TETRA TECH

September 12, 2022

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Subject: **Streamlined Risk Assessment**
Griffin Ashing Site (Flat Top Mine OU1)
Griffin, Bowman County, North Dakota
EPA Contract No. 68-HE-082 D0001
TD No. 2071-2108-05
DTN #0506c

Dear Ms. Chau:

Tetra Tech, Inc. (Tetra Tech) Superfund Technical Assessment and Response Team (START) is pleased to submit this Streamlined Risk Assessment - Revision 0 for the Griffin Ashing Site (Flat Top Mine OU1) in Griffin, Bowman County, North Dakota, for your review and comment.

Please contact me at (303) 661-0294 if you have any questions regarding this submittal.

Sincerely,

Ann Weise, MPH

START R8 Project Manager

cc: Didi Fung, START Region 8 Program Manager
Clayton Longest, START Region 8 Document Control Coordinator

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1.0 Introduction

Tetra Tech, Inc. (Tetra Tech) Superfund Technical Assessment and Response Team (START) was tasked by the U.S. Environmental Protection Agency (EPA) Region 8 with conducting a streamlined risk assessment to evaluate the risk to human health and livestock, specifically cattle, associated with exposure to metals and uranium daughter products at the Griffin Ashing Site (the Site). The primary objective of this risk assessment is to provide information to aid EPA and the State of North Dakota in making decisions regarding future actions or land use at the Site.

This RA encompasses the following components:

- Streamlined Human Health Risk Assessment (HHRA): Evaluates current and future human health risks and hazards associated with potential exposure at the Site; identifies associated uncertainty and data gaps; and identifies any chemicals of potential concern (COPCs) that may require further assessment.
- Screening-Level Ecological Risk Assessment (SLERA): Evaluates current ecological risks associated with exposure at the Site. The SLERA also identifies potentially complete exposure pathways and chemicals of potential ecological concern (COPECs) at the Site.

1.1 Site Background

The Site is in the former town of Griffin, Bowman County, North Dakota. The geographic coordinates for the approximate center of the Site are 46.215780º north latitude and -103.540617º west longitude. While active during the 1960s, mining wastes were accepted for processing from multiple mines, including both the Flat Top and North Cave Hills mines located in South Dakota. The material was transported to the Site via rail and was processed on site using a rotary kiln. The former processing site encompasses approximately 1 acre. Portions of the Site are currently farmed for hay. In addition, railroad tracks are adjacent to the northern boundary of the former processing area (Tetra Tech 2022). The site location is depicted in Figure 1, and the site layout is depicted in Figure 2.

In October 2021, EPA, North Dakota Department of Environmental Quality (ND DEQ), and START conducted soil and plant tissue sampling at the Site. Soil and plant tissue samples were collected from grid cells within the 1-acre former processing area. Additional transect samples were collected from the north, east, south, and west of the former processing area; targeted soil samples were collected from areas with elevated gamma readings identified during a radiation survey conducted by ND DEQ.

Sixty-two surface (0 to 6 inches below ground surface [bgs]) soil samples (58 investigative samples and four field duplicates) were analyzed for Target Analyte List (TAL) metals (excluding mercury and including molybdenum, thorium, and uranium). Thirty-three surface soil samples (30 investigative samples and three field duplicates) were analyzed for potassium-40 (K-40), cesium-137 (Cs-137), lead-210 (Pb-210), polonium-210 (Po-210), radium-226 (Ra-226), radium-228 (Ra-228), thorium-230 (Th-230), thorium-232 (Th-232), uranium-234 (U-234), uranium-235 (U-235), and uranium-238 (U-238). In addition to soil samples, 17 plant tissue samples (16 investigative samples and one field duplicate) were collected and analyzed for TAL metals (Tetra Tech 2022). Analytical data summary tables for the October 2021 sampling event are provided in Appendix A. Figure 3 provides the locations of the soil and plant samples collected and used in the risk assessment.

1.2 Risk Assessment

The purpose of the risk evaluation is to estimate current and future human health risk under appropriate reasonable maximum exposure (RME) scenarios and risk to livestock, specifically cattle, based on current or hypothetical future Site use. The results of the risk assessment may be used to inform future decisions regarding land use at the Site. The HHRA identifies human health contaminants of concern (COCs) and the SLERA identifies contaminants of ecological concern (COECs).

1.3 Data Evaluation and Selection of Contaminants of Potential Concern and Contaminants of Potential Ecological Concern

The compiled investigation data from October 2021 were reviewed to ensure that the appropriate data were used for evaluation of the Site. Data compilation and management tasks included the selection of usable data and calculation of exposure point concentrations (EPCs) and other statistical values.

Evaluation of potential human and ecological exposure at the Site is limited to radionuclides and metals in soil because these are the contaminants of interest based on site history. All available data were screened for COPCs and COPECs using conservative risk-based screening levels.

COPCs to be included in the HHRA were screened using residential soil screening levels using a target cancer risk of 1 in 1 million (1E-06) and a target noncancer hazard quotient (HQ) of 0.1 (EPA 2022a). Cesium-137, potassium-40, thorium-232, and radium-228 were not evaluated as COPCs since they are not related to uranium mining and are, therefore, unrelated to historical site activities. **Tables 1a** and **1b** provide a summary of the sample results and the COPC screening. All detected analytes are included as COPECs in the SLERA.

An EPC is calculated for each COPC and COPEC for the Site based on the available data. The approach and calculations for EPCs follow EPA guidance (EPA 1992, 1994, 2000, 2002b, 2022b, 2022c) and are provided in **Appendix B**. A minimum of 10 samples and 4 detected results are required to calculate an EPC. If the dataset is smaller than 10 or the number of detections is fewer than 4, the maximum detected value should be used as the EPC. The EPC calculations were performed using ProUCL Version 5.2.00 (EPA 2022b). The EPC for each COPC is presented in **Table 2**.

2.0 Human Health Risk Assessment

This section describes the key elements of the HHRA methodology. An HHRA is the process for evaluating how people are impacted as a result of exposure to one or more environmental stressors, such as metals or radiation. Exposure is how a contaminant can enter a body, for example, by eating produce that absorbed contaminants, breathing contaminated dust, touching contaminated materials, or radiation emanating from soil. This risk assessment uses default exposure factors for outdoor workers and residents to evaluate how people may be exposed, currently and in the future, at the Site. This HHRA focuses on soil contamination only. The HHRA does not include ingestion of on-site surface water or groundwater by humans or animals.

The HHRA evaluates whether site-related COPCs detected in soil pose unacceptable risk to potential current and future people at the Site under conditions at the time of the investigation (EPA 1989, 1993). The HHRA is intended to provide input for risk-management decision-making for a site while maintaining a conservative approach protective of people at the site.

The methodology for the HHRA is based on the following primary guidance documents:

- Risk Assessment Guidance for Superfund (RAGS), Volume 1: Human Health Evaluation Manual (Part A) (EPA 1989)
- Preliminary Remediation Goals (PRG) for Radionuclide Contaminants at Superfund Sites User's Guide (EPA 2022d)
- Regional Screening Levels (RSL) – User's Guide (EPA 2022e)
- Conducting Non-Time-Critical Removal Actions under CERCLA (EPA 1993)

Consistent with standard risk assessment practice and EPA guidance, the HHRA will include the following components:

- Data evaluation and selection of COPCs
- Exposure assessment
- Toxicity assessment
- Risk characterization

2.1 Exposure Assessment

The exposure assessment is the process of measuring or estimating intensity, frequency, and duration of human exposure to a contaminant in the environment. The exposure assessment considers land use assumptions, discusses the mechanisms by which people might come in contact with COPCs in environmental media, characterizes exposure factors (for example, time on site). The intake assumptions are combined with the estimated concentration for each COPC (the EPC), to quantitatively estimate the contaminant exposure for the receptors at the site. In accordance with EPA (1989) guidance, an exposure assessment consists of three steps:

1. Characterization of the exposure setting (physical environment and potential receptors)
2. Identification of exposure pathways (constituent sources, exposure points, and exposure routes)
3. Quantification of pathway-specific exposures (EPCs) (receptor intake calculations and exposure assumptions)

The risk assessment conceptual site model (CSM) identifies potentially complete exposure pathways that receptors (both human and ecological) could come in contact with site-related constituents. The CSM is used throughout the site investigation and removal process to (1) provide a framework for addressing potential risks, (2) evaluate the need for additional data acquisition activities, and (3) evaluate health risks and the need for corrective measures. As defined in RAGS Part A (EPA 1989), the following four elements are necessary to form a complete exposure pathway:

- A source or release from a source
- A mechanism of release and transport
- A point of contact for potential receptors
- An exposure route

If any one of the four elements is missing, the exposure pathway is incomplete. In general, only potentially complete exposure pathways are evaluated in the HHRA. A graphical representation of the CSM is provided in **Figure 4**.

In HHRAs, the existing or proposed future land use for an area is key in determining the potential receptors evaluated in the HHRA for a site. This HHRA only evaluates the RME individual at the Site. Currently, the Site is accessed by ranchers and outdoor workers who use the Site to grow hay for cattle. In

the future, the Site may be used as a residential property. It is assumed most livestock consuming hay farmed on site are sold for slaughter and enter the larger food supply; however, the exposure of the general public to these livestock is *de minimis* and not a significant exposure pathway because these cattle represent a very small portion of the beef supply. The following table presents a brief description of each potential receptor at the Site.

Receptor Name	Receptor Timeframe	Receptor Description
Rancher	Current	Adults who farm the Site for hay. Includes external exposure to radiation, incidental ingestion of soil, dermal exposure to soil (metals only), inhalation of soil or dust, and ingestion of meat from cattle grazing on site.
Resident	Future	Adults and children who may live at the Site full time. Includes external exposure to radiation, incidental ingestion of soil, dermal exposure to soil (metals only), inhalation of soil (or dust), and ingestion of homegrown produce and meat from cattle grazing on site.

The following list provides the RME scenarios evaluated at the Site and the potentially complete human exposure pathways. The specific exposure inputs for these receptors evaluated in the HHRA are provided in **Tables 3a, 3b**, and **3c**.

Current Adult Rancher:

- Potential exposure to gamma radiation via external exposure
- Potential exposure to site-related COPCs present in soil through incidental ingestion, dermal contact, and inhalation
- Potential exposure to site-related COPCs present in meat through ingestion

Future Resident:

- Potential exposure to gamma radiation via external exposure
- Potential exposure to site-related COPCs present in soil through incidental ingestion, dermal contact, and inhalation
- Potential exposure to site-related COPCs present in homegrown produce and meat through ingestion

2.2 Toxicity Assessment

The toxicity assessment describes the relationship between a dose of a contaminant and the potential likelihood of an adverse health effect. The purpose of the toxicity assessment is to quantitatively estimate the inherent toxicity of COPCs for use in risk characterization. Potential effects of contaminants are separated into two categories: cancer and noncancer effects. Some contaminants can cause cancer while others cause noncancer health effects like neurological problems, kidney disease, thyroid disease, etc. Some contaminants, such as arsenic, have both cancer and noncancer health effects. For carcinogens, such as radionuclides, EPA assumes that there is no dose low enough to not cause an adverse health effect and that there is an increased risk as the dose increases. Noncancer COPCs, such as vanadium, are toxic above a threshold dose. Potential health risks for radionuclide COPCs are evaluated only for cancer risks while metal COPCs are evaluated for both cancer risk and noncancer hazard, as appropriate.

Potential carcinogenic effects resulting from human exposure to contaminants are estimated quantitatively using cancer slope factors (SFs), which represent the theoretical increased risk per milligram of constituent intake per kilogram body weight per day (milligram per kilogram per day [mg/kg-day])$^{-1}$, or unit risk factors (URFs), which are the theoretical increased risk at a defined exposure concentration (milligram per cubic meter [mg/m^3])$^{-1}$. SFs or URFs are used to estimate a theoretical upper-bound lifetime probability of an individual developing cancer as a result of exposure to a potential carcinogen.

Potential noncarcinogenic effects resulting from human exposure to contaminants are generally estimated quantitatively using reference doses (RfDs) and reference concentrations (RfCs). The RfD, expressed in units of daily dose (mg/kg-day), is an estimate of the daily maximum level of exposure to human populations (including sensitive sub-populations) that is likely to be without an appreciable risk of deleterious effects (EPA 1989). EPA has derived RfCs for inhalation exposures for some contaminants. An inhalation RfC is similar to an RfD. If the concentration of a contaminant in air to which a human exposure is lower than the RfC, no appreciable risk for noncancer health effects results from that exposure.

Risk-based screening levels (RBSLs) were developed for each COPC for the RME scenarios using a lifetime probability of an individual developing cancer as a result of exposure to a potential carcinogen of one in a million (1E-06); this value is called the target cancer risk in the risk assessment. For noncancer hazards, an estimate of the daily maximum level of human exposure to a contaminant (including sensitive subpopulations) that is likely to be without an appreciable risk of deleterious effects is called the target hazard quotient (HQ). The target HQ is 1 in this risk assessment.

Human health RBSLs were derived for applicable receptors and radionuclide and metal COPCs using all potentially complete soil-related exposure pathways. For metal COPCs with both carcinogenic and noncarcinogenic toxicity, the human health RBSL is equal to the lesser (more conservative) of the carcinogenic- and noncarcinogenic-based goal. For radionuclides, the human health RBSL is the carcinogenic-based screening level assuming secular equilibrium of the radionuclides and their decay products. **Tables 3**, **4**, **5**, and **6** provide the assumptions, inputs, and RBSLs calculated for cancer risk and noncancer hazard for each COPC for each exposure scenario used in the HHRA.

2.3 Risk Characterization

In general, risk characterization proceeds by combining results of exposure and toxicity assessments. RBSLs used in the HHRA were calculated using the EPA Preliminary Remediation Goal (PRG) calculator (for radionuclides) and Regional Screening Level (RSL) calculator (for metals) (EPA 2022a, 2022f). The calculators generate exposure pathway-specific RBSLs, including animal product and produce consumption pathways (in the case of the PRG calculator), and exposure pathways specific to receptors on site, in addition to the external exposure to radiation and direct exposure to radiation in soil through incidental ingestion and inhalation. EPA's RSL calculator considers only direct soil exposures (for example, soil ingestion, dermal contact, and inhalation of fugitive dust).

Total soil-related cancer risks were calculated using the following equation:

$$\text{Cumulative Cancer Risk} = \Sigma \text{Risk}_{i\text{-}j}$$

Where:

$\text{Risk}_{i\text{-}j}$ = Contaminant-specific cancer risk for contaminants i through j

Where:

$Risk_i = TCR \times [EPC_i/RBSLc\text{-}tot])$

Where:

$RBSLc\text{-}tot = 1/(1/([1/RBSLep_1] + [1/RBSLep_2] + \ldots + [1/RBSLep_i]))$

Where:

ep_i = Exposure pathway i
c-tot = Total (inclusive of all potentially complete exposure pathways for a given receptor) for cancer
TCR = Target cancer risk

As described above for risk, receptors may be exposed to more than one COPC in soil with potential noncancer adverse health effects at a particular site. The cumulative hazard index (HI) from potential exposure to multiple contaminants was calculated using the following equation.

$$\text{Cumulative Hazard Index} = \Sigma HI_{i\text{-}j}$$

Where:

$HI_{i\text{-}j}$ = Contaminant-specific hazard indices from metal i through metal j

Where:

$HI_i = THQ \times [EPC_i/RBSLnc\text{-}tot])$

Where:

$RBSLnc\text{-}tot = 1/(1/([1/RBSLnc\text{-}ep_1] + [1/RBSLnc\text{-}ep_2] + \ldots + [1/RBSLnc\text{-}ep_i]))$

Where:

ep_i = Exposure pathway i
nc-tot = Total (inclusive of all potentially complete exposure pathways for a given receptor) for noncancer effects
THQ = Target hazard quotient

Cancer RBSLs for radionuclides and metals are calculated using a target risk of 1E-06 (the lower end of EPA's risk management range). Noncancer RBSLs for metals are calculated using a target HQ of 1.

The cancer risk (age-adjusted adult and child) and noncancer hazards for child (or adult receptor in the case of the rancher) for the Site are provided in Table 7 and summarized below. Table 8 presents a comparison of EPCs, RBSLs, and BTVs for COCs.

Receptor	Cancer Risk	Noncancer Hazard Index
Adult Rancher	**$3x10^{-3}$**	**4**
Resident	**$5x10^{-2}$**	**1,000**

Bolded values exceed the target cancer risk or target hazard.

The following COCs were identified:

Receptor	Cancer Risk	Noncancer Hazard
Adult Rancher	Lead-210	Uranium

	Radium-226 Uranium-234 Uranium-235 Arsenic	
Resident	Lead-210 Radium-226 Polonium-210 Thorium-230 Uranium-234 Uranium-235 Uranium-238 Arsenic	Antimony Arsenic Cadmium Cobalt Copper Iron Manganese Molybdenum Selenium Thallium Uranium

2.4 Uncertainties Associated with the Human Health Risk Assessment

Uncertainties are inherent in the process of quantitative risk assessments based on the use of environmental sampling results, assumptions regarding exposure, and the quantitative representation of contaminant toxicity. Analysis of the critical areas of uncertainty in a risk assessment provides a better understanding of the quantitative results through the identification of the uncertainties that most significantly affect the results.

EPA guidance stresses the importance of providing an in-depth analysis of uncertainties so that risk managers are better informed when evaluating risk assessment conclusions (EPA 1989). Potentially significant sources of uncertainty for this risk assessment are discussed in the following subsections.

2.4.1 Uncertainty in the Conceptual Site Model

The CSM for the Site incorporates several assumptions regarding the completeness and reasonableness of the exposure scenarios presumed at the Site. For example, potential future residential use of the Site is a key assumption. RBSLs were calculated using standard protective exposure parameters for residents and outdoor workers. Actual exposure at the Site may vary from the exposure assumptions.

2.4.2 Uncertainty in Analytical Data

Laboratory analysis of environmental samples is subject to a number of technical difficulties; however, the magnitude of uncertainty is generally small compared with other sources of uncertainty.

2.4.3 Identification of Contaminants of Potential Concern

Section 1.3 presents the screening process used to identify medium-specific COPCs. Tetra Tech assigned COPCs for soil by comparing the maximum detected concentrations in soil against RBSLs. Uncertainty was introduced because maximum detected soil concentrations were screened against RBSLs based only on direct soil exposure pathways. However, any uncertainty associated with the omission of other potentially complete exposure pathways is judged to be small for the following reasons. First, both metal and radionuclide analytes were screened using a target cancer risk of 1E-06. Metals not selected as COPCs are only associated with noncarcinogenic health effects; their metal-specific screening levels were based on a target HQ of 0.1. In most cases, the maximum detected concentrations for metals not selected as COPCs are much lower than their respective RBSLs. Therefore, any uncertainty associated with the COPC identification process is judged to be small.

2.4.4 Exposure Point Concentrations

Risks and hazards were calculated using maximum detected concentrations as EPCs for contaminants with fewer than 10 results. Use of maximum detected concentrations as EPCs likely overestimated risks, whereas use of a 95 percent upper confidence limit (95UCL) as the EPC could underestimate or overestimate risks. However, this parameter is designed to overestimate the risk 95 percent of the time. Assumptions about the distribution of the data affect the calculation of a 95UCL and, therefore, contributed to uncertainty in the calculation. Considering the simulations used to develop the ProUCL algorithm (resulting in nominal 95UCL coverage), use of the ProUCL-recommended UCL method is the most defensible and transparent approach and the uncertainty associated with the calculations is judged to be small.

2.4.5 Exposure Parameters

Values assumed for the exposure parameters used in the calculations of intakes were based on default parameters recommended by EPA guidance (EPA 2022a, 2022f). These assumptions might result in underestimating or overestimating the intakes calculated for specific receptors, depending on the accuracy of the assumptions relative to actual site conditions and land uses.

The on-site outdoor worker scenario is a protective scenario using default exposure inputs, including being on site 8 hours per day, 350 days per year. In addition, the scenario assumes 270 grams (approximately 10 ounces) of beef raised on site is consumed 350 days per year. These exposure inputs should be evaluated to verify that they are truly representative of the exposure at the Site. If these exposures are overestimated, the risk to the on-site outdoor worker would be reduced. These assumptions are likely to overestimate the risk for the current on-site outdoor worker. The assumptions for the hypothetical future resident are also more likely to be overestimated than underestimated.

2.4.6 Contaminant-Specific Assumptions

The primary contaminant-specific assumptions incorporated into the streamlined HHRA are related to the use of contaminant-specific uptake and bioaccumulation factors. The HHRA used default update and bioaccumulation factors incorporated into EPA's PRGs calculated for radionuclides (EPA 2022f). These default values are based on peer-reviewed guidance documents and represent the best available values. To the extent that site- and plant-specific uptake and bioaccumulation factors specific to the Site differ from the default values, uncertainty is introduced, and it is not possible to readily determine whether this uncertainty would result in an under- or overestimation in COPC uptake and bioaccumulation into forage and animal product concentrations. Altogether, the uncertainty associated with the use of default uptake and bioaccumulation factors is judged to be small to moderate.

