

# Calculation of Upper Confidence Limits for RCRA Monitoring at the 183-H Solar Evaporation Basins to Support the July - December 2020 Semiannual Report

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

Contractor for the U.S. Department of Energy  
under Contract 89303320DEM000030



**P.O. Box 1464**  
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Date Published  
March 2021

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Central Plateau  
Cleanup Company  
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**APPROVED**

*By Sarah Harrison at 10:10 am, Mar 08, 2021*

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Release Approval

Date

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## ENVIRONMENTAL CALCULATION COVER PAGE

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Project: Soil and Groundwater Project

**RELEASE / ISSUE**

Date: 03/08/2021

**Calculation Title and Description:**

Calculation of Upper Confidence Limits for RCRA Monitoring at the 183-H Solar Evaporation Basins to Support the July - December 2020 Semiannual Report

**DATE:**

**Mar 08, 2021**



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Calculation Number: ECF-HANFORD-21-0012

Revision Number: 0

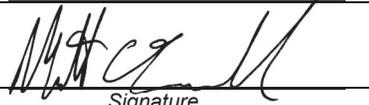
**Revision History**

Revision No.	Description	Date	Affected Pages
0	Initial Issue		All

**SECTION 3 - Completed by the Responsible Manager****Document Control:**Is the document intended to be controlled within the Document Management Control System (DMCS)?  Yes  NoDoes document contain scientific and technical information intended for public use?  Yes  NoDoes document contain controlled-use information?  Yes  No**SECTION 4 - Document Review and Approval****Preparer(s):**

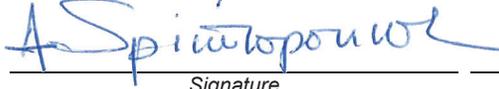
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## ENVIRONMENTAL CALCULATION COVER PAGE (Continued)

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Safety Software Approved:

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## Terms

CERCLA	<i>Comprehensive Environmental Response, Compensation, and Liability Act</i>
CPCCo	Central Plateau Cleanup Company
DF	dilution factor
ECF	environmental calculation file
EPC	exposure point concentration
GC/MS	gas chromatograph/mass spectrometer
HEIS	Hanford Environmental Information System
OU	operable unit
QC	quality control
RCRA	<i>Resource Conservation and Recovery Act of 1976</i>
UCL	upper confidence limit

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# 1 Purpose

This environmental calculation file (ECF) presents calculations of 95% upper confidence limits (UCLs) on the mean for filtered total chromium and nitrate (as NO<sub>3</sub>) at the 183-H Solar Evaporation Basins Resource Conservation and Recovery Act of 1976 (RCRA) site. The 95% UCLs are compared to the applicable concentration limits in WA7890008967, Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste (hereinafter referred to as the Hanford RCRA Permit). Calculations presented in this ECF were based on available results for groundwater samples collected through the end of December 2020.

# 2 Background

The 183-H Solar Evaporation Basins are located within the 100-H Area, overlying the 100-HR-3 Groundwater Operable Unit (OU) (Figure 1) and were used to evaporate various liquid waste streams from 300 Area fuel fabrication facilities. The final status groundwater monitoring plan was incorporated into the Hanford RCRA Permit, Revision 8c, on May 24, 2017. The new plan supersedes PNNL-11573, Groundwater Monitoring Plan for the 183-H Solar Evaporation Basins. The new corrective action monitoring plan requires calculation of the 95% UCLs on the mean for filtered total chromium and nitrate (as NO<sub>3</sub>) based on the last eight to ten independent samples, and comparison of the 95% UCLs, or non-detect data, to the concentration limits established in the Hanford RCRA Permit. For this analysis, when available, data were limited to the last eight RCRA sampling events only.

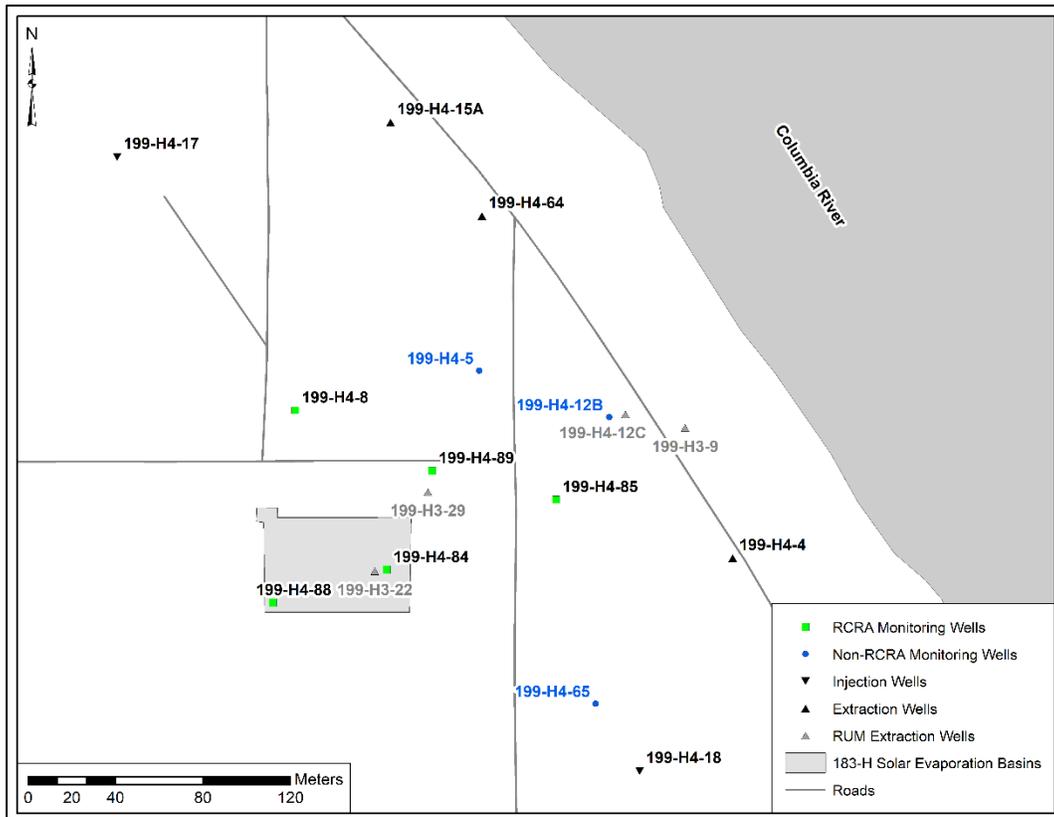


Figure 1. 183-H Solar Evaporation Basins and Associated Monitoring Wells

When all data are non-detects, all data are less than the concentration limits, or there are less than the required number of samples, calculation of the 95% UCL on the mean is not required and the data are evaluated visually to ensure compliance.

