3	B		µg/L	Yes
299-W19-41	7/11/2012	Dissolved/hexavalent chromium	N	8	U		µg/L	Yes
299-W19-41	10/1/2012	Dissolved/hexavalent chromium	Y	9.2	B		µg/L	Yes
299-W19-41	4/4/2013	Dissolved/hexavalent chromium	Y	9.3	B		µg/L	Yes
299-W19-41	10/8/2013	Dissolved/hexavalent chromium	N	4.4	B		µg/L	Yes
299-W19-41	10/8/2013	Dissolved/hexavalent chromium	Y	5	U		µg/L	Yes
299-W19-41	4/23/2014	Dissolved/hexavalent chromium	Y	6.99	B		µg/L	Yes
299-W19-41	10/13/2014	Dissolved/hexavalent chromium	Y	7.44			µg/L	Yes
299-W19-41	8/14/2015	Dissolved/hexavalent chromium	Y	8.69			µg/L	Yes
299-W19-41	10/1/2015	Dissolved/hexavalent chromium	Y	6.79			µg/L	Yes
299-W19-41	10/1/2015	Dissolved/hexavalent chromium	Y	7.44			µg/L	Yes
299-W19-41	4/1/2016	Dissolved/hexavalent chromium	Y	6.5			µg/L	Yes
299-W19-41	10/4/2016	Dissolved/hexavalent chromium	Y	8.52			µg/L	Yes
299-W19-41	4/7/2017	Dissolved/hexavalent chromium	Y	7.08	C		µg/L	Yes

Table A-1. HEIS Data Used for WMA U Evaluation

Well Name	Sample Date	Analyte	Filtered	Reported Value	Laboratory Qualifier	Review Qualifier	Units	Usable?
299-W19-41	10/15/2017	Dissolved/hexavalent chromium	Y	7.6	B		µg/L	Yes
299-W19-41	1/16/2018	Dissolved/hexavalent chromium	Y	7.95			µg/L	Yes
299-W19-41	4/10/2018	Dissolved/hexavalent chromium	Y	8.28			µg/L	Yes
299-W19-41	6/18/2018	Dissolved/hexavalent chromium	Y	6.7	B		µg/L	Yes
299-W19-41	10/22/2018	Dissolved/hexavalent chromium	Y	10.1			µg/L	Yes
299-W19-41	1/21/2019	Dissolved/hexavalent chromium	Y	7.8	B		µg/L	Yes
299-W19-41	4/15/2019	Dissolved/hexavalent chromium	Y	9.3	B		µg/L	Yes
299-W19-41	7/18/2019	Dissolved/hexavalent chromium	Y	10			µg/L	No
299-W19-41	7/18/2019	Dissolved/hexavalent chromium	Y	6.13	X		µg/L	No
299-W19-41	10/9/2019	Dissolved/hexavalent chromium	Y	8.8	B		µg/L	Yes
299-W19-41	10/9/2019	Dissolved/hexavalent chromium	Y	8.6	B		µg/L	Yes
299-W19-41	10/9/2019	Dissolved/hexavalent chromium	Y	7.3	X		µg/L	Yes
299-W19-42	1/6/2012	Dissolved/hexavalent chromium	Y	5.3	B		µg/L	Yes
299-W19-42	4/5/2012	Dissolved/hexavalent chromium	Y	5.1	B		µg/L	Yes
299-W19-42	7/16/2012	Dissolved/hexavalent chromium	Y	6.2	B		µg/L	Yes
299-W19-42	10/1/2012	Dissolved/hexavalent chromium	Y	5.3	B		µg/L	Yes
299-W19-42	4/4/2013	Dissolved/hexavalent chromium	Y	5.9	B		µg/L	Yes
299-W19-42	10/3/2013	Dissolved/hexavalent chromium	Y	6.3	B		µg/L	Yes
299-W19-42	10/3/2013	Dissolved/hexavalent chromium	Y	5.9	B		µg/L	Yes
299-W19-42	4/16/2014	Dissolved/hexavalent chromium	Y	6.11	B		µg/L	Yes
299-W19-42	10/13/2014	Dissolved/hexavalent chromium	Y	7.8	B		µg/L	Yes
299-W19-42	10/13/2014	Dissolved/hexavalent chromium	Y	6.2	B		µg/L	Yes
299-W19-42	4/3/2015	Dissolved/hexavalent chromium	Y	11.1			µg/L	Yes
299-W19-42	11/4/2015	Dissolved/hexavalent chromium	Y	9.9	BC		µg/L	Yes
299-W19-42	4/1/2016	Dissolved/hexavalent chromium	Y	6	B		µg/L	Yes
299-W19-42	10/4/2016	Dissolved/hexavalent chromium	Y	7.3	B		µg/L	Yes
299-W19-42	4/7/2017	Dissolved/hexavalent chromium	Y	6.2	B		µg/L	Yes
299-W19-42	10/15/2017	Dissolved/hexavalent chromium	Y	6.4	B		µg/L	Yes
299-W19-42	1/16/2018	Dissolved/hexavalent chromium	Y	7.1	B		µg/L	Yes
299-W19-42	4/10/2018	Dissolved/hexavalent chromium	Y	6.9	B		µg/L	Yes
299-W19-42	6/15/2018	Dissolved/hexavalent chromium	Y	9.6	B		µg/L	Yes
299-W19-42	10/19/2018	Dissolved/hexavalent chromium	Y	8.4	B		µg/L	Yes
299-W19-42	1/22/2019	Dissolved/hexavalent chromium	Y	9.4	B		µg/L	Yes
299-W19-42	4/12/2019	Dissolved/hexavalent chromium	Y	11.1		Q	µg/L	No

Table A-1. HEIS Data Used for WMA U Evaluation

Well Name	Sample Date	Analyte	Filtered	Reported Value	Laboratory Qualifier	Review Qualifier	Units	Usable?
299-W19-42	7/18/2019	Dissolved/hexavalent chromium	Y	9.74	B		µg/L	Yes
299-W19-42	7/18/2019	Dissolved/hexavalent chromium	Y	10.2			µg/L	Yes
299-W19-42	7/18/2019	Dissolved/hexavalent chromium	Y	11.1			µg/L	Yes
299-W19-42	7/18/2019	Dissolved/hexavalent chromium	Y	11			µg/L	Yes
299-W19-42	10/9/2019	Dissolved/hexavalent chromium	Y	10.3	D		µg/L	Yes
299-W19-42	10/9/2019	Dissolved/hexavalent chromium	Y	10.4			µg/L	Yes
299-W19-42	10/9/2019	Dissolved/hexavalent chromium	Y	10.1	X		µg/L	Yes
299-W19-44	1/6/2012	Dissolved/hexavalent chromium	Y	9.5	B	G	µg/L	Yes
299-W19-44	4/5/2012	Dissolved/hexavalent chromium	Y	8.8	B		µg/L	Yes
299-W19-44	7/13/2012	Dissolved/hexavalent chromium	Y	7.2	B		µg/L	Yes
299-W19-44	10/1/2012	Dissolved/hexavalent chromium	Y	13.8	B		µg/L	Yes
299-W19-44	1/18/2013	Dissolved/hexavalent chromium	Y	14.3	B		µg/L	Yes
299-W19-44	7/9/2013	Dissolved/hexavalent chromium	Y	8.4	B		µg/L	Yes
299-W19-44	1/20/2014	Dissolved/hexavalent chromium	Y	5	U		µg/L	Yes
299-W19-44	7/11/2014	Dissolved/hexavalent chromium	Y	7.2	B		µg/L	Yes
299-W19-44	1/9/2015	Dissolved/hexavalent chromium	Y	7.8	B		µg/L	Yes
299-W19-44	1/9/2015	Dissolved/hexavalent chromium	Y	7.8	B		µg/L	Yes
299-W19-44	7/10/2015	Dissolved/hexavalent chromium	Y	7.3	B		µg/L	Yes
299-W19-44	1/15/2016	Dissolved/hexavalent chromium	Y	11.1			µg/L	Yes
299-W19-44	7/10/2016	Dissolved/hexavalent chromium	Y	7.1	B		µg/L	Yes
299-W19-44	1/24/2017	Dissolved/hexavalent chromium	Y	6.4	B		µg/L	Yes
299-W19-44	7/5/2017	Dissolved/hexavalent chromium	Y	4.5	B		µg/L	Yes
299-W19-44	10/15/2017	Dissolved/hexavalent chromium	Y	7.4	B		µg/L	Yes
299-W19-44	1/17/2018	Dissolved/hexavalent chromium	Y	7.8	B		µg/L	Yes
299-W19-44	4/10/2018	Dissolved/hexavalent chromium	Y	10			µg/L	Yes
299-W19-44	6/18/2018	Dissolved/hexavalent chromium	Y	7.2	B		µg/L	Yes
299-W19-44	10/19/2018	Dissolved/hexavalent chromium	Y	20.3	C		µg/L	Yes
299-W19-44	1/21/2019	Dissolved/hexavalent chromium	Y	20.4			µg/L	Yes
299-W19-44	4/15/2019	Dissolved/hexavalent chromium	Y	13			µg/L	Yes
299-W19-44	7/19/2019	Dissolved/hexavalent chromium	Y	9.6	B		µg/L	Yes
299-W19-44	7/19/2019	Dissolved/hexavalent chromium	Y	11.4	X		µg/L	Yes
299-W19-44	10/9/2019	Dissolved/hexavalent chromium	Y	11.7			µg/L	Yes
299-W19-44	10/9/2019	Dissolved/hexavalent chromium	Y	11.1			µg/L	Yes
299-W19-44	10/9/2019	Dissolved/hexavalent chromium	Y	9.24	X		µg/L	Yes

Table A-1. HEIS Data Used for WMA U Evaluation

Well Name	Sample Date	Analyte	Filtered	Reported Value	Laboratory Qualifier	Review Qualifier	Units	Usable?
299-W19-45	2/29/2012	Dissolved/hexavalent chromium	Y	10.8	B		µg/L	Yes
299-W19-45	4/5/2012	Dissolved/hexavalent chromium	Y	9.6	B		µg/L	Yes
299-W19-45	7/16/2012	Dissolved/hexavalent chromium	Y	6.7	B		µg/L	Yes
299-W19-45	10/1/2012	Dissolved/hexavalent chromium	Y	6.6	B		µg/L	Yes
299-W19-45	1/14/2013	Dissolved/hexavalent chromium	Y	6.5	B		µg/L	Yes
299-W19-45	1/14/2013	Dissolved/hexavalent chromium	Y	5.7	B		µg/L	Yes
299-W19-45	7/9/2013	Dissolved/hexavalent chromium	Y	10.4	B		µg/L	Yes
299-W19-45	7/9/2013	Dissolved/hexavalent chromium	Y	9.2	B		µg/L	Yes
299-W19-45	1/17/2014	Dissolved/hexavalent chromium	Y	9.6	B		µg/L	Yes
299-W19-45	7/11/2014	Dissolved/hexavalent chromium	Y	9.62	B	Z	µg/L	Yes
299-W19-45	1/9/2015	Dissolved/hexavalent chromium	Y	9.32			µg/L	Yes
299-W19-45	7/10/2015	Dissolved/hexavalent chromium	Y	10.4			µg/L	Yes
299-W19-45	7/10/2015	Dissolved/hexavalent chromium	Y	10.7			µg/L	Yes
299-W19-45	1/15/2016	Dissolved/hexavalent chromium	Y	11.1			µg/L	Yes
299-W19-45	7/10/2016	Dissolved/hexavalent chromium	Y	13.7			µg/L	Yes
299-W19-45	1/23/2017	Dissolved/hexavalent chromium	Y	14.5			µg/L	Yes
299-W19-45	7/5/2017	Dissolved/hexavalent chromium	Y	19.2			µg/L	Yes
299-W19-45	7/5/2017	Dissolved/hexavalent chromium	Y	19.6			µg/L	Yes
299-W19-45	10/16/2017	Dissolved/hexavalent chromium	Y	19.9			µg/L	Yes
299-W19-45	10/16/2017	Dissolved/hexavalent chromium	Y	20.4			µg/L	Yes
299-W19-45	1/16/2018	Dissolved/hexavalent chromium	Y	16.7			µg/L	Yes
299-W19-45	1/16/2018	Dissolved/hexavalent chromium	Y	17.4			µg/L	Yes
299-W19-45	4/12/2018	Dissolved/hexavalent chromium	Y	17.7			µg/L	Yes
299-W19-45	6/15/2018	Dissolved/hexavalent chromium	Y	23			µg/L	Yes
299-W19-45	10/19/2018	Dissolved/hexavalent chromium	Y	16	C		µg/L	Yes
299-W19-45	1/22/2019	Dissolved/hexavalent chromium	Y	13.4			µg/L	Yes
299-W19-45	4/12/2019	Dissolved/hexavalent chromium	Y	20			µg/L	Yes
299-W19-45	7/19/2019	Dissolved/hexavalent chromium	Y	15.2			µg/L	Yes
299-W19-45	7/19/2019	Dissolved/hexavalent chromium	Y	18.5	X		µg/L	Yes
299-W19-45	10/9/2019	Dissolved/hexavalent chromium	Y	17			µg/L	Yes
299-W19-45	10/9/2019	Dissolved/hexavalent chromium	Y	17			µg/L	Yes
299-W19-45	10/9/2019	Dissolved/hexavalent chromium	Y	16			µg/L	Yes
299-W19-45	10/9/2019	Dissolved/hexavalent chromium	Y	17.2	X		µg/L	Yes
299-W19-47	1/6/2012	Dissolved/hexavalent chromium	Y	51.8		Y	µg/L	Yes

Table A-1. HEIS Data Used for WMA U Evaluation

Well Name	Sample Date	Analyte	Filtered	Reported Value	Laboratory Qualifier	Review Qualifier	Units	Usable?
299-W19-47	4/5/2012	Dissolved/hexavalent chromium	Y	5.1	B		µg/L	Yes
299-W19-47	7/11/2012	Dissolved/hexavalent chromium	Y	7.2	B		µg/L	Yes
299-W19-47	7/11/2012	Dissolved/hexavalent chromium	Y	7.7	B		µg/L	Yes
299-W19-47	7/11/2012	Dissolved/hexavalent chromium	N	8	U		µg/L	Yes
299-W19-47	10/1/2012	Dissolved/hexavalent chromium	Y	6.9	B		µg/L	Yes
299-W19-47	2/27/2013	Dissolved/hexavalent chromium	Y	6.1	B		µg/L	Yes
299-W19-47	7/9/2013	Dissolved/hexavalent chromium	Y	7.5	B		µg/L	Yes
299-W19-47	1/17/2014	Dissolved/hexavalent chromium	Y	5.24	D		µg/L	Yes
299-W19-47	1/17/2014	Dissolved/hexavalent chromium	Y	5.9	D		µg/L	Yes
299-W19-47	1/17/2014	Dissolved/hexavalent chromium	N	5.5	N		µg/L	Yes
299-W19-47	1/17/2014	Dissolved/hexavalent chromium	N	5.4	N		µg/L	Yes
299-W19-47	7/11/2014	Dissolved/hexavalent chromium	Y	5.3	B		µg/L	Yes
299-W19-47	1/9/2015	Dissolved/hexavalent chromium	Y	4.74	B		µg/L	Yes
299-W19-47	7/10/2015	Dissolved/hexavalent chromium	Y	4.88	B		µg/L	Yes
299-W19-47	1/15/2016	Dissolved/hexavalent chromium	Y	4.58	B		µg/L	Yes
299-W19-47	7/10/2016	Dissolved/hexavalent chromium	Y	4.84	B		µg/L	Yes
299-W19-47	1/23/2017	Dissolved/hexavalent chromium	Y	4.98	B		µg/L	Yes
299-W19-47	7/5/2017	Dissolved/hexavalent chromium	Y	5.5	B		µg/L	Yes
299-W19-47	10/15/2017	Dissolved/hexavalent chromium	Y	5.9	B		µg/L	Yes
299-W19-47	1/16/2018	Dissolved/hexavalent chromium	Y	6.1	B		µg/L	Yes
299-W19-47	4/12/2018	Dissolved/hexavalent chromium	Y	5.3	B		µg/L	Yes
299-W19-47	6/15/2018	Dissolved/hexavalent chromium	Y	7.4	B		µg/L	Yes
299-W19-47	6/15/2018	Dissolved/hexavalent chromium	Y	7.2	B		µg/L	Yes
299-W19-47	10/19/2018	Dissolved/hexavalent chromium	Y	11.1	C		µg/L	Yes
299-W19-47	1/22/2019	Dissolved/hexavalent chromium	Y	10.5			µg/L	Yes
299-W19-47	4/12/2019	Dissolved/hexavalent chromium	Y	11.2		Q	µg/L	No
299-W19-47	7/19/2019	Dissolved/hexavalent chromium	Y	11			µg/L	Yes
299-W19-47	7/19/2019	Dissolved/hexavalent chromium	Y	14.5	X		µg/L	Yes
299-W19-47	10/10/2019	Dissolved/hexavalent chromium	Y	11.1			µg/L	Yes
299-W19-47	10/10/2019	Dissolved/hexavalent chromium	Y	11			µg/L	Yes
299-W19-47	10/10/2019	Dissolved/hexavalent chromium	Y	11.6			µg/L	Yes
299-W18-260	8/10/2015	Total chromium	N	4.73	B	A	µg/L	Yes
299-W18-260	10/1/2015	Total chromium	N	12.8			µg/L	Yes
299-W18-260	4/1/2016	Total chromium	N	5.54			µg/L	Yes

Table A-1. HEIS Data Used for WMA U Evaluation

Well Name	Sample Date	Analyte	Filtered	Reported Value	Laboratory Qualifier	Review Qualifier	Units	Usable?
299-W18-260	10/4/2016	Total chromium	N	7.22			µg/L	Yes
299-W18-260	10/4/2016	Total chromium	N	7.4			µg/L	Yes
299-W18-260	4/7/2017	Total chromium	N	7.6	B		µg/L	Yes
299-W18-260	10/15/2017	Total chromium	N	9	B		µg/L	Yes
299-W18-260	1/16/2018	Total chromium	N	8.6	B		µg/L	Yes
299-W18-260	4/10/2018	Total chromium	N	10.7			µg/L	Yes
299-W18-260	6/20/2018	Total chromium	N	14			µg/L	Yes
299-W18-260	10/19/2018	Total chromium	N	17.4			µg/L	Yes
299-W18-260	1/22/2019	Total chromium	N	15.9			µg/L	Yes
299-W18-260	4/12/2019	Total chromium	N	15.7			µg/L	Yes
299-W18-260	7/19/2019	Total chromium	N	13.2	D		µg/L	Yes
299-W18-260	10/10/2019	Total chromium	N	10.8	D		µg/L	Yes
299-W18-260	10/10/2019	Total chromium	N	10.5			µg/L	Yes
299-W19-41	1/5/2012	Total chromium	N	11.1	B		µg/L	Yes
299-W19-41	4/5/2012	Total chromium	N	12.7	B		µg/L	Yes
299-W19-41	7/11/2012	Total chromium	N	12.1	B		µg/L	No
299-W19-41	7/11/2012	Total chromium	N	8.54	D		µg/L	No
299-W19-41	10/1/2012	Total chromium	N	16	B		µg/L	Yes
299-W19-41	4/4/2013	Total chromium	N	13.5	B		µg/L	Yes
299-W19-41	10/8/2013	Total chromium	N	10.4	DC		µg/L	Yes
299-W19-41	4/23/2014	Total chromium	N	10.5			µg/L	Yes
299-W19-41	10/13/2014	Total chromium	N	14.7			µg/L	Yes
299-W19-41	8/14/2015	Total chromium	N	15.8			µg/L	Yes
299-W19-41	10/1/2015	Total chromium	N	33.2		Q	µg/L	No
299-W19-41	10/1/2015	Total chromium	N	18.9		Q	µg/L	No
299-W19-41	4/1/2016	Total chromium	N	30.4			µg/L	Yes
299-W19-41	10/4/2016	Total chromium	N	20.3			µg/L	Yes
299-W19-41	4/7/2017	Total chromium	N	13.2	C		µg/L	Yes
299-W19-41	10/15/2017	Total chromium	N	29			µg/L	Yes
299-W19-41	1/16/2018	Total chromium	N	16			µg/L	Yes
299-W19-41	4/10/2018	Total chromium	N	17			µg/L	Yes
299-W19-41	6/18/2018	Total chromium	N	17.9			µg/L	Yes
299-W19-41	10/22/2018	Total chromium	N	17.2			µg/L	Yes
299-W19-41	1/21/2019	Total chromium	N	14.8			µg/L	Yes

Table A-1. HEIS Data Used for WMA U Evaluation

Well Name	Sample Date	Analyte	Filtered	Reported Value	Laboratory Qualifier	Review Qualifier	Units	Usable?
299-W19-41	4/15/2019	Total chromium	N	17.8			µg/L	Yes
299-W19-41	7/18/2019	Total chromium	N	25.2			µg/L	Yes
299-W19-41	10/9/2019	Total chromium	N	30			µg/L	Yes
299-W19-41	10/9/2019	Total chromium	N	32			µg/L	Yes
299-W19-42	1/6/2012	Total chromium	N	8	B	G	µg/L	Yes
299-W19-42	4/5/2012	Total chromium	N	10.2	B		µg/L	Yes
299-W19-42	7/16/2012	Total chromium	N	6.7	B		µg/L	Yes
299-W19-42	10/1/2012	Total chromium	N	8	B		µg/L	Yes
299-W19-42	4/4/2013	Total chromium	N	7.5	B		µg/L	Yes
299-W19-42	10/3/2013	Total chromium	N	6.4	B		µg/L	Yes
299-W19-42	10/3/2013	Total chromium	N	7.2	B		µg/L	Yes
299-W19-42	4/16/2014	Total chromium	N	8.78	B		µg/L	Yes
299-W19-42	10/13/2014	Total chromium	N	10.2			µg/L	Yes
299-W19-42	10/13/2014	Total chromium	N	10.9			µg/L	Yes
299-W19-42	4/3/2015	Total chromium	N	44.5			µg/L	Yes
299-W19-42	11/4/2015	Total chromium	N	13.7	C		µg/L	Yes
299-W19-42	4/1/2016	Total chromium	N	11.8			µg/L	Yes
299-W19-42	10/4/2016	Total chromium	N	12			µg/L	Yes
299-W19-42	4/7/2017	Total chromium	N	17.2			µg/L	Yes
299-W19-42	10/15/2017	Total chromium	N	40.1			µg/L	Yes
299-W19-42	1/16/2018	Total chromium	N	19.8			µg/L	Yes
299-W19-42	4/10/2018	Total chromium	N	28			µg/L	Yes
299-W19-42	6/15/2018	Total chromium	N	15			µg/L	Yes
299-W19-42	10/19/2018	Total chromium	N	17.9			µg/L	Yes
299-W19-42	1/22/2019	Total chromium	N	12.7			µg/L	Yes
299-W19-42	4/12/2019	Total chromium	N	15.5			µg/L	Yes
299-W19-42	7/18/2019	Total chromium	N	13.6			µg/L	Yes
299-W19-42	7/18/2019	Total chromium	N	13.8			µg/L	Yes
299-W19-42	10/9/2019	Total chromium	N	12.8			µg/L	Yes
299-W19-42	10/9/2019	Total chromium	N	12.9	D		µg/L	Yes
299-W19-44	1/6/2012	Total chromium	N	10.1	B	G	µg/L	Yes
299-W19-44	4/5/2012	Total chromium	N	11.5	B		µg/L	Yes
299-W19-44	7/13/2012	Total chromium	N	9.8	B		µg/L	Yes
299-W19-44	10/1/2012	Total chromium	N	13.7	B		µg/L	Yes