2.4.7 Uncertainty in Toxicity Estimates

Uncertainty is inherent in the toxicity values used in evaluating carcinogenic and noncarcinogenic risks. Such uncertainty is contaminant-specific and incorporated into the toxicity value during its development. For example, an uncertainty factor may be applied for interspecies and intrahuman variability, for extrapolation from subchronic to chronic exposures, or for epidemiological data limitations. Application of uncertainty factors is expected to overestimate risks. The HHRA used toxicity factors drawn from the most recent versions of EPA's RSL and PRG calculators (EPA 2022a, 2022f). Therefore, any uncertainty associated with the toxicity factors is consistent with EPA policies and procedures for selection of toxicity factors with all other risk assessments that rely on EPA-recommended toxicity factors.

2.4.8 Uncertainty Based on Background Threshold Values

Site-specific background threshold values (BTVs) are not available for many analytes at the Griffin Ashing Site. Site-specific BTVs for radium-226 and thorium-230 were obtained from historical site

investigations (Bendix Field Engineering Corporation 1986). However, BTVs for the rest of the radionuclides are not available. In lieu of site-specific BTVs, the BTVs for metals were selected as the mean concentration for the Western United States (Shacklette and Boerngen 1989).

3.0 Screening-Level Ecological Risk Assessment

The purpose of the SLERA is to evaluate the likelihood that adverse ecological effects are occurring or may occur as a result of site-specific constituent concentrations in environmental media. The Griffin Ashing Site is currently used to farm hay for cattle feed; therefore, cattle are the focus of the SLERA. This SLERA conservatively characterizes risks to livestock potentially associated with contaminated soil and plant tissue under current conditions at the time of the October 2021 assessment.

This ecological risk assessment (ERA) includes a Tier I SLERA and a Tier II Refined SLERA. The Tier I SLERA includes Steps 1 and 2 of EPA's eight-step ERA process (EPA 1997) and is intended to provide a conservative estimate of potential ecological risks and compensate for uncertainty in a precautionary manner by incorporating conservative assumptions. The Tier II Refined SLERA includes Step 3a of EPA's eight-step ERA process and introduces information to refine the risk estimates from Steps 1 and 2 (EPA 2000). Specifically, the Tier II Refined SLERA involves the refinement of the conservative screening-level assumptions used in the Tier I SLERA, the refinement of exposure estimates and ecological effects concentrations, and comparisons of site concentrations to background concentrations.

EPA's framework for ERA describes ERAs in three major phases: problem formulation, analysis of exposure and effects, and risk characterization (EPA 1992, 1998).

3.1 Problem Formation

The problem formation phase is a planning and scoping process that establishes the goals, breath, and focus of the risk assessment. Its end product is a CSM that identifies the environmental values to be protected (assessment endpoints [cattle]), data needed, and analyses to be used. The components of the problem formulation include:

- Ecological Habitat and Biological Resources
- Stressors and COPEC Selection
- Potentially Complete Exposure Pathways
- Assessment Endpoints
- Measurement Endpoints
- Ecological CSM

Tier I and Tier II SLERAs were conducted for radionuclides. The Tier I SLERA includes the screening-level problem formation (Step 1); and the exposure estimation, effects evaluation, and screening-level risk calculation (Step 2) of the EPA risk assessment process. The product of the Tier I SLERA is a list of COPECs in affected media that are recommended for further evaluation in a Tier II Refined SLERA. The Tier II Refined SLERA evaluates the Tier I COPECs by refining the exposure estimates and ecological effects concentrations and comparing site concentrations to background concentrations. Following the Tier II, COECs are identified.

To evaluate potential risks associated with metals, site-specific soil and plant tissue data were used to derive exposure estimates and risk calculations. The resulting list of COPECs were evaluated further by comparing site concentrations to background concentrations to identify COECs.

3.1.1 Ecological Habitat and Biological Resources

The Site is located in Griffin, North Dakota. Land use in the area is primarily agricultural. The Site consists of open grasslands and is used as a hay farm for cattle in the area; currently, cattle do not graze in the area. No surface water bodies are present at the Site. The primary potential ecological impact of contamination at the Site is uptake by plants and subsequent ingestion by cattle.

3.1.2 Stressors and Contaminants of Potential Ecological Concern Selection

All detected inorganic chemicals and radionuclides were considered Tier I COPECs in this SLERA. Essential nutrients that are not priority pollutants, such as calcium, magnesium, potassium, and sodium were not retained as COPECs. Cesium-137, potassium-40, thorium-232, and radium-228 were not retained as COPECs since they are naturally occurring and not associated with uranium mining. **Appendix A** presents the data included in the SLERA.

3.1.3 Potentially Complete Exposure Pathways

A chemical must be able to travel from the source to the receptor, in this case cattle, and must be taken up by cattle through one or more exposure routes for an exposure pathway to be complete. Complete exposure pathways present the greatest potential risk of adverse effects for cattle at the Site. Potential exposure pathways that may result in cattle contact with chemicals in the environment include soils, surface water, groundwater, air, and food-chain transfer.

Potential exposure pathways are diagrammed in the CSM (see **Figure 4**). Soil is the exposure medium of concern. The surface water and groundwater exposure pathways were not evaluated because no surface water exists at the Site, and chemical exposure is expected to occur primarily from contaminated soil. Exposure to surface water runoff that may contain site soils is considered a minor potentially complete pathway.

Windblown dust could represent a complete exposure pathway because areas of exposed soil exist at the Site. However, exposure to windblown dust is an insignificant pathway when compared with food-chain transfer and direct exposure to soils (see the discussion below). Therefore, it was not considered further in this SLERA.

Exposure routes, or points of entry of a chemical into a receptor, include root uptake and leaf sorption for plants and inhalation, dermal contact, and ingestion of contaminated soil and food for cattle (see **Figure 4**). Plants exposed to chemicals in soil may accumulate concentrations in tissue that cause adverse effects on growth, reproduction, or survival. Independent of direct effects on the plant, chemicals in plant tissues may be transferred to cattle.

Based on the physical characteristics of the site and surrounding areas, the following potential exposure pathways were identified:

- Potential exposure of cattle to site-related contaminants in soil through the ingestion of site-related contaminants in soil and plants.

3.1.4 Assessment Endpoints

EPA (1997) defines assessment endpoints as explicit expressions of the actual environmental values (for example, ecological resources) that are to be protected. Assessment endpoints are environmental characteristics that, if impaired, would indicate a need for action by risk managers.

The assessment endpoints identified for evaluation in the ERA were based on the ecological habitat, stressors and COPECs, and potentially complete exposure pathways identified in Sections 3.1.1 through

3.1.3. Each assessment endpoint is intended to protect the local populations of the identified resources. The assessment endpoints used to evaluate the potential ecological risk to receptors at the Site were:

- Protection of terrestrial plants
- Protection of cattle (herbivorous mammals)

3.1.5 Measurement Endpoints

Measurement endpoints related to the assessment endpoints were identified because assessment endpoints are usually not amenable to direct measurement. EPA defines a measurement endpoint as a measurable ecological characteristic that is related to the valued characteristics chosen as the assessment endpoint and is a measure of biological effects (such as mortality, reproduction, or growth) (EPA 1997).

3.1.5.1 Radionuclides

Tier I SLERA

A Tier I SLERA was conducted to assess receptor exposure to radionuclides at the Site. Tetra Tech used the no observed adverse effect level (NOAEL)-based toxicity value from the Los Alamos National Laboratory (LANL) EcoRisk database (N3B 2020) as the no observed effect concentration (NOEC) RBSL. The LANL EcoRisk database includes ecological screening levels (ESL) for plant, invertebrate, avian, and mammalian exposure models for radionuclides in soil. The ESLs for upper trophic level wildlife are based on incidental ingestion of soil and ingestion of food sources that have bioaccumulated contaminants. The no-effect ESLs are based on NOAEL-based toxicity reference values (TRVs) that are protective of wildlife populations and sensitive individuals because they represent exposures that are not associated with adverse impacts of low-level, long-term chemical effects. The NOEC RBSLs selected from LANL for use in the Tier I SLERA were the lowest NOECs for the evaluated receptor groups (plant and mammalian herbivores) for each radionuclide COPEC.

Tier II SLERA

COPECs identified in the Tier I SLERA were compared with the Tier II SLERA RBSLs, which represent a lowest observed adverse effect level (LOAEL). LOAELs are acceptable effect levels generally selected for population- and community-level assessment endpoints (Efroymson and others 1997). The LANL lowest observed effect concentration (LOEC) toxicity values were used for the Tier II SLERA.

3.1.5.2 Metals

A different methodology was used to evaluate the potential for adverse ecological effects related to metals concentrations in environmental media. Measurement endpoints for metals were derived from maximum tolerable levels (MTLs) of minerals for cattle, obtained from the National Research Council (NRC) (NRC 2005). The MTLs are defined as the dietary level that will not impair animal health or performance. MTLs of metals in feed were converted from milligram per kilogram (mg/kg) diet to mg/kg body weight per day to obtain a TRV using the equations below.

$$\text{TRV (mg/kg-bw-day)} = \text{MTL (mg/kg-diet)} \times \text{CF (1/day)}$$

$$\text{CF} = \text{FR (kg/day)}/\text{BW (kg)}$$

Where:

BW = Bodyweight (272 kg)

CF = Conversion Factor (0.033 day^{-1})

FR = Food Ingestion Rate (9.2 kg/day) (EPA 1993)

MTL = Maximum Tolerable Level (chemical-specific)

TRV = Toxicity Reference Value (chemical-specific)

3.1.6 Conceptual Site Model

The CSM illustrates exposure pathways to be evaluated and provides other key information such as chemical sources, release and transport mechanisms, and the relative importance of exposure pathways to specific receptors and receptor groups. The CSM incorporates all the components of the problem formulation as discussed above and as illustrated on **Figure 4**.

3.2 Analysis of Exposure and Effects

In the analysis phase, exposure to stressors (metals and radionuclides) and their relationship to ecological effects are evaluated. A determination is made of (1) the degree to which ecological receptors, that is cattle, are exposed; and, (2) whether that level of exposure is likely to cause harmful ecological effects.

3.2.1 Exposure Estimates

For Tier I, all site data were used to evaluate potential risk to ecological receptors. Exposure estimates for the Tier I SLERA are the maximum detected concentrations for COPECs in soil and plants compared to (1) the minimum NOEC RBSLs for radionuclides; and, (2) the MTL-based TRVs for metals.

For the Tier II SLERA exposure estimates, the 95UCL is typically used. However, the maximum detected concentration is used when the dataset is smaller than 10 samples or the number of detections is less than 4. **Table 2** summarizes the frequency of detection, the range of sample quantitation limits, the range of detected concentrations for each contaminant detected, and, the EPC for each detected contaminant in soil and plant tissue at the Site.

3.2.2 Ecological Effects

Ecological effects of potential concern are those that can impact populations by causing adverse effects on development, reproduction, and survival (EPA 1997). Literature-based effects concentrations (NOECs and LOECs), as described in Section 3.1.5, were used in the SLERA to characterize potential effects from direct contact and uptake through the food web to mammalian herbivores, specifically cattle.

For the Tier I SLERA, an HQ was calculated as the ratio of the maximum detected concentration to the effects concentration by COPEC and receptor. Tier I HQs greater than 1 indicate potential risk to receptors based on a comparison of the maximum detected concentration to minimum NOEC RBSLs for all receptors. Tier I HQs less than 1 indicate little to no potential ecological risk for a given COPEC, and the COPEC may be excluded from further consideration (that is, the COPEC was not evaluated in the Tier II SLERA). The Tier I SLERA HQ was calculated as follows:

$$Tier\ I\ HQ\ (metals) = \frac{Maximum\ Concentration}{No\ Observed\ Effect\ Concentration\ (NOEC)}$$

$$Tier\ I\ HQ\ (radionuclides) = \frac{Maximum\ Concentration}{Toxicity\ Reference\ Value\ (TRV)}$$

For the Tier II Refined SLERA, risk estimates were calculated by dividing EPCs by LANL LOEC RBSLs. Tier II HQs greater than 1 indicate potential risks to ecological receptors based on the estimated sitewide average (based on the lesser of the 95UCLs and maximum concentrations). Tier II HQs less than 1 indicate little potential ecological risk to the overall population for a given COPEC and receptor combination. The Tier II SLERA HQ was calculated as follows:

$$Tier\ II\ HQ\ (metals) = \frac{EPC}{Lowest\ Observed\ Effect\ Concentration\ (LOEC)}$$

$$Tier\ II\ HQ\ (radionuclides) = \frac{EPC}{Toxicity\ Reference\ Value\ (TRV)}$$

3.3 Risk Characterization

In the risk characterization phase, potential risk is estimated through integration of exposure and effects, potential risks are considered in the context of uncertainties associated with the SLERA, and risk descriptions are provided.

3.3.1 Tier I Screening for Contaminants of Potential Ecological Concern

Tier I HQs which represent the ratio of the maximum soil concentration to the NOEC RBSLs for radionuclides are presented in **Table 9a**; the HQs which represent the ratio of the maximum soil concentration to the TRVs for metals are presented in **Table 9b**. Contaminants for which the HQ was greater than 1 included radium-226, copper, iron, molybdenum, and selenium.

HQs equal to or less than 1 indicate that adverse ecological impacts are unlikely for a given COPEC and receptor combination (EPA 1997). For HQs greater than 1, the potential for ecological risk cannot be excluded and further evaluation or removal action may be warranted. COPECs and receptor combinations with Tier I SLERA HQs greater than 1 were further evaluated in the Tier II Refined SLERA.

3.3.2 Tier II Screening for Contaminants of Potential Concern

The Tier II Refined SLERA includes Step 3a of EPA's eight-step ERA process and refines the risk estimates for Tier I (EPA 2000). Specifically, the Tier II Refined SLERA involves the refinement of the conservative screening-level assumptions used in the Tier I SLERA for radionuclides, the refinement of exposure estimates and ecological effects concentrations, and the comparison of site concentrations to background concentrations.

EPCs for contaminants for which HQs exceeded 1 in Tier I were compared to BTVs to further refine the list of COPECs for further evaluation. The BTVs for metals are the mean concentrations for the Western United States as listed by Shacklette and Boerngen (1989). No COPECs were found to have site concentrations lower than the background concentrations based on the comparison of the EPC to the BTV (**Tables 10a** and **10b**).

As presented in **Tables 11a** and **11b**, the Tier II Refined SLERA COPECs for further refinement included radium-226, uranium-238, copper, iron, molybdenum, and selenium.

Based on the results of the Tier II Refined SLERA, molybdenum and selenium were identified as COECs for the Site.

3.4 Uncertainty Analysis

Uncertainty plays an important role in risk-based decision-making and is, therefore, incorporated explicitly into the risk characterization process. Identifying known sources of uncertainty is a critical component of an ERA because conservative default assumptions incorporated into the ERA protocol are associated with substantial uncertainty. The ERA process is based on a number of assumptions and extrapolations to evaluate potential risk to ecological receptors, specifically cattle. These assumptions are intentionally conservative and may result in overestimates of site-specific risk to ensure that no COPECs that pose actual risk are eliminated from the ERA. The primary components of uncertainties include those

associated with site data and exposure, the development and use of toxicity values, and interpretations of HQs to estimate potential risk to cattle and representative receptors.

3.4.1 Site Data and Exposure Estimates

Because Tetra Tech evaluated the entire Site using limited collected data, all concentrations measured are therefore only estimates of concentrations that may occur throughout the Site (with associated error). Tetra Tech assumed in the Tier I SLERA that the maximum detected concentration detected in soil and plant tissue at the Site represented the entire Site to ensure protectiveness. However, this method creates the bias in the data toward the more disturbed or affected environments at the Site and is likely to overestimate the Tier I COPEC exposure concentrations.

Similarly, in the Tier II SLERA, an EPC based on the lesser of the 95UCL concentration and maximum concentration of each COPEC for the Site was used to estimate sitewide exposures and promote protectiveness. The use of the 95UCL concentration may under- or overestimate COPEC concentrations used to characterize conditions throughout the Site, depending on their actual sitewide distribution. Therefore, the assumption that cattle are exposed to contaminants at their respective EPCs sitewide directly or via uptake through the food chain likely overestimates risk.

Site-specific bulk chemistry concentrations were compared with toxicity benchmark values such as LANL ESLs and MTL-derived TRVs as indicators of the potential for adverse effects. Bulk chemistry results for onsite soil samples likely overestimates the bioavailable fraction of each COPEC, as they do not consider whether the contaminant is bound to soil particles or other compounds that could prevent uptake by plants, and absorption upon direct contact or ingestion by cattle.

The ERA assumed that all cattle graze and feed exclusively from site-grown plants; this assumption is not necessarily true since cattle are not likely to be consistently exposed to COPECs in soil at the estimated site concentrations. Furthermore, use of the Site can vary seasonally. Therefore, the actual amount of soil or hay ingested from the Site would likely be less than the values used in the risk calculations, resulting in an overestimate of risk. Currently, cattle do not actively graze on site; therefore, the assumption that there will be incidental soil ingestion occurring during grazing is conservative and is likely to overestimate risks.

3.4.2 Development and Use of Toxicity Values

The uncertainties associated with LANL ESLs and MTL-derived TRVs can be assigned into two groups: (1) those pertaining to COPECs, including toxicity and bioavailability, and, (2) those pertaining to receptors, including the use of surrogate species and variation in body weight, associated food intake, and life history. The following subsections discuss these elements of uncertainty.

3.4.2.1 Toxicity Levels and Bioavailability

The toxicity values selected, including the NOEC and LOEC RBSLs and TRVs, are the primary drivers of uncertainty in this ERA because they were derived to be protective of ecological receptors. There are a limited number of species for which toxicity data are available; most of the RBSLs are derived for laboratory test species exposed to controlled dosing in laboratory environments. The conditions of controlled testing are not representative of bioavailability to cattle because of physiological and behavioral differences between species and the tendency for cattle to eat a more varied diet than a laboratory animal. These differences may over- or underestimate risks to cattle. Furthermore, differences between the bioavailability of a contaminant within site soil and contaminated media used in the toxicity tests may result in an overestimation of risk.

Uncertainty in the screening values varies according to how many toxicological studies were available and suitable for use in deriving the NOECs, LOECs, and MTLs. A low, medium, or high confidence level is assigned to each of the LANL values, and the availability of MTLs is limited because they are developed only when sufficient data are available (LANL 2017, NRC 2005).

Toxicity tests used to develop screening values typically focus on a single contaminant. However, the toxicity of a contaminant in the environment may be influenced by other elements and compounds. These effects may be additive, antagonistic, synergistic, or potentiating. As a result, the use of chemical-specific TRVs may over- or underestimate actual risk posed at the site.

LANL NOEC and LOEC RBSLs are modeled based on specific mammals representing general exposure scenarios. These species may not occur on site, which may result in over- or underestimation of exposure to those that do. Additionally, LANL used literature-based bioaccumulation factors (multipliers that estimate concentrations of constituents that can accumulate from media into tissue of food items such as from soil to plants) to develop the toxicity values. The selection and appropriateness of bioaccumulation data included in the bioaccumulation calculation may result in over- or underestimation of exposure. Uncertainties are addressed by a conservative approach, using the lowest of available receptor specific (NOEC in Tier I and LOEC in Tier II) for each COPC.

3.4.2.2 Receptor-Specific Assumptions

In the development of the LANL ESLs, the diet of each receptor type (plants and mammalian herbivores) was assumed to consist of a single target food type, which is not necessarily an accurate reflection of each receptor's diet. The diet of mammalian herbivores was assumed to be 100 percent plant material. These estimates of dietary composition may result in an over- or underestimate of risk depending on the actual diet of the cattle occupying the Site. The use of receptor species as surrogates for ecologically similar taxa is supported by EPA (1992) guidance; however, this type of analysis does not account for differences among taxa. In addition, uncertainty associated with assessments of risk to whole communities based on the detailed analysis of relatively few taxa may result in an over- or underestimate of risk.

Body weight for mammals has an allometric relationship to gross food intake (Nagy 1987 as cited in LANL 2017) and is used as a normalizing factor for food intake and NOAEL values (LANL 2017). Receptors used in the ERA were conservatively assumed to be relatively small species within a food intake per unit body mass (LANL 2017). This assumption is likely to overestimate risk to large mammals such as cattle, depending on the difference between actual values and literature values.

Individuals within a population vary in a number of life history and behavioral traits. The dose models used the develop the ESLs focused on adults and may not accurately represent ingestion of COPECs by juvenile stages that may feed in a different manger. The risk may be over- or underestimated, depending on the behavior and proportion of juveniles among the populations.

3.4.3 Interpretation of Hazard Quotients to Estimate Risk

The interpretation of HQs to estimate risk is a potentially large source of uncertainty because there is no clear guidance for interpreting an HQ greater than 1.