### 3 Methodology

This section discusses the data and methods used to complete the calculations presented in this document. Section 3.1 discusses the data acquisition and processing and Section 3.2 discusses the 95% UCL calculations on the mean.

#### 3.1 Data Acquisition and Processing

This section discusses the acquisition and processing of data prior to the 95% UCL calculations.

##### 3.1.1 Chemistry Data Acquisition

Groundwater chemistry data were downloaded from the Hanford Environmental Information System (HEIS) database, which is maintained by Central Plateau Cleanup Company (CPCCo), and exported into a Microsoft Access® database (named HEIS\_CHEM\_02082021.accdb). The data for this analysis were downloaded from the HEIS database on February 9, 2021. The HEIS database contains a table (HEIS\_ADM\_PNLGW\_STD\_RESULT\_MV), which comprises information on groundwater samples, including laboratory and review data qualifiers, sample medium, sample collection purpose, analytical method, and reporting limits. The fields extracted from the HEIS database for use in calculations described in this document are presented in Table 1.

**Table 1. HEIS Database Fields for Chemistry Data**

<b>Field Extracted*</b>	<b>Definition</b>
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
COLLECTION_PURPOSE	Primary Reason for Sample Collection
VALIDATION_QUALIFIER	Validation Qualifier
MEDIA	Sample Medium
METHOD_NAME	Analytical Method

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**Table 1. HEIS Database Fields for Chemistry Data**

Field Extracted*	Definition
REPORTING_LIMIT	Reporting Limit

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

HEIS = Hanford Environmental Information System

### 3.1.2 Wells and Constituents

The list of wells and constituents for this analysis was based on the groundwater monitoring plan incorporated on May 24, 2017, into the Hanford RCRA Permit (WA7890008967), as listed in Table 2.

**Table 2. Wells and Constituents**

Well Name	Constituent
199-H4-8	Filtered Total Chromium, Nitrate (as NO <sub>3</sub> )
199-H4-84	Filtered Total Chromium, Nitrate (as NO <sub>3</sub> )
199-H4-85	Filtered Total Chromium, Nitrate (as NO <sub>3</sub> )
199-H4-88	Filtered Total Chromium, Nitrate (as NO <sub>3</sub> )
199-H4-89	Filtered Total Chromium, Nitrate (as NO <sub>3</sub> )

### 3.1.3 Daily Averaging

A daily average was calculated for chemistry data with multiple measurements on the same day. When all measurements on the same day were non-detect, the highest detection limit was used for the daily value. For daily duplicates where only one of the samples was non-detect, the detected value was used for the daily value. Duplicate daily measurements and the calculated daily average within the last 8 samples dataset are presented in Table 3.

**Table 3. Duplicate Daily Measurements and Calculated Daily Averages**

Well Name	Constituent	Sample Date	Measured Concentration	Calculated Daily Average
199-H4-88	Filtered Total Chromium	5/1/2019	10.1 µg/L 10.2 µg/L	10.15 µg/L
199-H4-88	Nitrate (as NO <sub>3</sub> )	5/1/2019	47.8 mg/L 47.8 mg/L	47.8 mg/L

### 3.1.4 Data Qualifiers

Non-detects in the chemistry data set were identified using the laboratory qualifier (LAB\_QUALIFIER = U or any other qualifier that includes “U”). The method detection limit was substituted for concentration measurements when identified as a non-detect based on the laboratory qualifier. All estimated data (LAB\_QUALIFIER = B or J) were treated as detected values. Data with laboratory qualifiers C (the analyte was detected in both the sample and the associated quality control (QC) blank, and the sample concentration was  $\geq 5X$  the blank), D (analyte was reported at a secondary dilution factor (DF), typically  $DF > 1$ ), N (all (except Gas Chromatograph/Mass Spectrometer [GC/MS] based analysis) - spike and/or spike duplicated sample recovery is outside control limits) and X (recommended holding time exceeded) were included in this analysis.

### 3.1.5 Review Qualifiers

Chemistry data were removed from the data set prior to calculation of the 95% UCL if they had a review qualifier of “Y,” defined as, “Result is suspect. Review had insufficient evidence to show result valid or invalid” (HNF-38155, *HEIS Sample, Result, and Sampling Site Data Dictionary*). The data removed based on review qualifiers are presented in Table 4.

**Table 4. Data Removed Based on Review Qualifier**

Well Name	Constituent	Sample Date	Measured Concentration	Review Qualifier
199-H4-84	Filtered Total Chromium	6/17/2020	220 µg/L	Y
199-H4-84	Filtered Total Chromium	8/19/2020	51 µg/L	Y

The “Y” review qualifier for the sample collected on June 17, 2020, was added after RCRA reporting for the first and second quarter of 2020 (ECF-HANFORD-20-0082, *Calculation of Upper Confidence Limits for RCRA Monitoring at the 183-H Solar Evaporation Basins to Support the January - June 2020 Semiannual Report*). An updated UCL for the first and second quarter of 2020 for filtered total chromium at well 199-H4-84 is presented in the Results section of this document.

### 3.1.6 Time Period of Analysis

Due to the limited number of available RCRA sampling events, previous ECF calculations of the 95% UCLs on the mean for filtered total chromium and nitrate (as  $\text{NO}_3$ ) at the 183-H Solar Evaporation Basins contained the last ten samples, regardless of sampling program (ECF-HANFORD-19-0092, *Calculation of Upper Confidence Limits for RCRA Monitoring at the 183-H Solar Evaporation Basins to Support the January – June 2019 Semi-Annual Report*). Due to the increase in the number of available RCRA sampling events, datasets for the current analysis were limited to RCRA sampling events only, when available (Table 5). Data for monitoring wells 199-H4-8, 199-H4-84, 199-H4-88 and 199-H4-89 were limited to samples collected under the RCRA sampling program. Data for monitoring well 199-H4-85 included samples collected under the RCRA sampling program and the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) sampling program. The last eight independent samples (i.e., eight samples collected on different dates) scheduled to be collected through the end of December 2020 were included in the datasets if available.