Table A-1. HEIS Data Used for WMA U Evaluation

Well Name	Sample Date	Analyte	Filtered	Reported Value	Laboratory Qualifier	Review Qualifier	Units	Usable?
299-W19-44	1/18/2013	Total chromium	N	15	B		µg/L	Yes
299-W19-44	7/9/2013	Total chromium	N	11.7	B		µg/L	Yes
299-W19-44	1/20/2014	Total chromium	N	5	U		µg/L	Yes
299-W19-44	7/11/2014	Total chromium	N	7.5	B		µg/L	Yes
299-W19-44	1/9/2015	Total chromium	N	9.2	B		µg/L	Yes
299-W19-44	1/9/2015	Total chromium	N	9.2	B		µg/L	Yes
299-W19-44	7/10/2015	Total chromium	N	9	B		µg/L	Yes
299-W19-44	1/15/2016	Total chromium	N	34.2			µg/L	Yes
299-W19-44	7/10/2016	Total chromium	N	10			µg/L	Yes
299-W19-44	1/24/2017	Total chromium	N	7.5	B		µg/L	Yes
299-W19-44	7/5/2017	Total chromium	N	8.4	B		µg/L	Yes
299-W19-44	10/15/2017	Total chromium	N	7.4	B		µg/L	Yes
299-W19-44	1/17/2018	Total chromium	N	8.9	B		µg/L	Yes
299-W19-44	4/10/2018	Total chromium	N	33.7			µg/L	Yes
299-W19-44	6/18/2018	Total chromium	N	9.1	B		µg/L	Yes
299-W19-44	10/19/2018	Total chromium	N	63.5			µg/L	Yes
299-W19-44	1/21/2019	Total chromium	N	19.2			µg/L	Yes
299-W19-44	4/15/2019	Total chromium	N	48			µg/L	Yes
299-W19-44	7/19/2019	Total chromium	N	30			µg/L	Yes
299-W19-44	10/9/2019	Total chromium	N	12.7			µg/L	Yes
299-W19-44	10/9/2019	Total chromium	N	14.6			µg/L	Yes
299-W19-45	2/29/2012	Total chromium	N	9.9	B		µg/L	Yes
299-W19-45	4/5/2012	Total chromium	N	9.8	B		µg/L	Yes
299-W19-45	7/16/2012	Total chromium	N	8.9	B		µg/L	Yes
299-W19-45	10/1/2012	Total chromium	N	7.9	B		µg/L	Yes
299-W19-45	1/14/2013	Total chromium	N	6.8	B		µg/L	Yes
299-W19-45	1/14/2013	Total chromium	N	6.2	B		µg/L	Yes
299-W19-45	7/9/2013	Total chromium	N	9.9	B		µg/L	Yes
299-W19-45	7/9/2013	Total chromium	N	11	B		µg/L	Yes
299-W19-45	1/17/2014	Total chromium	N	10.4			µg/L	Yes
299-W19-45	7/11/2014	Total chromium	N	12.3		Z	µg/L	Yes
299-W19-45	1/9/2015	Total chromium	N	11			µg/L	Yes
299-W19-45	7/10/2015	Total chromium	N	12.1			µg/L	Yes
299-W19-45	7/10/2015	Total chromium	N	11.3			µg/L	Yes

Table A-1. HEIS Data Used for WMA U Evaluation

Well Name	Sample Date	Analyte	Filtered	Reported Value	Laboratory Qualifier	Review Qualifier	Units	Usable?
299-W19-45	1/15/2016	Total chromium	N	11.2			µg/L	Yes
299-W19-45	7/10/2016	Total chromium	N	14.5			µg/L	Yes
299-W19-45	1/23/2017	Total chromium	N	14.9			µg/L	Yes
299-W19-45	7/5/2017	Total chromium	N	20.1			µg/L	Yes
299-W19-45	7/5/2017	Total chromium	N	19.7			µg/L	Yes
299-W19-45	10/16/2017	Total chromium	N	20.4			µg/L	Yes
299-W19-45	10/16/2017	Total chromium	N	21.1			µg/L	Yes
299-W19-45	1/16/2018	Total chromium	N	17			µg/L	Yes
299-W19-45	1/16/2018	Total chromium	N	17.8			µg/L	Yes
299-W19-45	4/12/2018	Total chromium	N	18.9			µg/L	Yes
299-W19-45	6/15/2018	Total chromium	N	23			µg/L	Yes
299-W19-45	10/19/2018	Total chromium	N	18.1	C		µg/L	Yes
299-W19-45	1/22/2019	Total chromium	N	14.9			µg/L	Yes
299-W19-45	4/12/2019	Total chromium	N	19.6			µg/L	Yes
299-W19-45	7/19/2019	Total chromium	N	15.6			µg/L	Yes
299-W19-45	10/9/2019	Total chromium	N	17			µg/L	Yes
299-W19-45	10/9/2019	Total chromium	N	17			µg/L	Yes
299-W19-45	10/9/2019	Total chromium	N	18			µg/L	Yes
299-W19-47	1/6/2012	Total chromium	N	47.8		Y	µg/L	Yes
299-W19-47	4/5/2012	Total chromium	N	5.7	B		µg/L	Yes
299-W19-47	7/11/2012	Total chromium	N	4.94	D		µg/L	No
299-W19-47	7/11/2012	Total chromium	N	5.23	D		µg/L	No
299-W19-47	7/11/2012	Total chromium	N	8	B		µg/L	No
299-W19-47	7/11/2012	Total chromium	N	9.1	B		µg/L	No
299-W19-47	10/1/2012	Total chromium	N	6.6	B		µg/L	Yes
299-W19-47	2/27/2013	Total chromium	N	6.6	B		µg/L	Yes
299-W19-47	7/9/2013	Total chromium	N	7.6	B		µg/L	Yes
299-W19-47	1/17/2014	Total chromium	N	5.76	D		µg/L	Yes
299-W19-47	1/17/2014	Total chromium	N	6.3	D		µg/L	Yes
299-W19-47	7/11/2014	Total chromium	N	5.4	B		µg/L	Yes
299-W19-47	1/9/2015	Total chromium	N	4.6	B		µg/L	Yes
299-W19-47	7/10/2015	Total chromium	N	5.84			µg/L	Yes
299-W19-47	1/15/2016	Total chromium	N	4.49	B		µg/L	Yes
299-W19-47	7/10/2016	Total chromium	N	5.7			µg/L	Yes

Table A-1. HEIS Data Used for WMA U Evaluation

Well Name	Sample Date	Analyte	Filtered	Reported Value	Laboratory Qualifier	Review Qualifier	Units	Usable?
299-W19-47	1/23/2017	Total chromium	N	5.06			µg/L	Yes
299-W19-47	7/5/2017	Total chromium	N	6.5	B		µg/L	Yes
299-W19-47	10/15/2017	Total chromium	N	7.6	B		µg/L	Yes
299-W19-47	1/16/2018	Total chromium	N	6.4	B		µg/L	Yes
299-W19-47	4/12/2018	Total chromium	N	6.2	B		µg/L	Yes
299-W19-47	6/15/2018	Total chromium	N	7.7	B		µg/L	Yes
299-W19-47	6/15/2018	Total chromium	N	7.9	B		µg/L	Yes
299-W19-47	10/19/2018	Total chromium	N	10.9	C		µg/L	Yes
299-W19-47	1/22/2019	Total chromium	N	10.4			µg/L	Yes
299-W19-47	4/12/2019	Total chromium	N	11.7		Q	µg/L	No
299-W19-47	7/19/2019	Total chromium	N	12.2			µg/L	Yes
299-W19-47	10/10/2019	Total chromium	N	10.6			µg/L	Yes
299-W19-47	10/10/2019	Total chromium	N	11.4			µg/L	Yes

Note: Cells without an entry under the columns for laboratory or review qualifiers indicate that no qualifier was assigned to the data.

HEIS = Hanford Environmental Information System

WMA = waste management area

Laboratory qualifiers:

- B = The analyte was detected at a value less than the contract required detection limit but greater than or equal to the instrument detection limit/method detection limit (as appropriate).
- C = The analyte was detected in both the sample and the associated quality control blank, and the sample concentration was <= 5X the blank concentration.
- D = Analyte was reported at a secondary dilution factor, typically dilution factor> 1 (i.e., the primary preparation required dilution to either bring the analyte within calibration range or to minimize interference).
- N = Spike and/or spike duplicate sample recovery is outside control limits.
- U = Analyzed for but not detected above limiting criteria. Limiting criteria may be any of the following: value reported less than 0; value reported less than counting error; value reported less than total analytical error; value reported less than or equal to the method detection limit/instrument detection limit/minimum detectable activity/practical quantitation limit.
- X = Result-specific qualifier code.

Review qualifiers:

- A = Indicates an issue with the chain of custody that could affect data usability.
- G = Result has been reviewed and determined to be correct, or the result has been corrected with laboratory confirmation or other supporting information.
- Q = Associated quality control sample is out of limits.
- Y = Result suspect. Review - insufficient evidence to show result valid or invalid.
- Z = Miscellaneous circumstances exist.

Appendix B

Waste Management Area U Well Corrosion Evaluation

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B1 Well Corrosion Evaluation

Groundwater and vadose zone chemical conditions at some Hanford Site locations have been found to be corrosive to well construction components (e.g., screens and well casing). Corrosion has been found to affect both carbon steel and stainless steel components. Well component corrosion can result in particulates from the corroding steel entering the water column within the well. This metal particulate is frequently captured during groundwater sample collection and is subsequently detected and quantified as elemental metals in unfiltered sample aliquots. The presence of metals associated with stainless steel alloys (i.e., iron, chromium, nickel, and manganese) at concentrations consistent with their content in the steel alloy can indicate the presence of corrosion in the well.

Because chromium may be regulated as a dangerous waste and chromium is a known groundwater contaminant at the Hanford Site, it is important to understand the apparent source of metals, including chromium, detected in groundwater samples. The presence of well component corrosion products in groundwater samples can make the samples nonrepresentative of formation groundwater and, therefore, not usable for evaluation of potential releases to groundwater under dangerous waste monitoring activities. In response to this condition, the U.S. Department of Energy has undertaken a process of evaluating the relative concentrations of stainless steel alloy metals in groundwater monitoring samples. The measured concentrations are used to calculate the ratios of alloy metal concentrations relative to iron (the largest single component of stainless steel alloys) and then compare the ratios to that of reference alloys. The presence of the alloy metals at ratios similar to the reference alloy (i.e., the samples from the well will plot in the same region as the metal alloy standards on the ternary diagram) is indicative of corrosion and provides a basis for subsequent well inspection and well maintenance activities.

The ternary plots used for initial screening of corrosion in downgradient final status monitoring wells at Single-Shell Tank System Waste Management Area (WMA) U are included as Figures B-1 through B-6. Ternary plots were constructed using total (non-filtered) chromium, iron, nickel, and manganese samples collected after 2012 for each of the downgradient wells (Table B-1). Of those wells, two wells (299-W19-41 and 299-W19-42) exhibiting ratios of the unfiltered metals similar to the reference material ratios (for the stainless steel alloys) based on ternary plots were selected for secondary corrosion evaluation. The secondary evaluation was performed by inspecting the data to identify sample events for which all four of the major alloy metals in 304 stainless steel (i.e., iron, chromium, nickel, and manganese) were detected (laboratory qualifier not equal to “U”) in unfiltered measurements. These results were then manipulated to derive and plot the ratio of concentrations of each metal to the concentration of iron in each sample. The resulting ratios were then compared by inspection to the ratios present in a reference 304 stainless steel alloy. If the observed alloy metal ratios in a sample appeared similar to those of the reference alloy, the sample was identified as being potentially “corrosion affected.” The measured chromium concentration in “corrosion-affected” samples were subsequently identified as not representative of formation groundwater for the purposes of statistical analyses of the data set. The alloy metal ratios in the samples were then posted over a time-series plot of the alloy metal concentrations in groundwater to identify whether trends were consistent between the alloy metals. The combined plots were inspected to identify time periods over which the groundwater samples appear to be affected by corrosion and therefore are not representative of chromium concentration in the formation aquifer water.

The two downgradient wells considered in the secondary corrosion evaluation exhibited apparent corrosion effects during some portion of the monitoring time period. Those wells also exhibited apparent noncorrosion affected time periods. The results of the secondary evaluation are shown in Figures B-7 through B-8 and comments on corrosion classification are provided below.

- Well 299-W19-41 – Corrosion-affected period of April 2016 to April 2018
  - 304 stainless steel alloy metals ratios closely resemble the reference 304 stainless steel alloy ratios and the four metals follow similar trends from April 2016 to April 2018. Trends are less consistent for other periods. However, nickel concentrations are low for the entire period, indicating that corrosion is likely not severe even where present.
- Well 299-W19-42 – Corrosion-affected period of October 2014 to June 2018
  - Though not perfectly, 304 stainless steel alloy metals ratios generally resemble the reference to 304 stainless steel alloy ratios and nickel concentrations are moderately high from October 2014 to June 2018.