An HQ less than or equal to 1 indicates that adverse impacts to ecological receptors are considered unlikely (EPA 2001). HQs less than 1 indicate that there is little potential for ecological risk for a given COPEC and receptor combination and that the COPEC may be excluded from further consideration.

HQs exceeding 1 indicate that exposure to the COPEC at the corresponding effect level may lead to or may have caused adverse effects of some kind. The relationship of effects to HQ magnitude are not

necessarily linear; an HQ of 10 does not represent adverse effects 10 times greater than an HQ of 1. If an HQ is greater than 1, then there is potential for ecological risk. The use of HQs to interpret whether a COPEC poses risk to an ecological receptor may result in an over- or underestimation of risk.

Receptor	COEC	Noncancer Hazard Quotient
Cattle	Molybdenum	33
	Selenium	2

4.0 Risk Assessment Summary, Conclusions, and Recommendations

The human health and ecological risk assessments were completed using available laboratory data for soil and plant tissue. Two receptors were evaluated: the current on-site outdoor worker (rancher) and a hypothetical future resident. Both receptors were evaluated using the longer exposure duration of 40 years that is more representative of a farmer.

4.1 Human Health Risk Assessment

The current outdoor worker has an estimated cancer risk of 3E-03, which is greater than the upper limit of the acceptable risk range of 1E-04. The risk from radioisotopes, especially radium-226 at 1.9E-03, accounts for the majority of the calculated risk; however, arsenic alone exceeds the upper limit of the risk range at 1.4E-04. The noncancer hazard index for the on-site outdoor worker is 4, greater than the target hazard of 1. Uranium is the primary contributor to the noncancer hazard. The on-site outdoor worker scenario is a protective scenario using default exposure inputs, including being on site 8 hours per day, 350 days per year. In addition, the scenario assumes 270 gram (approximately 10 ounces) of beef raised on site is consumed 350 days per year. These exposure inputs should be evaluated to verify that they are truly representative of the exposure at the Site. If these exposures are overestimated, the risk to the on-site outdoor worker would be reduced.

The estimated cancer risk for a future resident is 5E-02, which is greater than the upper limit of the acceptable risk range. The risk from radioisotopes, especially radium-226 at 3.6E-03, accounts for the majority of the calculated risk; however, arsenic alone exceeds the upper limit of the risk range at 3.2E-04. The noncancer hazard index for the future resident child is 1,000, greater than the target hazard of 1. Uranium is the primary contributor to the noncancer hazard, with significant contributions from molybdenum and arsenic. The resident scenario used in this risk assessment used the standard exposure inputs other than the extended number of years on site.

After the exposure inputs, the most significant uncertainty in the risk evaluation is the lack of site-specific background concentrations that would allow differentiation of contamination from former site operations from naturally occurring levels in the area. However, given the elevated levels of radium-226 and other radioisotopes and arsenic on site, there is likely to be elevated cancer risk to receptors on site, regardless of background levels. In addition, the elevated metals, particularly uranium, molybdenum, and arsenic, are likely to result in unacceptable noncancer hazards to a resident child receptor because the onsite levels appear to be far greater than the expected background concentrations.

4.2 Risk to Cattle

The ERA identified two COECs, molybdenum and selenium, with individual HQs greater than 1, with molybdenum having a significantly larger HQ. A correlation between concentrations of metals in soil and plants was conducted as part of the October 2021 site assessment. The analysis revealed that the correlation of copper concentrations between colocated soil and plant tissue samples was negative.

Additionally, molybdenum exhibited the strongest positive correlation, with a correlation coefficient of 0.64 for soil and plant tissue concentrations (Tetra Tech 2022). The interaction between copper and molybdenum concentrations in feed has significant implications for overall cattle health. Excess concentrations of molybdenum are linked to reduced copper uptake, which may result in fatal copper deficiency diseases in grazing animals (Oregon State 2021).

4.3 Recommendations

The contamination observed on the Griffin Ashing Site does not appear to have been fully delineated for the COCs and COECs identified by the sampling performed in 2021. **Appendix C** contains 2D plume diagrams for all COCs and COECs. The lack of determination of the extent of the potential contamination warrants additional sampling at the Site. If additional sampling is conducted, then it is recommended that site-specific background samples also be collected to evaluate the risk and hazards attributable to naturally occurring background concentrations and what can be attributed to former site operations. Collection of additional data would allow for more informed risk management decisions.

Beef ingestion is the primary risk driver for the current outdoor worker (rancher) scenario evaluated. The exposure to homegrown produce is the primary cancer risk driver to the hypothetical future resident from radioactive elements, followed by beef ingestion. Note that ingestion of beef raised on site and sold to meat processors to be consumed by the general public is not considered a risk because the average consumer would be purchasing beef raised at multiple locations and not consuming beef from a single location, as is assumed in this risk assessment. However, even without the food ingestion exposure pathways, the estimated risk to the current outdoor worker and the future hypothetical resident from the soil exposure pathways will exceed 1E-04.

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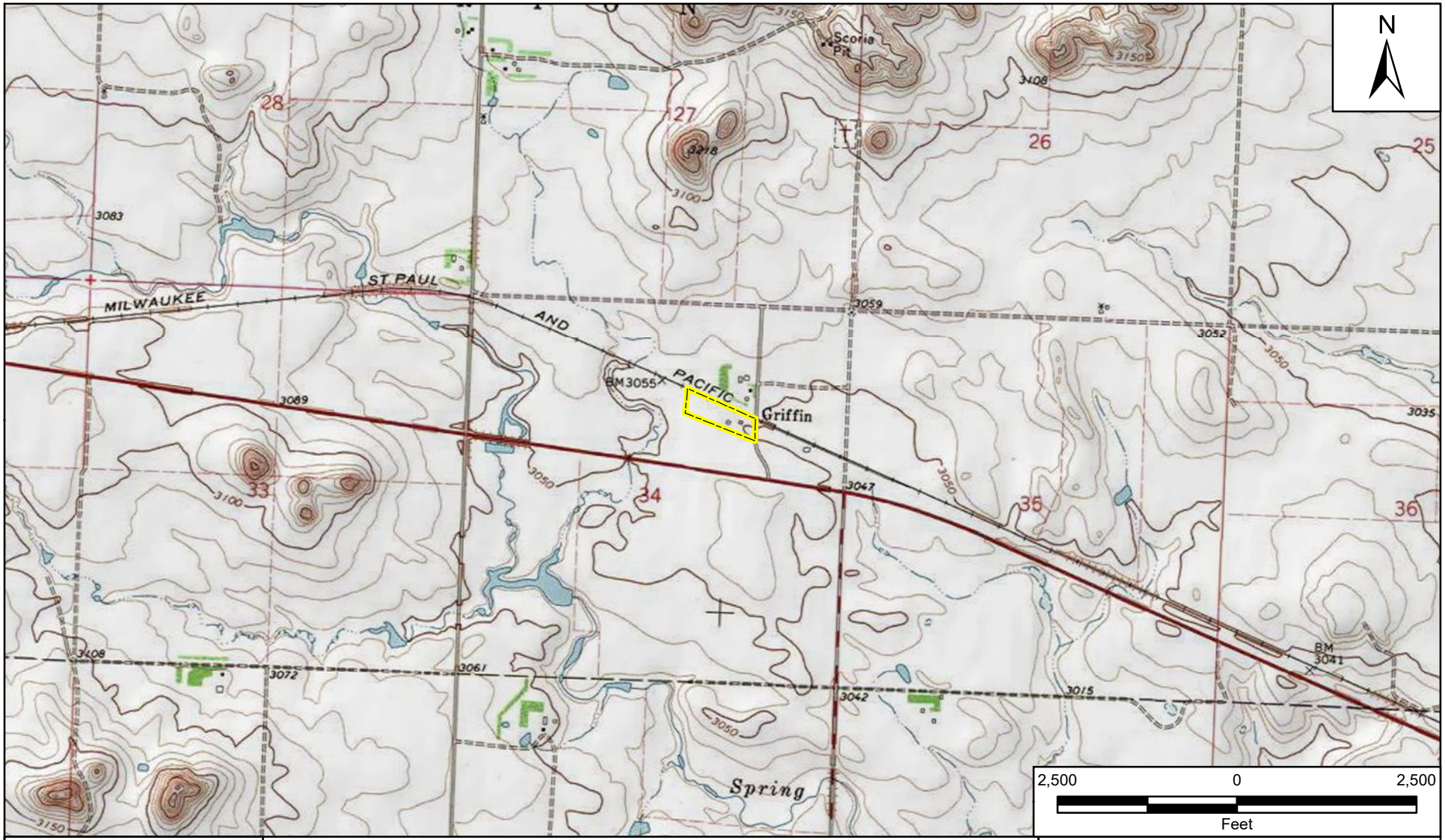
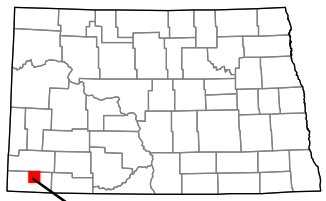
FIGURES





Legend

Site Boundary

Griffin Ashing Site (Flat Top Mine OU1)
Griffin, Bowman County, North Dakota

Figure 1
Site Location Map

TETRA TECH

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Date Saved: 12/6/2021

EPA Contract No.: 68-HE-0519-D0005

TO-TOLIN No.: 9035-20F0071210805

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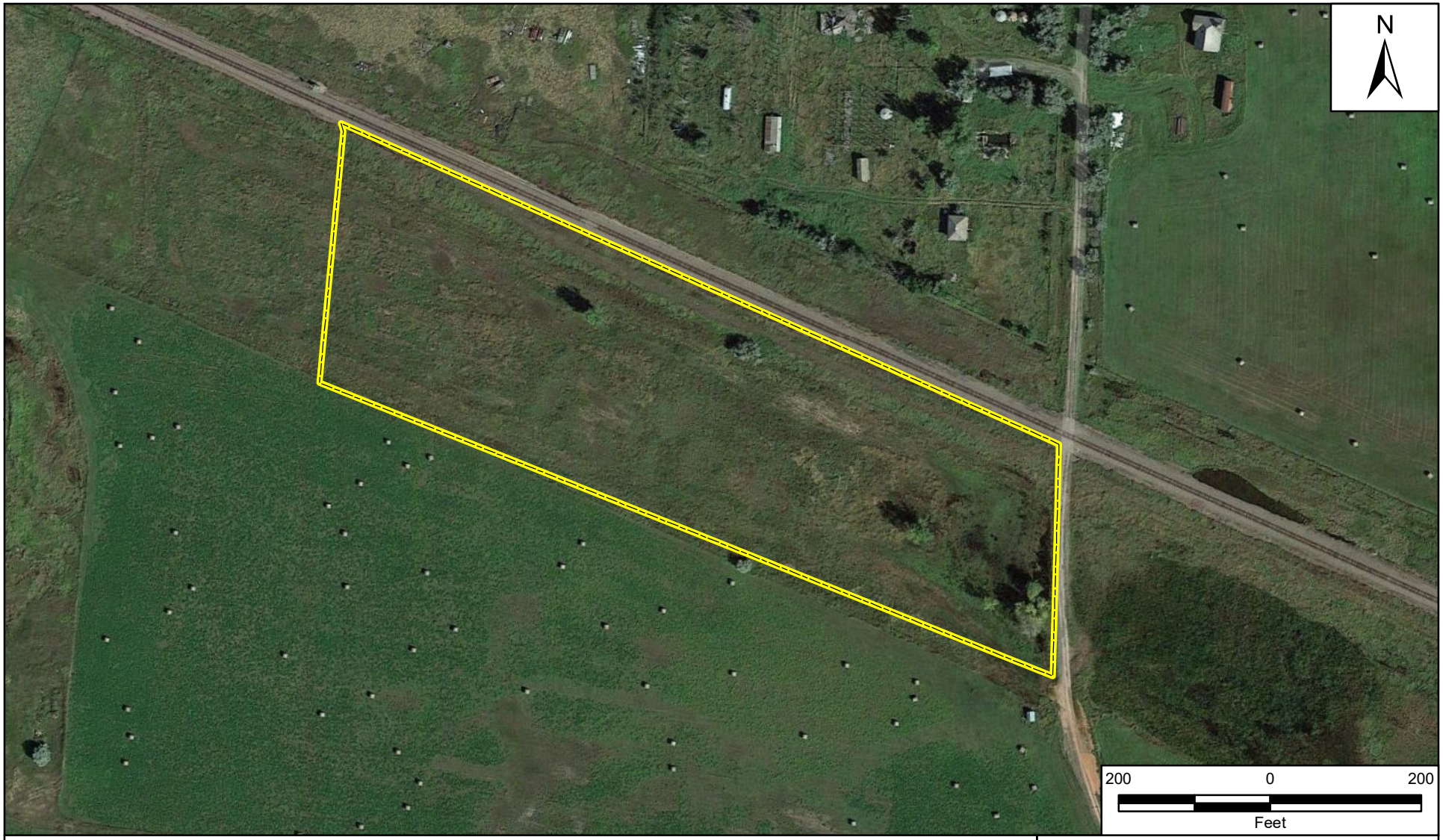

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Site Boundary

Griffin Ashing Site (Flat Top Mine OU1)
Griffin, Bowman County, North Dakota

Figure 2
Site Layout

TETRA TECH

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EPA Contract No.: 68-HE-0519-D0005

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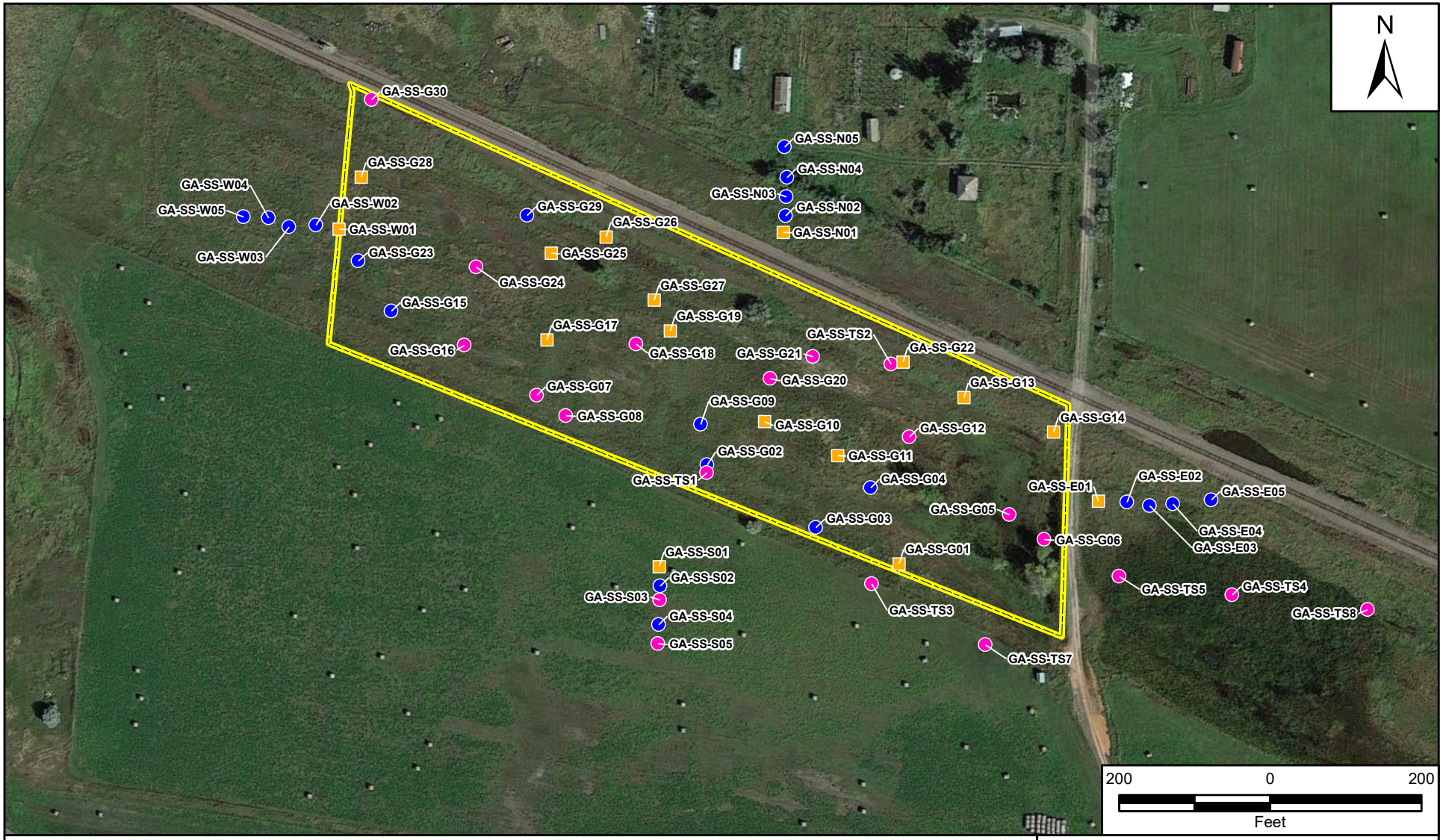

Legend

- Soil and Plant Sample Location
- Soil Sample Location - Metals Only
- Soil Sample Location - Metals and Isotopes
- Approximate Site Boundary

Griffin Ashing Site (Flat Top Mine OU1)
Griffin, Bowman County, North Dakota

Figure 3
Sample Location Map

TETRA TECH

Prepared For: EPA | Prepared By: Tetra Tech

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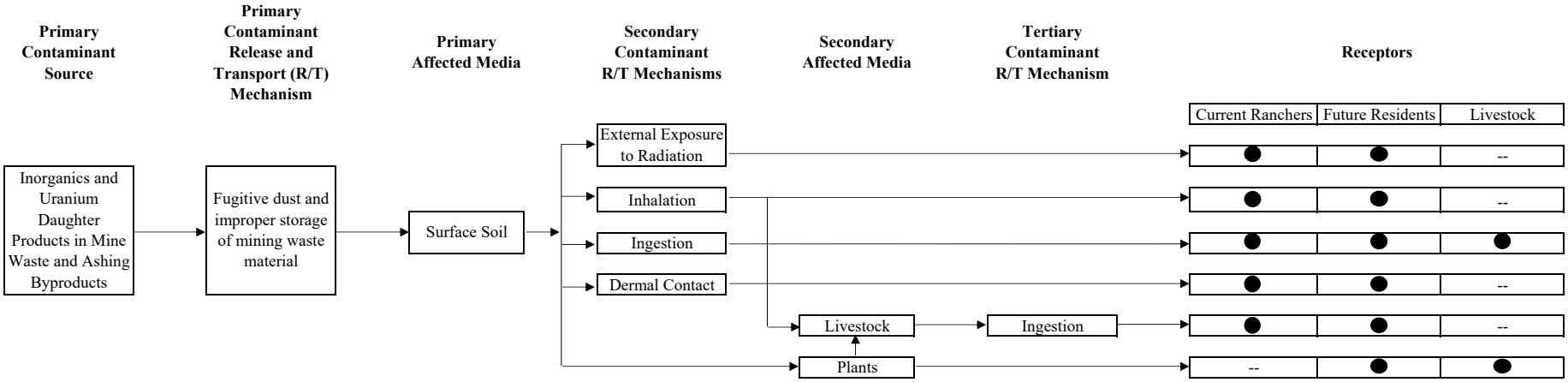

Notes:

-- Incomplete or negligible exposure pathway, not retained for evaluation.

● Potentially complete exposure pathway.