**Table 5. Sampling Data**

Well Name	Analyte	Sampling Date Range	Number of Samples
199-H4-8	Filtered Total Chromium	05/03/2017 – 12/29/2020 <sup>a</sup>	8
199-H4-84	Filtered Total Chromium	11/15/2016 – 05/01/2019 <sup>b,c</sup>	8
199-H4-85	Filtered Total Chromium	05/22/2016 – 12/29/2020	8 <sup>d</sup>
199-H4-88	Filtered Total Chromium	11/13/2018 – 12/29/2020	8
199-H4-89	Filtered Total Chromium	05/17/2018 – 12/29/2020 <sup>e</sup>	8
199-H4-8	Nitrate (as NO <sub>3</sub> )	05/03/2017 – 12/29/2020 <sup>a</sup>	8
199-H4-84	Nitrate (as NO <sub>3</sub> )	02/08/2017 – 06/17/2020 <sup>b</sup>	8
199-H4-85	Nitrate (as NO <sub>3</sub> )	03/07/2019 – 12/29/2020	8 <sup>d</sup>
199-H4-88	Nitrate (as NO <sub>3</sub> )	11/13/2018 – 12/29/2020	8
199-H4-89	Nitrate (as NO <sub>3</sub> )	05/17/2018 – 12/29/2020 <sup>e</sup>	8

a. RCRA sampling scheduled for the fourth quarter of 2019 was unsuccessful due to dry wells associated with low river stage.

b. RCRA sampling scheduled for the fourth quarter of 2019 and 2020 was unsuccessful due to dry wells associated with low river stage.

c. The last two samples (collected on 6/17/2020 and 8/19/2020) were removed from the analysis based on the review qualifier (see Table 4).

d. Dataset contains both RCRA and CERCLA samples.

e. No RCRA sample was collected during the 12/30/2019 sampling event due to limited water availability in the well associated with low river stage.

CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act*

RCRA = *Resource Conservation and Recovery Act of 1976*

### 3.1.7 Outliers

The data sets were evaluated for outliers through visual inspection of timeseries plots. No outliers were identified in the datasets used in this analysis.

## 3.2 Calculated 95% UCLs on the Mean

A statistical software package, ProUCL version 5.1, was used to calculate the 95% UCL on the mean, in accordance with the new corrective action 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 non-detects are present. There are several methods available in ProUCL for calculating 95% UCLs on the mean. These methods account for the underlying distribution of the data and the presence of non-detects. For datasets with non-detects, ProUCL uses the Kaplan-Meier method, a non-parametric method for

calculating the mean and standard deviation. ProUCL highlights a recommended UCL calculation 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.

The 95% UCL calculations were performed on datasets with a minimum of eight samples available and with at least one sample above the concentration limit. As shown in Table 6 below, only four datasets met these criteria. Calculation of 95% UCLs for the other datasets was not required.

**Table 6. Dataset Summary and Criteria to Calculate 95% UCL**

Analyte	Concentration Limit	Well Name	Number of Samples	Percent Non-Detect	Number of Samples Exceeding Concentration Limit	95% UCL Calculation Required
Filtered total chromium	48 µg/L	199-H4-8	8	13%	0	No
		199-H4-84	8	0%	1	Yes
		199-H4-85	8	13%	0	No
		199-H4-88	8	0%	0	No
		199-H4-89	8	13%	0	No
Nitrate (as NO <sub>3</sub> )	45 mg/L	199-H4-8	8	0%	0	No
		199-H4-84	8	0%	5	Yes
		199-H4-85	8	0%	0	No
		199-H4-88	8	0%	7	Yes
		199-H4-89	8	0%	2	Yes

UCL = upper confidence limit

## 4 Assumptions

Given the number of samples required by the permit, UCL calculations assume that:

- Concentrations observed at a well are not significantly affected by active remediation activities at the site for the period over which calculations are made.
- There are no concentration trends with time for the datasets used to calculate 95% UCLs. ProUCL does not explicitly test for concentration trends when calculating 95% UCLs. In the presence of a concentration trend, ProUCL will calculate a wider confidence interval on the mean.
- In addition, all of the data for a well/analyte pair are from the same statistical distribution. ProUCL tests the data distribution prior to calculating 95% UCLs and ProUCL highlights a recommended 95% UCL method based on the data distribution.

## 5 Software Applications

Software use for this calculation was in accordance with internal controlled software management procedures.

### 5.1 Approved Software

The following software was used to perform calculations and was approved and compliant with CPCCo procedures and consistent with CHPRC-01270, *ProUCL Software Management Plan*. Following are brief descriptions of the software.

#### 5.1.1 ProUCL (Controlled Calculation Software)

- **Software Title:** ProUCL (EPA/600/R-07/041, *ProUCL Version 5.1 Technical Guide, Statistical Software for Environmental Applications for Data Sets with and without Nondetect Observations*); Software uses statistical methods to estimate exposure point concentration (EPC) terms, not-to-exceed values, and background threshold values (BTVs) for data sets with non-detect (ND) and without ND observations.
- **Software Version:** Version 5.1
- **Hanford Information Systems Inventory (HISI) Identification Number:** 2831 (Safety Software, graded Level C).
- **Workstation type and property number (from which software is run):** S.S. Papadopoulos & Associates, Inc. workstation FE 485.

## 6 Calculation

The following input files were used in the implementation of this analysis:

- *qryChemHeis1.txt* and *qryChemHeis2.txt*: Concentration data from the HEIS database
- *ProUCL\_Datasets\_02082021.xlsx*: datasets for use in ProUCL

Datasets were imported into the ProUCL software and 95% UCLs were calculated using all available methods and accounting for the presence of non-detects. The reported 95% UCL was selected based on the ProUCL results, including evaluation of the data distribution and sample size.

## 7 Results

The datasets evaluated for 95% UCL calculation and the output files from ProUCL are presented in Appendix A, and the 95% UCL results are presented in Table 7. Results for nitrate (as NO<sub>3</sub>) were converted to milligrams per liter (mg/L) prior to processing with ProUCL. Timeseries plots for all wells and constituents are presented in Appendix B.

**Table 7. Calculated 95% UCLs**

Well Name	Analyte	Concentration Limit	95% UCL	95% UCL Result Evaluation
199-H4-84	Filtered total chromium	48 µg/L	46.91* µg/L	Below Concentration Limit
199-H4-84	Nitrate (as NO <sub>3</sub> )	45 mg/L	92.78* mg/L	Above Concentration Limit
199-H4-88	Nitrate (as NO <sub>3</sub> )	45 mg/L	68.86* mg/L	Above Concentration Limit
199-H4-89	Nitrate (as NO <sub>3</sub> )	45 mg/L	41.37* mg/L	Below Concentration Limit

\*ProUCL method: 95% Student's-t UCL

UCL = upper confidence limit

As discussed in Section 3.1.5 of this document, the review qualifier for filtered total chromium for well 199-H4-84 on June 17, 2020, was added after RCRA reporting for the first and second quarter of 2020 was completed. The 95% UCL of the mean was recalculated for the first and second quarter of 2020 after removing this qualified sample (Table 8).