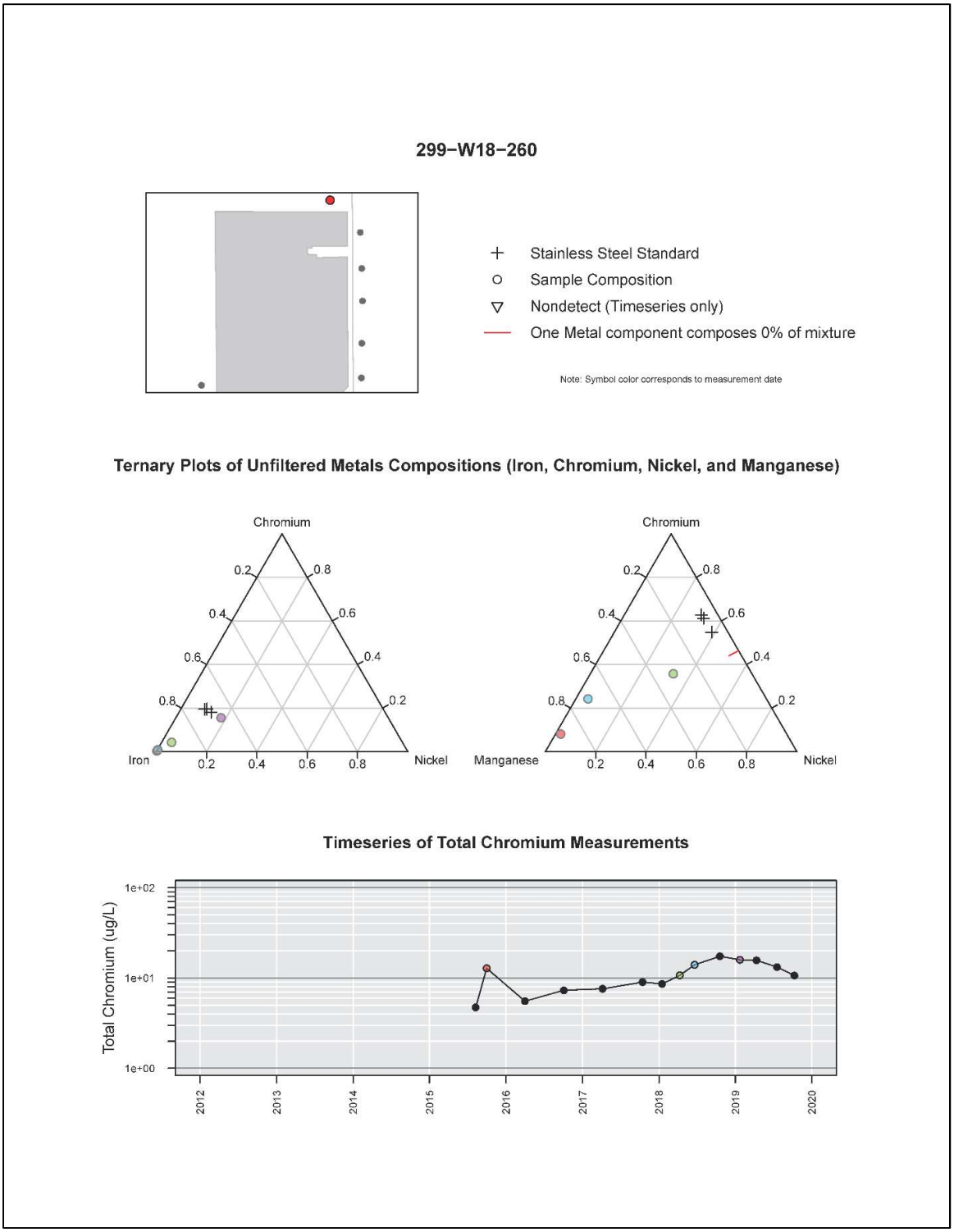

Figure B-1. Well Corrosion Analysis Result for Well 299-W18-260

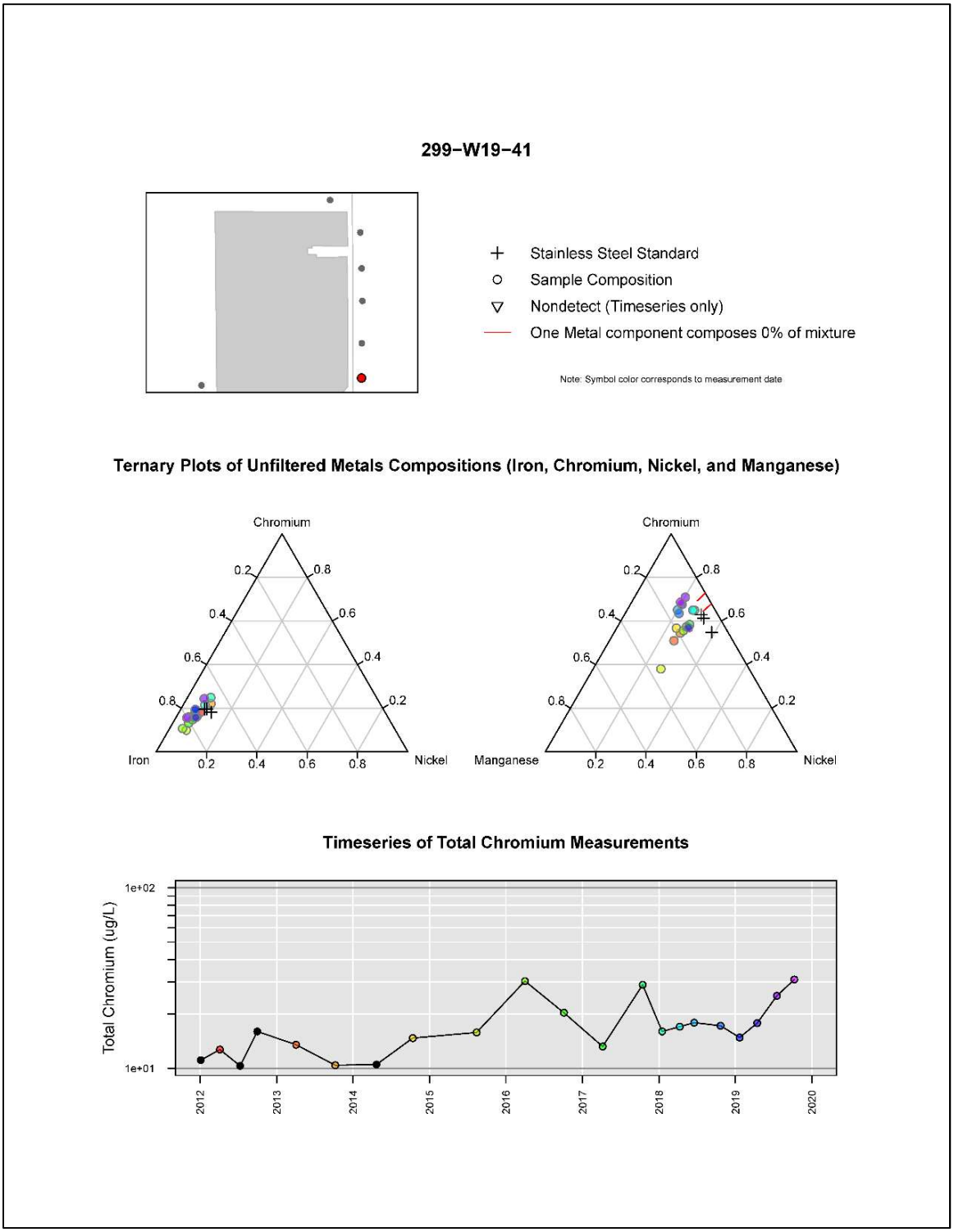

Figure B-2. Well Corrosion Analysis Result for Well 299-W19-41

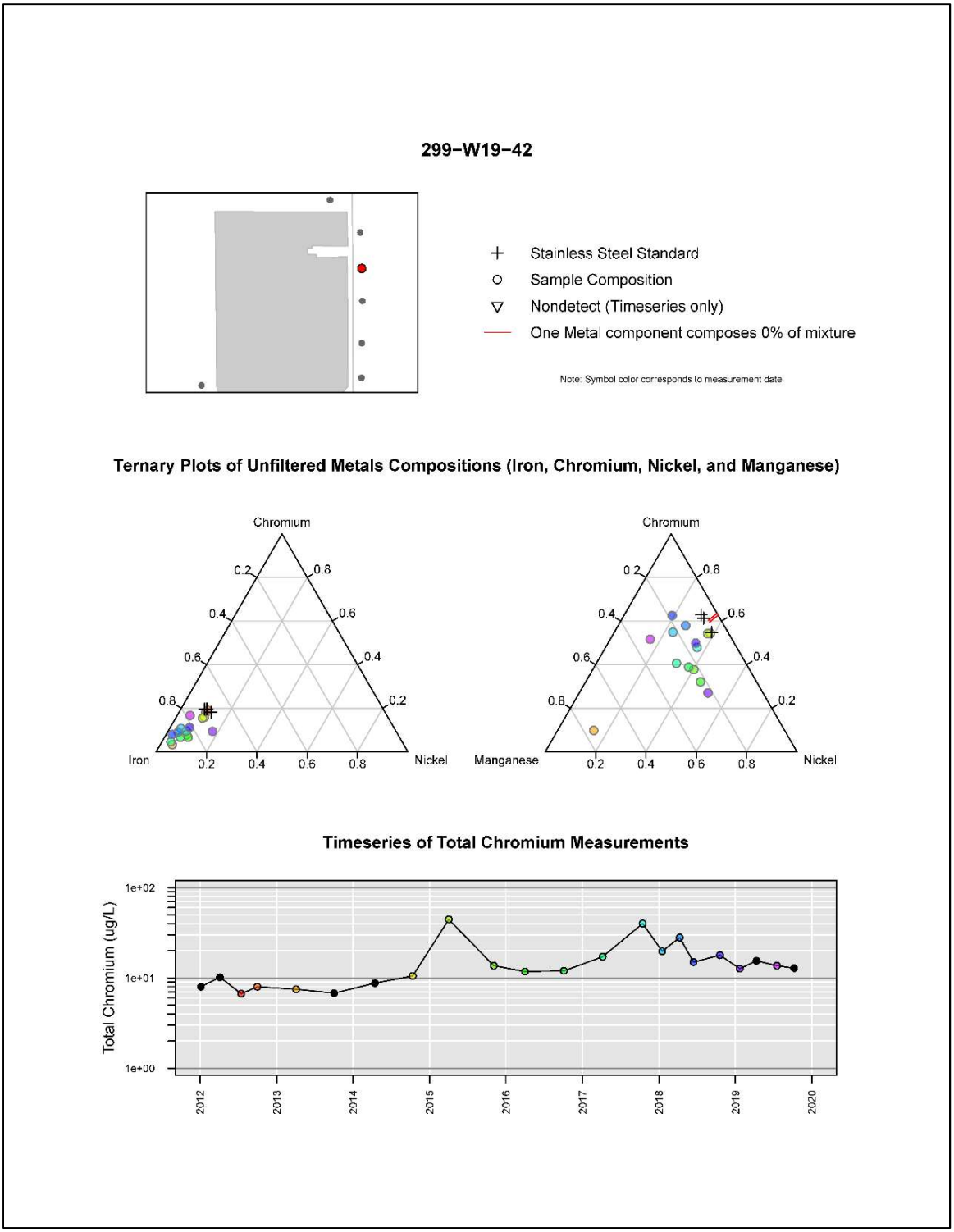

Figure B-3. Well Corrosion Analysis Result for Well 299-W19-42

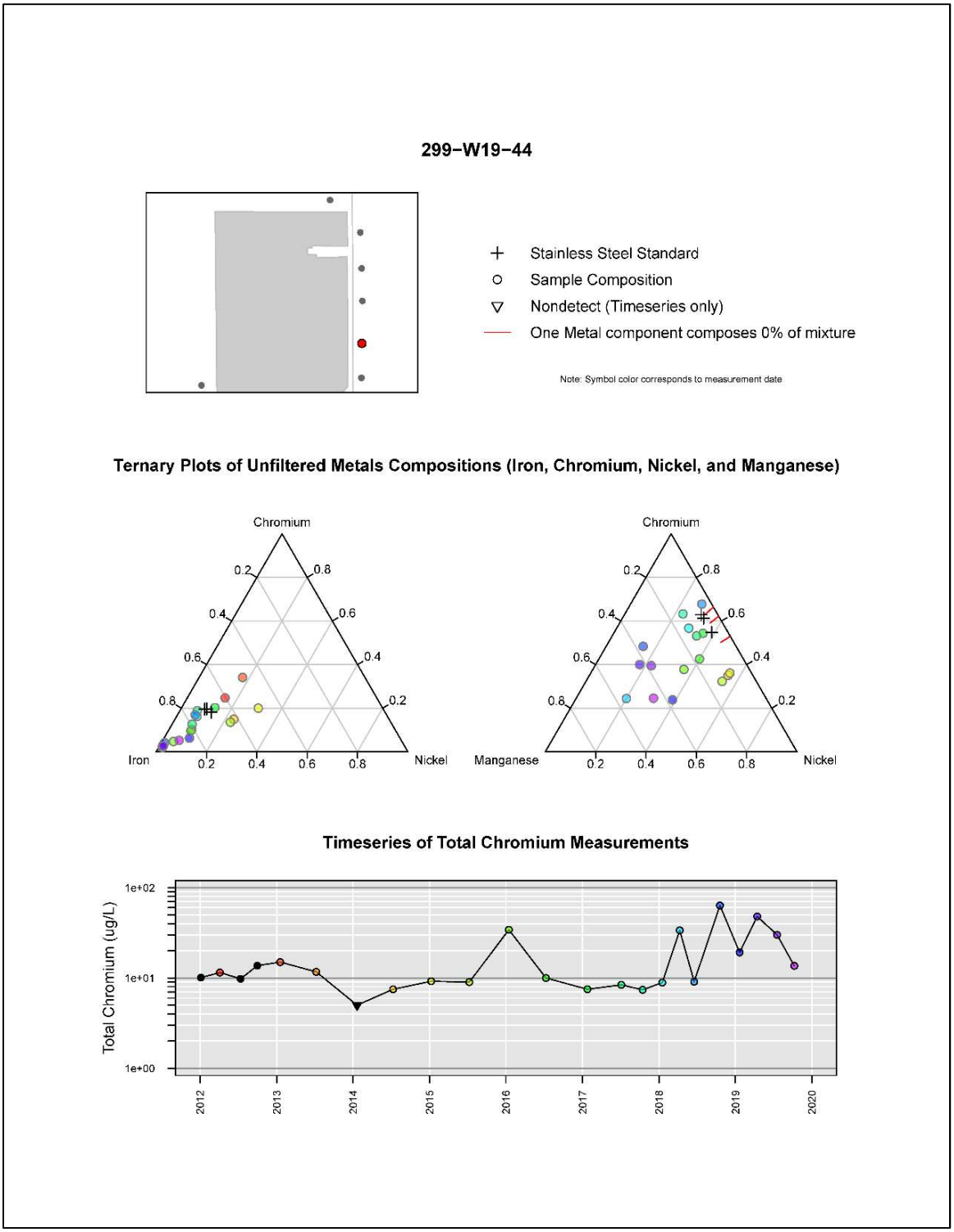

Figure B-4. Well Corrosion Analysis Result for Well 299-W19-44

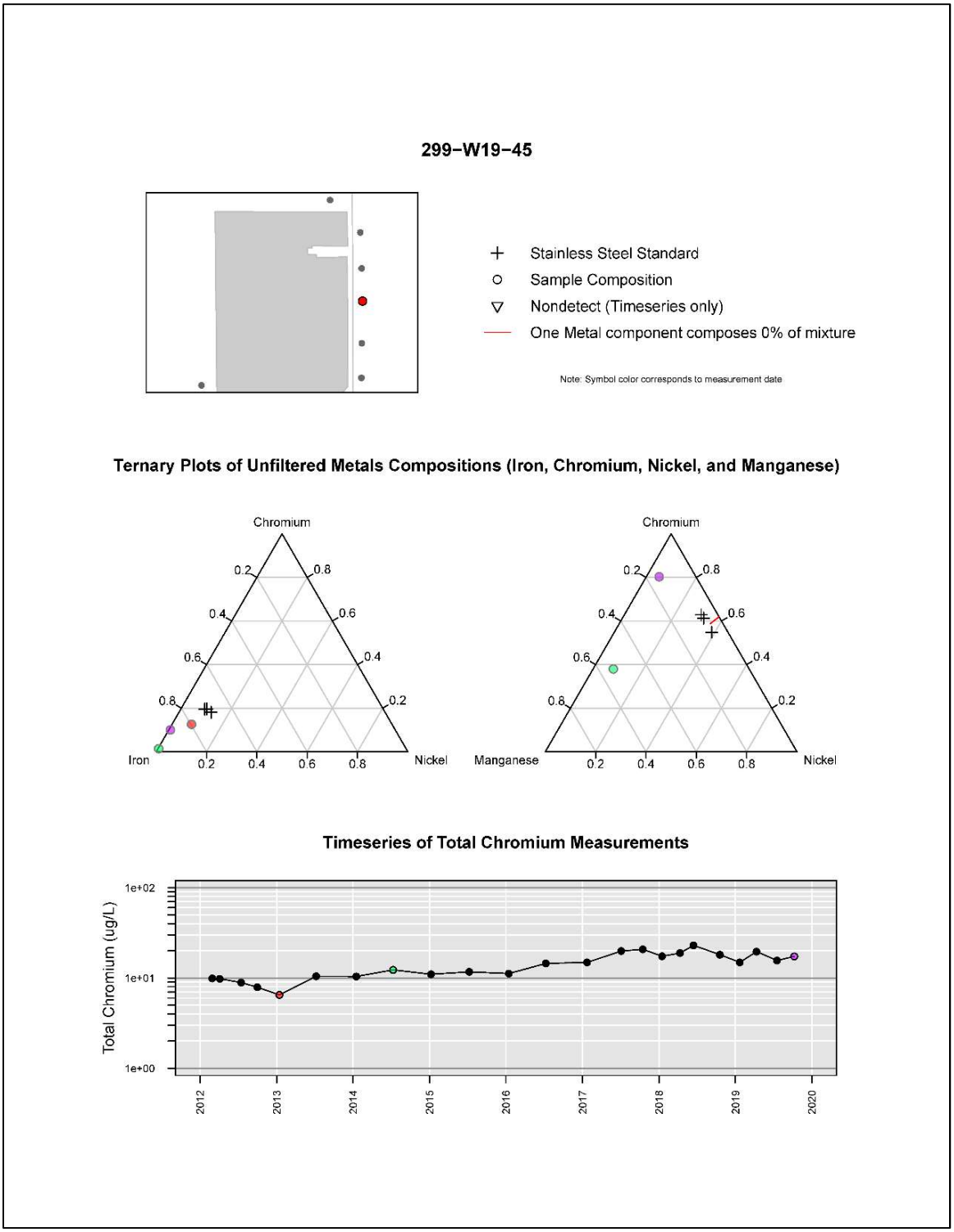

Figure B-5. Well Corrosion Analysis Result for Well 299-W19-45

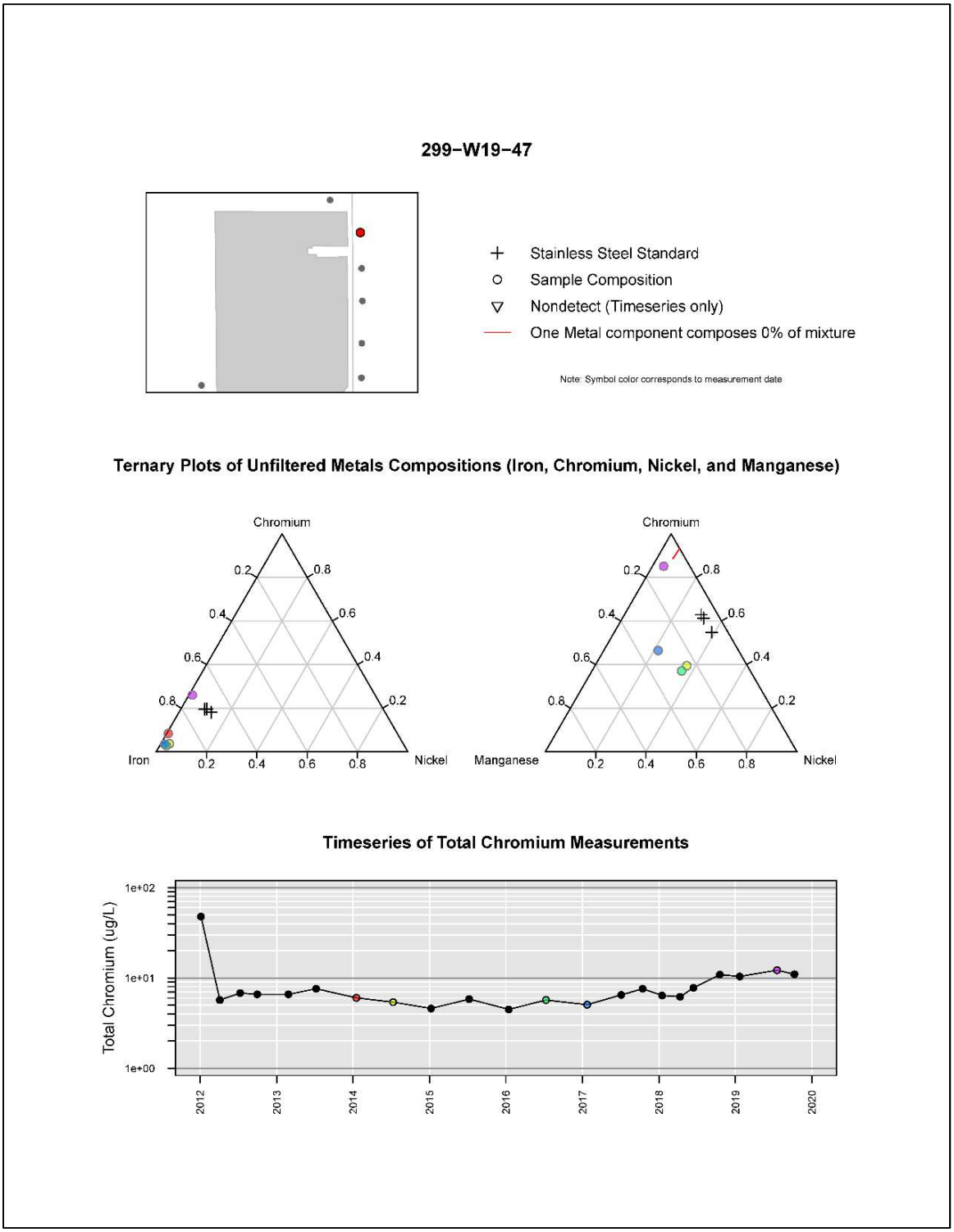

Figure B-6. Well Corrosion Analysis Result for Well 299-W19-47

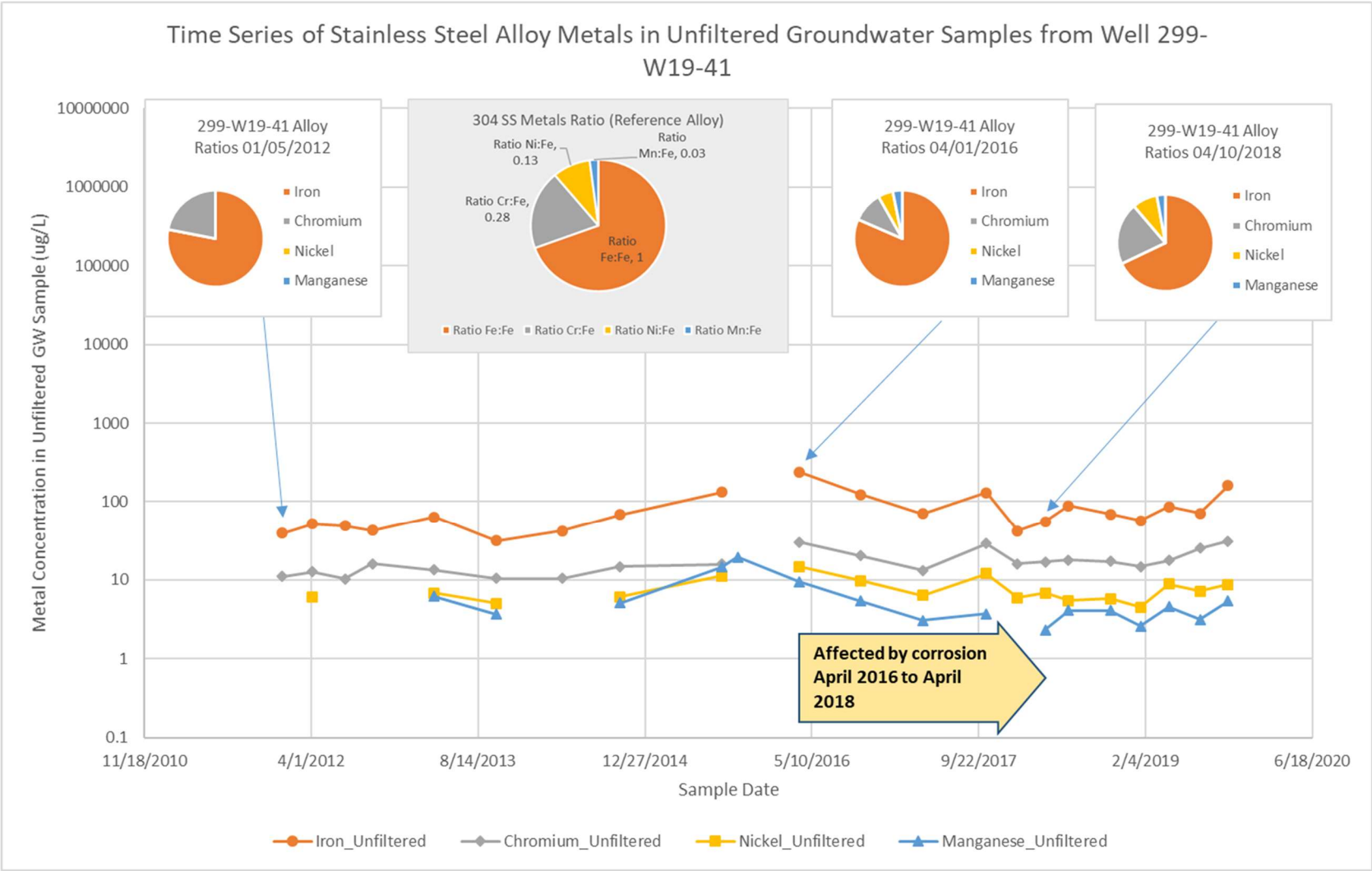

Figure B-7. Secondary Well Corrosion Analysis Result for Well 299-W19-41

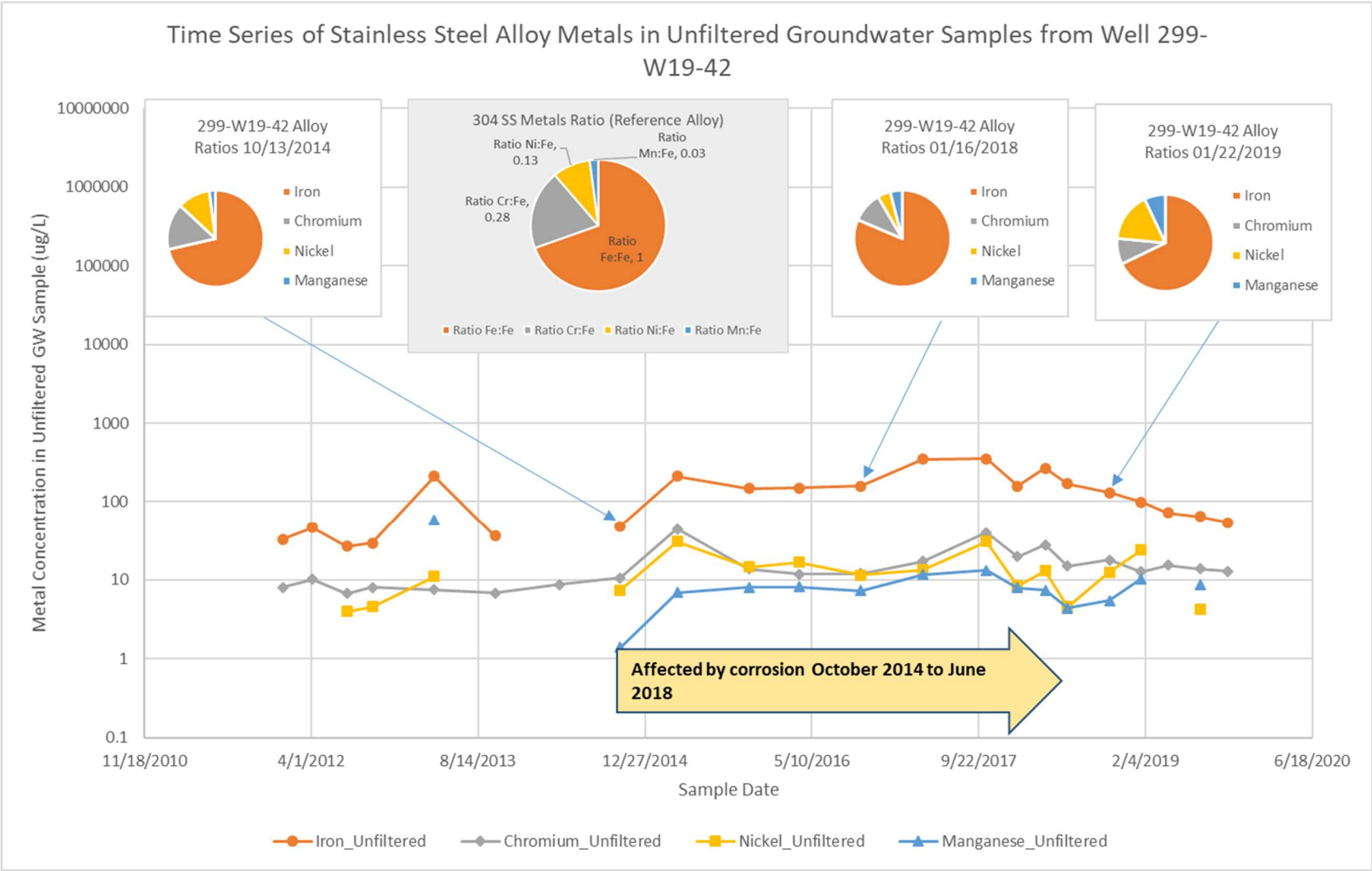

Figure B-8. Secondary Well Corrosion Analysis Result for Well 299-W19-42

Table B-1. Datasets for Well Corrosion Analysis at WMA U

Well Name	Sample Date	Analyte	Filtered	Result	Units	Laboratory Qualifier	Non-detect?
299-W18-260	8/10/2015	Chromium	N	4.73	µg/L	B	FALSE
299-W18-260	8/10/2015	Iron	N	296	µg/L		FALSE
299-W18-260	8/10/2015	Manganese	N	14.5	µg/L		FALSE
299-W18-260	8/10/2015	Nickel	N	1.5	µg/L	U	TRUE
299-W18-260	10/1/2015	Chromium	N	12.8	µg/L		FALSE
299-W18-260	10/1/2015	Iron	N	4020	µg/L		FALSE
299-W18-260	10/1/2015	Manganese	N	142	µg/L		FALSE
299-W18-260	10/1/2015	Nickel	N	3.27	µg/L	B	FALSE
299-W18-260	4/1/2016	Chromium	N	5.54	µg/L		FALSE
299-W18-260	4/1/2016	Iron	N	85.1	µg/L	B	FALSE
299-W18-260	4/1/2016	Manganese	N	2.03	µg/L	B	FALSE
299-W18-260	4/1/2016	Nickel	N	1.5	µg/L	U	TRUE
299-W18-260	10/4/2016	Chromium	N	7.31	µg/L		FALSE
299-W18-260	10/4/2016	Iron	N	133.5	µg/L		FALSE
299-W18-260	10/4/2016	Manganese	N	3.37	µg/L		FALSE
299-W18-260	10/4/2016	Nickel	N	1.5	µg/L	U	TRUE
299-W18-260	4/7/2017	Chromium	N	7.6	µg/L	B	FALSE
299-W18-260	4/7/2017	Iron	N	69.3	µg/L	B	FALSE
299-W18-260	4/7/2017	Manganese	N	3.8	µg/L	BC	FALSE
299-W18-260	4/7/2017	Nickel	N	2.6	µg/L	U	TRUE
299-W18-260	10/15/2017	Chromium	N	9	µg/L	B	FALSE
299-W18-260	10/15/2017	Iron	N	167	µg/L		FALSE
299-W18-260	10/15/2017	Manganese	N	6.3	µg/L	B	FALSE
299-W18-260	10/15/2017	Nickel	N	2.6	µg/L	U	TRUE
299-W18-260	1/16/2018	Chromium	N	8.6	µg/L	B	FALSE
299-W18-260	1/16/2018	Iron	N	379	µg/L		FALSE
299-W18-260	1/16/2018	Manganese	N	10.7	µg/L		FALSE
299-W18-260	1/16/2018	Nickel	N	2.6	µg/L	U	TRUE
299-W18-260	4/10/2018	Chromium	N	10.7	µg/L		FALSE
299-W18-260	4/10/2018	Iron	N	229	µg/L		FALSE
299-W18-260	4/10/2018	Manganese	N	9.36	µg/L	B	FALSE
299-W18-260	4/10/2018	Nickel	N	9.87	µg/L		FALSE