Griffin Ashing Site (Flat Top Mine OU1)
Griffin, Bowman County, North Dakota

Figure 4
Risk Assessment Conceptual Site Model

TETRA TECH

TABLES

Table 1a
COPC Screening of Maximum Detected Concentrations against Risk-Based Values - Soil
Griffin Ashing Site (Flat Top Mine OU1)

CAS Number	Contaminant	Detection Frequency	Units	Minimum Detected Concentration (qualifier)	Maximum Detected Concentration (qualifier)	Location of Maximum Concentration	Residential Soil PRG or RSL [a,b]	Include Contaminant as a COPC?
Radionuclides								
14255-04-0	Pb-210	30 / 30	pCi/g	2.8	194	GA-SS-TS01-211005	0.0058	**Yes**
13981-52-7	Po-210	30 / 30	pCi/g	2.9	192	GA-SS-TS01-211005	0.74	**Yes**
13982-63-3	Ra-226	30 / 30	pCi/g	7.4	539 J	GA-SS-TS03-211005	0.0069	**Yes**
14269-63-7	Th-230	30 / 30	pCi/g	5.4	366	GA-SS-TS03-211005	0.44	**Yes**
13966-29-5	U-234	30 / 30	pCi/g	4.9	347 J-	GA-SS-TS03-211005	0.11	**Yes**
15117-96-1	U-235	30 / 30	pCi/g	0.23	17 J-	GA-SS-TS03-211005	0.072	**Yes**
7440-61-1	U-238	30 / 30	pCi/g	4.6	356 J-	GA-SS-TS03-211005	0.12	**Yes**
Metals								
7429-90-5	Aluminum	58 / 58	mg/kg	2,400	16,000	GA-SS-TS01-211005	7,700	**Yes**
7440-36-0	Antimony	58 / 58	mg/kg	0.12 J-	7.2	GA-SS-G09-211004	3.1	**Yes**
7440-38-2	Arsenic	58 / 58	mg/kg	8.2	550	GA-SS-TS01-211005	0.68	**Yes**
7440-39-3	Barium	58 / 58	mg/kg	100	440	GA-SS-G24-211004	1,500	No
7440-41-7	Beryllium	58 / 58	mg/kg	0.27	2.9	GA-SS-TS03-211005	16	No
7440-43-9	Cadmium	58 / 58	mg/kg	0.13	2.4	GA-SS-TS03-211005	0.71	**Yes**
7440-70-2	Calcium	58 / 58	mg/kg	1,800	18,000	GA-SS-N05-211005	NSC	No
7440-47-3	Chromium[c]	58 / 58	mg/kg	6.9	33	GA-SS-G09-211004	12,000	No
7440-48-4	Cobalt	58 / 58	mg/kg	4.2	16 J-	GA-SS-G09-211004	2.3	**Yes**
7440-50-8	Copper	58 / 58	mg/kg	7.3	3,800	GA-SS-G09-211004	310	**Yes**
7439-89-6	Iron	58 / 58	mg/kg	9,700	63,000	GA-SS-G15-211004	5,500	**Yes**
7439-92-1	Lead	58 / 58	mg/kg	5.8 J+	540	GA-SS-G09-211004	400	**Yes**
7439-95-4	Magnesium	58 / 58	mg/kg	1800	5,400	GA-SS-E03-211005	NSC	No
7439-96-5	Manganese	58 / 58	mg/kg	260	1,100	GA-SS-G09-211004	180	**Yes**
7439-98-7	Molybdenum	58 / 58	mg/kg	3.5	680	GA-SS-TS01-211005	39	**Yes**
7440-02-0	Nickel	58 / 58	mg/kg	9.3	58	GA-SS-G09-211004	150	No
7440-9-7	Potassium	58 / 58	mg/kg	640	4,000	GA-SS-N05-211005	NSC	No
7782-49-2	Selenium	58 / 58	mg/kg	0.83 J	43.0	GA-SS-TS03-211005	39	**Yes**
7440-22-4	Silver	58 / 58	mg/kg	0.021 J	0.83	GA-SS-G09-211004	39	No
7440-23-5	Sodium	58 / 58	mg/kg	65 J	7,900	GA-SS-TS01-211005	NSC	No
7440-28-0	Thallium	58 / 58	mg/kg	0.081	1.8	GA-SS-TS01-211005	0.078	**Yes**
7440-29-1	Thorium	58 / 58	mg/kg	1.5	5	GA-SS-G06-211004	NSC	No
7440-61-1	Uranium	58 / 58	mg/kg	5.9	1,000	GA-SS-TS03-211005	1.6	**Yes**
7440-62-2	Vanadium	58 / 58	mg/kg	12	54	GA-SS-G15-211004	39	**Yes**
7440-66-6	Zinc	58 / 58	mg/kg	23	120	GA-SS-G09-211004	2,300	No

Notes:

Includes all soil samples from the Griffin Ashing Site. All soil samples were collected from 0 to 6 inches below ground surface.

Duplicate samples were not included in sample counts and were treated consistent with Section 1.3 of the Risk Assessment Memorandum.

a A target cancer risk of one in one million (1E-06) and a target noncancer hazard quotient of 0.1 were used for all human health risk-based screening levels.

b The residential soil PRG for radioisotopes were obtained from the online PRG calculator (https://epa-prgs.ornl.gov/radionuclides/). The residential soil RSLs for metals are from the RSL summary tables (https://www.epa.gov/risk/regional-screening-levels-rsls).

Definitions:

bgs Below ground surface
CAS Chemical Abstract Service
COPC Chemical of potential concern
mg/kg Milligrams per kilogram
NSL No screening level
pCi/g Picocuries per gram
PRG Preliminary remediation goal
RSL Regional Screening Level
SE Secular equilibrium
USEPA United States Environmental Protection Agency

Table 1b
COPEC Screening of Maximum Detected Concentrations against Risk-Based Values - Plant Tissue
Griffin Ashing Site (Flat Top Mine OU1)

CAS Number	Contaminant	Detection Frequency	Units	Minimum Detected Concentration (qualifier)	Maximum Detected Concentration (qualifier)	Location of Maximum Concentration	Include Contaminant as a COPEC?
Plant Tissue							
7429-90-5	Aluminum	16 / 16	mg/kg	6.5 J	48	GA-PT-G25-211004	**Yes**
7440-36-0	Antimony	15 / 16	mg/kg	0.022 J	0.069 J	GA-PT-S01-211005	**Yes**
7440-38-2	Arsenic	15 / 16	mg/kg	0.055 J	0.77	GA-PT-G22-211004	**Yes**
7440-39-3	Barium	16 / 16	mg/kg	3.0	36	GA-PT-G17-211004	**Yes**
7440-43-9	Cadmium	2 / 16	mg/kg	0.032 J	0.036 J	GA-PT-G25-211004	**Yes**
7440-48-4	Cobalt	3 / 16	mg/kg	0.036 J	0.051 J	GA-PT-S01-211005	**Yes**
7440-50-8	Copper	16 / 16	mg/kg	0.80 J	3.3	GA-PT-S01-211005	**Yes**
7439-89-6	Iron	16 / 16	mg/kg	22	100	GA-PT-G25-211004	**Yes**
7439-92-1	Lead	10 / 16	mg/kg	0.064 J	0.14 J	GA-PT-G01-211004	**Yes**
7439-96-5	Manganese	16 / 16	mg/kg	10	110	GA-PT-G19-211004	**Yes**
7439-98-7	Molybdenum	16 / 16	mg/kg	5	150	GA-PT-G27-211004	**Yes**
7440-02-0	Nickel	1 / 16	mg/kg	0.48 J	0.48 J	GA-PT-S01-211005	**Yes**
7440-9-7	Potassium	16 / 16	mg/kg	1,500	8,200	GA-PT-E01-211005	**Yes**
7782-49-2	Selenium	16 / 16	mg/kg	0.33 J	5.7	GA-PT-G10-211004	**Yes**
7440-28-0	Thallium	1 / 16	mg/kg	0.0046 J	0.0046 J	GA-PT-G19-211004	**Yes**
7440-29-1	Thorium	14 / 16	mg/kg	0.0077 J+	0.024 J+	GA-PT-G25-211004	**Yes**
7440-61-1	Uranium	16 / 16	mg/kg	0.011 J	0.36	GA-PT-S01-211005	**Yes**
7440-62-2	Vanadium	2 / 16	mg/kg	0.13 J	0.14 J	GA-PT-G25-211004	**Yes**
7440-66-6	Zinc	16 / 16	mg/kg	4.9 J	17	GA-PT-G27-211004	**Yes**

Notes:

Includes all plant tissue samples from the Griffin Ashing Site. Duplicate samples were not included in sample counts and were treated consistent with Section 1.3 of the Risk Assessment Memorandum.

No screening levels available

Definitions:

bgs	Below ground surface
CAS	Chemical Abstract Service
COPEC	Chemical of potential ecological concern
mg/kg	Milligrams per kilogram
USEPA	United States Environmental Protection Agency

Table 2
Summary Statistics and Exposure Point Concentrations
Griffin Ashing Site (Flat Top Mine OU1)

Griffin Ashing Site (Flat Top Mine OU1)											
COPC / COPEC	Units	Detection Frequency	Number of High Nondetect Results[a]	Maximum Concentration (qualifier)	Location of Maximum Concentration	Arithmetic Mean[b]	UCL95 / Distribution[c,d]		Exposure Point Concentration		
									Value	Statistic[e]	Method[f]
Soil											
Lead-210	pCi/g	30 / 30	0	194	GA-SS-TS01-211005	40	55	G	5.5E+01	UCL	(5)
Polonium-210	pCi/g	30 / 30	0	192	GA-SS-TS01-211005	42	57	G	5.7E+01	UCL	(5)
Radium-226	pCi/g	30 / 30	0	539 J	GA-SS-TS03-211005	116	160	G	1.6E+02	UCL	(5)
Thorium-230	pCi/g	30 / 30	0	366	GA-SS-TS03-211005	92	126	G	1.3E+02	UCL	(5)
Uranium-234	pCi/g	30 / 30	0	347 J-	GA-SS-TS03-211005	83	152	LN	1.5E+02	UCL	(4)
Uranium-235	pCi/g	30 / 30	0	17 J-	GA-SS-TS03-211005	4.1	8	LN	7.6E+00	UCL	(4)
Uranium-238	pCi/g	30 / 30	0	356 J-	GA-SS-TS03-211005	85	120	G	1.2E+02	UCL	(5)
Aluminum	mg/kg	58 / 58	0	16,000	GA-SS-TS01-211005	6,540	6,955	NP	7.0E+03	UCL	(3)
Antimony	mg/kg	58 / 58	0	7.2	GA-SS-G09-211004	0.57	1.12	NP	1.1E+00	UCL	(4)
Arsenic	mg/kg	58 / 58	0	550	GA-SS-TS01-211005	140.10	173.50	G	1.7E+02	UCL	(5)
Cadmium	mg/kg	58 / 58	0	2.4	GA-SS-TS03-211005	0.70	0.78	G	7.8E-01	UCL	(5)
Cobalt	mg/kg	58 / 58	0	16 J-	GA-SS-G09-211004	8.10	8.63	G	8.6E+00	UCL	(5)
Copper	mg/kg	58 / 58	0	3,800	GA-SS-G09-211004	80.90	365.30	NP	3.7E+02	UCL	(4)
Iron	mg/kg	58 / 58	0	63,000	GA-SS-G15-211004	22,483	24,867	LN	2.5E+04	UCL	(3)
Lead	mg/kg	58 / 58	0	540	GA-SS-G09-211004	27	67	NP	6.7E+01	UCL	(4)
Manganese	mg/kg	58 / 58	0	1,100	GA-SS-G09-211004	466	499	G	5.0E+02	UCL	(5)
Molybdenum	mg/kg	58 / 58	0	680	GA-SS-TS01-211005	129	165	G	1.7E+02	UCL	(5)
Selenium	mg/kg	58 / 58	0	43	GA-SS-TS03-211005	18	19	NP	1.9E+01	UCL	(3)
Thallium	mg/kg	58 / 58	0	1.8	GA-SS-TS01-211005	0.34	0.49	LN	4.9E-01	UCL	(4)
Uranium	mg/kg	58 / 58	0	1,000	GA-SS-TS03-211005	212	271	G	2.7E+02	UCL	(5)
Vanadium	mg/kg	58 / 58	0	54	GA-SS-G15-211004	27	29	G	2.9E+01	UCL	(5)
Plant Tissue											
Aluminum	mg/kg	16 / 16	0	48	GA-PT-G25-211004	24	30	N	3.0E+01	UCL	(2)
Antimony	mg/kg	15 / 16	0	0.069 J	GA-PT-S01-211005	0.046	0.053	N	5.3E-02	UCL	(6)
Arsenic	mg/kg	15 / 16	0	0.77	GA-PT-G22-211004	0.28	0.37	N	3.7E-01	UCL	(6)
Barium	mg/kg	16 / 16	0	36	GA-PT-G17-211004	20	24	G	2.4E+01	UCL	(2)
Cadmium	mg/kg	2 / 16	0	0.036 J	GA-PT-G25-211004	0.034	--		3.6E-02	Max	(1)
Cobalt	mg/kg	3 / 16	0	0.051 J	GA-PT-S01-211005	0.042	--		5.1E-02	Max	(1)
Copper	mg/kg	16 / 16	0	3.3	GA-PT-S01-211005	1.5	1.7	N	1.7E+00	UCL	(2)
Iron	mg/kg	16 / 16	0	100	GA-PT-G25-211004	54	64.82	N	6.5E+01	UCL	(2)
Lead	mg/kg	10 / 16	0	0.14 J	GA-PT-G01-211004	0.090	0.1	N	1.1E-01	UCL	(6)
Manganese	mg/kg	16 / 16	0	110	GA-PT-G19-211004	50	64	N	6.4E+01	UCL	(2)
Molybdenum	mg/kg	16 / 16	0	150	GA-PT-G27-211004	53	72	N	7.2E+01	UCL	(2)
Nickel	mg/kg	1 / 16	0	0.48 J	GA-PT-S01-211005	0.48	--		4.8E-01	Max	(1)
Selenium	mg/kg	16 / 16	0	5.7	GA-PT-G10-211004	2.1	3	N	2.8E+00	UCL	(6)
Thallium	mg/kg	1 / 16	0	0.0046 J	GA-PT-G19-211004	0.0046	--		4.6E-03	Max	(1)
Thorium	mg/kg	14 / 16	0	0.024 J+	GA-PT-G25-211004	0.014	0	N	1.6E-02	UCL	(6)
Uranium	mg/kg	16 / 16	0	0.36	GA-PT-S01-211005	0.079	0	LN	1.5E-01	UCL	(4)
Vanadium	mg/kg	2 / 16	0	0.14 J	GA-PT-G25-211004	0.14	--		1.4E-01	Max	(1)
Zinc	mg/kg	16 / 16	0	17	GA-PT-G27-211004	8.4	10	G	1.0E+01	UCL	(5)

Table 2
Summary Statistics and Exposure Point Concentrations
Griffin Ashing Site (Flat Top Mine OU1)

Notes: All samples collected from 0 to 6 inches bgs.

[a] Number of nondetect results that exceeded the maximum detected concentration. These results were not included in the statistical calculations.

[b] The arithmetic mean for datasets with nondetected results is calculated using the Kaplan-Meier (KM) method.

[c] Following USEPA (2002, 2015) guidance, this value may be estimated by a 95, 97.5, or 99 percent UCL depending on the sample size, skewness, and degree of censorship.

[d] Tested using the Shapiro-Wilk W or Lilliefors test for normal and lognormal distributions and the Anderson-Darling and Kolmogorov-Smirnov tests for gamma distributions. A 5 percent level of significance was used in all tests. Distribution tests were conducted only for samples with at least four detected results. Distributions not confirmed as normal (N), lognormal (LN), or gamma (G) were treated as nonparametric (NP) in all statistical calculations.

[e] The EPC is the lesser of the UCL95 and the maximum detected result. The maximum detected result is the default when there are fewer than 10 samples or fewer than four detected results. All methods follow USEPA (2002, 2015).

[f] The statistical methods for selecting the exposure point concentration are as follows:

(1)	Maximum detected concentrati	(2)	Student's-t UCL	(3)	Modified-t UCL	-4.0E+00	95% Chebyshev UCL
(5)	95 % Adjusted Gamma UCL			(6)	KM(t) UCL		

Notes (continued):

--	Not applicable	mg/kg	Milligram per kilogram
bgs	Below ground surface	N	Normal distribution
COPC	Contaminant of potential concern	NP	Nonparametric distribution
COPEC	Contaminant of potential ecological concern	pCi/g	Picocurie per gram
EPC	Exposure point concentration	UCL	Upper confidence limit of the mean
G	Gamma distribution	UCL95	One-sided 95 percent upper confidence limit of the mean
KM	Kaplan-Meier	USEPA	U.S. Environmental Protection Agency
LN	Lognormal distribution		

References:

U.S. Environmental Protection Agency (USEPA). 2002. “Calculating Exposure Point Concentrations at Hazardous Waste Sites.” Office of Solid Waste and Emergency Response. Directive 9285.6-10. December.

USEPA. 2015. “ProUCL Version 5.1 Technical Guide.” Prepared by A. Singh and A.K. Singh. EPA/600/R-07/041. October.

Table 3a
Values Used for Noncancer Risk-Based Concentrations for Soil based on a Current Rancher (Lives Offsite, Eats Beef from Site)
Griffin Ashing Site (Flat Top Mine OU1)

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference
All	Rancher	Adult	Soil	EF	Exposure Frequency	350	days/year	USEPA 2022a (1)
				ED	Exposure Duration	34	years	USEPA 2022a (2)
				BW	Body Weight	80	kg	USEPA 2022a,b (3)
				ATc	Averaging Time - Carcinogens	25,550	days	USEPA, 1989, 2022b (4)
				ATnc	Averaging Time - Noncarcinogens	12,410	days	USEPA, 1989, 2022a,b (5)
Ingestion	Rancher	Adult	Soil	RBA	Relative Bioavailability Factor (metals only)	contaminant-specific	unitless	See Table 4.3
				IRs	Soil Ingestion Rate	100	mg/day	EPA 2022a (6)
		Child		CFs	Conversion Factor - Soil	1.0E-06	kg/mg	--
Dermal	Rancher	Adult	Soil	DAF	Dermal Absorption Factor (metals only)	contaminant-specific	unitless	See Table 4.3
				SA	Skin Surface Area	3,527	cm^2	EPA 2022b (7)
				AF	Soil-to-Skin Adherence Factor	0.12	mg/cm^2	EPA 2022b (8)
				CFs	Conversion Factor - Soil	1.0E-06	kg/mg	--
Inhalation	Rancher	Adult	Air	PEF	Particulate Emission Factor	1.36E+09	m^3/kg	EPA 2022a,b (9)
			Particulates	ET	Exposure Time	8	hours/day	EPA 2022b (10)
			from Soil	CFt	Conversion Factor - Time (1/24)	0.042	day/hours	--
Ingestion	Rancher	Adult	Soil	IR_{beef}	The daily ingestion rate for beef	270.1	g/day	EPA 2022a (11)
			From	CF	The fraction of an animal product consumed by the receptor from animals raised onsite.	1	unitless	EPA 2022a (11)
			Beef	fp	The fraction of forage consumed by the animal that is grown onsite.	1	unitless	EPA 2022a (11)
			Ingestion	fs	The fraction of soil consumed by the animal that is from onsite.	1	unitless	EPA 2022a (11)
				$MLF_{pasture}$	Pasture plant mass loading factor	0.25	unitless	EPA 2022a (11)
				Qp	The mass of fodder consumed by the animal each day.	11.77	kg fodder/day	EPA 2022a (11)
				Qs	The mass of soil consumed by the animal each day.	0.5	kg soil/day	EPA 2022a (11)
External Radiation	Rancher	Adult	Soil	ACF	Area Correction Factor	1,000,000	m^2	EPA 2022b (11)
				GSF	Cover Thickness	0	cm	EPA 2022b (11)
				--	Climate Zone	Temperate	unitless	EPA 2022b (11)
				--	Soil Type	Default	unitless	EPA 2022b (11)

Table 3a
Values Used for Noncancer Risk-Based Concentrations for Soil based on a Current Rancher (Lives Offsite, Eats Beef from Site)
Griffin Ashing Site (Flat Top Mine OU1)
Notes:

(1) EF: Default exposure frequency for an adult farmer
(2) ED: Default exposure duration for an adult farmer
(3) BW: Default adult body weight
(4) ATc: 365 days/year x 70 -year expected lifespan
(5) ATnc: 365 days/year x 34-year ED
(6) IRs: Default soil ingestion rate for farmer
(7) SA: Default skin surface area for outdoor worker
(8) AF: Default soil-to-skin adherence factor for outdoor worker
(9) PEF: Default value
(10) ET: Default exposure time for outdoor worker
(11) Default farmer values from Preliminary Remediation Goals calculator (EPA 2022a)

Sources:

U.S. Environmental Protection Agency (EPA). 1989. “Risk Assessment Guidance for Superfund: Volume I – Human Health Evaluation Manual (Part A).” Office of Solid Waste and Emergency Response (OSWER). EPA/540/1-89/002a. December.

EPA. 2005. Human Health Risk Assessment Protocol (HHRAP) for Hazardous Waste Combustion Facilities. OSWER. EPA-530-R-05-006. September.

EPA. 2022a. Preliminary Remedial Goals (PRGs). May.

EPA. 2022b. Regional Screening Levels (RSLs). May.