**Table 8. Recalculated 95% UCL for First and Second Quarter of 2020**

Well Name	Analyte	Concentration Limit	95% UCL		Revised 95% UCL Result Evaluation
			Original Calculation	Revised Calculation	
199-H4-84	Filtered total chromium	48 µg/L	185.7 <sup>a</sup> µg/L	46.91 <sup>b</sup> µg/L	Below Concentration Limit

a. ProUCL method: 95% Adjusted Gamma UCL

b. ProUCL method: 95% Student's-t UCL

UCL = upper confidence limit

## 8 References

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*Resource Conservation and Recovery Act of 1976*, 42 USC 6901, et seq. Available at: <https://elr.info/sites/default/files/docs/statutes/full/rcra.pdf>.

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## **Appendix A**

### **Upper Confidence Limit (UCL) Datasets and ProUCL Output Results**

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**Table A-1. Dataset for 183-H Solar Evaporation Basins**

<b>Well Name</b>	<b>Sample Date</b>	<b>Analyte</b>	<b>Reported Value</b>	<b>Units</b>	<b>Laboratory Qualifier</b>	<b>ProUCL Non-detect Identification*</b>
199-H4-8	5/3/2017	Chromium	3.3	µg/L		1
199-H4-8	11/10/2017	Chromium	3	µg/L	BC	1
199-H4-8	2/12/2018	Chromium	2.8	µg/L		1
199-H4-8	5/17/2018	Chromium	4.2	µg/L	BC	1
199-H4-8	11/13/2018	Chromium	3.6	µg/L		1
199-H4-8	5/1/2019	Chromium	5.5	µg/L		1
199-H4-8	6/16/2020	Chromium	4	µg/L	UD	0
199-H4-8	12/29/2020	Chromium	4.15	µg/L	B	1
199-H4-84	11/15/2016	Chromium	46.5	µg/L	D	1
199-H4-84	2/8/2017	Chromium	33	µg/L		1
199-H4-84	5/3/2017	Chromium	8.1	µg/L		1
199-H4-84	11/10/2017	Chromium	2.9	µg/L	BC	1
199-H4-84	2/12/2018	Chromium	83.9	µg/L	D	1
199-H4-84	5/17/2018	Chromium	8	µg/L	BC	1
199-H4-84	11/13/2018	Chromium	20	µg/L		1
199-H4-84	5/1/2019	Chromium	30	µg/L		1
199-H4-85	5/22/2016	Chromium	6.76	µg/L	B	1
199-H4-85	2/12/2018	Chromium	4.4	µg/L	B	1
199-H4-85	5/17/2018	Chromium	5.8	µg/L	BC	1
199-H4-85	11/13/2018	Chromium	6.58	µg/L	B	1
199-H4-85	5/1/2019	Chromium	5	µg/L	N	1
199-H4-85	12/30/2019	Chromium	5.74	µg/L	B	1
199-H4-85	6/17/2020	Chromium	3	µg/L	U	0
199-H4-85	12/29/2020	Chromium	3.59	µg/L	B	1
199-H4-88	11/13/2018	Chromium	12.1	µg/L		1
199-H4-88	3/7/2019	Chromium	11.5	µg/L		1
199-H4-88	5/1/2019	Chromium	10.15	µg/L	N	1
199-H4-88	8/5/2019	Chromium	7.82	µg/L	B	1
199-H4-88	11/8/2019	Chromium	10	µg/L		1
199-H4-88	12/30/2019	Chromium	8.8	µg/L	B	1
199-H4-88	6/17/2020	Chromium	8.67	µg/L	B	1
199-H4-88	12/29/2020	Chromium	6.6	µg/L		1

**Table A-1. Dataset for 183-H Solar Evaporation Basins**

<b>Well Name</b>	<b>Sample Date</b>	<b>Analyte</b>	<b>Reported Value</b>	<b>Units</b>	<b>Laboratory Qualifier</b>	<b>ProUCL Non-detect Identification*</b>
199-H4-89	5/17/2018	Chromium	3.9	µg/L	BC	1
199-H4-89	8/16/2018	Chromium	3.77	µg/L	B	1
199-H4-89	11/13/2018	Chromium	7.1	µg/L	BD	1
199-H4-89	3/7/2019	Chromium	4.3	µg/L	BD	1
199-H4-89	5/2/2019	Chromium	4.4	µg/L	BD	1
199-H4-89	8/5/2019	Chromium	4.92	µg/L	B	1
199-H4-89	6/17/2020	Chromium	3	µg/L	U	0
199-H4-89	12/29/2020	Chromium	4.9	µg/L	BD	1
199-H4-8	5/3/2017	Nitrate	12.4	mg/L		1
199-H4-8	11/10/2017	Nitrate	11.1	mg/L	D	1
199-H4-8	2/12/2018	Nitrate	12.2	mg/L		1
199-H4-8	5/17/2018	Nitrate	11.1	mg/L	D	1
199-H4-8	11/13/2018	Nitrate	13.3	mg/L	D	1
199-H4-8	5/1/2019	Nitrate	11.5	mg/L	D	1
199-H4-8	6/16/2020	Nitrate	20.5	mg/L		1
199-H4-8	12/29/2020	Nitrate	14.8	mg/L		1
199-H4-84	2/8/2017	Nitrate	75.3	mg/L	D	1
199-H4-84	5/3/2017	Nitrate	13.1	mg/L	D	1
199-H4-84	11/10/2017	Nitrate	30.5	mg/L	D	1
199-H4-84	2/12/2018	Nitrate	100	mg/L	D	1
199-H4-84	5/17/2018	Nitrate	25.2	mg/L	D	1
199-H4-84	11/13/2018	Nitrate	70.8	mg/L	D	1
199-H4-84	5/1/2019	Nitrate	55.8	mg/L	D	1
199-H4-84	6/17/2020	Nitrate	142	mg/L	D	1
199-H4-85	3/7/2019	Nitrate	7.53	mg/L		1
199-H4-85	5/1/2019	Nitrate	5.31	mg/L	D	1
199-H4-85	8/6/2019	Nitrate	3.53	mg/L		1
199-H4-85	12/30/2019	Nitrate	1.7	mg/L		1
199-H4-85	2/24/2020	Nitrate	1.96	mg/L		1
199-H4-85	6/17/2020	Nitrate	4.03	mg/L		1
199-H4-85	9/2/2020	Nitrate	5.31	mg/L		1
199-H4-85	12/29/2020	Nitrate	2.82	mg/L		1