Table B-1. Datasets for Well Corrosion Analysis at WMA U

Well Name	Sample Date	Analyte	Filtered	Result	Units	Laboratory Qualifier	Non-detect?
299-W18-260	6/20/2018	Chromium	N	14	µg/L		FALSE
299-W18-260	6/20/2018	Iron	N	1600	µg/L		FALSE
299-W18-260	6/20/2018	Manganese	N	41	µg/L		FALSE
299-W18-260	6/20/2018	Nickel	N	2.8	µg/L	B	FALSE
299-W18-260	10/19/2018	Chromium	N	17.4	µg/L		FALSE
299-W18-260	10/19/2018	Iron	N	150	µg/L		FALSE
299-W18-260	10/19/2018	Manganese	N	4.2	µg/L	B	FALSE
299-W18-260	10/19/2018	Nickel	N	10	µg/L	U	TRUE
299-W18-260	1/22/2019	Chromium	N	15.9	µg/L		FALSE
299-W18-260	1/22/2019	Iron	N	68	µg/L	B	FALSE
299-W18-260	1/22/2019	Manganese	N	4	µg/L	U	TRUE
299-W18-260	1/22/2019	Nickel	N	18.4	µg/L	B	FALSE
299-W18-260	4/12/2019	Chromium	N	15.7	µg/L		FALSE
299-W18-260	4/12/2019	Iron	N	442	µg/L		FALSE
299-W18-260	4/12/2019	Manganese	N	16.8	µg/L		FALSE
299-W18-260	4/12/2019	Nickel	N	10	µg/L	U	TRUE
299-W18-260	7/19/2019	Chromium	N	13.2	µg/L	D	FALSE
299-W18-260	7/19/2019	Iron	N	295	µg/L		FALSE
299-W18-260	7/19/2019	Manganese	N	11.3	µg/L	D	FALSE
299-W18-260	7/19/2019	Nickel	N	2	µg/L	UD	TRUE
299-W18-260	10/10/2019	Chromium	N	10.65	µg/L		FALSE
299-W18-260	10/10/2019	Iron	N	96.4	µg/L	B	FALSE
299-W18-260	10/10/2019	Manganese	N	5.9	µg/L	B	FALSE
299-W18-260	10/10/2019	Nickel	N	10	µg/L	U	TRUE
299-W19-41	1/5/2012	Chromium	N	11.1	µg/L	B	FALSE
299-W19-41	1/5/2012	Iron	N	39.5	µg/L	B	FALSE
299-W19-41	1/5/2012	Manganese	N	4	µg/L	U	TRUE
299-W19-41	1/5/2012	Nickel	N	4	µg/L	U	TRUE
299-W19-41	4/5/2012	Chromium	N	12.7	µg/L	B	FALSE
299-W19-41	4/5/2012	Iron	N	52	µg/L	B	FALSE
299-W19-41	4/5/2012	Manganese	N	4	µg/L	U	TRUE
299-W19-41	4/5/2012	Nickel	N	6	µg/L	B	FALSE

Table B-1. Datasets for Well Corrosion Analysis at WMA U

Well Name	Sample Date	Analyte	Filtered	Result	Units	Laboratory Qualifier	Non-detect?
299-W19-41	7/11/2012	Chromium	N	10.32	µg/L		FALSE
299-W19-41	7/11/2012	Iron	N	49.4	µg/L	B	FALSE
299-W19-41	7/11/2012	Manganese	N	4	µg/L	U	TRUE
299-W19-41	7/11/2012	Nickel	N	4	µg/L	U	TRUE
299-W19-41	10/1/2012	Chromium	N	16	µg/L	B	FALSE
299-W19-41	10/1/2012	Iron	N	42.5	µg/L	B	FALSE
299-W19-41	10/1/2012	Manganese	N	4	µg/L	U	TRUE
299-W19-41	10/1/2012	Nickel	N	4	µg/L	U	TRUE
299-W19-41	4/4/2013	Chromium	N	13.5	µg/L	B	FALSE
299-W19-41	4/4/2013	Iron	N	63.8	µg/L	B	FALSE
299-W19-41	4/4/2013	Manganese	N	6.2	µg/L	B	FALSE
299-W19-41	4/4/2013	Nickel	N	6.8	µg/L	B	FALSE
299-W19-41	10/8/2013	Chromium	N	10.4	µg/L	DC	FALSE
299-W19-41	10/8/2013	Iron	N	31.7	µg/L	B	FALSE
299-W19-41	10/8/2013	Manganese	N	3.66	µg/L	DC	FALSE
299-W19-41	10/8/2013	Nickel	N	5.04	µg/L	DC	FALSE
299-W19-41	4/23/2014	Chromium	N	10.5	µg/L		FALSE
299-W19-41	4/23/2014	Iron	N	42.1	µg/L	B	FALSE
299-W19-41	4/23/2014	Manganese	N	4	µg/L	U	TRUE
299-W19-41	4/23/2014	Nickel	N	10	µg/L	U	TRUE
299-W19-41	10/13/2014	Chromium	N	14.7	µg/L		FALSE
299-W19-41	10/13/2014	Iron	N	68.7	µg/L	B	FALSE
299-W19-41	10/13/2014	Manganese	N	5.07	µg/L	B	FALSE
299-W19-41	10/13/2014	Nickel	N	6.15	µg/L		FALSE
299-W19-41	8/14/2015	Chromium	N	15.8	µg/L		FALSE
299-W19-41	8/14/2015	Iron	N	133	µg/L		FALSE
299-W19-41	8/14/2015	Manganese	N	14.6	µg/L		FALSE
299-W19-41	8/14/2015	Nickel	N	11.2	µg/L		FALSE
299-W19-41	10/1/2015	Manganese	N	19.55	µg/L		FALSE
299-W19-41	4/1/2016	Chromium	N	30.4	µg/L		FALSE
299-W19-41	4/1/2016	Iron	N	241	µg/L		FALSE
299-W19-41	4/1/2016	Manganese	N	9.48	µg/L	B	FALSE

Table B-1. Datasets for Well Corrosion Analysis at WMA U

Well Name	Sample Date	Analyte	Filtered	Result	Units	Laboratory Qualifier	Non-detect?
299-W19-41	4/1/2016	Nickel	N	14.8	µg/L		FALSE
299-W19-41	10/4/2016	Chromium	N	20.3	µg/L		FALSE
299-W19-41	10/4/2016	Iron	N	124	µg/L		FALSE
299-W19-41	10/4/2016	Manganese	N	5.36	µg/L	B	FALSE
299-W19-41	10/4/2016	Nickel	N	9.71	µg/L		FALSE
299-W19-41	4/7/2017	Chromium	N	13.2	µg/L	C	FALSE
299-W19-41	4/7/2017	Iron	N	70.2	µg/L	B	FALSE
299-W19-41	4/7/2017	Manganese	N	3.06	µg/L	B	FALSE
299-W19-41	4/7/2017	Nickel	N	6.38	µg/L		FALSE
299-W19-41	10/15/2017	Chromium	N	29	µg/L		FALSE
299-W19-41	10/15/2017	Iron	N	130	µg/L		FALSE
299-W19-41	10/15/2017	Manganese	N	3.7	µg/L	B	FALSE
299-W19-41	10/15/2017	Nickel	N	12	µg/L	B	FALSE
299-W19-41	1/16/2018	Chromium	N	16	µg/L		FALSE
299-W19-41	1/16/2018	Iron	N	42.4	µg/L	B	FALSE
299-W19-41	1/16/2018	Manganese	N	2	µg/L	U	TRUE
299-W19-41	1/16/2018	Nickel	N	5.95	µg/L		FALSE
299-W19-41	4/10/2018	Chromium	N	17	µg/L		FALSE
299-W19-41	4/10/2018	Iron	N	55.4	µg/L	B	FALSE
299-W19-41	4/10/2018	Manganese	N	2.33	µg/L	B	FALSE
299-W19-41	4/10/2018	Nickel	N	6.84	µg/L		FALSE
299-W19-41	6/18/2018	Chromium	N	17.9	µg/L		FALSE
299-W19-41	6/18/2018	Iron	N	89	µg/L	B	FALSE
299-W19-41	6/18/2018	Manganese	N	4.1	µg/L	BC	FALSE
299-W19-41	6/18/2018	Nickel	N	5.5	µg/L	B	FALSE
299-W19-41	10/22/2018	Chromium	N	17.2	µg/L		FALSE
299-W19-41	10/22/2018	Iron	N	69.8	µg/L	B	FALSE
299-W19-41	10/22/2018	Manganese	N	4.1	µg/L	BC	FALSE
299-W19-41	10/22/2018	Nickel	N	5.8	µg/L	B	FALSE
299-W19-41	1/21/2019	Chromium	N	14.8	µg/L		FALSE
299-W19-41	1/21/2019	Iron	N	57.1	µg/L	B	FALSE
299-W19-41	1/21/2019	Manganese	N	2.6	µg/L	B	FALSE

Table B-1. Datasets for Well Corrosion Analysis at WMA U

Well Name	Sample Date	Analyte	Filtered	Result	Units	Laboratory Qualifier	Non-detect?
299-W19-41	1/21/2019	Nickel	N	4.5	µg/L	B	FALSE
299-W19-41	4/15/2019	Chromium	N	17.8	µg/L		FALSE
299-W19-41	4/15/2019	Iron	N	86.8	µg/L	B	FALSE
299-W19-41	4/15/2019	Manganese	N	4.6	µg/L	B	FALSE
299-W19-41	4/15/2019	Nickel	N	8.9	µg/L	B	FALSE
299-W19-41	7/18/2019	Chromium	N	25.2	µg/L		FALSE
299-W19-41	7/18/2019	Iron	N	71.2	µg/L	B	FALSE
299-W19-41	7/18/2019	Manganese	N	3.17	µg/L	B	FALSE
299-W19-41	7/18/2019	Nickel	N	7.18	µg/L		FALSE
299-W19-41	10/9/2019	Chromium	N	31	µg/L		FALSE
299-W19-41	10/9/2019	Iron	N	160	µg/L		FALSE
299-W19-41	10/9/2019	Manganese	N	5.4	µg/L		FALSE
299-W19-41	10/9/2019	Nickel	N	8.8	µg/L	B	FALSE
299-W19-42	1/6/2012	Chromium	N	8	µg/L	B	FALSE
299-W19-42	1/6/2012	Iron	N	33.1	µg/L	B	FALSE
299-W19-42	1/6/2012	Manganese	N	4	µg/L	U	TRUE
299-W19-42	1/6/2012	Nickel	N	4	µg/L	U	TRUE
299-W19-42	4/5/2012	Chromium	N	10.2	µg/L	B	FALSE
299-W19-42	4/5/2012	Iron	N	46.5	µg/L	B	FALSE
299-W19-42	4/5/2012	Manganese	N	4	µg/L	U	TRUE
299-W19-42	4/5/2012	Nickel	N	4	µg/L	U	TRUE
299-W19-42	7/16/2012	Chromium	N	6.7	µg/L	B	FALSE
299-W19-42	7/16/2012	Iron	N	26.9	µg/L	B	FALSE
299-W19-42	7/16/2012	Manganese	N	4	µg/L	U	TRUE
299-W19-42	7/16/2012	Nickel	N	4	µg/L	B	FALSE
299-W19-42	10/1/2012	Chromium	N	8	µg/L	B	FALSE
299-W19-42	10/1/2012	Iron	N	29.5	µg/L	B	FALSE
299-W19-42	10/1/2012	Manganese	N	4	µg/L	U	TRUE
299-W19-42	10/1/2012	Nickel	N	4.6	µg/L	B	FALSE
299-W19-42	4/4/2013	Chromium	N	7.5	µg/L	B	FALSE
299-W19-42	4/4/2013	Iron	N	213	µg/L		FALSE
299-W19-42	4/4/2013	Manganese	N	58.3	µg/L		FALSE

Table B-1. Datasets for Well Corrosion Analysis at WMA U

Well Name	Sample Date	Analyte	Filtered	Result	Units	Laboratory Qualifier	Non-detect?
299-W19-42	4/4/2013	Nickel	N	11	µg/L	B	FALSE
299-W19-42	10/3/2013	Chromium	N	6.8	µg/L		FALSE
299-W19-42	10/3/2013	Iron	N	36.4	µg/L		FALSE
299-W19-42	10/3/2013	Manganese	N	4	µg/L	U	TRUE
299-W19-42	10/3/2013	Nickel	N	5	µg/L	U	TRUE
299-W19-42	4/16/2014	Chromium	N	8.78	µg/L	B	FALSE
299-W19-42	4/16/2014	Iron	N	40	µg/L	U	TRUE
299-W19-42	4/16/2014	Manganese	N	4	µg/L	U	TRUE
299-W19-42	4/16/2014	Nickel	N	10	µg/L	U	TRUE
299-W19-42	10/13/2014	Chromium	N	10.55	µg/L		FALSE
299-W19-42	10/13/2014	Iron	N	48.5	µg/L		FALSE
299-W19-42	10/13/2014	Manganese	N	1.4	µg/L		FALSE
299-W19-42	10/13/2014	Nickel	N	7.45	µg/L		FALSE
299-W19-42	4/3/2015	Chromium	N	44.5	µg/L		FALSE
299-W19-42	4/3/2015	Iron	N	213	µg/L		FALSE
299-W19-42	4/3/2015	Manganese	N	6.9	µg/L	B	FALSE
299-W19-42	4/3/2015	Nickel	N	30.7	µg/L	B	FALSE
299-W19-42	11/4/2015	Chromium	N	13.7	µg/L	C	FALSE
299-W19-42	11/4/2015	Iron	N	148	µg/L	C	FALSE
299-W19-42	11/4/2015	Manganese	N	8.1	µg/L	BC	FALSE
299-W19-42	11/4/2015	Nickel	N	14.6	µg/L	B	FALSE
299-W19-42	4/1/2016	Chromium	N	11.8	µg/L		FALSE
299-W19-42	4/1/2016	Iron	N	151	µg/L		FALSE
299-W19-42	4/1/2016	Manganese	N	8.2	µg/L	B	FALSE
299-W19-42	4/1/2016	Nickel	N	16.8	µg/L	B	FALSE
299-W19-42	10/4/2016	Chromium	N	12	µg/L		FALSE
299-W19-42	10/4/2016	Iron	N	159	µg/L		FALSE
299-W19-42	10/4/2016	Manganese	N	7.3	µg/L	B	FALSE
299-W19-42	10/4/2016	Nickel	N	11.6	µg/L	B	FALSE
299-W19-42	4/7/2017	Chromium	N	17.2	µg/L		FALSE
299-W19-42	4/7/2017	Iron	N	350	µg/L		FALSE
299-W19-42	4/7/2017	Manganese	N	11.7	µg/L	B	FALSE

Table B-1. Datasets for Well Corrosion Analysis at WMA U

Well Name	Sample Date	Analyte	Filtered	Result	Units	Laboratory Qualifier	Non-detect?
299-W19-42	4/7/2017	Nickel	N	13.5	µg/L	B	FALSE
299-W19-42	10/15/2017	Chromium	N	40.1	µg/L		FALSE
299-W19-42	10/15/2017	Iron	N	352	µg/L		FALSE
299-W19-42	10/15/2017	Manganese	N	13.2	µg/L	B	FALSE
299-W19-42	10/15/2017	Nickel	N	30.5	µg/L	B	FALSE
299-W19-42	1/16/2018	Chromium	N	19.8	µg/L		FALSE
299-W19-42	1/16/2018	Iron	N	158	µg/L		FALSE
299-W19-42	1/16/2018	Manganese	N	7.9	µg/L	B	FALSE
299-W19-42	1/16/2018	Nickel	N	8.4	µg/L	B	FALSE
299-W19-42	4/10/2018	Chromium	N	28	µg/L		FALSE
299-W19-42	4/10/2018	Iron	N	270	µg/L		FALSE
299-W19-42	4/10/2018	Manganese	N	7.4	µg/L		FALSE
299-W19-42	4/10/2018	Nickel	N	13	µg/L	B	FALSE
299-W19-42	6/15/2018	Chromium	N	15	µg/L		FALSE
299-W19-42	6/15/2018	Iron	N	170	µg/L		FALSE
299-W19-42	6/15/2018	Manganese	N	4.4	µg/L	B	FALSE
299-W19-42	6/15/2018	Nickel	N	4.6	µg/L	B	FALSE
299-W19-42	10/19/2018	Chromium	N	17.9	µg/L		FALSE
299-W19-42	10/19/2018	Iron	N	131	µg/L		FALSE
299-W19-42	10/19/2018	Manganese	N	5.5	µg/L	B	FALSE
299-W19-42	10/19/2018	Nickel	N	12.5	µg/L	B	FALSE
299-W19-42	1/22/2019	Chromium	N	12.7	µg/L		FALSE
299-W19-42	1/22/2019	Iron	N	99.3	µg/L	B	FALSE
299-W19-42	1/22/2019	Manganese	N	10.3	µg/L	B	FALSE
299-W19-42	1/22/2019	Nickel	N	24.1	µg/L	B	FALSE
299-W19-42	4/12/2019	Chromium	N	15.5	µg/L		FALSE
299-W19-42	4/12/2019	Iron	N	71.8	µg/L	B	FALSE
299-W19-42	4/12/2019	Manganese	N	4	µg/L	U	TRUE
299-W19-42	4/12/2019	Nickel	N	10	µg/L	U	TRUE
299-W19-42	7/18/2019	Chromium	N	13.7	µg/L		FALSE
299-W19-42	7/18/2019	Iron	N	64.4	µg/L		FALSE
299-W19-42	7/18/2019	Manganese	N	8.625	µg/L		FALSE

Table B-1. Datasets for Well Corrosion Analysis at WMA U

Well Name	Sample Date	Analyte	Filtered	Result	Units	Laboratory Qualifier	Non-detect?
299-W19-42	7/18/2019	Nickel	N	4.205	µg/L		FALSE
299-W19-42	10/9/2019	Chromium	N	12.85	µg/L		FALSE
299-W19-42	10/9/2019	Iron	N	54.1	µg/L	B	FALSE
299-W19-42	10/9/2019	Manganese	N	4	µg/L	U	TRUE
299-W19-42	10/9/2019	Nickel	N	10	µg/L	U	TRUE
299-W19-44	1/6/2012	Chromium	N	10.1	µg/L	B	FALSE
299-W19-44	1/6/2012	Iron	N	19	µg/L	U	TRUE
299-W19-44	1/6/2012	Manganese	N	4	µg/L	U	TRUE
299-W19-44	1/6/2012	Nickel	N	6.9	µg/L	B	FALSE
299-W19-44	4/5/2012	Chromium	N	11.5	µg/L	B	FALSE
299-W19-44	4/5/2012	Iron	N	28.1	µg/L	B	FALSE
299-W19-44	4/5/2012	Manganese	N	4	µg/L	U	TRUE
299-W19-44	4/5/2012	Nickel	N	7	µg/L	B	FALSE
299-W19-44	7/13/2012	Chromium	N	9.8	µg/L	B	FALSE
299-W19-44	7/13/2012	Iron	N	19	µg/L	U	TRUE
299-W19-44	7/13/2012	Manganese	N	4	µg/L	U	TRUE
299-W19-44	7/13/2012	Nickel	N	6.2	µg/L	B	FALSE
299-W19-44	10/1/2012	Chromium	N	13.7	µg/L	B	FALSE
299-W19-44	10/1/2012	Iron	N	78.7	µg/L	B	FALSE
299-W19-44	10/1/2012	Manganese	N	4.4	µg/L	B	FALSE
299-W19-44	10/1/2012	Nickel	N	4	µg/L	U	TRUE
299-W19-44	1/18/2013	Chromium	N	15	µg/L	B	FALSE
299-W19-44	1/18/2013	Iron	N	21.4	µg/L	B	FALSE
299-W19-44	1/18/2013	Manganese	N	4	µg/L	U	TRUE
299-W19-44	1/18/2013	Nickel	N	7.6	µg/L	B	FALSE
299-W19-44	7/9/2013	Chromium	N	11.7	µg/L	B	FALSE
299-W19-44	7/9/2013	Iron	N	93	µg/L	B	FALSE
299-W19-44	7/9/2013	Manganese	N	4	µg/L	U	TRUE
299-W19-44	7/9/2013	Nickel	N	10.4	µg/L	B	FALSE
299-W19-44	1/20/2014	Chromium	N	5	µg/L	U	TRUE
299-W19-44	1/20/2014	Iron	N	40	µg/L	U	TRUE
299-W19-44	1/20/2014	Manganese	N	4	µg/L	U	TRUE

Table B-1. Datasets for Well Corrosion Analysis at WMA U

Well Name	Sample Date	Analyte	Filtered	Result	Units	Laboratory Qualifier	Non-detect?
299-W19-44	1/20/2014	Nickel	N	10	µg/L	U	TRUE
299-W19-44	7/11/2014	Chromium	N	7.5	µg/L	B	FALSE
299-W19-44	7/11/2014	Iron	N	31.1	µg/L	B	FALSE
299-W19-44	7/11/2014	Manganese	N	2.1	µg/L	B	FALSE
299-W19-44	7/11/2014	Nickel	N	11.8	µg/L	B	FALSE
299-W19-44	1/9/2015	Chromium	N	9.2	µg/L		FALSE
299-W19-44	1/9/2015	Iron	N	22.8	µg/L		FALSE
299-W19-44	1/9/2015	Manganese	N	2.2	µg/L		FALSE
299-W19-44	1/9/2015	Nickel	N	14.1	µg/L		FALSE
299-W19-44	7/10/2015	Chromium	N	9	µg/L	B	FALSE
299-W19-44	7/10/2015	Iron	N	42.4	µg/L	BC	FALSE
299-W19-44	7/10/2015	Manganese	N	3.8	µg/L	BC	FALSE
299-W19-44	7/10/2015	Nickel	N	15.1	µg/L	B	FALSE
299-W19-44	1/15/2016	Chromium	N	34.2	µg/L		FALSE
299-W19-44	1/15/2016	Iron	N	661	µg/L		FALSE
299-W19-44	1/15/2016	Manganese	N	23.6	µg/L		FALSE
299-W19-44	1/15/2016	Nickel	N	32.8	µg/L	B	FALSE
299-W19-44	7/10/2016	Chromium	N	10	µg/L		FALSE
299-W19-44	7/10/2016	Iron	N	85	µg/L		FALSE
299-W19-44	7/10/2016	Manganese	N	4.1	µg/L	B	FALSE
299-W19-44	7/10/2016	Nickel	N	9.4	µg/L	B	FALSE
299-W19-44	1/24/2017	Chromium	N	7.5	µg/L	B	FALSE
299-W19-44	1/24/2017	Iron	N	24.7	µg/L	B	FALSE
299-W19-44	1/24/2017	Manganese	N	1.4	µg/L	B	FALSE
299-W19-44	1/24/2017	Nickel	N	4.9	µg/L	B	FALSE
299-W19-44	7/5/2017	Chromium	N	8.4	µg/L	B	FALSE
299-W19-44	7/5/2017	Iron	N	53	µg/L	C	FALSE
299-W19-44	7/5/2017	Manganese	N	2.1	µg/L	B	FALSE
299-W19-44	7/5/2017	Nickel	N	5.3	µg/L	B	FALSE
299-W19-44	10/15/2017	Chromium	N	7.4	µg/L	B	FALSE
299-W19-44	10/15/2017	Iron	N	29.2	µg/L	B	FALSE
299-W19-44	10/15/2017	Manganese	N	1.6	µg/L	B	FALSE