Table 3b
Values Used for Noncancer Risk-Based Concentrations for Soil based on a Future Aggregate Resident
Griffin Ashing Site (Flat Top Mine OU1)

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference
All	Farmer	Adult	Soil	EF	Exposure Frequency	350	days/year	USEPA 2022a (1)
		and		ED_a	Exposure Duration - Adult	34	years	USEPA 2022a (2)
		Child		ED_c	Exposure Duration - Child	6	years	USEPA 2022a (2)
				ED	Exposure Duration	40	years	Calculated (2)
				BW_a	Body Weight - Adult	80	kg	USEPA 2022a,b (3)
				BW_c	Body Weight - Child	15	kg	USEPA 2022a,b (4)
				ATc	Averaging Time - Carcinogens	25,550	days	USEPA, 1989, 2022a,b (5)
				ATnc	Averaging Time - Noncarcinogens	14,600	days	USEPA, 1989, 2022a,b (6)
Ingestion	Farmer	Adult	Soil	RBA	Relative Bioavailability Factor	contaminant-specific	unitless	See Table 4.3
		and		IR_{s-a}	Soil Ingestion Rate - Farmer Adult	100	mg/day	EPA 2022a (7)
		Child		IR_{s-c}	Soil Ingestion Rate - Child	200	mg/day	EPA 2022a,b (7)
				IR_{s-adj}	Soil Ingestion Rate - Age Adjusted	122.5	mg-year/kg-day	Calculated (7)
				CFs	Conversion Factor - Soil	1.0E-06	kg/mg	--
Dermal	Farmer	Adult	Soil	DAF	Dermal Absorption Factor	contaminant-specific	unitless	See Table 4.3
		and		SA_a	Skin Surface Area - Farmer Adult	3,527	cm^2	EPA 2022b (8)
		Child		SA_c	Skin Surface Area - Child	2,373	cm^2	EPA 2022b (8)
				AF_a	Soil-to-Skin Adherence Factor - Adult	0.12	mg/cm^2	EPA 2022a,b (9)
				AF_c	Soil-to-Skin Adherence Factor - Child	0.2	mg/cm^2	EPA 2022a,b (9)
				DFSadj	Age-Adjusted Dermal Contact Factor - Soil	370	mg-year/kg-day	Calculated (10)
				CFs	Conversion Factor - Soil	1.0E-06	kg/mg	--
Inhalation	Farmer	Adult	Particulates	PEF	Particulate Emission Factor	1.36E+09	m^3/kg	EPA 2022a,b (11)
		and	from Soil	ET	Exposure Time	24	hours/day	EPA 2022a,b (12)
		Child		ET_o	Exposure Time - Outdoor	12.168	hours/day	EPA 2022b (13)
				ET_i	Exposure Time - Indoor	10.008	hours/day	EPA 2022b (13)
				CFt	Conversion Factor - Time (1/24)	0.042	day/hours	--
Ingestion	Farmer	Adult	Soil	CR_{ag-a}	Aboveground Produce Consumption Rate - Adult	9.30E-04	kg DW/kg-day	EPA 2005 (14)
		and	from	CR_{ag-c}	Aboveground Produce Consumption Rate - Child	2.27E-03	kg DW/kg-day	EPA 2005 (14)
		Child	Homegrown	CR_{ag-adj}	Aboveground Produce Consumption Rate - Age-adjusted	1.30E-03	yr-kg DW plant/ kg-day	calculated (14)
			Produce	CR_{bg-a}	Belowground Produce Consumption Rate - Adult	1.40E-04	kg-year/kg-day	EPA 2005 (14)
				CR_{bg-c}	Belowground Produce Consumption Rate - Child	2.30E-04	kg DW/kg-day	EPA 2005 (14)
				CR_{bg-adj}	Belowground Produce Consumption Rate - Age-adjusted	1.52E-04	yr-kg DW plant/ kg-day	calculated (14)
				Br_{ag}	Plant-Soil Bioconcentration Factor for Aboveground Produce	contaminant-specific	[mg/kg DW]/[mg/kg]	See Table 4.3
				$Br_{rootveg}$	Plant-Soil Bioconcentration Factor for Belowground Produce	contaminant-specific	[mg/kg DW]/[mg/kg]	See Table 4.3
				$VG_{rootveg}$	Empirical Correction Factor for Belowground Produce	contaminant-specific	unitless	See Table 4.3
				Fp	Fraction of Homegrown Produce Ingested From Contaminated Source	1	unitless	EPA 2005 (14)
Ingestion	Farmer	Adult	Soil	IR_{beef-a}	The daily ingestion rate for beef - Adult	270.1	g/day	EPA 2022a (13)
		and	From	IR_{beef-c}	The daily ingestion rate for beef - Child	64.6	g/day	EPA 2022a (13)
		Child	Beef	$IR_{beef-adj}$	The daily ingestion rate for beef - Age-Adjusted	141	g/day	Calculated (15)
			Ingestion	CF	The fraction of an animal product consumed by the receptor from animals raised onsite.	1	unitless	EPA 2022a (13)
				fp	The fraction of forage consumed by the animal that is grown onsite.	1	unitless	EPA 2022a (13)
				fs	The fraction of soil consumed by the animal that is from onsite.	1	unitless	EPA 2022a (13)
				$MLF_{pasture}$	Pasture plant mass loading factor	0.25	unitless	EPA 2022a (13)
				Qp	The mass of fodder consumed by the animal each day.	11.77	kg fodder/day	EPA 2022a (13)
				Qs	The mass of soil consumed by the animal each day.	0.5	kg soil/day	EPA 2022a (13)

Table 3b
Values Used for Noncancer Risk-Based Concentrations for Soil based on a Future Aggregate Resident
Griffin Ashing Site (Flat Top Mine OU1)

Notes:

(1) EF: Default exposure frequency for a farmer

(2) ED: Default exposure duration for adult and child residents. Total exposure duration the sum of $ED_a + ED_c$.

(3) BW_a: Default body weight for adult

(4) BW_c: Default body weight for child

(5) ATc: 365 days/year x 70 year expected lifespan

(6) ATnc: 365 days/year x ED

(7) IRs: The default soil ingestion rates for adult farmer and child. Age adjusted soil ingestion rate is calculated as follows:
$IR_{s\text{-}adj}$ (mg-year/kg-day) = [EDc (6 years) x $Ir_{s\text{-}c}$(200 mg/day) / BWc (15kg)] + [EDa (34 years) x $IR_{s\text{-}a}$(100 mg/day) / BWa (80kg)]

(8) SA: Default skin surface area for children and adult outdoor worker for soil. Age-adjusted surface area calculated as follows:

(9) AF: Default soil-to-skin adherence factor for children and for adult outdoor worker

(10) DFS_{adj}=[(EDchild (6 years) x SA_{child} (2,373 cm^2) x AF_{child} (0.2 mg/cm^2)/ BW_{child} (15kg)] + [(EDadult (34 yr) x SA_{adult} (3,527 cm^2) x AF_{adult} (0.12 mg/cm^2) / BW_{adult} (80kg)]

(11) PEF: Default value

(12) ET: Default exposure time for residents.

(13) Default values for farmer from Preliminary Remediation Goals calculator (EPA 2022a)

(14) Default values from Human Health Risk Assessment Protocol (HHRAP) for Hazardous Waste Combustion Facilities (EPA 2005).
$CR_{ag\text{-}adj}$ (yr-kg DW/kg-day) = (ED_{child} (6 yrs) x $CR_{ag\text{-}child}$ (2.27E-03 kg DW plant/day))/BW_{child} (15 kg) + (ED_{adult} (34 yrs) x $CR_{ag\text{-}adult}$ (9.3E-04 kg DW plant/day))/BW_{adult} (80 kg)
$CR_{bg\text{-}adj}$ (yr-kg DW/kg-day) = (ED_{child} (6 yrs) x $CR_{bg\text{-}child}$ (2.3E-04 kg DW plant/day))/BW_{child} (15 kg) + (ED_{adult} (34 yrs) x $CRb_{g\text{-}adult}$ (1.4E-04 kg DW plant/day))/BW_{adult} (80 kg)

(15) IR_{beef}: Age-adjusted beef ingestion rate is calculated as follows:
$IR_{beef\text{-}adj}$ (mg-year/kg-day) = [ED_c (6 years) x $IR_{beef\text{-}c}$(64.6 g/day) / BW_c (15kg)] + [ED_a (34 years) x $IR_{beef\text{-}a}$(270.1 g/day) / BW_a (80kg)]

Sources:

U.S. Environmental Protection Agency (EPA). 1989. "Risk Assessment Guidance for Superfund: Volume I – Human Health Evaluation Manual (Part A)." Office of Solid Waste and Emergency Response (OSWER). EPA/540/1-89/002a. December.

EPA. 2005. Human Health Risk Assessment Protocol (HHRAP) for Hazardous Waste Combustion Facilities. OSWER. EPA-530-R-05-006. September.

EPA. 2022a. Preliminary Remedial Goals (PRGs). May.

EPA. 2022b. Regional Screening Levels (RSLs). May.

Table 3c
Values Used for Noncancer Risk-Based Concentrations for Soil based on a Future Child Resident
Griffin Ashing Site (Flat Top Mine OU1)

Exposure Route	Receptor Population	Receptor Age	Exposure Point	Parameter Code	Parameter Definition	Value	Units	Rationale/ Reference
All	Resident	Child Age 0-6	Soil	EF	Exposure Frequency	350	days/year	USEPA 2022a,b (1)
				ED	Exposure Duration	6	years	USEPA 2022a,b (2)
				BW	Body Weight	15	kg	USEPA 2022a,b (3)
				ATnc	Averaging Time - Noncarcinogens	2,190	days	USEPA, 1989, 2022b (4)
Ingestion	Resident	Child Age 0-6	Soil	RBA	Relative Bioavailability Factor	contaminant-specific	unitless	See Table 4.3
				IRs	Soil Ingestion Rate	200	mg/day	EPA 2022a,b (5)
				CFs	Conversion Factor - Soil	1.0E-06	kg/mg	--
Dermal	Resident	Child Age 0-6	Soil	DAF	Dermal Absorption Factor	contaminant-specific	unitless	See Table 4.3
				SA	Skin Surface Area	2,373	cm^2	EPA 2022a,b (6)
				AF	Soil-to-Skin Adherence Factor	0.2	mg/cm^2	EPA 2022a,b (7)
				CFs	Conversion Factor - Soil	1.0E-06	kg/mg	--
Inhalation	Resident	Child Age 0-6	Air Particulates from Soil	PEF	Particulate Emission Factor	1.36E+09	m^3/kg	EPA 2022a,b (8)
				ET	Exposure Time	24	hours/day	EPA 2022a,b (9)
				CFt	Conversion Factor - Time (1/24)	0.042	day/hours	--
Ingestion	Resident	Child Age 0-6	Soil from Homegrown Produce	IRag	Aboveground Produce Ingestion Rate	2.27E-03	kg DW/kg-day	EPA 2005 (10)
				IRbg	Belowground Produce Ingestion Rate	2.30E-04	kg DW/kg-day	EPA 2005 (10)
				Br_{ag}	Plant-Soil Bioconcentration Factor for Aboveground Produce	contaminant-specific	[mg/kg DW]/[mg/kg]	See Table 4.3
				$Br_{rootveg}$	Plant-Soil Bioconcentration Factor for Belowground Produce	contaminant-specific	[mg/kg DW]/[mg/kg]	See Table 4.3
				$VG_{rootveg}$	Empirical Correction Factor for Belowground Produce	contaminant-specific	unitless	See Table 4.3
				Fp	Fraction of Homegrown Produce Ingested From Contaminated Source	1	unitless	EPA 2005 (10)
Ingestion	Resident	Child Age 0-6	Soil From Beef Ingestion	IR_{beef}	The daily ingestion rate for beef	64.6	g/day	EPA 2022a (11)
				CF	The fraction of an animal product consumed by the receptor from animals raised onsite.	1	unitless	EPA 2022a (11)
				fp	The fraction of forage consumed by the animal that is grown onsite.	1	unitless	EPA 2022a (11)
				fs	The fraction of soil consumed by the animal that is from onsite.	1	unitless	EPA 2022a (11)
				$MLF_{pasture}$	Pasture plant mass loading factor	0.25	unitless	EPA 2022a (11)
				Qp	The mass of fodder consumed by the animal each day.	11.77	kg fodder/day	EPA 2022a (11)
				Qs	The mass of soil consumed by the animal each day.	0.5	kg soil/day	EPA 2022a (11)

Table 3c
Values Used for Noncancer Risk-Based Concentrations for Soil based on a Future Child Resident
Griffin Ashing Site (Flat Top Mine OU1)

Notes:
(1) EF: Default exposure frequency for a child.
(2) ED: Default exposure duration for child residents.
(3) BW: Default child body weight.
(4) ATnc: 365 days/year x 6 year ED; note, carcinogenic effects for residents were evaluated using the more-sensitive aggregate resident receptor only.
(5) IRS: Default soil ingestion rate for children.
(6) SA: Default skin surface area for children for soil. Weighted average of mean values for head, hands, forearms, lower legs, and feet (male and female, birth to < 6 years).
(7) AF: Default soil-to-skin adherence factor for children.
(8) PEF: Default value
(9) ET: Default exposure time for residents.
(10) Default values from Human Health Risk Assessment Protocol (HHRAP) for Hazardous Waste Combustion Facilities (EPA 2005).
(11) Default values from Preliminary Remediation Goals calculator (EPA 2022a)

Sources:
U.S. Environmental Protection Agency (EPA). 1989. “Risk Assessment Guidance for Superfund: Volume I – Human Health Evaluation Manual (Part A).” Office of Solid Waste and Emergency Response (OSWER). EPA/540/1-89/002a. December.

EPA. 2005. Human Health Risk Assessment Protocol (HHRAP) for Hazardous Waste Combustion Facilities. OSWER. EPA-530-R-05-006. September.

EPA. 2022a. Preliminary Remedial Goals (PRGs). May.

EPA. 2022b. Regional Screening Levels (RSLs). May.

Table 4a
Toxicity Criteria for Metals
Griffin Ashing Site (Flat Top Mine OU1)

Metal		CAS No.	Carcinogenic				Noncarcinogenic			
			CSFo $(mg/kg\text{-}day)^{-1}$		IUR $(\mu g/m^3)^{-1}$		RfDo (mg/kg-day)		RfCi (mg/m^3)	
Aluminum		7429-90-5	--		--		1.0E+00	P	5.0E-03	P
Antimony		7440-36-0	--		--		4.0E-04	I	3.0E-04	A
Arsenic		7440-38-2	1.5E+00	I	4.3E-03	I	3.0E-04	I	1.5E-05	C
Cadmium	a	7440-43-9	--		1.8E-03	I	1.0E-04	A	1.0E-05	A
Cobalt		7440-48-4	--		9.0E-03	P	3.0E-04	P	6.0E-06	P
Copper		7440-50-8	--		--		4.0E-02	H	--	
Iron		7439-89-6	--		--		7.0E-01	P	--	
Manganese	c	7439-96-5	--		--		1.4E-01	I	5.0E-05	I
Molybdenum		7439-98-7	--		--		5.0E-03	I	2.0E-03	A
Selenium		7782-49-2	--		--		5.0E-03	I	2.0E-02	C
Thallium		7440-28-0	--		--		1.0E-05	X	--	
Uranium		7440-61-1	--		--		2.0E-04	A	4.0E-05	A
Vanadium		7440-62-2	--		--		5.0E-03	G	1.0E-04	A

Notes:

a The toxicity criteria for cadmium (diet) was used for cadmium.

b The toxicity criteria for chromium (III) was used for chromium.

c The toxicity criteria for manganese (non-diet) was used for manganese.

--	Not available	IUR	Inhalation unit risk
$(\mu g/m^3)^{-1}$	Per microgram per cubic meter	mg/kg-day	Milligram per kilogram per day
$(mg/kg\text{-}day)^{-1}$	Per milligram per kilogram per day	mg/m^3	Milligram per cubic meter
CAS No.	Chemical Abstract Service number	RfCi	Reference concentration, inhalation
CSFo	Cancer slope factor, oral	RfDo	Reference dose, oral

Sources:
USEPA. 2022. Regional Screening Levels (RSLs). May.

A Agency for Toxic Substances and Disease Registry (ATSDR) Minimal Risk Levels [as cited in EPA 2022]

C Criteria for CSFo and IUR are taken from OEHHA Toxicity Criteria Database [as cited in EPA 2022]

G Adjusted per Section 5 of the RSL User Guide

H Health Effects Assessment Summary Tables (HEAST) [as cited in EPA 2022]

I Integrated Risk Information System (IRIS) [as cited in EPA 2022]

P Provisional Peer Reviewed Toxicity Value [as cited in EPA 2022]

X Provisional Peer Reviewed Toxicity Appendix Value [as cited in EPA 2022]

Table 4b
Toxicity Criteria for Radionuclides
Griffin Ashing Site (Flat Top Mine OU1)

Isotope	Carcinogenic			
	Inhalation Slope Factor (risk/pCi)	External Exposure Slope Factor (risk/year per pCi/g)	Food Ingestion Slope Factor (risk/pCi)	Soil Ingestion Slope Factor (risk/pCi)
Pb-210	1.59E-08	1.48E-09	1.18E-09	1.72E-09
Po-210	1.45E-08	4.51E-11	2.25E-09	3.27E-09
Ra-226	2.82E-08	2.50E-08	5.14E-10	6.77E-10
Th-230	3.41E-08	8.45E-10	1.19E-10	1.66E-10
U-234	2.78E-08	2.53E-10	9.55E-11	1.48E-10
U-235	2.50E-08	5.51E-07	9.44E-11	1.48E-10
U-238	2.36E-08	1.24E-10	8.66E-11	1.34E-10

Notes:

pCi	Picocurie
pCi/g	Picocuries per gram
risk/pCi	Risk per picocuries per gram
risk/year	Risk per year

Sources:

EPA. 2022. Provisional Remedial Goals (PRGs). May.

Table 4c
Chemical-Specific Parameters
Griffin Ashing Site (Flat Top Mine OU1)

Chemical of Potential Concern	CAS No.	Mutagen	Organic/ Inorganic	RBA	DAF	Brag [mg/kg DW]/[mg/kg]	BRrootveg [mg/kg DW]/[mg/kg]	Vgrootveg [Unitless]
Aluminum	7429-90-5	No	I	1	1	1.08E-03	6.50E-04	1.00E-02
Antimony	7440-36-0	No	I	1	0.15	3.19E-02	3.00E-02	1.00E-02
Arsenic	7440-38-2	No	I	0.6	1	6.33E-03	8.00E-03	1.00E-02
Cadmium	7440-43-9	No	I	1	0.025	1.25E-01	6.40E-02	1.00E-02
Cobalt	7440-48-4	No	I	1	1	8.65E-03	7.00E-03	1.00E-02
Copper	7440-50-8	No	I	1	1	2.69E-01	2.50E-01	1.00E-02
Iron	7439-89-6	No	I	1	1	1.38E-03	1.00E-03	1.00E-02
Manganese	7439-96-5	No	I	1	1	7.54E-02	5.00E-02	1.00E-02
Molybdenum	7439-98-7	No	I	1	1	2.50E-01	6.00E-02	1.00E-02
Selenium	7782-49-2	No	I	1	1	1.95E-02	2.20E-02	1.00E-02
Thallium	7440-28-0	No	I	1	1	8.58E-04	4.00E-04	1.00E-02
Uranium	7440-61-1	No	I	1	1	8.50E-03	4.00E-03	1.00E-02
Vanadium	7440-62-2	No	I	1	0.026	3.32E-03	3.00E-03	1.00E-02

Notes:
Mutagen values were obtained from EPA 2021; Brag, Brrootveg, and Vgrootveg were obtained from EPA 2005.

Abbreviations:

[mg/kg DW]/[mg/kg]	Milligram per kilogram dry weight per milligram per kilogram
Brag	Plant-Soil Bioconcentration Factor for Aboveground Produce
BRrootveg	Plant-Soil Bioconcentration Factor for Belowground Produce
CAS No.	Chemical Abstract Service number
DAF	Dermal Absorption Factor
DDE	Dichlorodiphenyldichloroethene
DDT	Dichlorodiphenyltrichloroethane
I	Inorganic
O	Organic
RBA	Relative Bioavailability
VGrootveg	Empirical Correction Factor for Belowground Produce

References:
EPA. 2005. "Human Health Risk Assessment Protocol (HHRAP) for Hazardous Waste Combustion Facilities." OSWER. EPA-530-R-05-006. September.
EPA. 2022. “Regional Screening Levels (RSLs).” May.