**Table A-1. Dataset for 183-H Solar Evaporation Basins**

Well Name	Sample Date	Analyte	Reported Value	Units	Laboratory Qualifier	ProUCL Non-detect Identification*
199-H4-88	11/13/2018	Nitrate	53.1	mg/L	D	1
199-H4-88	3/7/2019	Nitrate	53.1	mg/L	D	1
199-H4-88	5/1/2019	Nitrate	47.8	mg/L	D	1
199-H4-88	8/5/2019	Nitrate	45.2	mg/L	DX	1
199-H4-88	11/8/2019	Nitrate	66.4	mg/L		1
199-H4-88	12/30/2019	Nitrate	70.8	mg/L	D	1
199-H4-88	6/17/2020	Nitrate	88.5	mg/L	D	1
199-H4-88	12/29/2020	Nitrate	39.8	mg/L	D	1
199-H4-89	5/17/2018	Nitrate	19.9	mg/L	D	1
199-H4-89	8/16/2018	Nitrate	22.1	mg/L	D	1
199-H4-89	11/13/2018	Nitrate	57.5	mg/L	D	1
199-H4-89	3/7/2019	Nitrate	19.9	mg/L	D	1
199-H4-89	5/2/2019	Nitrate	21.3	mg/L		1
199-H4-89	8/5/2019	Nitrate	37.6	mg/L	D	1
199-H4-89	6/17/2020	Nitrate	50.5	mg/L	D	1
199-H4-89	12/29/2020	Nitrate	18.7	mg/L		1

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

DF = dilution factor

GC/MS = gas chromatograph/mass spectrometer

IDL/MDL = instrument detection limit/method detection limit

QC = quality control

RDL = required detection limit

Qualifier Definitions:

B = The analyte was detected at a value less than the contract RDL, but greater than or equal to the IDL/MDL (as appropriate).

C = The analyte was detected in both the same and the associated QC blank, and the sample concentration was  $\geq 5X$  the blank.

D = Analyte was reported at a secondary dilution factor, typically  $DF > 1$ .

N = All (except GC/MS based analysis) - Spike and/or spike duplicated sample recovery is outside control limits.

U = Analyzed for but not detected above limiting criteria.

X = Recommended holding time exceeded.

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**ProUCL Results for Filtered Total Chromium**

**UCL Statistics for Data Sets with Non-Detects**

User Selected Options  
 Date/Time of Computation ProUCL 5.12/10/2021 9:07:59 AM  
 From File ProUCL\_Datasets\_02082021\_a.xls  
 Full Precision OFF  
 Confidence Coefficient 95%  
 Number of Bootstrap Operations 2000

**VAL (199-h4-84)**

**General Statistics**

Total Number of Observations	8	Number of Distinct Observations	8
		Number of Missing Observations	0
Minimum	2.9	Mean	29.05
Maximum	83.9	Median	25
SD	26.67	Std. Error of Mean	9.428
Coefficient of Variation	0.918	Skewness	1.339

**Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest. For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012). Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.1**

**Normal GOF Test**

Shapiro Wilk Test Statistic	0.878	<b>Shapiro Wilk GOF Test</b>
5% Shapiro Wilk Critical Value	0.818	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.191	<b>Lilliefors GOF Test</b>
5% Lilliefors Critical Value	0.283	Data appear Normal at 5% Significance Level

**Data appear Normal at 5% Significance Level**

**Assuming Normal Distribution**

<b>95% Normal UCL</b>		<b>95% UCLs (Adjusted for Skewness)</b>	
95% Student's-t UCL	46.91	95% Adjusted-CLT UCL (Chen-1995)	49.32
		95% Modified-t UCL (Johnson-1978)	47.65

**Gamma GOF Test**

A-D Test Statistic	0.205	<b>Anderson-Darling Gamma GOF Test</b>
5% A-D Critical Value	0.732	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.182	<b>Kolmogorov-Smirnov Gamma GOF Test</b>
5% K-S Critical Value	0.3	Detected data appear Gamma Distributed at 5% Significance Level

**Detected data appear Gamma Distributed at 5% Significance Level**

**Gamma Statistics**

k hat (MLE)	1.266	k star (bias corrected MLE)	0.875
Theta hat (MLE)	22.94	Theta star (bias corrected MLE)	33.21
nu hat (MLE)	20.26	nu star (bias corrected)	14
MLE Mean (bias corrected)	29.05	MLE Sd (bias corrected)	31.06
		Approximate Chi Square Value (0.05)	6.569
Adjusted Level of Significance	0.0195	Adjusted Chi Square Value	5.337

**Assuming Gamma Distribution**

95% Approximate Gamma UCL (use when n>=50)	61.9	95% Adjusted Gamma UCL (use when n<50)	76.19
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**Lognormal GOF Test**

Shapiro Wilk Test Statistic	0.96	<b>Shapiro Wilk Lognormal GOF Test</b>
5% Shapiro Wilk Critical Value	0.818	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.167	<b>Lilliefors Lognormal GOF Test</b>
5% Lilliefors Critical Value	0.283	Data appear Lognormal at 5% Significance Level

**Data appear Lognormal at 5% Significance Level**

**Lognormal Statistics**

Minimum of Logged Data	1.065	Mean of logged Data	2.925
Maximum of Logged Data	4.43	SD of logged Data	1.104

**Assuming Lognormal Distribution**

95% H-UCL	159.5	90% Chebyshev (MVUE) UCL	67.76
95% Chebyshev (MVUE) UCL	84.47	97.5% Chebyshev (MVUE) UCL	107.7
99% Chebyshev (MVUE) UCL	153.2		

**Nonparametric Distribution Free UCL Statistics**

**Data appear to follow a Discernible Distribution at 5% Significance Level**

**Nonparametric Distribution Free UCLs**

95% CLT UCL	44.56	95% Jackknife UCL	46.91
95% Standard Bootstrap UCL	43.78	95% Bootstrap-t UCL	57.12
95% Hall's Bootstrap UCL	112.5	95% Percentile Bootstrap UCL	44.3
95% BCA Bootstrap UCL	48.31		
90% Chebyshev(Mean, Sd) UCL	57.33	95% Chebyshev(Mean, Sd) UCL	70.14
97.5% Chebyshev(Mean, Sd) UCL	87.93	99% Chebyshev(Mean, Sd) UCL	122.9

**Suggested UCL to Use**

95% Student's-t UCL 46.91

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.

Recommendations are based upon data size, data distribution, and skewness.

These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).