Table B-1. Datasets for Well Corrosion Analysis at WMA U

Well Name	Sample Date	Analyte	Filtered	Result	Units	Laboratory Qualifier	Non-detect?
299-W19-44	10/15/2017	Nickel	N	2.7	µg/L	B	FALSE
299-W19-44	1/17/2018	Chromium	N	8.9	µg/L	B	FALSE
299-W19-44	1/17/2018	Iron	N	41.8	µg/L	B	FALSE
299-W19-44	1/17/2018	Manganese	N	2.3	µg/L	B	FALSE
299-W19-44	1/17/2018	Nickel	N	4.5	µg/L	B	FALSE
299-W19-44	4/10/2018	Chromium	N	33.7	µg/L		FALSE
299-W19-44	4/10/2018	Iron	N	1720	µg/L		FALSE
299-W19-44	4/10/2018	Manganese	N	76.9	µg/L		FALSE
299-W19-44	4/10/2018	Nickel	N	27.7	µg/L	B	FALSE
299-W19-44	6/18/2018	Chromium	N	9.1	µg/L	B	FALSE
299-W19-44	6/18/2018	Iron	N	41	µg/L	B	FALSE
299-W19-44	6/18/2018	Manganese	N	0.53	µg/L	B	FALSE
299-W19-44	6/18/2018	Nickel	N	3.8	µg/L	B	FALSE
299-W19-44	10/19/2018	Chromium	N	63.5	µg/L		FALSE
299-W19-44	10/19/2018	Iron	N	1460	µg/L		FALSE
299-W19-44	10/19/2018	Manganese	N	48.5	µg/L		FALSE
299-W19-44	10/19/2018	Nickel	N	19.3	µg/L	B	FALSE
299-W19-44	1/21/2019	Chromium	N	19.2	µg/L		FALSE
299-W19-44	1/21/2019	Iron	N	258	µg/L		FALSE
299-W19-44	1/21/2019	Manganese	N	30.2	µg/L		FALSE
299-W19-44	1/21/2019	Nickel	N	31.1	µg/L	B	FALSE
299-W19-44	4/15/2019	Chromium	N	48	µg/L		FALSE
299-W19-44	4/15/2019	Iron	N	1700	µg/L		FALSE
299-W19-44	4/15/2019	Manganese	N	51	µg/L		FALSE
299-W19-44	4/15/2019	Nickel	N	21	µg/L		FALSE
299-W19-44	7/19/2019	Chromium	N	30	µg/L		FALSE
299-W19-44	7/19/2019	Iron	N	1100	µg/L		FALSE
299-W19-44	7/19/2019	Manganese	N	29	µg/L		FALSE
299-W19-44	7/19/2019	Nickel	N	17	µg/L	B	FALSE
299-W19-44	10/9/2019	Chromium	N	13.65	µg/L		FALSE
299-W19-44	10/9/2019	Iron	N	232	µg/L		FALSE
299-W19-44	10/9/2019	Manganese	N	24.9	µg/L		FALSE

Table B-1. Datasets for Well Corrosion Analysis at WMA U

Well Name	Sample Date	Analyte	Filtered	Result	Units	Laboratory Qualifier	Non-detect?
299-W19-44	10/9/2019	Nickel	N	17.1	µg/L		FALSE
299-W19-45	2/29/2012	Chromium	N	9.9	µg/L	B	FALSE
299-W19-45	2/29/2012	Iron	N	137	µg/L		FALSE
299-W19-45	2/29/2012	Manganese	N	4	µg/L	U	TRUE
299-W19-45	2/29/2012	Nickel	N	4	µg/L	U	TRUE
299-W19-45	4/5/2012	Chromium	N	9.8	µg/L	B	FALSE
299-W19-45	4/5/2012	Iron	N	107	µg/L		FALSE
299-W19-45	4/5/2012	Manganese	N	4	µg/L	U	TRUE
299-W19-45	4/5/2012	Nickel	N	4	µg/L	U	TRUE
299-W19-45	7/16/2012	Chromium	N	8.9	µg/L	B	FALSE
299-W19-45	7/16/2012	Iron	N	103	µg/L		FALSE
299-W19-45	7/16/2012	Manganese	N	4.2	µg/L	B	FALSE
299-W19-45	7/16/2012	Nickel	N	4	µg/L	U	TRUE
299-W19-45	10/1/2012	Chromium	N	7.9	µg/L	B	FALSE
299-W19-45	10/1/2012	Iron	N	54.2	µg/L	B	FALSE
299-W19-45	10/1/2012	Manganese	N	4	µg/L	U	TRUE
299-W19-45	10/1/2012	Nickel	N	4	µg/L	U	TRUE
299-W19-45	1/14/2013	Chromium	N	6.5	µg/L		FALSE
299-W19-45	1/14/2013	Iron	N	41.2	µg/L		FALSE
299-W19-45	1/14/2013	Manganese	N	4	µg/L	U	TRUE
299-W19-45	1/14/2013	Nickel	N	4	µg/L		FALSE
299-W19-45	7/9/2013	Chromium	N	10.45	µg/L		FALSE
299-W19-45	7/9/2013	Iron	N	59.2	µg/L		FALSE
299-W19-45	7/9/2013	Manganese	N	4	µg/L	U	TRUE
299-W19-45	7/9/2013	Nickel	N	4	µg/L	U	TRUE
299-W19-45	1/17/2014	Chromium	N	10.4	µg/L		FALSE
299-W19-45	1/17/2014	Iron	N	87.6	µg/L		FALSE
299-W19-45	1/17/2014	Manganese	N	4	µg/L	U	TRUE
299-W19-45	1/17/2014	Nickel	N	10	µg/L	U	TRUE
299-W19-45	7/11/2014	Chromium	N	12.3	µg/L		FALSE
299-W19-45	7/11/2014	Iron	N	887	µg/L		FALSE
299-W19-45	7/11/2014	Manganese	N	17.5	µg/L		FALSE

Table B-1. Datasets for Well Corrosion Analysis at WMA U

Well Name	Sample Date	Analyte	Filtered	Result	Units	Laboratory Qualifier	Non-detect?
299-W19-45	7/11/2014	Nickel	N	2.61	µg/L	B	FALSE
299-W19-45	1/9/2015	Chromium	N	11	µg/L		FALSE
299-W19-45	1/9/2015	Iron	N	397	µg/L		FALSE
299-W19-45	1/9/2015	Manganese	N	9.42	µg/L	B	FALSE
299-W19-45	1/9/2015	Nickel	N	1.5	µg/L	U	TRUE
299-W19-45	7/10/2015	Chromium	N	11.7	µg/L		FALSE
299-W19-45	7/10/2015	Iron	N	472	µg/L		FALSE
299-W19-45	7/10/2015	Manganese	N	9.25	µg/L		FALSE
299-W19-45	7/10/2015	Nickel	N	1.5	µg/L	U	TRUE
299-W19-45	1/15/2016	Chromium	N	11.2	µg/L		FALSE
299-W19-45	1/15/2016	Iron	N	100	µg/L		FALSE
299-W19-45	1/15/2016	Manganese	N	3.22	µg/L	B	FALSE
299-W19-45	1/15/2016	Nickel	N	1.5	µg/L	U	TRUE
299-W19-45	7/10/2016	Chromium	N	14.5	µg/L		FALSE
299-W19-45	7/10/2016	Iron	N	184	µg/L		FALSE
299-W19-45	7/10/2016	Manganese	N	2.15	µg/L	B	FALSE
299-W19-45	7/10/2016	Nickel	N	1.5	µg/L	U	TRUE
299-W19-45	1/23/2017	Chromium	N	14.9	µg/L		FALSE
299-W19-45	1/23/2017	Iron	N	101	µg/L		FALSE
299-W19-45	1/23/2017	Manganese	N	2.26	µg/L	B	FALSE
299-W19-45	1/23/2017	Nickel	N	1.5	µg/L	U	TRUE
299-W19-45	7/5/2017	Chromium	N	19.9	µg/L		FALSE
299-W19-45	7/5/2017	Manganese	N	4.1	µg/L		FALSE
299-W19-45	7/5/2017	Nickel	N	2.6	µg/L	U	TRUE
299-W19-45	10/16/2017	Chromium	N	20.75	µg/L		FALSE
299-W19-45	10/16/2017	Nickel	N	2.6	µg/L	U	TRUE
299-W19-45	1/16/2018	Chromium	N	17.4	µg/L		FALSE
299-W19-45	1/16/2018	Iron	N	76.85	µg/L		FALSE
299-W19-45	1/16/2018	Manganese	N	2	µg/L	U	TRUE
299-W19-45	1/16/2018	Nickel	N	1.5	µg/L	U	TRUE
299-W19-45	4/12/2018	Chromium	N	18.9	µg/L		FALSE
299-W19-45	4/12/2018	Iron	N	105	µg/L		FALSE

Table B-1. Datasets for Well Corrosion Analysis at WMA U

Well Name	Sample Date	Analyte	Filtered	Result	Units	Laboratory Qualifier	Non-detect?
299-W19-45	4/12/2018	Manganese	N	2	µg/L	U	TRUE
299-W19-45	4/12/2018	Nickel	N	1.5	µg/L	U	TRUE
299-W19-45	6/15/2018	Chromium	N	23	µg/L		FALSE
299-W19-45	6/15/2018	Iron	N	30	µg/L	U	TRUE
299-W19-45	6/15/2018	Manganese	N	2	µg/L	U	TRUE
299-W19-45	6/15/2018	Nickel	N	1.5	µg/L	U	TRUE
299-W19-45	10/19/2018	Chromium	N	18.1	µg/L	C	FALSE
299-W19-45	10/19/2018	Iron	N	185	µg/L	C	FALSE
299-W19-45	10/19/2018	Manganese	N	3.9	µg/L	BC	FALSE
299-W19-45	10/19/2018	Nickel	N	2.6	µg/L	U	TRUE
299-W19-45	1/22/2019	Chromium	N	14.9	µg/L		FALSE
299-W19-45	1/22/2019	Iron	N	66.7	µg/L	B	FALSE
299-W19-45	1/22/2019	Manganese	N	2	µg/L	U	TRUE
299-W19-45	1/22/2019	Nickel	N	1.5	µg/L	U	TRUE
299-W19-45	4/12/2019	Chromium	N	19.6	µg/L		FALSE
299-W19-45	4/12/2019	Iron	N	113	µg/L		FALSE
299-W19-45	4/12/2019	Manganese	N	2	µg/L	U	TRUE
299-W19-45	4/12/2019	Nickel	N	1.5	µg/L	U	TRUE
299-W19-45	7/19/2019	Chromium	N	15.6	µg/L		FALSE
299-W19-45	7/19/2019	Iron	N	72.7	µg/L	B	FALSE
299-W19-45	7/19/2019	Manganese	N	2.96	µg/L	B	FALSE
299-W19-45	7/19/2019	Nickel	N	0.6	µg/L	U	TRUE
299-W19-45	10/9/2019	Chromium	N	17.333333	µg/L		FALSE
299-W19-45	10/9/2019	Iron	N	155	µg/L		FALSE
299-W19-45	10/9/2019	Manganese	N	3.15	µg/L		FALSE
299-W19-45	10/9/2019	Nickel	N	1.1	µg/L		FALSE
299-W19-47	1/6/2012	Chromium	N	47.8	µg/L		FALSE
299-W19-47	1/6/2012	Iron	N	267	µg/L		FALSE
299-W19-47	1/6/2012	Manganese	N	37.3	µg/L		FALSE
299-W19-47	1/6/2012	Nickel	N	4	µg/L	U	TRUE
299-W19-47	4/5/2012	Chromium	N	5.7	µg/L	B	FALSE
299-W19-47	4/5/2012	Iron	N	19	µg/L	U	TRUE

Table B-1. Datasets for Well Corrosion Analysis at WMA U

Well Name	Sample Date	Analyte	Filtered	Result	Units	Laboratory Qualifier	Non-detect?
299-W19-47	4/5/2012	Manganese	N	4	µg/L	U	TRUE
299-W19-47	4/5/2012	Nickel	N	4	µg/L	U	TRUE
299-W19-47	7/11/2012	Chromium	N	6.8175	µg/L		FALSE
299-W19-47	7/11/2012	Iron	N	19	µg/L	U	TRUE
299-W19-47	7/11/2012	Manganese	N	4	µg/L	U	TRUE
299-W19-47	7/11/2012	Nickel	N	4	µg/L	U	TRUE
299-W19-47	10/1/2012	Chromium	N	6.6	µg/L	B	FALSE
299-W19-47	10/1/2012	Iron	N	19	µg/L	U	TRUE
299-W19-47	10/1/2012	Manganese	N	4	µg/L	U	TRUE
299-W19-47	10/1/2012	Nickel	N	4	µg/L	U	TRUE
299-W19-47	2/27/2013	Chromium	N	6.6	µg/L	B	FALSE
299-W19-47	2/27/2013	Iron	N	48.9	µg/L	B	FALSE
299-W19-47	2/27/2013	Manganese	N	4	µg/L	U	TRUE
299-W19-47	2/27/2013	Nickel	N	4	µg/L	U	TRUE
299-W19-47	7/9/2013	Chromium	N	7.6	µg/L	B	FALSE
299-W19-47	7/9/2013	Iron	N	93.1	µg/L	B	FALSE
299-W19-47	7/9/2013	Manganese	N	4	µg/L	U	TRUE
299-W19-47	7/9/2013	Nickel	N	4	µg/L	U	TRUE
299-W19-47	1/17/2014	Chromium	N	6.03	µg/L		FALSE
299-W19-47	1/17/2014	Iron	N	65.95	µg/L		FALSE
299-W19-47	1/17/2014	Nickel	N	0.437	µg/L		FALSE
299-W19-47	7/11/2014	Chromium	N	5.4	µg/L	B	FALSE
299-W19-47	7/11/2014	Iron	N	137	µg/L		FALSE
299-W19-47	7/11/2014	Manganese	N	3.3	µg/L	B	FALSE
299-W19-47	7/11/2014	Nickel	N	5	µg/L	B	FALSE
299-W19-47	1/9/2015	Chromium	N	4.6	µg/L	B	FALSE
299-W19-47	1/9/2015	Iron	N	31.2	µg/L	B	FALSE
299-W19-47	1/9/2015	Manganese	N	2	µg/L	U	TRUE
299-W19-47	1/9/2015	Nickel	N	1.5	µg/L	U	TRUE
299-W19-47	7/10/2015	Chromium	N	5.84	µg/L		FALSE
299-W19-47	7/10/2015	Iron	N	334	µg/L		FALSE
299-W19-47	7/10/2015	Manganese	N	6.53	µg/L	B	FALSE

Table B-1. Datasets for Well Corrosion Analysis at WMA U

Well Name	Sample Date	Analyte	Filtered	Result	Units	Laboratory Qualifier	Non-detect?
299-W19-47	7/10/2015	Nickel	N	1.5	µg/L	U	TRUE
299-W19-47	1/15/2016	Chromium	N	4.49	µg/L	B	FALSE
299-W19-47	1/15/2016	Iron	N	115	µg/L		FALSE
299-W19-47	1/15/2016	Manganese	N	3.44	µg/L	B	FALSE
299-W19-47	1/15/2016	Nickel	N	1.5	µg/L	U	TRUE
299-W19-47	7/10/2016	Chromium	N	5.7	µg/L		FALSE
299-W19-47	7/10/2016	Iron	N	195	µg/L		FALSE
299-W19-47	7/10/2016	Manganese	N	4.2	µg/L	B	FALSE
299-W19-47	7/10/2016	Nickel	N	5.49	µg/L		FALSE
299-W19-47	1/23/2017	Chromium	N	5.06	µg/L		FALSE
299-W19-47	1/23/2017	Iron	N	138	µg/L		FALSE
299-W19-47	1/23/2017	Manganese	N	3.48	µg/L	B	FALSE
299-W19-47	1/23/2017	Nickel	N	2.36	µg/L	B	FALSE
299-W19-47	7/5/2017	Chromium	N	6.5	µg/L	B	FALSE
299-W19-47	7/5/2017	Iron	N	175	µg/L	C	FALSE
299-W19-47	7/5/2017	Manganese	N	7.4	µg/L	B	FALSE
299-W19-47	7/5/2017	Nickel	N	2.6	µg/L	U	TRUE
299-W19-47	10/15/2017	Chromium	N	7.6	µg/L	B	FALSE
299-W19-47	10/15/2017	Iron	N	370	µg/L		FALSE
299-W19-47	10/15/2017	Manganese	N	8.2	µg/L		FALSE
299-W19-47	10/15/2017	Nickel	N	2.9	µg/L	U	TRUE
299-W19-47	1/16/2018	Chromium	N	6.4	µg/L	B	FALSE
299-W19-47	1/16/2018	Iron	N	95.4	µg/L	B	FALSE
299-W19-47	1/16/2018	Manganese	N	3.2	µg/L	B	FALSE
299-W19-47	1/16/2018	Nickel	N	2.6	µg/L	U	TRUE
299-W19-47	4/12/2018	Chromium	N	6.2	µg/L	B	FALSE
299-W19-47	4/12/2018	Iron	N	210	µg/L		FALSE
299-W19-47	4/12/2018	Manganese	N	4.1	µg/L	B	FALSE
299-W19-47	4/12/2018	Nickel	N	1.1	µg/L	U	TRUE
299-W19-47	6/15/2018	Chromium	N	7.8	µg/L		FALSE
299-W19-47	6/15/2018	Manganese	N	5.45	µg/L		FALSE
299-W19-47	6/15/2018	Nickel	N	2.6	µg/L	U	TRUE

Table B-1. Datasets for Well Corrosion Analysis at WMA U

Well Name	Sample Date	Analyte	Filtered	Result	Units	Laboratory Qualifier	Non-detect?
299-W19-47	10/19/2018	Chromium	N	10.9	µg/L	C	FALSE
299-W19-47	10/19/2018	Iron	N	78.2	µg/L	BC	FALSE
299-W19-47	10/19/2018	Manganese	N	3.2	µg/L	BC	FALSE
299-W19-47	10/19/2018	Nickel	N	2.6	µg/L	U	TRUE
299-W19-47	1/22/2019	Chromium	N	10.4	µg/L		FALSE
299-W19-47	1/22/2019	Iron	N	31.4	µg/L	B	FALSE
299-W19-47	1/22/2019	Manganese	N	1.5	µg/L	B	FALSE
299-W19-47	1/22/2019	Nickel	N	2.6	µg/L	U	TRUE
299-W19-47	4/12/2019	Iron	N	59.8	µg/L	B	FALSE
299-W19-47	4/12/2019	Manganese	N	2.5	µg/L	B	FALSE
299-W19-47	4/12/2019	Nickel	N	2.6	µg/L	U	TRUE
299-W19-47	7/19/2019	Chromium	N	12.2	µg/L		FALSE
299-W19-47	7/19/2019	Iron	N	34.1	µg/L	B	FALSE
299-W19-47	7/19/2019	Manganese	N	1.49	µg/L	B	FALSE
299-W19-47	7/19/2019	Nickel	N	0.641	µg/L	B	FALSE
299-W19-47	10/10/2019	Chromium	N	11	µg/L		FALSE
299-W19-47	10/10/2019	Iron	N	65.1	µg/L	B	FALSE
299-W19-47	10/10/2019	Manganese	N	2	µg/L	U	TRUE
299-W19-47	10/10/2019	Nickel	N	1.5	µg/L	U	TRUE

Note: Cells without an entry for the laboratory qualifier column indicate that no qualifier was assigned to the data.

WMA = waste management area

Laboratory qualifiers:

B = The analyte was detected at a value less than the contract required detection limit, but greater than or equal to the instrument detection limit/method detection limit (as appropriate).

C = The analyte was detected in both the sample and the associated quality control blank, and the sample concentration was <= 5X the blank concentration.

D = Analyte was reported at a secondary dilution factor, typically dilution factor > 1 (i.e., the primary preparation required dilution to either bring the analyte within calibration range or to minimize interference).

N = Spike and/or spike duplicate sample recovery is outside control limits.

U = Analyzed for but not detected above limiting criteria. Limiting criteria may be any of the following: value reported less than 0; value reported less than counting error; value reported less than total analytical error; value reported less than or equal to the method detection limit/instrument detection limit/minimum detectable activity/practical quantitation limit.