Table 5a
Risk-Based Screening Levels for Direct Soil Pathways
Griffin Ashing Site (Flat Top Mine OU1)

Analytical Group	Contaminant	Current Adult Rancher						Future Resident (Rancher with Homegrown Produce)					
		Carcincogenic			Noncarcinogenic			Age-Adjusted Carcinogenic			Child Noncarcinogenic		
		Incidental Ingestion	External (Rad) Dermal (Metals)	Inhalation of Particulates	Incidental Ingestion	External (Rad) Dermal (Metals)	Inhalation of Particulates	Incidental Ingestion	External (Rad) Dermal (Metals)	Inhalation of Particulates	Incidental Ingestion	External (Rad) Dermal (Metals)	Inhalation of Particulates
Radionuclides pCi/g	Pb-210	6.33E-01	4.57E+01	5.79E+02	--	--	--	7.59E-01	5.86E+01	7.77E+02	--	--	--
	Po-210	1.39E+01	6.28E+04	2.65E+04	--	--	--	1.30E+01	6.28E+04	2.77E+04	--	--	--
	Ra-226	9.25E-01	1.56E+00	1.88E+02	--	--	--	1.33E+00	2.40E+00	3.02E+02	--	--	--
	Th-230	3.74E+00	4.58E+01	1.54E+02	--	--	--	5.38E+00	7.04E+01	2.48E+02	--	--	--
	U-234	4.19E+00	1.53E+02	1.89E+02	--	--	--	6.02E+00	2.35E+02	3.03E+02	--	--	--
	U-235	4.21E+00	7.02E-02	2.10E+02	--	--	--	6.05E+00	1.08E-01	3.38E+02	--	--	--
	U-238	4.62E+00	3.13E+02	2.22E+02	--	--	--	6.65E+00	4.81E+02	3.57E+02	--	--	--
Metals mg/kg	Aluminum	--	--	--	8.34E+05	--	2.13E+07	--	--	--	7.82E+04	--	7.1E+06
	Antimony	--	--	--	3.34E+02	--	1.28E+06	--	--	--	3.13E+01	--	4.3E+05
	Arsenic	1.91E+00	9.02E+00	2.04E+03	4.17E+02	1.97E+03	6.38E+04	6.62E-01	5.50E+00	5.77E+02	3.91E+01	3.30E+02	2.1E+04
	Cadmium	--	--	4.86E+03	8.34E+01	4.93E+02	4.25E+04	--	--	1.38E+03	7.82E+00	8.24E+01	1.4E+04
	Cobalt	--	--	9.73E+02	2.50E+02	--	2.55E+04	--	--	2.76E+02	2.35E+01	--	8.5E+03
	Copper	--	--	--	3.34E+04	--	--	--	--	--	3.13E+03	--	--
	Iron	--	--	--	5.84E+05	--	--	--	--	--	5.48E+04	--	--
	Manganese	--	--	--	2.00E+04	--	2.13E+05	--	--	--	1.88E+03	--	7.1E+04
	Molybdenum	--	--	--	4.17E+03	--	8.51E+06	--	--	--	3.91E+02	--	2.8E+06
	Selenium	--	--	--	4.17E+03	--	8.51E+07	--	--	--	3.91E+02	--	2.8E+07
	Thallium	--	--	--	8.34E+00	--	--	--	--	--	7.82E-01	--	--
	Uranium	--	--	--	1.67E+02	--	1.70E+05	--	--	--	1.56E+01	--	5.7E+04
	Vanadium	--	--	--	4.20E+03	--	4.25E+05	--	--	--	3.94E+02	--	1.4E+05

Notes:
mg/kg Milligrams per kilogram
pCi/g Picocuries per gram

Table 5b
Risk-Based Screening Levels for Soil for Produce Ingestion Pathway
Griffin Ashing Site (Flat Top Mine OU1)

Analytical Group	Contaminant	Future Resident	
		Age-Adjusted Carcinogenic	Child Noncarcinogenic
Radionuclides pCi/g	Pb-210	5.06E-03	--
	Po-210	7.43E-01	--
	Ra-226	4.74E-03	--
	Th-230	3.22E-01	--
	U-234	7.10E-02	--
	U-235	7.18E-02	--
	U-238	7.83E-02	--
Metals mg/kg	Aluminum	--	1.7E+04
	Antimony	--	2.4E-01
	Arsenic	5.89E+00	8.9E-01
	Cadmium	--	1.5E-02
	Cobalt	--	6.5E-01
	Copper	--	2.8E+00
	Iron	--	9.6E+03
	Manganese	--	3.5E+01
	Molybdenum	--	3.8E-01
	Selenium	--	4.8E+00
	Thallium	--	2.2E-01
	Uranium	--	4.4E-01
	Vanadium	--	2.8E+01

Notes:
mg/kg Milligrams per kilogram
pCi/g Picocuries per gram

Table 5c
Risk-Based Screening Levels for Soil for Beef Ingestion Pathway
Griffin Ashing Site (Flat Top Mine OU1)

Analytical Group	Contaminant	Current Adult Rancher		Future Resident	
		Carcincogenic	Noncarcinogenic	Age-Adjusted Carcinogenic	Child Noncarcinogenic
Radionuclides pCi/g	Pb-210	1.84E-01	--	1.77E-01	--
	Po-210	9.77E-01	--	9.37E-01	--
	Ra-226	9.77E-02	--	9.38E-02	--
	Th-230	3.27E+00	--	3.14E+00	--
	U-234	2.37E+00	--	2.27E+00	--
	U-235	2.40E+00	--	2.30E+00	--
	U-238	2.61E+00	--	2.51E+00	--
Metals mg/kg	Aluminum	--	2.26E+06	--	8.47E+05
	Antimony	--	2.60E+02	--	9.74E+01
	Arsenic	1.78E+02	3.89E+02	1.21E+02	1.46E+02
	Cadmium	--	3.23E+03	--	1.21E+03
	Cobalt	--	3.78E+01	--	1.42E+01
	Copper	--	1.42E+03	--	5.34E+02
	Iron	--	1.19E+05	--	4.45E+04
	Manganese	--	1.27E+05	--	4.76E+04
	Molybdenum	--	1.76E+03	--	6.61E+02
	Selenium	--	5.85E+03	--	2.19E+03
	Thallium	--	8.47E-01	--	3.18E-01
	Uranium	--	2.67E+03	--	1.00E+03
	Vanadium	--	5.36E+03	--	2.01E+03

Notes:
mg/kg Milligrams per kilogram
pCi/g Picocuries per gram

Table 6
Risk-Based Screening Levels for All Exposure Pathways
Griffin Ashing Site (Flat Top Mine OU1)

Analytical Group	Contaminant	Current Adult Rancher		Future Resident	
		Carcincogenic	Noncarcinogenic	Carcinogenic	Noncarcinogenic
Radionuclides pCi/g	Lead-210	1.42E-01	--	4.88E-03	--
	Polonium-210	9.12E-01	--	4.02E-01	--
	Radium-226	8.36E-02	--	4.48E-03	--
	Thorium-230	1.66E+00	--	2.69E-01	--
	Uranium-234	1.49E+00	--	6.77E-02	--
	Uranium-235	6.71E-02	--	3.47E-02	--
	Uranium-238	1.65E+00	--	7.46E-02	--
Metals mg/kg	Aluminum	--	5.92E+05	--	1.40E+04
	Antimony	--	1.46E+02	--	2.34E-01
	Arsenic	1.23E+00	1.82E+02	5.34E-01	8.66E-01
	Cadmium	4.86E+03	6.97E+01	1.38E+03	1.51E-02
	Cobalt	9.73E+02	3.28E+01	2.76E+02	6.09E-01
	Copper	--	1.37E+03	--	2.79E+00
	Iron	--	9.86E+04	--	6.89E+03
	Manganese	--	1.60E+04	--	3.43E+01
	Molybdenum	--	1.24E+03	--	3.77E-01
	Selenium	--	2.43E+03	--	4.77E+00
	Thallium	--	7.69E-01	--	1.11E-01
	Uranium	--	1.57E+02	--	4.32E-01
	Vanadium	--	2.34E+03	--	2.61E+01

Notes:
Values calculated using a TCR=1E-06 and THQ=1.

TCR	Target cancer risk
THQ	Target hazard quotient
mg/kg	Milligrams per kilogram
pCi/g	Picocuries per gram

Table 7
Human Health Risk and Hazard Summary
Griffin Ashing Site (Flat Top Mine OU1)

Current Adult Rancher						
COPC[a]	**Units**	**Exposure Point Concentration**	**Cancer RBSL**	**Cancer Risk[b]**	**Noncancer RBSL**	**Noncancer Hazard[b]**
						Adult
Soil						
Radionuclides						
Lead-210	pCi/g	5.5E+01	1.4E-01	**3.9E-04**	--	--
Polonium-210	pCi/g	5.7E+01	9.1E-01	6.2E-05	--	--
Radium-226	pCi/g	1.6E+02	8.4E-02	**1.9E-03**	--	--
Thorium-230	pCi/g	1.3E+02	1.7E+00	7.6E-05	--	--
Uranium-234	pCi/g	1.5E+02	1.5E+00	**1.0E-04**	--	--
Uranium-235	pCi/g	7.6E+00	6.7E-02	**1.1E-04**	--	--
Uranium-238	pCi/g	1.2E+02	1.7E+00	7.3E-05	--	--
Radionuclide Total				**3E-03**		--
Metals						
Aluminum	mg/kg	7.0E+03	--	--	5.9E+05	0.012
Antimony	mg/kg	1.1E+00	--	--	1.5E+02	0.0077
Arsenic	mg/kg	1.7E+02	1.2E+00	**1.4E-04**	1.8E+02	0.95
Cadmium	mg/kg	7.8E-01	4.9E+03	1.6E-10	7.0E+01	0.011
Cobalt	mg/kg	8.6E+00	9.7E+02	8.9E-09	3.3E+01	0.26
Copper	mg/kg	3.7E+02	--	--	1.4E+03	0.27
Iron	mg/kg	2.5E+04	--	--	9.9E+04	0.25
Manganese	mg/kg	5.0E+02	--	--	1.6E+04	0.031
Molybdenum	mg/kg	1.7E+02	--	--	1.2E+03	0.13
Selenium	mg/kg	1.9E+01	--	--	2.4E+03	0.0079
Thallium	mg/kg	4.9E-01	--	--	7.7E-01	0.64
Uranium	mg/kg	2.7E+02	--	--	1.6E+02	**1.7**
Vanadium	mg/kg	2.9E+01	--	--	2.3E+03	0.012
Metal Total				**1.4E-04**		**4**
Grand Total				**3E-03**		**4**

Table 7
Human Health Risk and Hazard Summary
Griffin Ashing Site (Flat Top Mine OU1)

Future Resident						
COPC[a]	**Units**	**Exposure Point Concentration**	**Cancer RBSL**	**Cancer Risk[b]**	**Noncancer RBSL**	**Noncancer Hazard[b]**
						Adult
Soil						
Radionuclides						
Lead-210	pCi/g	5.5E+01	4.9E-03	**1.1E-02**	--	--
Polonium-210	pCi/g	5.7E+01	4.0E-01	**1.4E-04**	**--**	--
Radium-226	pCi/g	1.6E+02	4.5E-03	**3.6E-02**	**--**	--
Thorium-230	pCi/g	1.3E+02	2.7E-01	**4.7E-04**	**--**	--
Uranium-234	pCi/g	1.5E+02	6.8E-02	**2.2E-03**	**--**	--
Uranium-235	pCi/g	7.6E+00	3.5E-02	**2.2E-04**	**--**	--
Uranium-238	pCi/g	1.2E+02	7.5E-02	**1.6E-03**	**--**	--
Radionuclide Total				**5E-02**		--
Metals						
Aluminum	mg/kg	7.0E+03		**--**	1.4E+04	0.50
Antimony	mg/kg	1.1E+00	--	**--**	2.3E-01	**4.8**
Arsenic	mg/kg	1.7E+02	5.3E-01	**3.2E-04**	8.7E-01	**200**
Cadmium	mg/kg	7.8E-01	1.4E+03	5.7E-10	1.5E-02	**52**
Cobalt	mg/kg	8.6E+00	2.8E+02	3.1E-08	6.1E-01	**14**
Copper	mg/kg	3.7E+02	--	**--**	2.8E+00	**131**
Iron	mg/kg	2.5E+04	--	**--**	6.9E+03	**3.6**
Manganese	mg/kg	5.0E+02	--	**--**	3.4E+01	**15**
Molybdenum	mg/kg	1.7E+02	--	**--**	3.8E-01	**439**
Selenium	mg/kg	1.9E+01	--	**--**	4.8E+00	**4.1**
Thallium	mg/kg	4.9E-01	--	**--**	1.1E-01	**4.4**
Uranium	mg/kg	2.7E+02	--	**--**	4.3E-01	**627**
Vanadium	mg/kg	2.9E+01	--	**--**	2.6E+01	1.1
Metal Total				**3.2E-04**		**1,000**
Grand Total				**5E-02**		**1,000**

Table 7
Human Health Risk and Hazard Summary
Griffin Ashing Site (Flat Top Mine OU1)

Notes:

[a] **Bolded** COPCs are selected as risk-based contaminants of concern because cancer risk is greater than one in ten thousand (1E-04) or noncancer hazard is greater than 1.

[b] **Bolded** values are values greater than the target cancer risk of one in ten thousand (1E-04) or noncancer target hazard of 1. Cancer risk is calculated by dividing the EPC by the cancer RBSL and multiplying by the target risk used for the cancer RBSL. Noncancer hazard is calculated by dividing the EPC by the noncancer RBSL for the age group evaluated. The methodology for calculating the risks and hazards and the inputs for cancer and noncancer equations are provided in the Streamlined Risk Assessment. Total risks and total hazards are reported to one significant digit; thus, values are commonly rounded. In practice, values can be slightly higher than the stated cutoff but still be considered equal to the cutoff because of rounding.

--	Not applicable
COPC	Contaminant of potential concern
EPC	Exposure point concentration
mg/kg	Milligram per kilogram
pCi/g	Picocurie per gram
RBSL	Risk-based screening level

Table 8

Human Health Risk-Based Contaminants of Concern Compared to Risk-Based Screening Levels and Background Threshold Values
Griffin Ashing Site (Flat Top Mine OU1)

Current Adult Rancher					
COC	**Units**	**EPC[a]**	**Human Health RBSL[b]**	**BTV[c]**	**Is EPC > RBSL and BTV?**
Soil					
Lead-210	pCi/g	55	0.14	--	**Yes**
Radium-226	pCi/g	160	0.084	1.4	**Yes**
Uranium-234	pCi/g	152	1.5	--	**Yes**
Uranium-235	pCi/g	7.6	0.07	--	**Yes**
Arsenic	mg/kg	174	1.2	5.5	**Yes**

Future Resident					
COC	**Units**	**EPC[a]**	**Human Health RBSL[b]**	**BTV[c]**	**Is EPC > RBSL and BTV?**
Soil					
Lead-210	pCi/g	55	0.0049	--	**Yes**
Radium-226	pCi/g	160	0.0045	1.4	**Yes**
Thorium-230	pCi/g	126	0.27	1.4	**Yes**
Uranium-234	pCi/g	152	0.068	--	**Yes**
Uranium-235	pCi/g	7.6	0.035	--	**Yes**
Uranium-238	pCi/g	120	0.075	--	**Yes**
Antimony	mg/kg	1.1	0.23	0.90	**Yes**
Arsenic	mg/kg	174	0.53	5.5	**Yes**
Cadmium	mg/kg	0.78	0.015	--	**Yes**
Cobalt	mg/kg	8.6	0.61	7.1	**Yes**
Copper	mg/kg	365	2.8	21	**Yes**
Iron	mg/kg	24,867	6,885	21,000	**Yes**
Manganese	mg/kg	499	34	380	**Yes**
Molybdenum	mg/kg	165	0.38	0.85	**Yes**
Selenium	mg/kg	19	4.8	0.23	**Yes**
Thallium	mg/kg	0.49	0.11	9.1	No
Uranium	mg/kg	271	0.43	1.5	**Yes**

Table 8

Human Health Risk-Based Contaminants of Concern Compared to Risk-Based Screening Levels and Background Threshold Values

Griffin Ashing Site (Flat Top Mine OU1)

Notes:

[a]	EPCs are provided in Table 2.
[b]	The human health RBSLs are provided in Table 6.
[c]	The BTVs for metals are the mean concentrations for Western United States from Shacklette and Boerngen (1984). The BTVs for Radium-226 and Thorium-230 are the average soil radioactivity - background concentration for the Site from the Bendix Field Engineering Corporation (BFEC) Radiologic Characterization (1986).
--	BTV not available.
BTV	Background threshold value
COC	Contaminant of concern
EPC	Exposure point concentration
mg/kg	Milligram per kilogram
pCi/g	Picocurie per gram
RBSL	Risk-based screening level

References:

BFEC. 1986. *Radiologic Characterization of the Bowman, North Dakota, Uranium Mill Tailings Remedial Action Site,* GJ-52, prepared for the U.S. Department of Energy, UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexic

Shacklette, H.T. and J.G. Boerngren. 1984. Element Concentrations in Soil and Other Surface Materials of the Conterminous United States. USGS Professional Paper 1270)

Table 9a
Ecological Risk Tier I Risk-Based Screening Levels and Hazard Quotients - Radionuclides
Griffin Ashing Site (Flat Top Mine OU1)

COPEC	Units	Maximum Detected Concentration	Mammalian Herbivore NOEC	HQ based on NOEC	Include Chemical as a COPEC in Tier II?
Soil					
Radionuclides					
Lead-210	pCi/g	194	4,400	0.04	No
Polonium-210	pCi/g	192	--	--	No
Radium-226	pCi/g	539	340	**2**	**Yes**
Thorium-230	pCi/g	366	21,000	0.02	No
Uranium-234	pCi/g	347	36,000	0.01	No
Uranium-235	pCi/g	17.2	4,700	0.004	No
Uranium-238	pCi/g	356	2,000	0.2	No

Notes:

HQ is calculated by dividing the maximum concentration by the minimum NOEC. **Bolded** HQ values indicate

mg/kg	Milligram per kilogram
pCi/g	Picocurie per gram
COPEC	Chemical of potential ecological concern
ESL	Ecological Soil Screening Level
LANL	Los Alamos National Laboratory
NOEC	No observed effect concentration
HQ	Hazard quotient
--	Not available

LANL no effect ESLs are used for all radionuclides. ESLs available online at: https://www.intellusnm.com/

References:

Newport News Nuclear BWXT-Los Alamos, LLC. 2020. “ECORISK Database (Release 4.2).” Docu
Los Alamos, New Mexico. N3B 2020, 701067. November.

Table 9b
Ecological Risk Tier I Risk-Based Screening Levels and Hazard Quotients - Metals
Griffin Ashing Site (Flat Top Mine OU1)

COPEC	CAS No.	Soil Ingestion Rate[a] (kg/day)	Soil Concentration[b] (mg/kg)	Soil Daily Dose[c] (mg/day)	Plant Ingestion Rate[d] (kg/day)	Plant Tissue Concentration[e] (mg/kg)	Plant Daily Dose[f] (mg/day)	Body Weight[g] (kg)	Total Daily Dose[h]	TRV[i] (mg/kg/day)	HQ	Include Chemical as a COPEC in Tier II?	Source of TRV
Aluminum	7429-90-5	0.083	16000	1326	9.2	48	442	272	6.5	33	0.2	No	NCRS 2005
Antimony	7440-36-0	0.083	7.2	0.60	10.2	0.069	0.70	272	0.0048	NA	--	--	--
Arsenic	7440-38-2	0.083	550	46	11.2	0.77	8.6	272	0.20	1.0	0.2	No	NCRS 2005
Barium	7440-39-3	0.083	440	36	12.2	36	440	272	1.8	NA	--	--	--
Beryllium	7440-41-7	0.083	2.9	0.24	13.2	--	--	272	0.00088	NA	--	--	--
Cadmium	7440-43-9	0.083	2.4	0.20	14.2	0.036	0.51	272	0.0026	0.30	0.009	No	NCRS 2005
Chromium	7440-47-3	0.083	33	2.7	15.2	--	--	272	0.010	3.3	0.003	No	NCRS 2005
Cobalt	7440-48-4	0.083	16	1.3	16.2	0.051	0.83	272	0.0079	0.83	0.01	No	NCRS 2005
Copper	7440-50-8	0.083	3800	315	17.2	3.3	57	272	1.4	1.3	**1**	**Yes**	NCRS 2005
Iron	7439-89-6	0.083	63000	5223	18.2	100	1821	272	26	17	**2**	**Yes**	NCRS 2005
Lead	7439-92-1	0.083	540	45	19.2	0.14	2.7	272	0.17	3.2	0.05	No	NCRS 2005
Manganese	7439-96-5	0.083	1100	91	20.2	110	2223	272	8.5	66	0.1	No	NCRS 2005
Molybdenum	7439-98-7	0.083	680	56	21.2	150	3182	272	12	0.17	**70**	**Yes**	NCRS 2005
Nickel	7440-02-0	0.083	58	4.8	22.2	0.48	11	272	0.057	3.3	0.02	No	NCRS 2005
Selenium	7782-49-2	0.083	43	3.6	23.2	5.7	132	272	0.50	0.17	**3**	**Yes**	NCRS 2005
Silver	7440-22-4	0.083	0.83	0.069	24.2	--	--	272	0.00025	NA	--	--	
Thallium	7440-28-0	0.083	1.8	0.15	25.2	0.0046	0.12	272	0.0010	NA	--	--	--
Thorium	7440-29-1	0.083	5.0	0.41	26.2	0.024	0.63	272	0.0038	NA	--	--	
Uranium	7440-61-1	0.083	1000	83	27.2	0.36	10	272	0.34	NA	--	--	--
Vanadium	7440-62-2	0.083	54	4.5	28.2	0.14	3.9	272	0.031	1.7	0.02	No	NCRS 2005
Zinc	7440-66-6	0.083	120	10	29.2	17	497	272	1.9	17	0.1	No	NCRS 2005