However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

**ProUCL Results for Nitrate**

**UCL Statistics for Data Sets with Non-Detects**

User Selected Options  
 Date/Time of Computation ProUCL 5.12/10/2021 9:08:24 AM  
 From File ProUCL\_Datasets\_02082021\_b.xls  
 Full Precision OFF  
 Confidence Coefficient 95%  
 Number of Bootstrap Operations 2000

VAL (199-h4-84)

**General Statistics**

Total Number of Observations	8	Number of Distinct Observations	8
		Number of Missing Observations	0
Minimum	13.1	Mean	64.09
Maximum	142	Median	63.3
SD	42.83	Std. Error of Mean	15.14
Coefficient of Variation	0.668	Skewness	0.706

**Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.**

**For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).**

**Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.1**

**Normal GOF Test**

Shapiro Wilk Test Statistic	0.948	<b>Shapiro Wilk GOF Test</b>
5% Shapiro Wilk Critical Value	0.818	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.159	<b>Lilliefors GOF Test</b>
5% Lilliefors Critical Value	0.283	Data appear Normal at 5% Significance Level

**Data appear Normal at 5% Significance Level**

**Assuming Normal Distribution**

<b>95% Normal UCL</b>		<b>95% UCLs (Adjusted for Skewness)</b>
95% Student's-t UCL	92.78	95% Adjusted-CLT UCL (Chen-1995) 93.03
		95% Modified-t UCL (Johnson-1978) 93.41

**Gamma GOF Test**

A-D Test Statistic	0.192	<b>Anderson-Darling Gamma GOF Test</b>
5% A-D Critical Value	0.723	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.151	<b>Kolmogorov-Smirnov Gamma GOF Test</b>
5% K-S Critical Value	0.297	Detected data appear Gamma Distributed at 5% Significance Level

**Detected data appear Gamma Distributed at 5% Significance Level**

**Gamma Statistics**

k hat (MLE)	2.257	k star (bias corrected MLE)	1.494
Theta hat (MLE)	28.39	Theta star (bias corrected MLE)	42.9
nu hat (MLE)	36.11	nu star (bias corrected)	23.9
MLE Mean (bias corrected)	64.09	MLE Sd (bias corrected)	52.43
		Approximate Chi Square Value (0.05)	13.78
Adjusted Level of Significance	0.0195	Adjusted Chi Square Value	11.88

**Assuming Gamma Distribution**

95% Approximate Gamma UCL (use when n>=50)	111.2	95% Adjusted Gamma UCL (use when n<50)	129
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**Lognormal GOF Test**

Shapiro Wilk Test Statistic	0.959	<b>Shapiro Wilk Lognormal GOF Test</b>
5% Shapiro Wilk Critical Value	0.818	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.175	<b>Lilliefors Lognormal GOF Test</b>
5% Lilliefors Critical Value	0.283	Data appear Lognormal at 5% Significance Level

**Data appear Lognormal at 5% Significance Level**

**Lognormal Statistics**

Minimum of Logged Data	2.573	Mean of logged Data	3.923
Maximum of Logged Data	4.956	SD of logged Data	0.791

**Assuming Lognormal Distribution**

95% H-UCL	165.9	90% Chebyshev (MVUE) UCL	122.2
95% Chebyshev (MVUE) UCL	147.7	97.5% Chebyshev (MVUE) UCL	183.1
99% Chebyshev (MVUE) UCL	252.7		

**Nonparametric Distribution Free UCL Statistics**

**Data appear to follow a Discernible Distribution at 5% Significance Level**

**Nonparametric Distribution Free UCLs**

95% CLT UCL	88.99	95% Jackknife UCL	92.78
95% Standard Bootstrap UCL	86.78	95% Bootstrap-t UCL	99.68
95% Hall's Bootstrap UCL	101.2	95% Percentile Bootstrap UCL	87.29
95% BCA Bootstrap UCL	93.94		
90% Chebyshev(Mean, Sd) UCL	109.5	95% Chebyshev(Mean, Sd) UCL	130.1
97.5% Chebyshev(Mean, Sd) UCL	158.6	99% Chebyshev(Mean, Sd) UCL	214.7

**Suggested UCL to Use**

95% Student's-t UCL  
92.78

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.

Recommendations are based upon data size, data distribution, and skewness.

These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).

However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

VAL (199-h4-88)

**General Statistics**

Total Number of Observations	8	Number of Distinct Observations	7
		Number of Missing Observations	0
Minimum	39.8	Mean	58.09
Maximum	88.5	Median	53.1
SD	16.09	Std. Error of Mean	5.688
Coefficient of Variation	0.277	Skewness	0.968

**Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.**

**For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).**

**Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.1**

**Normal GOF Test**

Shapiro Wilk Test Statistic	0.919	<b>Shapiro Wilk GOF Test</b>
5% Shapiro Wilk Critical Value	0.818	Data appear Normal at 5% Significance Level

Lilliefors Test Statistic	0.247	<b>Lilliefors GOF Test</b>
5% Lilliefors Critical Value	0.283	Data appear Normal at 5% Significance Level

**Data appear Normal at 5% Significance Level**

**Assuming Normal Distribution**

<b>95% Normal UCL</b>		<b>95% UCLs (Adjusted for Skewness)</b>
95% Student's-t UCL	68.86	95% Adjusted-CLT UCL (Chen-1995) 69.52
		95% Modified-t UCL (Johnson-1978) 69.19

**Gamma GOF Test**

A-D Test Statistic	0.288	<b>Anderson-Darling Gamma GOF Test</b>
5% A-D Critical Value	0.716	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.232	<b>Kolmogorov-Smirnov Gamma GOF Test</b>
5% K-S Critical Value	0.294	Detected data appear Gamma Distributed at 5% Significance Level

**Detected data appear Gamma Distributed at 5% Significance Level**

**Gamma Statistics**

k hat (MLE)	16.12	k star (bias corrected MLE)	10.16
Theta hat (MLE)	3.603	Theta star (bias corrected MLE)	5.718
nu hat (MLE)	257.9	nu star (bias corrected)	162.5
MLE Mean (bias corrected)	58.09	MLE Sd (bias corrected)	18.23
		Approximate Chi Square Value (0.05)	134.1
Adjusted Level of Significance	0.0195	Adjusted Chi Square Value	127.5

**Assuming Gamma Distribution**

95% Approximate Gamma UCL (use when n>=50)	70.43	95% Adjusted Gamma UCL (use when n<50)	74.04
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**Lognormal GOF Test**

Shapiro Wilk Test Statistic	0.959	<b>Shapiro Wilk Lognormal GOF Test</b>
5% Shapiro Wilk Critical Value	0.818	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.213	<b>Lilliefors Lognormal GOF Test</b>
5% Lilliefors Critical Value	0.283	Data appear Lognormal at 5% Significance Level

**Data appear Lognormal at 5% Significance Level**

**Lognormal Statistics**

Minimum of Logged Data	Mean of logged Data	4.031
3.684		
Maximum of Logged Data	SD of logged Data	0.264
4.483		

**Assuming Lognormal Distribution**

95% H-UCL	90% Chebyshev (MVUE) UCL	74.3
71.24		
95% Chebyshev (MVUE) UCL	97.5% Chebyshev (MVUE) UCL	91.91
81.68		
99% Chebyshev (MVUE) UCL		112

**Nonparametric Distribution Free UCL Statistics**

**Data appear to follow a Discernible Distribution at 5% Significance Level**

**Nonparametric Distribution Free UCLs**

95% CLT UCL	95% Jackknife UCL	68.86
67.44		
95% Standard Bootstrap UCL	95% Bootstrap-t UCL	73.38
66.66		
95% Hall's Bootstrap UCL	95% Percentile Bootstrap UCL	67.49
70.7		
95% BCA Bootstrap UCL		
67.84		
90% Chebyshev(Mean, Sd) UCL	95% Chebyshev(Mean, Sd) UCL	82.88
75.15		
97.5% Chebyshev(Mean, Sd) UCL	99% Chebyshev(Mean, Sd) UCL	114.7
93.61		

**Suggested UCL to Use**

95% Student's-t UCL  
68.86

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.