Appendix C

Waste Management Area U Trend Analysis Datasets and Plots

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Figures

Figure C-1. WMA U Trend Plot for Well 299-W18-260 ..... C-1
Figure C-2. WMA U Trend Plot for Well 299-W19-41 ..... C-2
Figure C-3. WMA U Trend Plot for Well 299-W19-42 ..... C-3
Figure C-4. WMA U Trend Plot for Well 299-W19-44 ..... C-4
Figure C-5. WMA U Trend Plot for Well 299-W19-45 ..... C-5
Figure C-6. WMA U Trend Plot for Well 299-W19-47 ..... C-6

Table

Table C-1. Datasets for Trend Analysis at WMA U C-7

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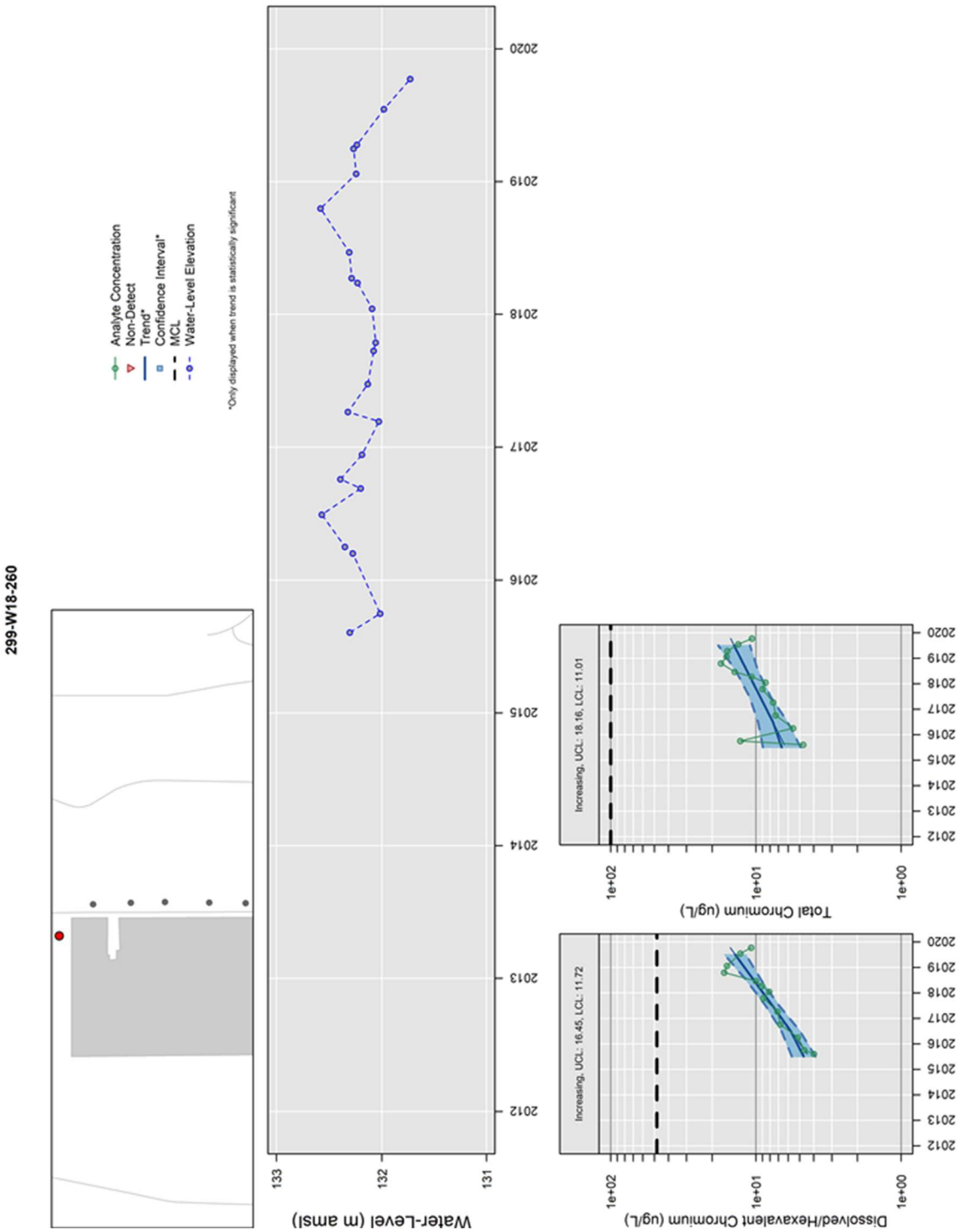

Figure C-1. WMA U Trend Plot for Well 299-W18-260

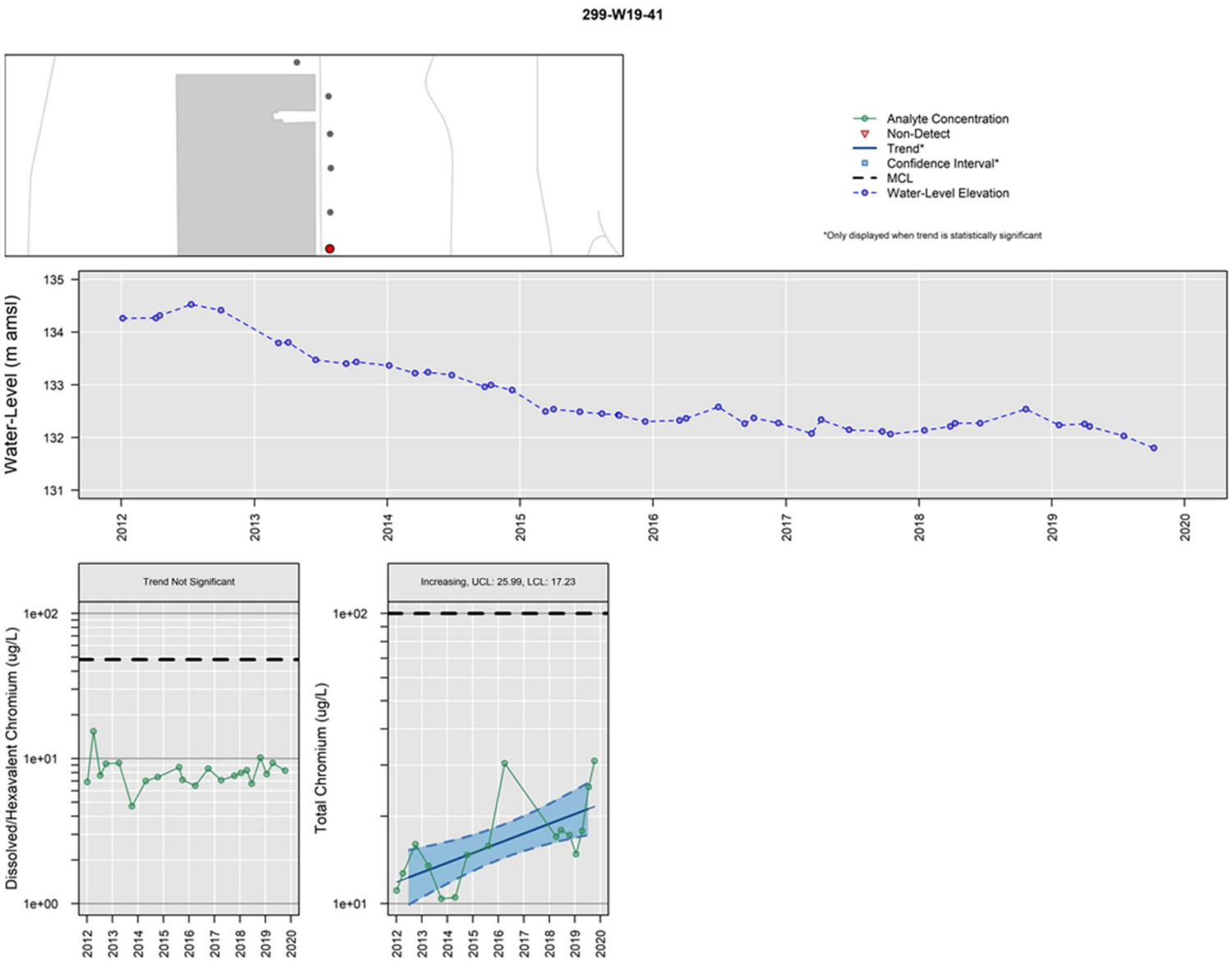

Figure C-2. WMA U Trend Plot for Well 299-W19-41

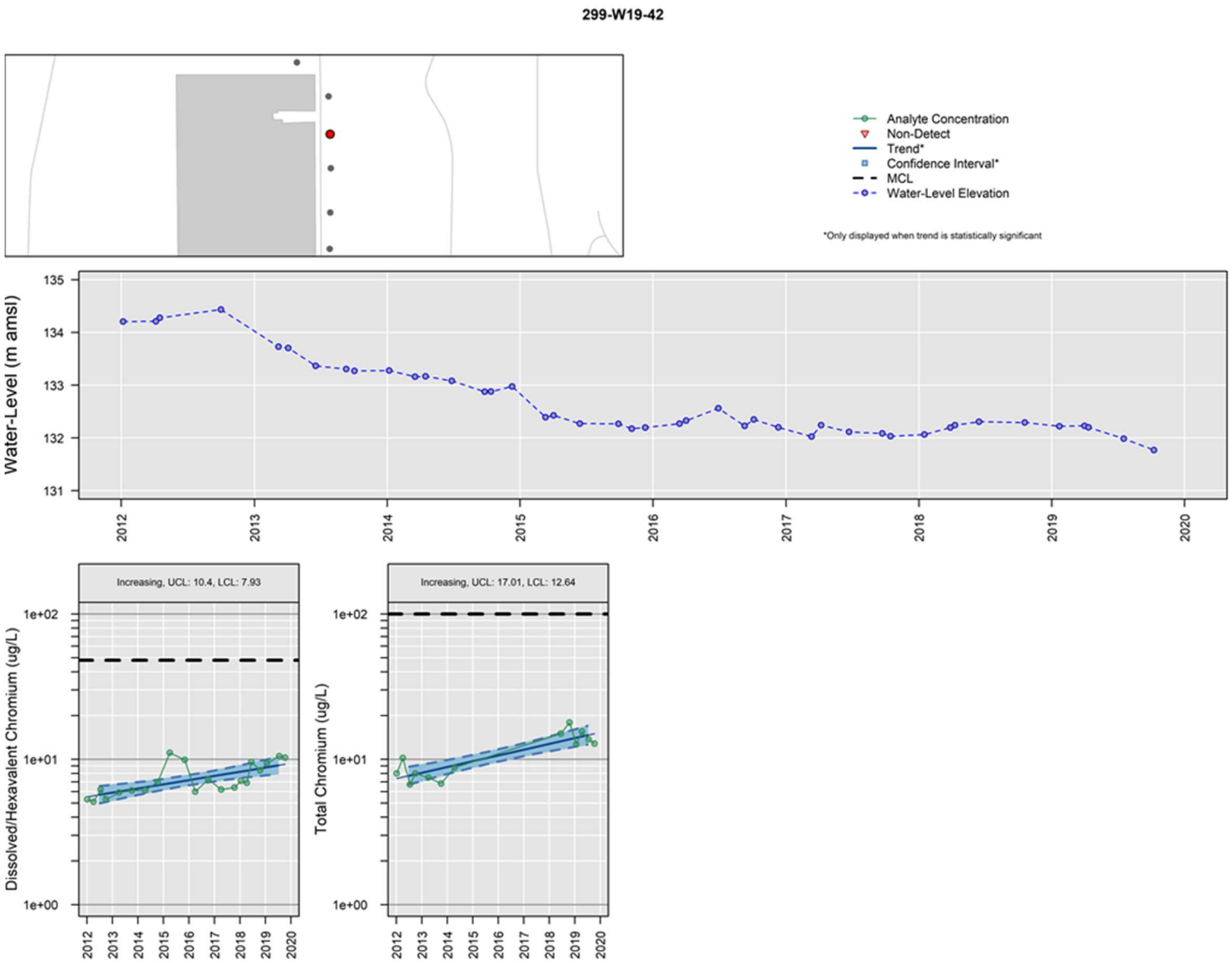

Figure C-3. WMA U Trend Plot for Well 299-W19-42

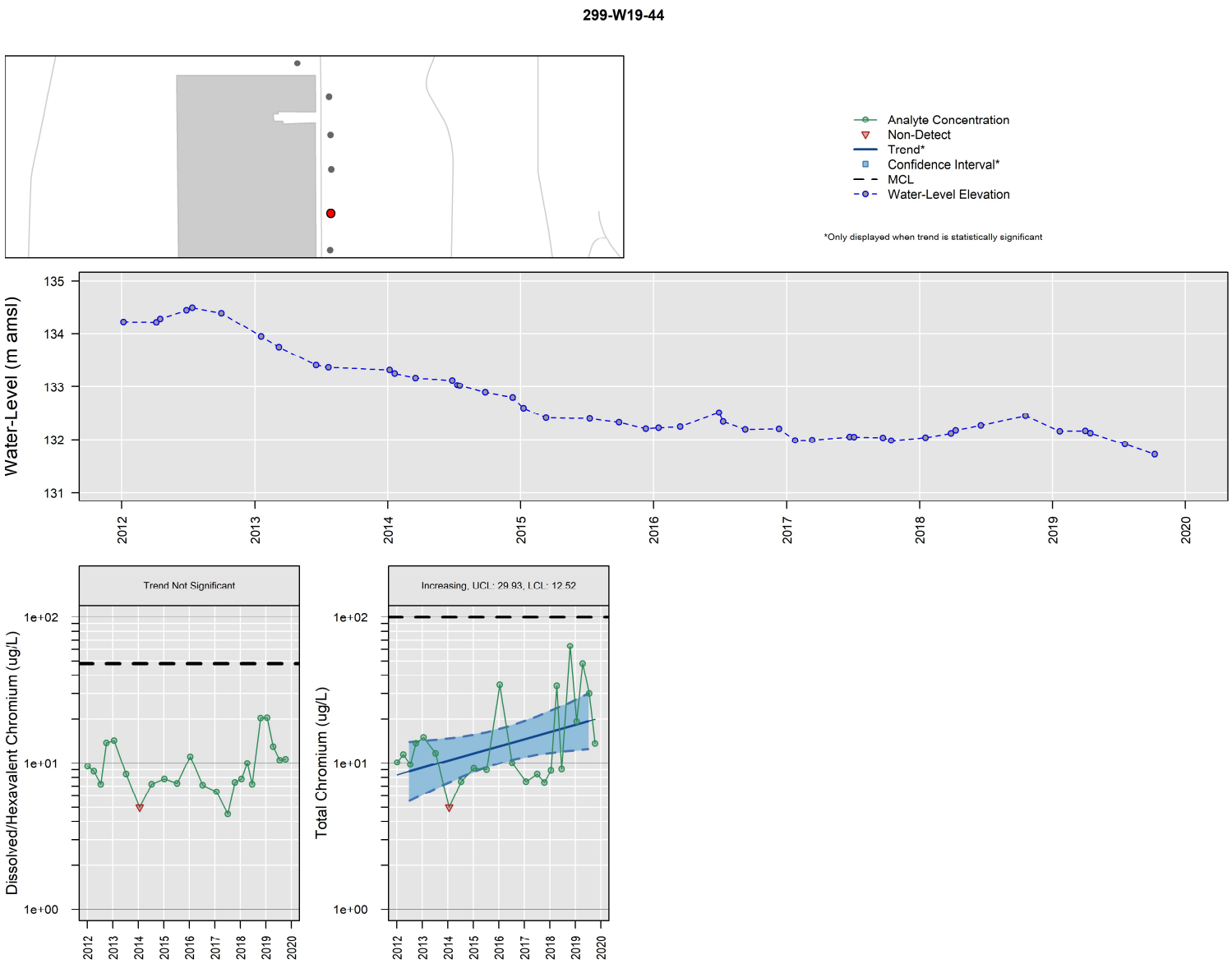

Figure C-4. WMA U Trend Plot for Well 299-W19-44

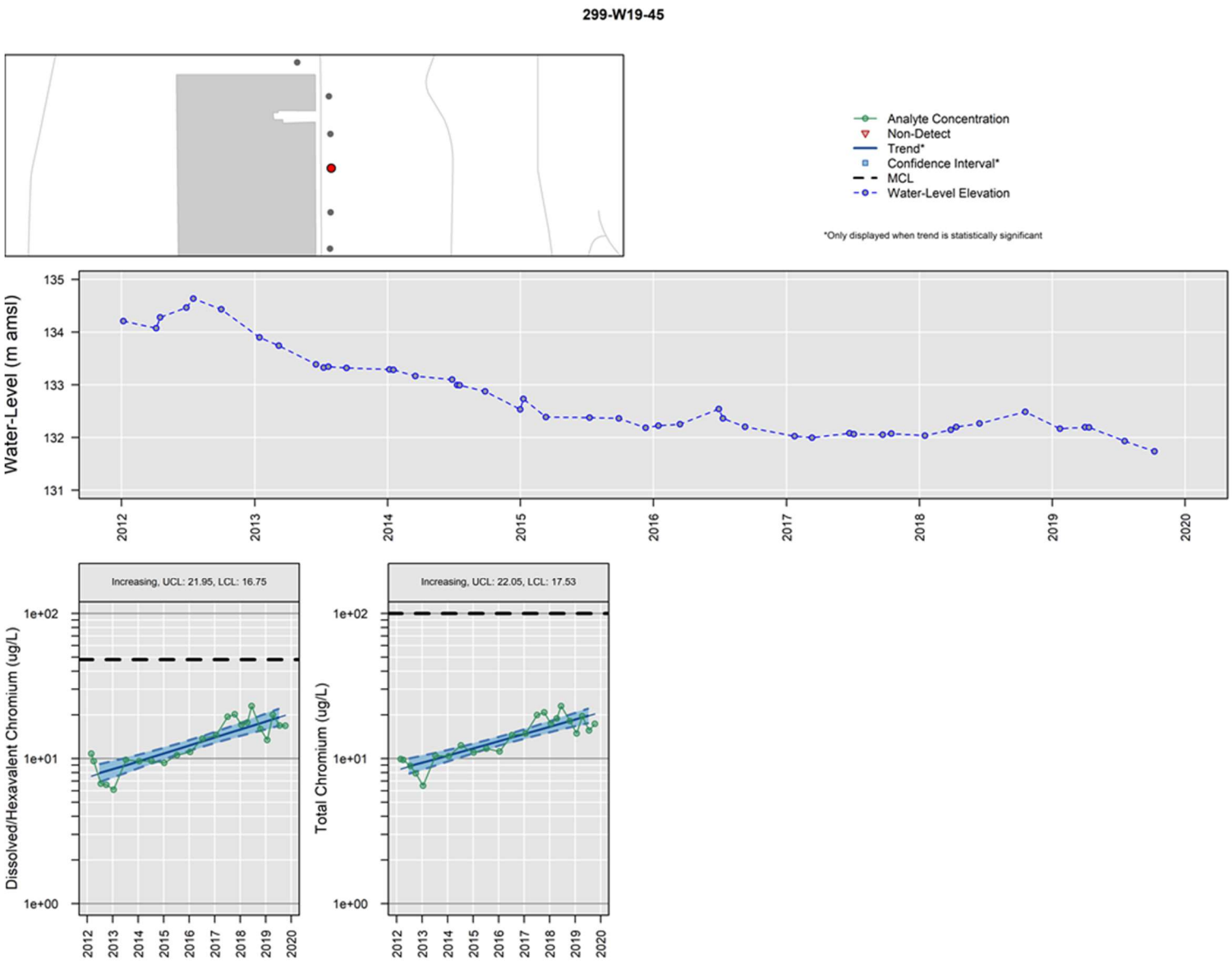

Figure C-5. WMA U Trend Plot for Well 299-W19-45

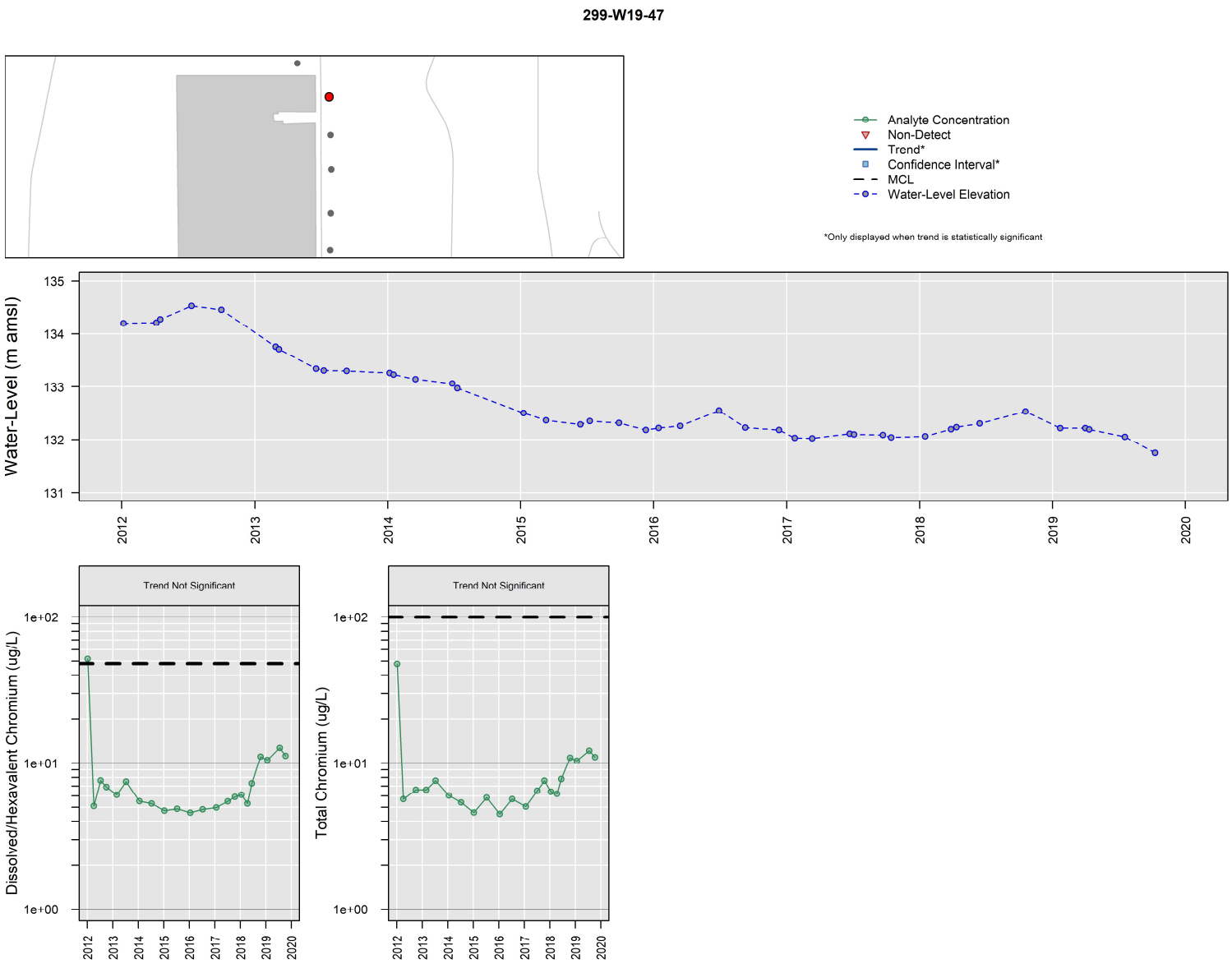

Figure C-6. WMA U Trend Plot for Well 299-W19-47

Table C-1. Datasets for Trend Analysis at WMA U

Well Name	Sample Date	Analyte	Result Used in Trend Analysis	Units	Laboratory Qualifier	Non-detect?
299-W18-260	8/10/2015	Dissolved/hexavalent chromium	3.99	µg/L	B	FALSE
299-W18-260	10/1/2015	Dissolved/hexavalent chromium	4.64	µg/L	B	FALSE
299-W18-260	4/1/2016	Dissolved/hexavalent chromium	5.15	µg/L		FALSE
299-W18-260	10/4/2016	Dissolved/hexavalent chromium	6.785	µg/L		FALSE
299-W18-260	4/7/2017	Dissolved/hexavalent chromium	7.1	µg/L	B	FALSE
299-W18-260	10/15/2017	Dissolved/hexavalent chromium	8.9	µg/L	B	FALSE
299-W18-260	1/16/2018	Dissolved/hexavalent chromium	8.1	µg/L	B	FALSE
299-W18-260	4/10/2018	Dissolved/hexavalent chromium	9.09	µg/L		FALSE
299-W18-260	6/20/2018	Dissolved/hexavalent chromium	10	µg/L		FALSE
299-W18-260	10/19/2018	Dissolved/hexavalent chromium	16.5	µg/L		FALSE
299-W18-260	1/22/2019	Dissolved/hexavalent chromium	15.8	µg/L		FALSE
299-W18-260	7/19/2019	Dissolved/hexavalent chromium	12.8	µg/L		FALSE
299-W18-260	10/10/2019	Dissolved/hexavalent chromium	10.76666667	µg/L		FALSE
299-W19-41	1/5/2012	Dissolved/hexavalent chromium	6.9	µg/L	B	FALSE
299-W19-41	4/5/2012	Dissolved/hexavalent chromium	15.4	µg/L	B	FALSE
299-W19-41	7/11/2012	Dissolved/hexavalent chromium	7.65	µg/L		FALSE
299-W19-41	10/1/2012	Dissolved/hexavalent chromium	9.2	µg/L	B	FALSE
299-W19-41	4/4/2013	Dissolved/hexavalent chromium	9.3	µg/L	B	FALSE
299-W19-41	10/8/2013	Dissolved/hexavalent chromium	4.7	µg/L		FALSE
299-W19-41	4/23/2014	Dissolved/hexavalent chromium	6.99	µg/L	B	FALSE
299-W19-41	10/13/2014	Dissolved/hexavalent chromium	7.44	µg/L		FALSE