Notes:

a	Soil ingestion rate calculated as 9 percent of food ingestion (Mayland et al 1997).
b	Maximum detected soil concentration, as presented in Table 1a.
c	Soil daily dose calculated as the soil ingestion rate multiplied by the soil concentration.
d	Plant ingestion rate for cattle obtained from food ingestion rates presented in the Wildlife Exposure Factors Handbook, Volumes I and II (EPA 1993)
e	Maximum detected plant tissue concentration, as presented in Table 1b.
f	Plant daily dose calculated as the plant ingestion rate multiplied by the plant tissue concentration.
g	Body weight obtained from the National Range and Pasture Handbook (NRCS 2003).
h	Total daily dose calculated as the sum of the soil daily dose and plant daily dose, divided by body weight.
i	TRVs derived from maximum tolerable levels of minerals after converting mg/kg diet to mg/kg body weight per day (NRC 2005, Ford and Beyer 2013)
--	Not available
CAS	Chemical Abstract Service
COPEC	Contaminant of Potential Ecological Concern
g/day	grams per day
HQ	Hazard Quotient
mg/day	milligrams per day
mg/kg	milligrams per kilogram
mg/kg/day	milligrams per kilogram per day
kg	kilogram
kg/day	kilograms per day
TRV	Toxicity Reference Value

Table 9b

Ecological Risk Tier I Risk-Based Screening Levels and Hazard Quotients - Metals

Griffin Ashing Site (Flat Top Mine OU1)

References:
EPA. 1993. Wildlife Exposure Factors Handbook, Volumes I and II.
Ford, Karl L. and Beyer, W. Nelson. 2013. Soil Criteria to Protect Terrestrail Wildlife and Open-Range Livestock from Metal Toxicity and Mining Sites. Environmental Monitoring and Assessment, Vol. 186. 1899-1905. Available online: https://pubmed.ncbi.nlm.nih.gov/24310366/
Mayland et al. 1997. Soil Ingestion by Cattle Grazing Crested Wheatgrass. Journal of Range Management, 30(4), 264-265. Available online: https://eprints.nwisrl.ars.usda.gov/id/eprint/329/
National Resource Council (NRC). 2005. Mineral Tolerance of Animals. Chapter 2, Maximum Tolerable Levels. Available online: https://nap.nationalacademies.org/read/11309/chapter/1
National Resources Conservation Service (NRCS). 2003. National Range and Pasture Handbook. Available online: https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/landuse/rangepasture/?cid=stelprdb1043084

Table 10a

Ecological Potential Contaminants of Concern Compared to Background Thr

Griffin Ashing Site (Flat Top Mine OU1)

Griffin Ashing Site				
COC	**Units**	**EPC[a]**	**BTV[b]**	**Tier II COPEC (EPC > BTV)?**
Soil				
Radium-226	pCi/g	160	1.4	**Yes**

Notes:

[a]	EPCs are provided on Table 2.
[b]	The BTV for Radium-226 is the average soil radioactivity - background concentration for the Site from the Bendix Field Engineering Corporation Radiologic Characterization (1986).
--	BTV not available.
bgs	below ground surface
BTV	Background threshold value
COC	Contaminant of concern
EPC	Exposure point concentration
pCi/g	Picocurie per gram

Reference:

BFEC. 1986. *Radiologic Characterization of the Bowman, North Dakota, Uranium Mill Tailin*

Remedial Action Site, GJ-52, prepared for the U.S. Department of Energy, UMTRA Projec Office, Albuquerque Operations Office, Albuquerque, New Mexico.

Table 10b

Ecological Potential Contaminants of Concern Compared to Background Thr

Griffin Ashing Site (Flat Top Mine OU1)

Griffin Ashing Site				
COC	**Units**	**EPC[a]**	**BTV[b]**	**Tier II COPEC (EPC > BTV)?**
Soil				
Copper	mg/kg	365	21	**Yes**
Iron	mg/kg	24,867	21,000	**Yes**
Molybdenum	mg/kg	165	0.85	**Yes**
Selenium	mg/kg	19	0.23	**Yes**

Notes:

[a] EPCs are provided on Table 2.

[b] The BTVs for metals are the mean concentrations for Western United Sta and Boerngen (1984).

BTV Background threshold value

COC Contaminant of concern

EPC Exposure point concentration

mg/kg Milligram per kilogram

pCi/g Picocurie per gram

Reference:

Shacklette, H.T. and J.G. Boerngen. 1984. Element Concentrations in Soil and Other Surfac Conterminous United States. USGS Professional Paper 1270

Table 11a
Ecological Risk Tier II Risk-Based Screening Levels and Hazard Quotients - Ra
Griffin Ashing Site (Flat Top Mine OU1)

Griffin Ashing Site				
COPEC [a]	**Units**	**EPC**	**Mammalian Herbivore LOEC**	**Mammalian Herbivore HQ**
Soil				
Radionuclides				
Radium-226	pCi/g	160	3,400	0.05

Notes:

HQ is calculated by dividing the EPC by the ecological RBSL. **Bolded** HQ values indicate HQs greater than 1.

Ecological RBSLs are LOEC/LOAELs based on the Los Alamos National Laboratory ECORISK database low-effect level environmental screening levels (Newport News Nuclear BWXT-Los Alamos, LLC. 2020).

[a] **Bolded** COPECs have a HQ greater than 1.

Notes (continued):

--	No screening level
COPEC	Contaminant of potential ecological concern
EPC	Exposure point concentration
HQ	Hazard quotient
LOAEL	Lowest observed adverse effect level
LOEC	Lowest observed effects concentration
mg/kg	Milligram per kilogram
pCi/g	Picocurie per gram

Reference:

Newport News Nuclear BWXT-Los Alamos, LLC. 2020. “ECORISK Database (Release 4.2).” Document EM2020-0575, Los Alamos, New Mexico. N3B 2020, 701067. November.

Table 11b
Ecological Risk Tier II Risk-Based Screening Levels and Hazard Quotients - Metals
Griffin Ashing Site (Flat Top Mine OU1)

COPEC	CAS No.	Soil Ingestion Rate[a] (g/day)	Soil EPC[b] (mg/kg)	Soil Daily Dose[c] (mg/day)	Plant Ingestion Rate[d] (kg/day)	Plant Tissue EPC[e] (mg/kg)	Plant Daily Dose[f] (mg/day)	Body Weight[g] (kg)	Total Daily Dose[h]	TRV[i] (mg/kg/day)	HQ	COEC?	Source of TRV
Copper	7440-50-8	0.083	365	30	17.2	1.7	30	272	0.2	1.3	0.2	No	NCRS 2005
Iron	7439-89-6	0.083	24867	2061	18.2	65	1181	272	11.9	17	0.7	No	NCRS 2005
Molybdenum	7439-98-7	0.083	165	14	21.2	72	1527	272	5.7	0.17	**33**	**Yes**	NCRS 2005
Selenium	7782-49-2	0.083	19	1.6	23.2	2.8	64	272	0.24	0.17	**2**	**Yes**	NCRS 2005

Notes:

a	Soil ingestion rate calculated as 9 percent of food ingestion (Mayland et al 1997).
b	Soil EPC, as presented in Table 2.
c	Soil daily dose calculated as the soil ingestion rate multiplied by the soil concentration.
d	Plant ingestion rate obtained from food ingestion rates presented in the Wildlife Exposure Factors Handbook, Volumes I and II (EPA 1993)
e	Plant tissue EPC, as presented in Table 2.
f	Plant daily dose calculated as the plant ingestion rate multiplied by the plant tissue concentration.
g	Body weight obtained from the National Range and Pasture Handbook (NRCS 2003).
h	Total daily dose calculated as the sum of the soil daily dose and plant daily dose, divided by body weight.
i	TRVs derived from maximum tolerable levels of minerals after converting mg/kg diet to mg/kg body weight per day (NRC 2005, Ford and Beyer 2013)

Bolded values have an HQ greater than 1.

CAS	Chemical Abstract Service
COEC	Contaminant of Ecological Concern
COPEC	Contaminant of Potential Ecological Concern
EPC	Exposure Point Concentration
g/day	grams per day
HQ	Hazard Quotient
mg/day	milligrams per day
mg/kg	milligrams per kilogram
mg/kg/day	milligrams per kilogram per day
kg	kilogram
kg/day	kilograms per day
TRV	Toxicity Reference Value

References:

EPA. 1993. Wildlife Exposure Factors Handbook, Volumes I and II. EPA/600/R-93/187 a and b. Washington, DC. Available online: https://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=2799

Ford, Karl L. and Beyer, W. Nelson. 2013. Soil Criteria to Protect Terrestrial Wildlife and Open-Range Livestock from Metal Toxicity and Mining Sites. Environmental Monitoring and Assessment, Vol. 186. 1899-1905. Available online: https://pubmed.ncbi.nlm.nih.gov/24310366/

Mayland et al. 1997. Soil Ingestion by Cattle Grazing Crested Wheatgrass. Journal of Range Management, 30(4), 264-265. Available online: https://eprints.nwisrl.ars.usda.gov/id/eprint/329/

National Resource Council (NRC). 2005. Mineral Tolerance of Animals. Chapter 2, Maximum Tolerable Levels. Available online: https://nap.nationalacademies.org/read/11309/chapter/1

National Resources Conservation Service (NRCS). 2003. National Range and Pasture Handbook. Available online: https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/landuse/rangepasture/?cid=stelprdb1043084

APPENDIX A

ANALYTICAL DATA SUMMARY TABLES

APPENDIX A
TABLE 1. Validated Soil Sample Metals Analytical Results
Griffin Ashing Site (Flat Top Mine Site OU1)

Analyte		Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Molybdenum	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Thorium	Uranium	Vanadium	Zinc
CAS Number		7429-90-5	7440-36-0	7440-38-2	7440-39-3	7440-41-7	7440-43-9	7440-70-2	7440-47-3	7440-48-4	7440-50-8	7439-89-6	7439-92-1	7439-95-4	7439-96-5	7439-98-7	7440-02-0	7440-09-7	7782-49-2	7440-22-4	7440-23-5	7440-28-0	7440-29-1	7440-61-1	7440-62-2	7440-66-6
Project Action Limits	EPA RSL Residential Soil[a]	77,000	31	0.68	15,000	160	71	NS	NS	23	3,100	55,000	400	NS	1,800	390	1,500	NS	390.0	390.0	NS	0.78	NS	16	390	13,000
	Ecological Screening Levels[b]	NS	NS	18	NS	NS	NS	NS	NS	NS	28	NS	NS	NS	NS	2	NS	NS	NS	NS	NS	NS	NB	5	7.8	NS
GA-SS-E01-211005		5,500	0.36	36	190	0.66	0.51	10,000	11	7	20	15,000	42	4,100	510	21	16	2,500	2.7	0.17	150	0.19	2.7	35	17	85
GA-SS-E02-211005		3,800	0.2	21	140	0.46	0.37	13,000	7.2	6.4	12	9,800	26	4,600	430	22	13	1,700	2.2	0.05 J	130	0.15	1.5	32	12	57
GA-SS-E03-211005		3,100	0.13	12	120	0.27	0.23	13,000	6.9	5.3	9.1	9,700	12	5,400	330	3.7	13	1,200	0.86 J	0.032 J	76 J	0.11	1.7	5.9	13	39
GA-SS-E04-211005		3,000	0.13	8.2	100	0.27	0.13 J	6,600	7.6	4.2	7.3	12,000	8.3	2,400	260	3.5	9.5	890	0.83 J	0.021 J	160	0.082	2.1	6.9	14	23
GA-SS-E05-211005		4,300	0.19	13	160	0.48	0.28	8,800	8.4	5.4	12	13,000	22	3,600	330	7.9	12	1,500	1.4	0.046 J	640	0.13	2.9	17	14	46
GA-SS-G01-211004		7,300	0.25	67	210	0.9	0.58	4,900	11	7.1	14	18,000	14	2,800	400	42	15	2,500	4.2	0.066	290	0.25	3.7	88	20	62
GA-SS-G02-211004		8,500	0.26	160	280	1.2	0.73	6,100	9	7.2	13	17,000	14	2,200	330	130	15	2,400	8.6	0.058	1,500	0.5	3.6	210	26	49
GA-SS-G03-211004		6,400	0.22	110	230	1	0.77	6,100	9.2	6.8	12	13,000	16	2,500	320	88	15	2,500	8.9	0.059	760	0.33	2.9	180	20	62
GA-SS-G04-211004		5,600	0.21	21	140	0.52	0.28	7,800	8.7	5.5	11	12,000	9.7	2,900	280	13	12	1,800	1.6	0.051 J	110	0.14	2.9	18	13	38
GA-SS-G05-211004		5,800	1.8	290	220	1.2	0.63	5,400	10	8.3	17	39,000	24	2,700	520	230	16	2,400	6.8	0.057 J	220	0.26	3.3	130	43	77
GA-SS-G06-211004		8,700	0.45	150	250	1.7	1.1	4,600	15	9	20	24,000	22	3,100	350	140	22	3,100	13	0.063	190	0.45	5	300	36	72
GA-SS-G07-211004		6,500	0.33	37	210	0.81	0.41	3,000	11	7.5	12	23,000	11	2,400	500	49	15	2,100	3	0.051 J	97 J	0.19	3.6	42	28	53
GA-SS-G07-211004-DUP		6,700	0.31	54	220	0.77	0.41	3,300	11	7.3	12	20,000	11	2,400	470	41	16	2,100	3.5	0.05 J	180	0.2	3.5	67	23	46
GA-SS-G08-211004		7,200	0.5	35	170	0.74	0.34	2,800	13	8.5	12	22,000	11	2,400	460	17	14	2,200	2.3	0.054 J	79 J	0.17	3.6	23	24	51
GA-SS-G09-211004		8,800	7.2	280	340	1.8	1.3	12,000	33	13	3,800	55,000	540	2,200	1,100	330	58	2,200	18	0.83	1,600	0.61	4.6	500	44	120
GA-SS-G10-211004		7,900	0.72	110	270	1.2	0.72	8,200	12	12	27	34,000	20	2,900	850	78	25	2,200	3.6	0.057	530	0.33	4.3	43	40	64
GA-SS-G11-211004		6,200	0.51	120	220	1.1	0.7	5,000	9.8	8.1	17	32,000	25	2,400	740	80	18	2,000	5.9	0.051 J	320	0.32	3.6	97	43	56
GA-SS-G12-211004		6,000	0.25	42	180	0.69	0.4	10,000	9	6.8	15	15,000	13	3,900	300	31	14	1,800	2.9	0.053 J	290	0.2	3.8	45	17	45
GA-SS-G13-211004		7,700	0.27	97	190	1	0.52	6,500	11	6.9	13	16,000	16	2,700	370	90	17	2,700	3.9	0.056 J	360	0.26	3.1	110	19	48
GA-SS-G14-211004		6,400	0.54	74	290	1	0.51	8,300	9.3	7	19	20,000	28	2,600	550	49	14	2,200	4	0.05 J	200	0.18	2.7	78	28	60
GA-SS-G15-211004		5,900	0.67	110	200	1.2	0.63	3,000	13	7.9	14	63,000	13	2,300	990	99	18	2,100	5.5	0.049 J	140	0.35	3.5	110	54	52
GA-SS-G16-211004		5,100	2.5	120	140	0.76	0.47	1,800	9.7	9.5	12	48,000	17	1,900	620	62	18	1,600	4.1	0.054 J	110	0.17	2.6	49	33	53
GA-SS-G17-211004		7,100	0.56	74	200	0.87	0.49	4,900	11	7.7	13	22,000	13	2,600	500	67	15	2,200	4.9	0.044 J	300	0.23	3.6	95	27	52
GA-SS-G18-211004		6,100	0.63	67	190	0.81	0.48	3,500	11	8.5	13	22,000	14	2,500	510	42	14	1,900	4.8	0.039 J	510	0.21	3.1	87	27	56
GA-SS-G19-211004		6,200	0.36	87	210	0.93	0.55	8,900 J	10	7.4	13	19,000	15	3,700	370	51	15	2,000	5.7	0.053 J	310	0.24	3.6	100	34	51
GA-SS-G19-211004-DUP		6,100	0.25	110	220	0.98	0.7	21,000 J	10	7.7	15	21,000	15 J-	4,700	540	62	17	2,200	6.4	0.055 J	330	0.27	3.8	200	23	53
GA-SS-G20-211004		6,200	1.1	69	210	0.77	0.47	14,000	11	8.5	20	19,000	18 J-	4,900	320	39	18	1,800	2.8	0.065	240	0.2	4	33	27	55
GA-SS-G21-211004		2,400	0.12 J-	25 J+	290	0.41	0.21	15,000 J	7.1	4.7	7.6	22,000	5.8 J+	3,000 J-	560 J	13	9.3	640	1.6	0.046 J	82 J	0.081	2.5	12	23 J-	24
GA-SS-G22-211004		7,000	0.39	160	220	1.2	0.59	12,000	12	8	16	18,000	21	3,600	380	200	19	2,800	6.9	0.053 J	640	0.41	3.1	230	28	48
GA-SS-G22-211004-DUP		7,100	0.48	160	220	1.3	0.63	9,200	11	7.8	16	18,000	20	2,800	350	220	19	2,800	7.4	0.057	840	0.41	3.3	250	24	51
GA-SS-G23-211004		6,600	0.41	250	250	1.4	1.1	4,600	12	9.1	14	32,000	17	2,200	570	200	20	2,300	15	0.052 J	480	0.51	3.8	490	33	53
GA-SS-G24-211004		8,400	0.55	440	440	2.8	2.2	7,700	11	13	15	26,000	24	2,000	370	420	38	2,000	30	0.058	1,800	0.52	4.7	860	42	56
GA-SS-G25-211004		6,600	0.29	150	260	1.1	0.82	5,700	16	8.2	25	23,000	16	2,700	530	110	21	2,500	9	0.067	410	0.39	3.8	240	24	51
GA-SS-G26-211004		6,800	0.25	67	250	0.84	0.59	4,600	11	7.9	14	19,000	15	2,500	570	47	15	2,900	5.4	0.048 J	210	0.26	2.9	110	22	54
GA-SS-G27-211004		6,200	0.46	160	230	0.94	0.75	7,000	10	8	15	21,000	15	2,900	420	96	18	2,300	8.3	0.055	440	0.32	3.7	170	22	51
GA-SS-G28-211004		6,100	0.58	230	280	1.1	0.92	4,500	12	9	16	26,000	20 J-	2,300	500	180	20	2,400	11	0.05 J	290	0.34	3.4	310	37	56
GA-SS-G29-211004		6,900	0.24	30	200	0.68	0.38	3,500	12	7.6	14	17,000	12	2,600	490	23	14	2,900	2.6	0.047 J	86 J	0.19	3.2	41	21	48
GA-SS-G30-211004		5,100	0.28	35	250	0.69	0.51	5,100	9.4	5.2	14	13,000	14	2,000	420	24	11	2,800	2.7	0.044 J	73 J	0.15	2.5	53	15	61
GA-SS-N01-211005		6,600	0.32	56	180	0.75	0.44	5,000	11	6.3	16	20,000	15	2,500	420	44	14	3,000	3	0.049 J	100 J	0.17	2.8	89	22	60
GA-SS-N02-211005		6,100	0.22	44	170	0.67	0.43	4,000	9.6	5.8	14	13,000	14	2,400	420	32	11	2,900	2.7	0.045 J	72 J	0.16	2.5	78	17	50
GA-SS-N03-211005		5,900	0.49	69	190	0.73	0.47	4,700	9.4	5.9	14	17,000	14	2,400	450	40	12	3,000	3.8	0.041 J	130	0.17	2.5	89	21	49
GA-SS-N04-211005		5,800	0.24	18	130	0.55	0.41	4,700	10	5.3	14	14,000	15	2,500	480	18	11	3,100	1.9	0.036 J	65 J	0.16	2.2	31	15	56
GA-SS-N05-211005		6,100	0.33	14	180	0.55	0.49	18,000	11	5.5	19	15,000	37	4,200	570	7.9	11	4,000	1.7	0.059	91 J	0.15	2	15	16	88
GA-SS-S01-211005		7,700	0.43	140	230	1.1	0.66	3,500	13	9	14	21,000	17	2,200	440	150	16	2,500	9.7	0.044 J	1,300	0.51	3.9	200	26	46
GA-SS-S02-211005		7,800	0.3	290	300	1.5	1.1	5,200	11	9.8	14	21,000	18	2,300	400	340	20	2,600	19	0.038 J	1,800	0.64	3.9	380	32	45
GA-SS-S03-211005		7,400	0.93 J-	330	350	1.7	1.5	5,200	11	16 J-	15	41,000 J	26	2,200	660	380	28	4,000	26	0.062	2,800 J-	0.81 J-	4.2	550 J	41 J-	79
GA-SS-S04-211005		6,700	0.77	210	240	1.3	1	4,200	13	12	16	29,000	18	2,400	570	220	21	2,600	14	0.05 J	670	0.38	3.8	300	34	66
GA-SS-S05-211005		6,100	0.39	260	180	1.1	0.93	3,200	12	9.5	14	18,000	18	2,400	410	200	18	2,500	16	0.047 J	700	0.39	4	450	28	44