Recommendations are based upon data size, data distribution, and skewness.

These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).

However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

VAL (199-h4-89)

**General Statistics**

Total Number of Observations	8	Number of Distinct Observations	7
		Number of Missing Observations	0
Minimum	18.7	Mean	30.94
Maximum	57.5	Median	21.7
SD	15.57	Std. Error of Mean	5.505

Coefficient of Variation 0.503 Skewness 1.03

Note: Sample size is small (e.g., <10), if data are collected using ISM approach, you should use guidance provided in ITRC Tech Reg Guide on ISM (ITRC, 2012) to compute statistics of interest.

For example, you may want to use Chebyshev UCL to estimate EPC (ITRC, 2012).

Chebyshev UCL can be computed using the Nonparametric and All UCL Options of ProUCL 5.1

**Normal GOF Test**

Shapiro Wilk Test Statistic 0.776  
 5% Shapiro Wilk Critical Value 0.818  
 Lilliefors Test Statistic 0.34  
 5% Lilliefors Critical Value 0.283

**Shapiro Wilk GOF Test**

Data Not Normal at 5% Significance Level

**Lilliefors GOF Test**

Data Not Normal at 5% Significance Level

**Data Not Normal at 5% Significance Level**

**Assuming Normal Distribution**

**95% Normal UCL**

95% Student's-t UCL 41.37

**95% UCLs (Adjusted for Skewness)**

95% Adjusted-CLT UCL (Chen-1995) 42.13  
 95% Modified-t UCL (Johnson-1978) 41.7

**Gamma GOF Test**

A-D Test Statistic 0.878  
 5% A-D Critical Value 0.719  
 K-S Test Statistic 0.343  
 5% K-S Critical Value 0.295

**Anderson-Darling Gamma GOF Test**

Data Not Gamma Distributed at 5% Significance Level

**Kolmogorov-Smirnov Gamma GOF Test**

Data Not Gamma Distributed at 5% Significance Level

**Data Not Gamma Distributed at 5% Significance Level**

**Gamma Statistics**

k hat (MLE) 5.219	k star (bias corrected MLE) 3.346
Theta hat (MLE) 5.927	Theta star (bias corrected MLE) 9.247
nu hat (MLE) 83.51	nu star (bias corrected) 53.53
MLE Mean (bias corrected) 30.94	MLE Sd (bias corrected) 16.91
	Approximate Chi Square Value (0.05) 37.72
Adjusted Level of Significance 0.0195	Adjusted Chi Square Value 34.39

**Assuming Gamma Distribution**

95% Approximate Gamma UCL (use when n>=50)	43.9	95% Adjusted Gamma UCL (use when n<50)	48.15
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**Lognormal GOF Test**

Shapiro Wilk Test Statistic	0.799	<b>Shapiro Wilk Lognormal GOF Test</b>
5% Shapiro Wilk Critical Value	0.818	Data Not Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.322	<b>Lilliefors Lognormal GOF Test</b>
5% Lilliefors Critical Value	0.283	Data Not Lognormal at 5% Significance Level

**Data Not Lognormal at 5% Significance Level**

**Lognormal Statistics**

Minimum of Logged Data	2.929	Mean of logged Data	3.333
Maximum of Logged Data	4.052	SD of logged Data	0.46

**Assuming Lognormal Distribution**

95% H-UCL	46.35	90% Chebyshev (MVUE) UCL	45.82
95% Chebyshev (MVUE) UCL	52.66	97.5% Chebyshev (MVUE) UCL	62.16
99% Chebyshev (MVUE) UCL	80.82		

**Nonparametric Distribution Free UCL Statistics**

**Data do not follow a Discernible Distribution (0.05)**

**Nonparametric Distribution Free UCLs**

95% CLT UCL	39.99	95% Jackknife UCL	41.37
95% Standard Bootstrap UCL	39.36	95% Bootstrap-t UCL	50.98
95% Hall's Bootstrap UCL	40.95	95% Percentile Bootstrap UCL	39.74
95% BCA Bootstrap UCL	40.9		
90% Chebyshev(Mean, Sd) UCL	47.45	95% Chebyshev(Mean, Sd) UCL	54.93
97.5% Chebyshev(Mean, Sd) UCL	65.32	99% Chebyshev(Mean, Sd) UCL	85.71

**Suggested UCL to Use**

95% Student's-t UCL	41.37	or 95% Modified-t UCL	41.7
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Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.

Recommendations are based upon data size, data distribution, and skewness.

These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).

However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

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**Appendix B**  
**Timeseries Plots**

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### Filtered Total Chromium

- RCRA Sample - Below Concentration Limit
- RCRA Sample - Above Concentration Limit
- CERCLA Sample - Below Concentration Limit
- CERCLA Sample - Above Concentration Limit
- ▽ RCRA Sample - Non-Detect
- △ CERCLA Sample - Non-Detect
- - Concentration Limit