Table C-1. Datasets for Trend Analysis at WMA U

Well Name	Sample Date	Analyte	Result Used in Trend Analysis	Units	Laboratory Qualifier	Non-detect?
299-W19-41	8/14/2015	Dissolved/hexavalent chromium	8.69	µg/L		FALSE
299-W19-41	10/1/2015	Dissolved/hexavalent chromium	7.115	µg/L		FALSE
299-W19-41	4/1/2016	Dissolved/hexavalent chromium	6.5	µg/L		FALSE
299-W19-41	10/4/2016	Dissolved/hexavalent chromium	8.52	µg/L		FALSE
299-W19-41	4/7/2017	Dissolved/hexavalent chromium	7.08	µg/L	C	FALSE
299-W19-41	10/15/2017	Dissolved/hexavalent chromium	7.6	µg/L	B	FALSE
299-W19-41	1/16/2018	Dissolved/hexavalent chromium	7.95	µg/L		FALSE
299-W19-41	4/10/2018	Dissolved/hexavalent chromium	8.28	µg/L		FALSE
299-W19-41	6/18/2018	Dissolved/hexavalent chromium	6.7	µg/L	B	FALSE
299-W19-41	10/22/2018	Dissolved/hexavalent chromium	10.1	µg/L		FALSE
299-W19-41	1/21/2019	Dissolved/hexavalent chromium	7.8	µg/L	B	FALSE
299-W19-41	4/15/2019	Dissolved/hexavalent chromium	9.3	µg/L	B	FALSE
299-W19-41	10/9/2019	Dissolved/hexavalent chromium	8.233333333	µg/L		FALSE
299-W19-42	1/6/2012	Dissolved/hexavalent chromium	5.3	µg/L	B	FALSE
299-W19-42	4/5/2012	Dissolved/hexavalent chromium	5.1	µg/L	B	FALSE
299-W19-42	7/16/2012	Dissolved/hexavalent chromium	6.2	µg/L	B	FALSE
299-W19-42	10/1/2012	Dissolved/hexavalent chromium	5.3	µg/L	B	FALSE
299-W19-42	4/4/2013	Dissolved/hexavalent chromium	5.9	µg/L	B	FALSE
299-W19-42	10/3/2013	Dissolved/hexavalent chromium	6.1	µg/L		FALSE
299-W19-42	4/16/2014	Dissolved/hexavalent chromium	6.11	µg/L	B	FALSE
299-W19-42	10/13/2014	Dissolved/hexavalent chromium	7	µg/L		FALSE

Table C-1. Datasets for Trend Analysis at WMA U

Well Name	Sample Date	Analyte	Result Used in Trend Analysis	Units	Laboratory Qualifier	Non-detect?
299-W19-42	4/3/2015	Dissolved/hexavalent chromium	11.1	µg/L		FALSE
299-W19-42	11/4/2015	Dissolved/hexavalent chromium	9.9	µg/L	BC	FALSE
299-W19-42	4/1/2016	Dissolved/hexavalent chromium	6	µg/L	B	FALSE
299-W19-42	10/4/2016	Dissolved/hexavalent chromium	7.3	µg/L	B	FALSE
299-W19-42	4/7/2017	Dissolved/hexavalent chromium	6.2	µg/L	B	FALSE
299-W19-42	10/15/2017	Dissolved/hexavalent chromium	6.4	µg/L	B	FALSE
299-W19-42	1/16/2018	Dissolved/hexavalent chromium	7.1	µg/L	B	FALSE
299-W19-42	4/10/2018	Dissolved/hexavalent chromium	6.9	µg/L	B	FALSE
299-W19-42	6/15/2018	Dissolved/hexavalent chromium	9.6	µg/L	B	FALSE
299-W19-42	10/19/2018	Dissolved/hexavalent chromium	8.4	µg/L	B	FALSE
299-W19-42	1/22/2019	Dissolved/hexavalent chromium	9.4	µg/L	B	FALSE
299-W19-42	7/18/2019	Dissolved/hexavalent chromium	10.51	µg/L		FALSE
299-W19-42	10/9/2019	Dissolved/hexavalent chromium	10.26666667	µg/L		FALSE
299-W19-44	1/6/2012	Dissolved/hexavalent chromium	9.5	µg/L	B	FALSE
299-W19-44	4/5/2012	Dissolved/hexavalent chromium	8.8	µg/L	B	FALSE
299-W19-44	7/13/2012	Dissolved/hexavalent chromium	7.2	µg/L	B	FALSE
299-W19-44	10/1/2012	Dissolved/hexavalent chromium	13.8	µg/L	B	FALSE
299-W19-44	1/18/2013	Dissolved/hexavalent chromium	14.3	µg/L	B	FALSE
299-W19-44	7/9/2013	Dissolved/hexavalent chromium	8.4	µg/L	B	FALSE
299-W19-44	1/20/2014	Dissolved/hexavalent chromium	5	µg/L	U	TRUE
299-W19-44	7/11/2014	Dissolved/hexavalent chromium	7.2	µg/L	B	FALSE

Table C-1. Datasets for Trend Analysis at WMA U

Well Name	Sample Date	Analyte	Result Used in Trend Analysis	Units	Laboratory Qualifier	Non-detect?
299-W19-44	1/9/2015	Dissolved/hexavalent chromium	7.8	µg/L		FALSE
299-W19-44	7/10/2015	Dissolved/hexavalent chromium	7.3	µg/L	B	FALSE
299-W19-44	1/15/2016	Dissolved/hexavalent chromium	11.1	µg/L		FALSE
299-W19-44	7/10/2016	Dissolved/hexavalent chromium	7.1	µg/L	B	FALSE
299-W19-44	1/24/2017	Dissolved/hexavalent chromium	6.4	µg/L	B	FALSE
299-W19-44	7/5/2017	Dissolved/hexavalent chromium	4.5	µg/L	B	FALSE
299-W19-44	10/15/2017	Dissolved/hexavalent chromium	7.4	µg/L	B	FALSE
299-W19-44	1/17/2018	Dissolved/hexavalent chromium	7.8	µg/L	B	FALSE
299-W19-44	4/10/2018	Dissolved/hexavalent chromium	10	µg/L		FALSE
299-W19-44	6/18/2018	Dissolved/hexavalent chromium	7.2	µg/L	B	FALSE
299-W19-44	10/19/2018	Dissolved/hexavalent chromium	20.3	µg/L	C	FALSE
299-W19-44	1/21/2019	Dissolved/hexavalent chromium	20.4	µg/L		FALSE
299-W19-44	4/15/2019	Dissolved/hexavalent chromium	13	µg/L		FALSE
299-W19-44	7/19/2019	Dissolved/hexavalent chromium	10.5	µg/L		FALSE
299-W19-44	10/9/2019	Dissolved/hexavalent chromium	10.68	µg/L		FALSE
299-W19-45	2/29/2012	Dissolved/hexavalent chromium	10.8	µg/L	B	FALSE
299-W19-45	4/5/2012	Dissolved/hexavalent chromium	9.6	µg/L	B	FALSE
299-W19-45	7/16/2012	Dissolved/hexavalent chromium	6.7	µg/L	B	FALSE
299-W19-45	10/1/2012	Dissolved/hexavalent chromium	6.6	µg/L	B	FALSE
299-W19-45	1/14/2013	Dissolved/hexavalent chromium	6.1	µg/L		FALSE
299-W19-45	7/9/2013	Dissolved/hexavalent chromium	9.8	µg/L		FALSE

Table C-1. Datasets for Trend Analysis at WMA U

Well Name	Sample Date	Analyte	Result Used in Trend Analysis	Units	Laboratory Qualifier	Non-detect?
299-W19-45	1/17/2014	Dissolved/hexavalent chromium	9.6	µg/L	B	FALSE
299-W19-45	7/11/2014	Dissolved/hexavalent chromium	9.62	µg/L	B	FALSE
299-W19-45	1/9/2015	Dissolved/hexavalent chromium	9.32	µg/L		FALSE
299-W19-45	7/10/2015	Dissolved/hexavalent chromium	10.55	µg/L		FALSE
299-W19-45	1/15/2016	Dissolved/hexavalent chromium	11.1	µg/L		FALSE
299-W19-45	7/10/2016	Dissolved/hexavalent chromium	13.7	µg/L		FALSE
299-W19-45	1/23/2017	Dissolved/hexavalent chromium	14.5	µg/L		FALSE
299-W19-45	7/5/2017	Dissolved/hexavalent chromium	19.4	µg/L		FALSE
299-W19-45	10/16/2017	Dissolved/hexavalent chromium	20.15	µg/L		FALSE
299-W19-45	1/16/2018	Dissolved/hexavalent chromium	17.05	µg/L		FALSE
299-W19-45	4/12/2018	Dissolved/hexavalent chromium	17.7	µg/L		FALSE
299-W19-45	6/15/2018	Dissolved/hexavalent chromium	23	µg/L		FALSE
299-W19-45	10/19/2018	Dissolved/hexavalent chromium	16	µg/L	C	FALSE
299-W19-45	1/22/2019	Dissolved/hexavalent chromium	13.4	µg/L		FALSE
299-W19-45	4/12/2019	Dissolved/hexavalent chromium	20	µg/L		FALSE
299-W19-45	7/19/2019	Dissolved/hexavalent chromium	16.85	µg/L		FALSE
299-W19-45	10/9/2019	Dissolved/hexavalent chromium	16.8	µg/L		FALSE
299-W19-47	1/6/2012	Dissolved/hexavalent chromium	51.8	µg/L		FALSE
299-W19-47	4/5/2012	Dissolved/hexavalent chromium	5.1	µg/L	B	FALSE
299-W19-47	7/11/2012	Dissolved/hexavalent chromium	7.633333333	µg/L		FALSE
299-W19-47	10/1/2012	Dissolved/hexavalent chromium	6.9	µg/L	B	FALSE

Table C-1. Datasets for Trend Analysis at WMA U

Well Name	Sample Date	Analyte	Result Used in Trend Analysis	Units	Laboratory Qualifier	Non-detect?
299-W19-47	2/27/2013	Dissolved/hexavalent chromium	6.1	µg/L	B	FALSE
299-W19-47	7/9/2013	Dissolved/hexavalent chromium	7.5	µg/L	B	FALSE
299-W19-47	1/17/2014	Dissolved/hexavalent chromium	5.51	µg/L		FALSE
299-W19-47	7/11/2014	Dissolved/hexavalent chromium	5.3	µg/L	B	FALSE
299-W19-47	1/9/2015	Dissolved/hexavalent chromium	4.74	µg/L	B	FALSE
299-W19-47	7/10/2015	Dissolved/hexavalent chromium	4.88	µg/L	B	FALSE
299-W19-47	1/15/2016	Dissolved/hexavalent chromium	4.58	µg/L	B	FALSE
299-W19-47	7/10/2016	Dissolved/hexavalent chromium	4.84	µg/L	B	FALSE
299-W19-47	1/23/2017	Dissolved/hexavalent chromium	4.98	µg/L	B	FALSE
299-W19-47	7/5/2017	Dissolved/hexavalent chromium	5.5	µg/L	B	FALSE
299-W19-47	10/15/2017	Dissolved/hexavalent chromium	5.9	µg/L	B	FALSE
299-W19-47	1/16/2018	Dissolved/hexavalent chromium	6.1	µg/L	B	FALSE
299-W19-47	4/12/2018	Dissolved/hexavalent chromium	5.3	µg/L	B	FALSE
299-W19-47	6/15/2018	Dissolved/hexavalent chromium	7.3	µg/L		FALSE
299-W19-47	10/19/2018	Dissolved/hexavalent chromium	11.1	µg/L	C	FALSE
299-W19-47	1/22/2019	Dissolved/hexavalent chromium	10.5	µg/L		FALSE
299-W19-47	7/19/2019	Dissolved/hexavalent chromium	12.75	µg/L		FALSE
299-W19-47	10/10/2019	Dissolved/hexavalent chromium	11.23333333	µg/L		FALSE
299-W18-260	8/10/2015	Total chromium	4.73	µg/L	B	FALSE
299-W18-260	10/1/2015	Total chromium	12.8	µg/L		FALSE
299-W18-260	4/1/2016	Total chromium	5.54	µg/L		FALSE
299-W18-260	10/4/2016	Total chromium	7.31	µg/L		FALSE
299-W18-260	4/7/2017	Total chromium	7.6	µg/L	B	FALSE

Table C-1. Datasets for Trend Analysis at WMA U

Well Name	Sample Date	Analyte	Result Used in Trend Analysis	Units	Laboratory Qualifier	Non-detect?
299-W18-260	10/15/2017	Total chromium	9	µg/L	B	FALSE
299-W18-260	1/16/2018	Total chromium	8.6	µg/L	B	FALSE
299-W18-260	4/10/2018	Total chromium	10.7	µg/L		FALSE
299-W18-260	6/20/2018	Total chromium	14	µg/L		FALSE
299-W18-260	10/19/2018	Total chromium	17.4	µg/L		FALSE
299-W18-260	1/22/2019	Total chromium	15.9	µg/L		FALSE
299-W18-260	4/12/2019	Total chromium	15.7	µg/L		FALSE
299-W18-260	7/19/2019	Total chromium	13.2	µg/L	D	FALSE
299-W18-260	10/10/2019	Total chromium	10.65	µg/L		FALSE
299-W19-41	1/5/2012	Total chromium	11.1	µg/L	B	FALSE
299-W19-41	4/5/2012	Total chromium	12.7	µg/L	B	FALSE
299-W19-41	10/1/2012	Total chromium	16	µg/L	B	FALSE
299-W19-41	4/4/2013	Total chromium	13.5	µg/L	B	FALSE
299-W19-41	10/8/2013	Total chromium	10.4	µg/L	DC	FALSE
299-W19-41	4/23/2014	Total chromium	10.5	µg/L		FALSE
299-W19-41	10/13/2014	Total chromium	14.7	µg/L		FALSE
299-W19-41	8/14/2015	Total chromium	15.8	µg/L		FALSE
299-W19-41	4/1/2016	Total chromium	30.4	µg/L		FALSE
299-W19-41	4/10/2018	Total chromium	17	µg/L		FALSE
299-W19-41	6/18/2018	Total chromium	17.9	µg/L		FALSE
299-W19-41	10/22/2018	Total chromium	17.2	µg/L		FALSE
299-W19-41	1/21/2019	Total chromium	14.8	µg/L		FALSE
299-W19-41	4/15/2019	Total chromium	17.8	µg/L		FALSE
299-W19-41	7/18/2019	Total chromium	25.2	µg/L		FALSE
299-W19-41	10/9/2019	Total chromium	31	µg/L		FALSE
299-W19-42	1/6/2012	Total chromium	8	µg/L	B	FALSE
299-W19-42	4/5/2012	Total chromium	10.2	µg/L	B	FALSE
299-W19-42	7/16/2012	Total chromium	6.7	µg/L	B	FALSE
299-W19-42	10/1/2012	Total chromium	8	µg/L	B	FALSE
299-W19-42	4/4/2013	Total chromium	7.5	µg/L	B	FALSE
299-W19-42	10/3/2013	Total chromium	6.8	µg/L		FALSE
299-W19-42	4/16/2014	Total chromium	8.78	µg/L	B	FALSE
299-W19-42	6/15/2018	Total chromium	15	µg/L		FALSE

Table C-1. Datasets for Trend Analysis at WMA U

Well Name	Sample Date	Analyte	Result Used in Trend Analysis	Units	Laboratory Qualifier	Non-detect?
299-W19-42	10/19/2018	Total chromium	17.9	µg/L		FALSE
299-W19-42	1/22/2019	Total chromium	12.7	µg/L		FALSE
299-W19-42	4/12/2019	Total chromium	15.5	µg/L		FALSE
299-W19-42	7/18/2019	Total chromium	13.7	µg/L		FALSE
299-W19-42	10/9/2019	Total chromium	12.85	µg/L		FALSE
299-W19-44	1/6/2012	Total chromium	10.1	µg/L	B	FALSE
299-W19-44	4/5/2012	Total chromium	11.5	µg/L	B	FALSE
299-W19-44	7/13/2012	Total chromium	9.8	µg/L	B	FALSE
299-W19-44	10/1/2012	Total chromium	13.7	µg/L	B	FALSE
299-W19-44	1/18/2013	Total chromium	15	µg/L	B	FALSE
299-W19-44	7/9/2013	Total chromium	11.7	µg/L	B	FALSE
299-W19-44	1/20/2014	Total chromium	5	µg/L	U	TRUE
299-W19-44	7/11/2014	Total chromium	7.5	µg/L	B	FALSE
299-W19-44	1/9/2015	Total chromium	9.2	µg/L		FALSE
299-W19-44	7/10/2015	Total chromium	9	µg/L	B	FALSE
299-W19-44	1/15/2016	Total chromium	34.2	µg/L		FALSE
299-W19-44	7/10/2016	Total chromium	10	µg/L		FALSE
299-W19-44	1/24/2017	Total chromium	7.5	µg/L	B	FALSE
299-W19-44	7/5/2017	Total chromium	8.4	µg/L	B	FALSE
299-W19-44	10/15/2017	Total chromium	7.4	µg/L	B	FALSE
299-W19-44	1/17/2018	Total chromium	8.9	µg/L	B	FALSE
299-W19-44	4/10/2018	Total chromium	33.7	µg/L		FALSE
299-W19-44	6/18/2018	Total chromium	9.1	µg/L	B	FALSE
299-W19-44	10/19/2018	Total chromium	63.5	µg/L		FALSE
299-W19-44	1/21/2019	Total chromium	19.2	µg/L		FALSE
299-W19-44	4/15/2019	Total chromium	48	µg/L		FALSE
299-W19-44	7/19/2019	Total chromium	30	µg/L		FALSE
299-W19-44	10/9/2019	Total chromium	13.65	µg/L		FALSE
299-W19-45	2/29/2012	Total chromium	9.9	µg/L	B	FALSE
299-W19-45	4/5/2012	Total chromium	9.8	µg/L	B	FALSE
299-W19-45	7/16/2012	Total chromium	8.9	µg/L	B	FALSE
299-W19-45	10/1/2012	Total chromium	7.9	µg/L	B	FALSE
299-W19-45	1/14/2013	Total chromium	6.5	µg/L		FALSE

Table C-1. Datasets for Trend Analysis at WMA U

Well Name	Sample Date	Analyte	Result Used in Trend Analysis	Units	Laboratory Qualifier	Non-detect?
299-W19-45	7/9/2013	Total chromium	10.45	µg/L		FALSE
299-W19-45	1/17/2014	Total chromium	10.4	µg/L		FALSE
299-W19-45	7/11/2014	Total chromium	12.3	µg/L		FALSE
299-W19-45	1/9/2015	Total chromium	11	µg/L		FALSE
299-W19-45	7/10/2015	Total chromium	11.7	µg/L		FALSE
299-W19-45	1/15/2016	Total chromium	11.2	µg/L		FALSE
299-W19-45	7/10/2016	Total chromium	14.5	µg/L		FALSE
299-W19-45	1/23/2017	Total chromium	14.9	µg/L		FALSE
299-W19-45	7/5/2017	Total chromium	19.9	µg/L		FALSE
299-W19-45	10/16/2017	Total chromium	20.75	µg/L		FALSE
299-W19-45	1/16/2018	Total chromium	17.4	µg/L		FALSE
299-W19-45	4/12/2018	Total chromium	18.9	µg/L		FALSE
299-W19-45	6/15/2018	Total chromium	23	µg/L		FALSE
299-W19-45	10/19/2018	Total chromium	18.1	µg/L	C	FALSE
299-W19-45	1/22/2019	Total chromium	14.9	µg/L		FALSE
299-W19-45	4/12/2019	Total chromium	19.6	µg/L		FALSE
299-W19-45	7/19/2019	Total chromium	15.6	µg/L		FALSE
299-W19-45	10/9/2019	Total chromium	17.33333333	µg/L		FALSE
299-W19-47	1/6/2012	Total chromium	47.8	µg/L		FALSE
299-W19-47	4/5/2012	Total chromium	5.7	µg/L	B	FALSE
299-W19-47	10/1/2012	Total chromium	6.6	µg/L	B	FALSE
299-W19-47	2/27/2013	Total chromium	6.6	µg/L	B	FALSE
299-W19-47	7/9/2013	Total chromium	7.6	µg/L	B	FALSE
299-W19-47	1/17/2014	Total chromium	6.03	µg/L		FALSE
299-W19-47	7/11/2014	Total chromium	5.4	µg/L	B	FALSE
299-W19-47	1/9/2015	Total chromium	4.6	µg/L	B	FALSE
299-W19-47	7/10/2015	Total chromium	5.84	µg/L		FALSE
299-W19-47	1/15/2016	Total chromium	4.49	µg/L	B	FALSE
299-W19-47	7/10/2016	Total chromium	5.7	µg/L		FALSE
299-W19-47	1/23/2017	Total chromium	5.06	µg/L		FALSE
299-W19-47	7/5/2017	Total chromium	6.5	µg/L	B	FALSE
299-W19-47	10/15/2017	Total chromium	7.6	µg/L	B	FALSE
299-W19-47	1/16/2018	Total chromium	6.4	µg/L	B	FALSE

Table C-1. Datasets for Trend Analysis at WMA U

Well Name	Sample Date	Analyte	Result Used in Trend Analysis	Units	Laboratory Qualifier	Non-detect?
299-W19-47	4/12/2018	Total chromium	6.2	µg/L	B	FALSE
299-W19-47	6/15/2018	Total chromium	7.8	µg/L		FALSE
299-W19-47	10/19/2018	Total chromium	10.9	µg/L	C	FALSE
299-W19-47	1/22/2019	Total chromium	10.4	µg/L		FALSE
299-W19-47	7/19/2019	Total chromium	12.2	µg/L		FALSE
299-W19-47	10/10/2019	Total chromium	11	µg/L		FALSE

Note: Cells without an entry for the laboratory qualifier column indicate that no qualifier was assigned to the data.

WMA = waste management area

Laboratory qualifiers:

B = The analyte was detected at a value less than the contract required detection limit, but greater than or equal to the instrument detection limit/method detection limit (as appropriate).

C = The analyte was detected in both the sample and the associated quality control blank, and the sample concentration was <= 5X the blank concentration.

D = Analyte was reported at a secondary dilution factor, typically dilution factor > 1 (i.e., the primary preparation required dilution to either bring the analyte within calibration range or to minimize interference).

U = Analyzed for but not detected above limiting criteria. Limiting criteria may be any of the following: value reported less than 0; value reported less than counting error; value reported less than total analytical error; value reported less than or equal to the method detection limit/instrument detection limit/minimum detectable activity/practical quantitation limit.

Appendix D

Waste Management Area U ProUCL Datasets and Results

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Tables

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Table D-3. WMA U ProUCL Total Chromium Results D-8

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Table D-1. Dataset for WMA U ProUCL Calculations

Well Name	Sample Date	Analyte	Reported Value	Units	Qualifier	ProUCL Nondetect Identification*
299-W19-41	10/15/2017	Dissolved/hexavalent chromium	7.6	µg/L	B	1
299-W19-41	1/16/2018	Dissolved/hexavalent chromium	7.95	µg/L		1
299-W19-41	4/10/2018	Dissolved/hexavalent chromium	8.28	µg/L		1
299-W19-41	6/18/2018	Dissolved/hexavalent chromium	6.7	µg/L	B	1
299-W19-41	10/22/2018	Dissolved/hexavalent chromium	10.1	µg/L		1
299-W19-41	1/21/2019	Dissolved/hexavalent chromium	7.8	µg/L	B	1
299-W19-41	4/15/2019	Dissolved/hexavalent chromium	9.3	µg/L	B	1
299-W19-41	10/9/2019	Dissolved/hexavalent chromium	8.23333333	µg/L	B	1
299-W19-44	1/17/2018	Dissolved/hexavalent chromium	7.8	µg/L	B	1
299-W19-44	4/10/2018	Dissolved/hexavalent chromium	10	µg/L		1
299-W19-44	6/18/2018	Dissolved/hexavalent chromium	7.2	µg/L	B	1
299-W19-44	10/19/2018	Dissolved/hexavalent chromium	20.3	µg/L	C	1
299-W19-44	1/21/2019	Dissolved/hexavalent chromium	20.4	µg/L		1
299-W19-44	4/15/2019	Dissolved/hexavalent chromium	13	µg/L		1
299-W19-44	7/19/2019	Dissolved/hexavalent chromium	10.5	µg/L	B	1
299-W19-44	10/9/2019	Dissolved/hexavalent chromium	10.68	µg/L		1
299-W19-47	10/15/2017	Dissolved/hexavalent chromium	5.9	µg/L	B	1
299-W19-47	1/16/2018	Dissolved/hexavalent chromium	6.1	µg/L	B	1
299-W19-47	4/12/2018	Dissolved/hexavalent chromium	5.3	µg/L	B	1
299-W19-47	6/15/2018	Dissolved/hexavalent chromium	7.3	µg/L	B	1
299-W19-47	10/19/2018	Dissolved/hexavalent chromium	11.1	µg/L	C	1
299-W19-47	1/22/2019	Dissolved/hexavalent chromium	10.5	µg/L		1
299-W19-47	7/19/2019	Dissolved/hexavalent chromium	12.75	µg/L		1
299-W19-47	10/10/2019	Dissolved/hexavalent chromium	11.2333333	µg/L		1
299-W19-47	10/15/2017	Total chromium	7.6	µg/L	B	1
299-W19-47	1/16/2018	Total chromium	6.4	µg/L	B	1
299-W19-47	4/12/2018	Total chromium	6.2	µg/L	B	1
299-W19-47	6/15/2018	Total chromium	7.8	µg/L	B	1
299-W19-47	10/19/2018	Total chromium	10.9	µg/L	C	1
299-W19-47	1/22/2019	Total chromium	10.4	µg/L		1
299-W19-47	7/19/2019	Total chromium	12.2	µg/L		1

Table D-1. Dataset for WMA U ProUCL Calculations

Well Name	Sample Date	Analyte	Reported Value	Units	Qualifier	ProUCL Nondetect Identification*
299-W19-47	10/10/2019	Total chromium	11	µg/L		1

Note: Cells without an entry for the laboratory qualifier column indicate that no qualifier was assigned to the data.

*Value used in ProUCL to identify non-detects (0) and detected values (1).

WMA = waste management area

Laboratory qualifiers:

B = The analyte was detected at a value less than the contract required detection limit, but greater than or equal to the instrument detection limit/method detection limit (as appropriate).

C = The analyte was detected in both the sample and the associated quality control blank, and the sample concentration was <= 5X the blank concentration.

Table D-2. WMA U ProUCL Hexavalent Chromium Results

	A	B	C	D	E	F	G	H	I	J	K	L
1	**UCL Statistics for Data Sets with Non-Detects**											
3	User Selected Options											
4	Date/Time of Computation			ProUCL 5.12/11/2020 10:37:37 AM								
5	From File			ProUCL_Datasets_01152020 - WMA U_c.xls								
6	Full Precision			OFF								
7	Confidence Coefficient			95%								
8	Number of Bootstrap Operations			2000								
9												
10												
11	**VAL (299-w19-41)**											
12												
13	**General Statistics**											
14	Total Number of Observations					8	Number of Distinct Observations					8
15							Number of Missing Observations					0
16	Minimum					6.7	Mean					8.245
17	Maximum					10.1	Median					8.092
18	SD					1.045	Std. Error of Mean					0.369
19	Coefficient of Variation					0.127	Skewness					0.581
20												
21	**Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use**											
22	**guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.**											
23	**For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).**											
24	**Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.1**											
25												
26	**Normal GOF Test**											
27	Shapiro Wilk Test Statistic					0.95	**Shapiro Wilk GOF Test**					
28	5% Shapiro Wilk Critical Value					0.818	Data appear Normal at 5% Significance Level					
29	Lilliefors Test Statistic					0.237	**Lilliefors GOF Test**					
30	5% Lilliefors Critical Value					0.283	Data appear Normal at 5% Significance Level					
31	**Data appear Normal at 5% Significance Level**											
32												
33	**Assuming Normal Distribution**											
34	**95% Normal UCL**						**95% UCLs (Adjusted for Skewness)**					
35	95% Student's-t UCL					8.945	95% Adjusted-CLT UCL (Chen-1995)					8.934
36							95% Modified-t UCL (Johnson-1978)					8.958
37												
38	**Gamma GOF Test**											
39	A-D Test Statistic					0.287	**Anderson-Darling Gamma GOF Test**					
40	5% A-D Critical Value					0.715	Detected data appear Gamma Distributed at 5% Significance Level					
41	K-S Test Statistic					0.22	**Kolmogorov-Smirnov Gamma GOF Test**					
42	5% K-S Critical Value					0.293	Detected data appear Gamma Distributed at 5% Significance Level					
43	**Detected data appear Gamma Distributed at 5% Significance Level**											
44												
45	**Gamma Statistics**											
46	k hat (MLE)					72.73	k star (bias corrected MLE)					45.54
47	Theta hat (MLE)					0.113	Theta star (bias corrected MLE)					0.181
48	nu hat (MLE)					1164	nu star (bias corrected)					728.6
49	MLE Mean (bias corrected)					8.245	MLE Sd (bias corrected)					1.222
50							Approximate Chi Square Value (0.05)					667
51	Adjusted Level of Significance					0.0195	Adjusted Chi Square Value					652
52												
53	**Assuming Gamma Distribution**											

Table D-2. WMA U ProUCL Hexavalent Chromium Results

	A	B	C	D	E	F	G			H	I	J	K	L
54			95% Approximate Gamma UCL (use when n>=50))			9.007				95% Adjusted Gamma UCL (use when n<50)				9.215
55														
56			**Lognormal GOF Test**											
57			Shapiro Wilk Test Statistic			0.963				**Shapiro Wilk Lognormal GOF Test**				
58			5% Shapiro Wilk Critical Value			0.818				Data appear Lognormal at 5% Significance Level				
59			Lilliefors Test Statistic			0.215				**Lilliefors Lognormal GOF Test**				
60			5% Lilliefors Critical Value			0.283				Data appear Lognormal at 5% Significance Level				
61			**Data appear Lognormal at 5% Significance Level**											
62														
63			**Lognormal Statistics**											
64			Minimum of Logged Data			1.902				Mean of logged Data				2.103
65			Maximum of Logged Data			2.313				SD of logged Data				0.125
66														
67			**Assuming Lognormal Distribution**											
68			95% H-UCL			9.016				90% Chebyshev (MVUE) UCL				9.339
69			95% Chebyshev (MVUE) UCL			9.835				97.5% Chebyshev (MVUE) UCL				10.52
70			99% Chebyshev (MVUE) UCL			11.87								
71														
72			**Nonparametric Distribution Free UCL Statistics**											
73			**Data appear to follow a Discernible Distribution at 5% Significance Level**											
74														
75			**Nonparametric Distribution Free UCLs**											
76			95% CLT UCL			8.853				95% Jackknife UCL				8.945
77			95% Standard Bootstrap UCL			8.802				95% Bootstrap-t UCL				9.267
78			95% Hall's Bootstrap UCL			9.976				95% Percentile Bootstrap UCL				8.839
79			95% BCA Bootstrap UCL			8.942								
80			90% Chebyshev(Mean, Sd) UCL			9.354				95% Chebyshev(Mean, Sd) UCL				9.856
81			97.5% Chebyshev(Mean, Sd) UCL			10.55				99% Chebyshev(Mean, Sd) UCL				11.92
82														
83			**Suggested UCL to Use**											
84			95% Student's-t UCL			8.945								
85														
86			Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
87			Recommendations are based upon data size, data distribution, and skewness.											
88			These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
89			However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
90														
91														
92			**VAL (299-w19-44)**											
93														
94			**General Statistics**											
95			Total Number of Observations			8				Number of Distinct Observations				8
96										Number of Missing Observations				0
97			Minimum			7.2				Mean				12.49
98			Maximum			20.4				Median				10.59
99			SD			5.172				Std. Error of Mean				1.829
100			Coefficient of Variation			0.414				Skewness				0.955
101														
102			**Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use**											
103			**guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.**											
104			**For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).**											
105			**Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.1**											

Table D-2. WMA U ProUCL Hexavalent Chromium Results

	A	B	C	D	E	F	G	H	I	J	K	L
107						Normal GOF Test						
108					Shapiro Wilk Test Statistic	0.831	Shapiro Wilk GOF Test					
109					5% Shapiro Wilk Critical Value	0.818	Data appear Normal at 5% Significance Level					
110					Lilliefors Test Statistic	0.261	Lilliefors GOF Test					
111					5% Lilliefors Critical Value	0.283	Data appear Normal at 5% Significance Level					
112					Data appear Normal at 5% Significance Level							
113												
114					Assuming Normal Distribution							
115			95% Normal UCL				95% UCLs (Adjusted for Skewness)					
116					95% Student's-t UCL	15.95			95% Adjusted-CLT UCL (Chen-1995)			16.15
117									95% Modified-t UCL (Johnson-1978)			16.05
118												
119					Gamma GOF Test							
120					A-D Test Statistic	0.504	Anderson-Darling Gamma GOF Test					
121					5% A-D Critical Value	0.717	Detected data appear Gamma Distributed at 5% Significance Level					
122					K-S Test Statistic	0.239	Kolmogorov-Smirnov Gamma GOF Test					
123					5% K-S Critical Value	0.295	Detected data appear Gamma Distributed at 5% Significance Level					
124					Detected data appear Gamma Distributed at 5% Significance Level							
125												
126					Gamma Statistics							
127					k hat (MLE)	7.375			k star (bias corrected MLE)			4.693
128					Theta hat (MLE)	1.693			Theta star (bias corrected MLE)			2.66
129					nu hat (MLE)	118			nu star (bias corrected)			75.09
130					MLE Mean (bias corrected)	12.49			MLE Sd (bias corrected)			5.763
131									Approximate Chi Square Value (0.05)			56.13
132					Adjusted Level of Significance	0.0195			Adjusted Chi Square Value			52
133												
134					Assuming Gamma Distribution							
135					95% Approximate Gamma UCL (use when n>=50))	16.7			95% Adjusted Gamma UCL (use when n<50)			18.03
136												
137					Lognormal GOF Test							
138					Shapiro Wilk Test Statistic	0.898	Shapiro Wilk Lognormal GOF Test					
139					5% Shapiro Wilk Critical Value	0.818	Data appear Lognormal at 5% Significance Level					
140					Lilliefors Test Statistic	0.213	Lilliefors Lognormal GOF Test					
141					5% Lilliefors Critical Value	0.283	Data appear Lognormal at 5% Significance Level					
142					Data appear Lognormal at 5% Significance Level							
143												
144					Lognormal Statistics							
145					Minimum of Logged Data	1.974			Mean of logged Data			2.455
146					Maximum of Logged Data	3.016			SD of logged Data			0.391
147												
148					Assuming Lognormal Distribution							
149					95% H-UCL	17.35			90% Chebyshev (MVUE) UCL			17.64
150					95% Chebyshev (MVUE) UCL	19.99			97.5% Chebyshev (MVUE) UCL			23.26
151					99% Chebyshev (MVUE) UCL	29.67						
153					Nonparametric Distribution Free UCL Statistics							
154					Data appear to follow a Discernible Distribution at 5% Significance Level							
155												
156					Nonparametric Distribution Free UCLs							
157					95% CLT UCL	15.49			95% Jackknife UCL			15.95
158					95% Standard Bootstrap UCL	15.23			95% Bootstrap-t UCL			19.62
159					95% Hall's Bootstrap UCL	37.92			95% Percentile Bootstrap UCL			15.37

Table D-2. WMA U ProUCL Hexavalent Chromium Results

	A	B	C	D	E	F	G	H	I	J	K	L
160					95% BCA Bootstrap UCL	15.85						
161					90% Chebyshev(Mean, Sd) UCL	17.97				95% Chebyshev(Mean, Sd) UCL		20.46
162					97.5% Chebyshev(Mean, Sd) UCL	23.9				99% Chebyshev(Mean, Sd) UCL		30.68
163												
164					**Suggested UCL to Use**							
165					95% Student's-t UCL	15.95						
166												
167					Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.							
168					Recommendations are based upon data size, data distribution, and skewness.							
169					These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).							
170					However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.							
172												
173	**VAL (299-w19-47)**											
174												
175					**General Statistics**							
176					Total Number of Observations	8				Number of Distinct Observations		8
177										Number of Missing Observations		0
178					Minimum	5.3				Mean		8.773
179					Maximum	12.75				Median		8.9
180					SD	2.925				Std. Error of Mean		1.034
181					Coefficient of Variation	0.333				Skewness		0.0583
182												
183					**Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use**							
184					**guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.**							
185					**For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).**							
186					**Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.1**							
187												
188					**Normal GOF Test**							
189					Shapiro Wilk Test Statistic	0.877				**Shapiro Wilk GOF Test**		
190					5% Shapiro Wilk Critical Value	0.818				Data appear Normal at 5% Significance Level		
191					Lilliefors Test Statistic	0.223				**Lilliefors GOF Test**		
192					5% Lilliefors Critical Value	0.283				Data appear Normal at 5% Significance Level		
193					**Data appear Normal at 5% Significance Level**							
194												
195					**Assuming Normal Distribution**							
196					**95% Normal UCL**					**95% UCLs (Adjusted for Skewness)**		
197					95% Student's-t UCL	10.73				95% Adjusted-CLT UCL (Chen-1995)		10.5
198										95% Modified-t UCL (Johnson-1978)		10.74
199												
200					**Gamma GOF Test**							
201					A-D Test Statistic	0.564				**Anderson-Darling Gamma GOF Test**		
202					5% A-D Critical Value	0.715				Detected data appear Gamma Distributed at 5% Significance Level		
203					K-S Test Statistic	0.254				**Kolmogorov-Smimov Gamma GOF Test**		
204					5% K-S Critical Value	0.294				Detected data appear Gamma Distributed at 5% Significance Level		
205					**Detected data appear Gamma Distributed at 5% Significance Level**							
206												
207					**Gamma Statistics**							
208					k hat (MLE)	9.877				k star (bias corrected MLE)		6.257
209					Theta hat (MLE)	0.888				Theta star (bias corrected MLE)		1.402
210					nu hat (MLE)	158				nu star (bias corrected)		100.1
211					MLE Mean (bias corrected)	8.773				MLE Sd (bias corrected)		3.507
212										Approximate Chi Square Value (0.05)		78.02

Table D-2. WMA U ProUCL Hexavalent Chromium Results

	A	B	C	D	E	F	G	H	I	J	K	L
213					Adjusted Level of Significance	0.0195					Adjusted Chi Square Value	73.1
214												
215					**Assuming Gamma Distribution**							
216			95% Approximate Gamma UCL (use when n>=50))			11.26			95% Adjusted Gamma UCL (use when n<50)			12.01
217												
218					**Lognormal GOF Test**							
219					Shapiro Wilk Test Statistic	0.875			**Shapiro Wilk Lognormal GOF Test**			
220					5% Shapiro Wilk Critical Value	0.818			Data appear Lognormal at 5% Significance Level			
221					Lilliefors Test Statistic	0.247			**Lilliefors Lognormal GOF Test**			
222					5% Lilliefors Critical Value	0.283			Data appear Lognormal at 5% Significance Level			
223					**Data appear Lognormal at 5% Significance Level**							
224												
225					**Lognormal Statistics**							
226					Minimum of Logged Data	1.668			Mean of logged Data			2.12
227					Maximum of Logged Data	2.546			SD of logged Data			0.347
228												
229					**Assuming Lognormal Distribution**							
230					95% H-UCL	11.69			90% Chebyshev (MVUE) UCL			12.03
231					95% Chebyshev (MVUE) UCL	13.51			97.5% Chebyshev (MVUE) UCL			15.55
232					99% Chebyshev (MVUE) UCL	19.57						
233												
234					**Nonparametric Distribution Free UCL Statistics**							
235					**Data appear to follow a Discernible Distribution at 5% Significance Level**							
236												
237					**Nonparametric Distribution Free UCLs**							
238					95% CLT UCL	10.47			95% Jackknife UCL			10.73
239					95% Standard Bootstrap UCL	10.36			95% Bootstrap-t UCL			10.74
240					95% Hall's Bootstrap UCL	10.07			95% Percentile Bootstrap UCL			10.35
241					95% BCA Bootstrap UCL	10.38						
242					90% Chebyshev(Mean, Sd) UCL	11.88			95% Chebyshev(Mean, Sd) UCL			13.28
243					97.5% Chebyshev(Mean, Sd) UCL	15.23			99% Chebyshev(Mean, Sd) UCL			19.06
244												
245					**Suggested UCL to Use**							
246					95% Student's-t UCL	10.73						
247												
248					Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.							
249					Recommendations are based upon data size, data distribution, and skewness.							
250					These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).							
251					However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.							
252												

Table D-3. WMA U ProUCL Total Chromium Results

	A	B	C	D	E	F	G	H	I	J	K	L
1	**UCL Statistics for Data Sets with Non-Detects**											
2												
3			User Selected Options									
4			Date/Time of Computation	ProUCL 5.12/11/2020 10:38:11 AM								
5			From File	ProUCL_Datasets_01152020 - WMA U_d.xls								
6			Full Precision	OFF								
7			Confidence Coefficient	95%								
8			Number of Bootstrap Operations	2000								
10												
11	**VAL (299-w19-47)**											
12												
13					**General Statistics**							
14					Total Number of Observations	8			Number of Distinct Observations			8
15									Number of Missing Observations			0
16					Minimum	6.2			Mean			9.063
17					Maximum	12.2			Median			9.1
18					SD	2.323			Std. Error of Mean			0.821
19					Coefficient of Variation	0.256			Skewness			-0.0109
20												
21	**Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use**											
22	**guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.**											
23	**For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).**											
24	**Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.1**											
25												
26					**Normal GOF Test**							
27					Shapiro Wilk Test Statistic	0.893			**Shapiro Wilk GOF Test**			
28					5% Shapiro Wilk Critical Value	0.818			Data appear Normal at 5% Significance Level			
29					Lilliefors Test Statistic	0.218			**Lilliefors GOF Test**			
30					5% Lilliefors Critical Value	0.283			Data appear Normal at 5% Significance Level			
31					**Data appear Normal at 5% Significance Level**							
32												
33					**Assuming Normal Distribution**							
34					**95% Normal UCL**				**95% UCLs (Adjusted for Skewness)**			
35					95% Student's-t UCL	10.62			95% Adjusted-CLT UCL (Chen-1995)			10.41
36									95% Modified-t UCL (Johnson-1978)			10.62
37												
38					**Gamma GOF Test**							
39					A-D Test Statistic	0.495			**Anderson-Darling Gamma GOF Test**			
40					5% A-D Critical Value	0.716			Detected data appear Gamma Distributed at 5% Significance Level			
41					K-S Test Statistic	0.245			**Kolmogorov-Smirnov Gamma GOF Test**			
42					5% K-S Critical Value	0.294			Detected data appear Gamma Distributed at 5% Significance Level			
43					**Detected data appear Gamma Distributed at 5% Significance Level**							
44												
45					**Gamma Statistics**							
46					k hat (MLE)	16.82			k star (bias corrected MLE)			10.6
47					Theta hat (MLE)	0.539			Theta star (bias corrected MLE)			0.855
48					nu hat (MLE)	269.1			nu star (bias corrected)			169.6
49					MLE Mean (bias corrected)	9.063			MLE Sd (bias corrected)			2.784
50									Approximate Chi Square Value (0.05)			140.4
51					Adjusted Level of Significance	0.0195			Adjusted Chi Square Value			133.7
52												
53					**Assuming Gamma Distribution**							

Table D-3. WMA U ProUCL Total Chromium Results

	A	B	C	D	E	F	G	H	I	J	K	L
54	95% Approximate Gamma UCL (use when n>=50))					10.94	95% Adjusted Gamma UCL (use when n<50)					11.49
55												
56	**Lognormal GOF Test**											
57	Shapiro Wilk Test Statistic					0.888	**Shapiro Wilk Lognormal GOF Test**					
58	5% Shapiro Wilk Critical Value					0.818	Data appear Lognormal at 5% Significance Level					
59	Lilliefors Test Statistic					0.237	**Lilliefors Lognormal GOF Test**					
60	5% Lilliefors Critical Value					0.283	Data appear Lognormal at 5% Significance Level					
61	**Data appear Lognormal at 5% Significance Level**											
62												
63	**Lognormal Statistics**											
64	Minimum of Logged Data					1.825	Mean of logged Data					2.174
65	Maximum of Logged Data					2.501	SD of logged Data					0.265
66												
67	**Assuming Lognormal Distribution**											
68	95% H-UCL					11.14	90% Chebyshev (MVUE) UCL					11.62
69	95% Chebyshev (MVUE) UCL					12.78	97.5% Chebyshev (MVUE) UCL					14.38
70	99% Chebyshev (MVUE) UCL					17.54						
71												
72	**Nonparametric Distribution Free UCL Statistics**											
73	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
74												
75	**Nonparametric Distribution Free UCLs**											
76	95% CLT UCL					10.41	95% Jackknife UCL					10.62
77	95% Standard Bootstrap UCL					10.33	95% Bootstrap-t UCL					10.54
78	95% Hall's Bootstrap UCL					10.15	95% Percentile Bootstrap UCL					10.26
79	95% BCA Bootstrap UCL					10.3						
80	90% Chebyshev(Mean, Sd) UCL					11.53	95% Chebyshev(Mean, Sd) UCL					12.64
81	97.5% Chebyshev(Mean, Sd) UCL					14.19	99% Chebyshev(Mean, Sd) UCL					17.23
82												
83	**Suggested UCL to Use**											
84	95% Student's-t UCL					10.62						
85												
86	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
87	Recommendations are based upon data size, data distribution, and skewness.											
88	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
89	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
90												
91	**Note: For highly negatively-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be**											
92	**reliable. Chen's and Johnson's methods provide adjustments for positvely skewed data sets.**											
93												

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