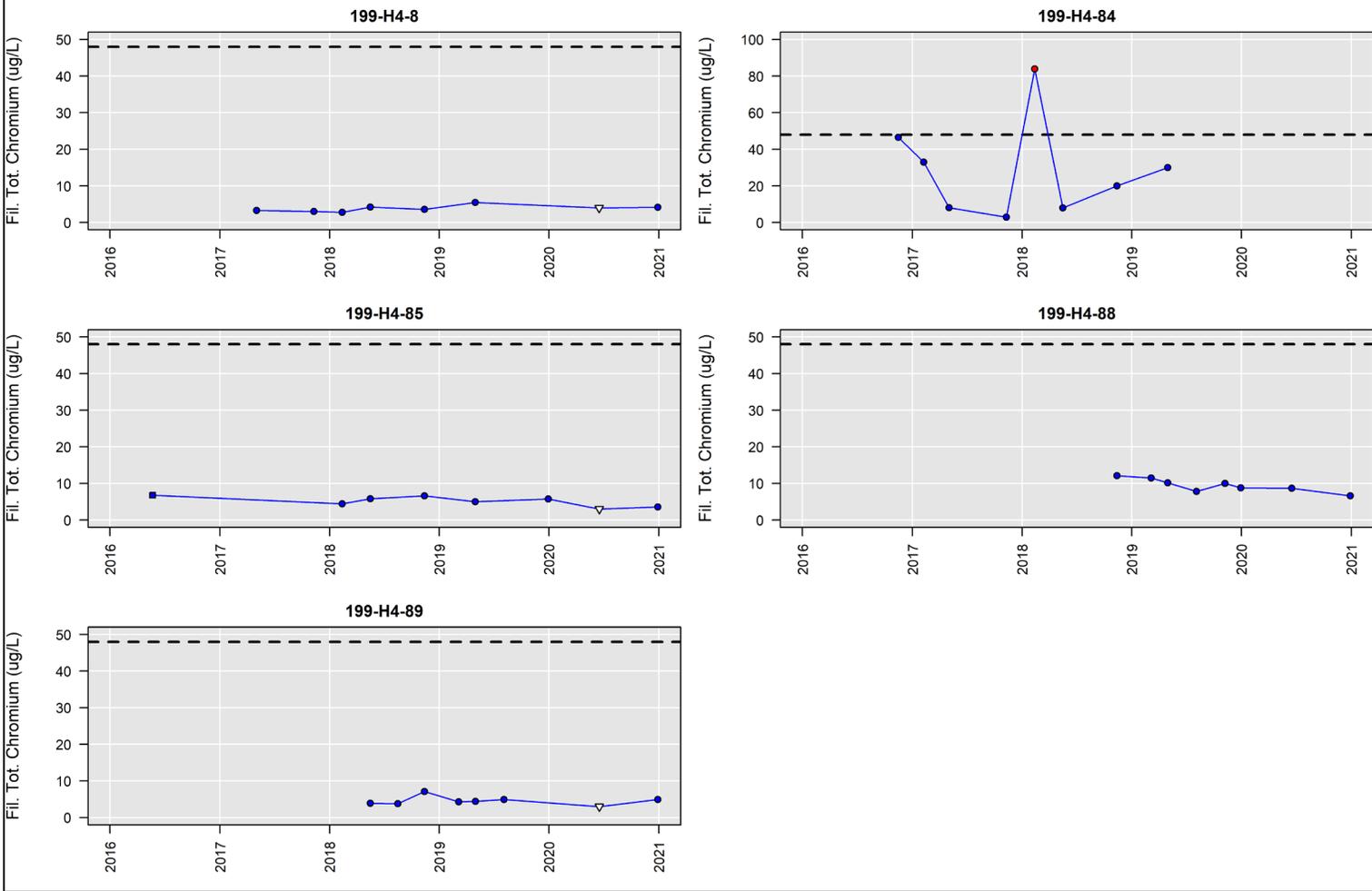


Figure B-1. Chromium Timeseries

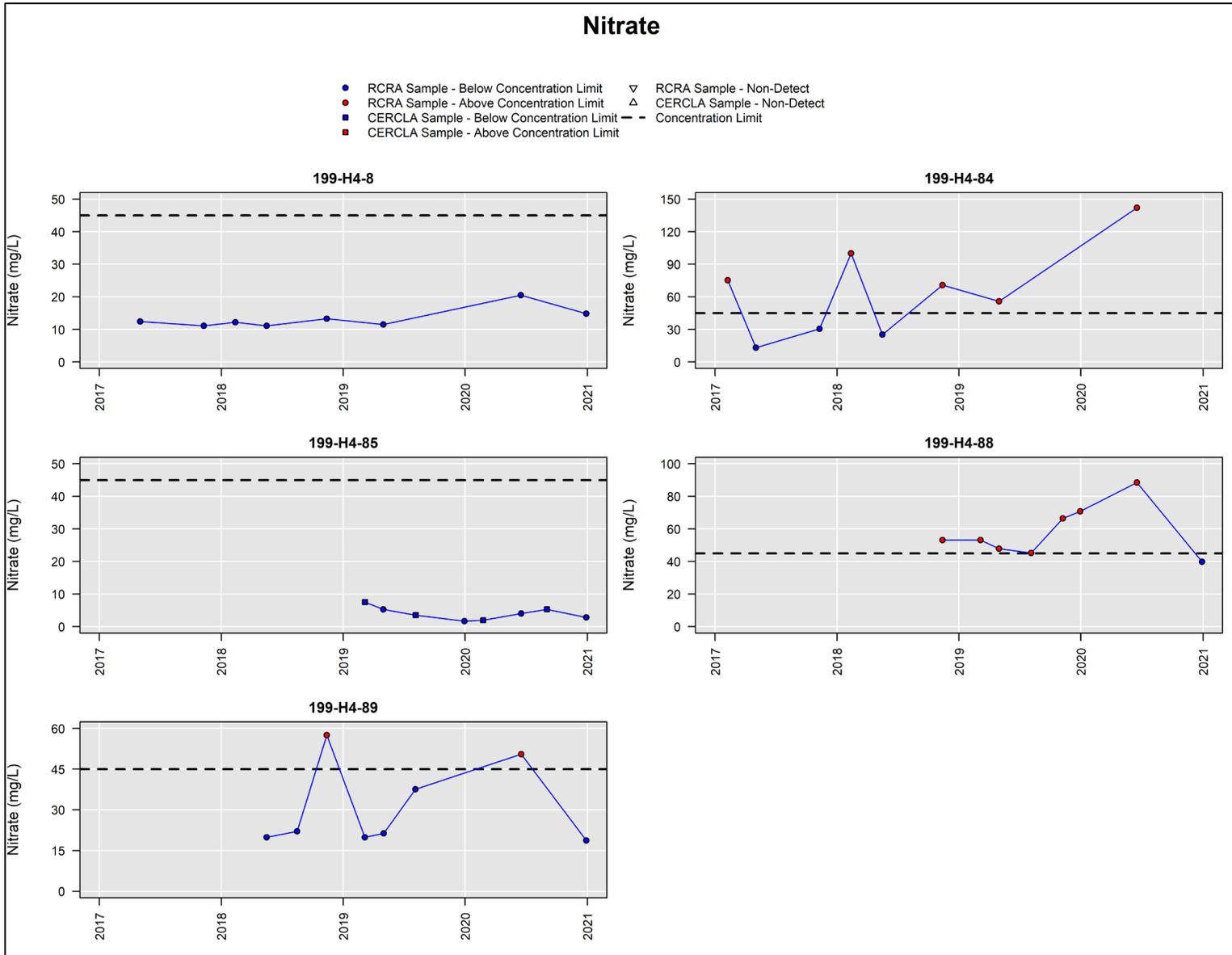


Figure B-2. Nitrate Timeseries