APPENDIX A

TABLE 1. Validated Soil Sample Metals Analytical Results

Griffin Ashing Site (Flat Top Mine Site OU1)

Analyte		Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Molybdenum	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Thorium	Uranium	Vanadium	Zinc
CAS Number		7429-90-5	7440-36-0	7440-38-2	7440-39-3	7440-41-7	7440-43-9	7440-70-2	7440-47-3	7440-48-4	7440-50-8	7439-89-6	7439-92-1	7439-95-4	7439-96-5	7439-98-7	7440-02-0	7440-09-7	7782-49-2	7440-22-4	7440-23-5	7440-28-0	7440-29-1	7440-61-1	7440-62-2	7440-66-6
Project Action Limits	EPA RSL Residential Soil[a]	77,000	31	0.68	15,000	160	71	NS	NS	23	3,100	55,000	400	NS	1,800	390	1,500	NS	390.0	390.0	NS	0.78	NS	16	390	13,000
	Ecological Screening Levels[b]	NS	NS	18	NS	NS	NS	NS	NS	NS	28	NS	NS	NS	NS	2	NS	NS	NS	NS	NS	NS	NB	5	7.8	NS
GA-SS-TS01-211005		16,000	0.43	550	420	2.1	0.76	6,900	11	14	15	41,000	26	1,800	280	680	24	3,500	18	0.066	7,900	1.8	4.9	720	48	42
GA-SS-TS02-211005		7,200	0.41	200	250	1.4	0.69	12,000	12	11	23	26,000	20	3,600	400	310	23	3,100	7.4	0.11	980	0.5	3.2	280	28	67
GA-SS-TS03-211005		9,200	0.37	530	380	2.9	2.4	7,800	13	13	17	22,000	29 J-	2,500	360	510	32	3,000	43	0.059 J	1,700	0.88	4.6	1000	39	60
GA-SS-TS04-211005		6,800	0.21	43	200	1.1	0.76	5,400	12	8.4	19	15,000	18	3,100	350	32 J	17	3,200	6	0.062	220	0.3	4.1	200	21	61
GA-SS-TS04-211005-DUP		5,600	0.15	23	190	0.79	0.51	4,700	11	7	15	13,000	16	2,900	340	15 J	15	2,500	3.4	0.054	220	0.25	3.4	100	17	53
GA-SS-TS05-211005		6,600	0.5	35	220	0.91	0.47	4,700	12	7.9	17	22,000	17 J-	3,100	510	18	16	2,600	2.5	0.061	170	0.19	3.7	39	23	59
GA-SS-TS06-211005		5,600	0.28	220	160	1.2	0.9	3,500	11	8.6	14	15,000	17	2,600	280	230	19	1,800	15	0.045 J	420	0.53	3.8	420	24	39
GA-SS-TS07-211005		8,300	0.39	260	270	1.5	1.2	5,500	13	9	17	19,000	20	2,700	400	190	19	3,000	28	0.061	770	0.53	3.8	470	25	54
GA-SS-TS08-211005		6,400	0.33	26	200	0.86	0.63	6,500	11	5.2	59	15,000	52	2,700	290	17	14	3,100	3.4	0.071	120 J	0.22	3	93	16	120
GA-SS-W01-211005		6,000	0.36	270	210	0.88	0.79	3,000	11	7.1	12	18,000	13	2,000	440	220	16	2,100	9.9	0.061	180	0.39	3.2	380	23	46
GA-SS-W02-211005		6,900	0.2	57	200	0.67	0.36	3,600	9.6	5.8	10	19,000	10	1,900	400	55	12	2,100	3.5	0.058	240	0.19	3.2	110	22	39
GA-SS-W03-211005		5,700	0.38	230	220	0.96	0.73	4,000	11	8.1	13	24,000	16	2,100	440	200	16	2,300	10	0.055 J	200	0.4	3.2	390	26	47
GA-SS-W04-211005		6,100	0.31	68	200	0.65	0.43	3,400	11	7.1	13	20,000	12	2,200	490	47	14	1,800	4.4	0.042 J	85 J	0.2	3.5	110	25	46
GA-SS-W05-211005		5,400	0.58	440	240	1.3	1.1	4,800	12	8	16	31,000	18	2,000	480	430	20	2,100	24	0.049 J	290	0.63	4	910	43	47

Notes:

All results and screening levels are in milligram per kilogram

The reported concentration exceeds the ESL.

The reported concentration exceeds the RSL.

The reported concentration exceeds both the RSL and ESL.

[a] EPA Regional Screening Levels for Residential Soils (EPA 2021), using a target cancer rate of 1 in 1 million (1E-06) and target hazard quotient=1.0 .

[b] The lower of EPA Region 4 Ecological Soil Screening Levels (EPA 2015) and toxicological benchmarks for effects on terrestrial plants (Efroymson, R. A., et. al 1997).

CAS Chemical Abstract Service

EPA U.S. Environmental Protection Agency

ESL Ecological Screening Level

J The analyte was positively identified; the associated value is the approximate concentration of the analyte in the sample.

J- The analyte was positively identified; the associated value is the approximate concentration of the analyte in the sample and may be biased low.

J+ The analyte was positively identified; the associated value is the approximate concentration of the analyte in the sample and may be biased high.

NS No screening level

RSL Regional Screening Level

U The analyte was analyzed for, but was not detected at or above the associated value (reporting limit).

References:

Efroymson, R. A., et. al. 1997. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision. Oak Ridge National Laboratories. ES/ER/TM-85/R3

United States Environmental Protection Agency (EPA). 2015. Region 4 Ecological Risk Assessment Supplemental Guidance. Interim Draft. August.https://www.epa.gov/sites/default/files/2015-09/documents/r4_era_guidance_document_draft_final_8-25-2015.pdf

EPA. 2021. Regional Screening Levels (RSLs), Target Cancer Risk of 1 in 1 million (1E-06 and Target Hazard Quotient=1.0. May 11. https://www.epa.gov/risk/regional-screening-levels-rsls

APPENDIX A

TABLE 2. Preliminary Plant Tissue Sample Metals Analytical Results
Griffin Ashing Site (Flat Top Mine Site OU1)

Analyte	Arsenic	Copper	Molybdenum	Uranium	Vanadium
CAS Number	7440-38-2	7440-50-8	7439-98-7	7440-61-1	7440-62-2
Project Action Level[a]	18	28	2	5	7.8
GA-PT-E01-211005	0.09 J	1.8 J	5.2	0.03	0.48 U
GA-PT-G01-211004	0.17 J	1.3 J	23	0.039	0.13 J
GA-PT-G10-211004	0.32	1.3 J	140	0.1	0.49 U
GA-PT-G11-211004	0.1 J	0.95 J	38	0.024	0.49 U
GA-PT-G13-211004	0.16 J	0.8 J	41	0.039	0.49 U
GA-PT-G14-211004	0.19 U	0.87 J	9.9	0.011 J	0.48 U
GA-PT-G17-211004	0.17 J	1.1 J	61	0.037	0.5 U
GA-PT-G19-211004	0.18 J	1.6 J	37	0.025	0.46 U
GA-PT-G22-211004	0.77	2.1	91	0.049	0.46 U
GA-PT-G25-211004	0.49	0.96 J	64	0.048	0.14 J
GA-PT-G26-211004	0.51	2	42	0.05	0.48 U
GA-PT-G27-211004	0.093 J	0.95 J	21 J	0.01 J	0.49 U
GA-PT-G27-211004-DUP	0.28	1.7 J	46 J	0.018 J	0.5 U
GA-PT-G28-211004	0.29	1.2 J	73	0.078	0.45 U
GA-PT-N01-211005	0.055 J	0.91 J	5	0.02 J	0.49 U
GA-PT-S01-211005	0.27	3.3	22	0.36	0.49 U
GA-PT-W01-211005	0.51	1.4 J	150	0.33	0.46 U

Notes:

All results and screening levels are in milligram per kilogram.

The report concentration exceeds the Project Action Level.

[a] The project action level is the lower of EPA Region 4 Ecological Soil Screening Levels (EPA 2015) and toxicological benchmarks for effects on terrestrial plants (Efroymson, R. A., et. al 1997).

CAS Chemical abstract service

J The analyte was positively identified; the associated value is the approximate concentration of the analyte in the sample.

U The analyte was analyzed for, but was not detected at or above the associated value (reporting limit).

References:

Efroymson, R. A., et. al. 1997. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision. Oak Ridge National Laboratories. ES/ER/TM-85/R3

United States Environmental Protection Agency (EPA). 2015. Region 4 Ecological Risk Assessment Supplemental Guidance. Interim Draft. August. https://www.epa.gov/sites/default/files/2015-09/documents/r4_era_guidance_document_draft_final_8-25-2015.pdf

APPENDIX A
TABLE 3. Validated Soil Sample Radionuclide Analytical Results
Griffin Ashing Site (Flat Top Mine Site OU1)

Analyte		Lead-210	Polonium-210	Radium-226	Radium-228	Thorium-230	Uranium-234	Uranium-235	Uranium-238
CAS Number		14255-04-0	13981-52-7	13982-63-3	15262-20-1	14269-63-7	13966-29-5	15117-96-1	7440-61-1
Project Action Limits	Project Action Limit[a]	5	5	5	5	5	5	5	5
	Farmer PRG for Soil[b]	0.079	0.012	0.080	0.030	1.6	1.5	0.067	1.6
	Farmer Peak PRG for Soil[b]	0.018	0.88	0.0033	0.015	0.0033	0.0052	0.014	0.0030
GA-SS-G05-211004		33.1	33.3	70.8 J	2.6 UJ	65	61	2.65	60.2
GA-SS-G06-211004		67	64.1	175 J	2.6 UJ	128	137	6.6	140
GA-SS-G07-211004		7.8	8.8	22.2 J	1.45 UJ	22.1	19.3	0.99	18.8
GA-SS-G07-211004-DUP		7.7	8.7	22.3 J	1.08 J	24.5	20.1	0.94	20.6
GA-SS-G08-211004		5.8	5.68	14.9 J	1.2 UJ	12.2	11.3	0.55	11.1
GA-SS-G10-211004		20.1	18.8	46.1 J	2.1 UJ	42.5	14.8	0.7	14.8
GA-SS-G11-211004		33.6	38.9	82.6 J	2.6 UJ	77	38.7	1.79	42
GA-SS-G12-211004		14.3	15.6	39.7 J	1.43 UJ	31.6	18	1.1	18.5
GA-SS-G13-211004		33.5 J-	33.1	74.9 J	1.7 UJ	62	42.5	2.25	45.6
GA-SS-G14-211004		22.5	22.6	48.8 J	1.79 UJ	43.8	30.4	1.53	28.8
GA-SS-G16-211004		10 J-	9.1	26.7 J	1.8 UJ	25.1	20.8	1.17	21.5
GA-SS-G17-211004		15.7 J-	15.5	58.2 J	1.55 UJ	41.9	38.2	1.64	39.1
GA-SS-G18-211004		16.1 J-	15.8	34.1 J	1.8 UJ	34.6	34.6	1.75	35
GA-SS-G19-211004		24.7	25.6	80 J	1.9 UJ	68	39.3	1.87	40.7
GA-SS-G19-211004-DUP		22.8	27.9	72 J	2.3 UJ	64	42.9	1.84	43.2
GA-SS-G20-211004		12	12.8	35 J	1.86 UJ	27.1	13.1	0.68	13.3
GA-SS-G21-211004		2.82	2.88	7.41	0.66 U	5.36	4.87	0.23	4.57
GA-SS-G24-211004		56	62	201 J	3.8 UJ	168	169	8.1	172
GA-SS-G25-211004		33.7	37	100 J	1.8 UJ	94	93	5.2	95
GA-SS-G27-211004		29.9	33.8	100 J	2.6 UJ	78	53.1	2.83	54
GA-SS-G28-211004		44	50.3	181 J	2.4 UJ	141	137	6.4	140
GA-SS-G30-211004		12	13.9	42.6 J	1.95 UJ	25	20.1	1.02	20.7
GA-SS-S03-211005		81	84	202 J	3.7 UJ	171	189	10	193
GA-SS-S05-211005		58	59.6	188 J	2.9 UJ	161	171	8.7	178
GA-SS-TS01-211005		194	192	369 J	4 UJ	284	291	14.9	293

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TABLE 3. Validated Soil Sample Radionuclide Analytical Results
Griffin Ashing Site (Flat Top Mine Site OU1)

	Analyte	Lead-210	Polonium-210	Radium-226	Radium-228	Thorium-230	Uranium-234	Uranium-235	Uranium-238
	CAS Number	14255-04-0	13981-52-7	13982-63-3	15262-20-1	14269-63-7	13966-29-5	15117-96-1	7440-61-1
Project Action Limits	Project Action Limit[a]	5	5	5	5	5	5	5	5
	Farmer PRG for Soil[b]	0.079	0.012	0.080	0.030	1.6	1.5	0.067	1.6
	Farmer Peak PRG for Soil[b]	0.018	0.88	0.0033	0.015	0.0033	0.0052	0.014	0.0030
GA-SS-TS02-211005		118	102	253 J	4.9 UJ	186	132	6.2	135
GA-SS-TS03-211005		104	127	539 J	5.4 UJ	366	347	17.2	356
GA-SS-TS04-211005		22.1	19	36 J	2 UJ	33	25.1	1.33	25.6
GA-SS-TS04-211005-DUP		21.2 J-	23.5	56.9 J	2.6 UJ	46.9	44	2.17	43.9

APPENDIX A
TABLE 3. Validated Soil Sample Radionuclide Analytical Results
Griffin Ashing Site (Flat Top Mine Site OU1)

	Analyte	Lead-210	Polonium-210	Radium-226	Radium-228	Thorium-230	Uranium-234	Uranium-235	Uranium-238
	CAS Number	14255-04-0	13981-52-7	13982-63-3	15262-20-1	14269-63-7	13966-29-5	15117-96-1	7440-61-1
Project Action Limits	**Project Action Limit**[a]	5	5	5	5	5	5	5	5
	Farmer PRG for Soil[b]	0.079	0.012	0.080	0.030	1.6	1.5	0.067	1.6
	Farmer Peak PRG for Soil[b]	0.018	0.88	0.0033	0.015	0.0033	0.0052	0.014	0.0030
GA-SS-TS05-211005		9.5	12.8	22.5 J	1.7 UJ	16.9	14.9	0.76	15
GA-SS-TS06-211005		53	58.5	199 J	1.8 UJ	169	147	7.3	145
GA-SS-TS07-211005		60	61.2	176 J	3.3 UJ	149	144	6.7	142
GA-SS-TS08-211005		15.7	17	37.1 J	1.62 UJ	29.4	26.6	1.35	27.1

Notes:

All results and screening levels are in picocuries per gram.

The reported concentration exceeds the Farmer Peak PRG.

The reported concentration exceeds the Farmer PRG.

The reported concentration exceeds the Project Action Level, and the PRG.

CAS	Chemical Abstract Service
EPA	U.S. Environmental Protection Agency
MDC	Minimum Detectable Concentration
PRG	Preliminary Remediation Goal
J	The analyte was positively identified; the associated value is the approximate concentration of the analyte in the sample.
J+	The analyte was positively identified; the associated value is the approximate concentration of the analyte in the sample and may be biased high.
J-	The analyte was positively identified; the associated value is the approximate concentration of the analyte in the sample and may be biased low.
U	The analyte was analyzed for, but was not detected at or above the associated value (reporting limit).
UJ	The analyte was analyzed for, but was not detected at or above the associated value (reporting limit), which is considered approximate due to deficiencies in one of m

References:

United States Environmental Protection Agency (EPA). 2015. Region 4 Ecological Risk Assessment Supplemental Guidance. Interim Draft. August. https://www.epa.gov/sites/default/files/2015-09/documents/r4_era_guidance_document_draft_final_8-25-2015.pdf

APPENDIX B

PROUCL OUTPUTS

UCL Statistics for Data Sets with Non-Detects

User Selected Options	
Date/Time of Computation	ProUCL 5.16/21/2022 1:24:31 PM
From File	Griffin_ProUCL_Input.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Aluminum

General Statistics

Total Number of Observations	58	Number of Distinct Observations	36
		Number of Missing Observations	0
Minimum	2400	Mean	6540
Maximum	16000	Median	6300
SD	1842	Std. Error of Mean	241.8
Coefficient of Variation	0.282	Skewness	2.08

Normal GOF Test

Shapiro Wilk Test Statistic	0.828	**Shapiro Wilk GOF Test**
5% Shapiro Wilk P Value	7.2075E-9	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.15	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.116	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	6944	95% Adjusted-CLT UCL (Chen-1995)	7008
		95% Modified-t UCL (Johnson-1978)	6955

Gamma GOF Test

A-D Test Statistic	2.269	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.75	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.163	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.117	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	13.88	k star (bias corrected MLE)	13.17
Theta hat (MLE)	471.1	Theta star (bias corrected MLE)	496.4
nu hat (MLE)	1610	nu star (bias corrected)	1528
MLE Mean (bias corrected)	6540	MLE Sd (bias corrected)	1802
		Approximate Chi Square Value (0.05)	1438
Adjusted Level of Significance	0.0459	Adjusted Chi Square Value	1436

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	6948	95% Adjusted Gamma UCL (use when n<50)	6959

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.884	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk P Value	7.4177E-6	Data Not Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.179	**Lilliefors Lognormal GOF Test**

55				5% Lilliefors Critical Value		0.116		Data Not Lognormal at 5% Significance Level				
56	**Data Not Lognormal at 5% Significance Level**											
57												
58	**Lognormal Statistics**											
59				Minimum of Logged Data		7.783		Mean of logged Data				8.749
60				Maximum of Logged Data		9.68		SD of logged Data				0.278
61												
62	**Assuming Lognormal Distribution**											
63				95% H-UCL		6977		90% Chebyshev (MVUE) UCL				7277
64				95% Chebyshev (MVUE) UCL		7606		97.5% Chebyshev (MVUE) UCL				8064
65				99% Chebyshev (MVUE) UCL		8963						
66												
67	**Nonparametric Distribution Free UCL Statistics**											
68	**Data do not follow a Discernible Distribution (0.05)**											
69												
70	**Nonparametric Distribution Free UCLs**											
71				95% CLT UCL		6937		95% Jackknife UCL				6944
72				95% Standard Bootstrap UCL		6941		95% Bootstrap-t UCL				7033
73				95% Hall's Bootstrap UCL		7246		95% Percentile Bootstrap UCL				6940
74				95% BCA Bootstrap UCL		7006						
75				90% Chebyshev(Mean, Sd) UCL		7265		95% Chebyshev(Mean, Sd) UCL				7594
76				97.5% Chebyshev(Mean, Sd) UCL		8050		99% Chebyshev(Mean, Sd) UCL				8946
77												
78	**Suggested UCL to Use**											
79				95% Student's-t UCL		6944		or 95% Modified-t UCL				6955
80												
81	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
82	Recommendations are based upon data size, data distribution, and skewness.											
83	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
84	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
85												
86												
87	**Antimony**											
88												
89	**General Statistics**											
90				Total Number of Observations		58		Number of Distinct Observations				43
91								Number of Missing Observations				0
92				Minimum		0.12		Mean				0.569
93				Maximum		7.2		Median				0.365
94				SD		0.964		Std. Error of Mean				0.127
95				Coefficient of Variation		1.693		Skewness				6.072
96												
97	**Normal GOF Test**											
98				Shapiro Wilk Test Statistic		0.368		**Shapiro Wilk GOF Test**				
99				5% Shapiro Wilk P Value		0		Data Not Normal at 5% Significance Level				
100				Lilliefors Test Statistic		0.34		**Lilliefors GOF Test**				
101				5% Lilliefors Critical Value		0.116		Data Not Normal at 5% Significance Level				
102	**Data Not Normal at 5% Significance Level**											
103												
104	**Assuming Normal Distribution**											
105	**95% Normal UCL**							**95% UCLs (Adjusted for Skewness)**				
106				95% Student's-t UCL		0.781		95% Adjusted-CLT UCL (Chen-1995)				0.886
107								95% Modified-t UCL (Johnson-1978)				0.798
108												

109	**Gamma GOF Test**											
110	A-D Test Statistic				4.547	**Anderson-Darling Gamma GOF Test**						
111	5% A-D Critical Value				0.769	Data Not Gamma Distributed at 5% Significance Level						
112	K-S Test Statistic				0.228	**Kolmogorov-Smirnov Gamma GOF Test**						
113	5% K-S Critical Value				0.119	Data Not Gamma Distributed at 5% Significance Level						
114	**Data Not Gamma Distributed at 5% Significance Level**											
115												
116	**Gamma Statistics**											
117	k hat (MLE)				1.486	k star (bias corrected MLE)						1.421
118	Theta hat (MLE)				0.383	Theta star (bias corrected MLE)						0.401
119	nu hat (MLE)				172.4	nu star (bias corrected)						164.8
120	MLE Mean (bias corrected)				0.569	MLE Sd (bias corrected)						0.478
121						Approximate Chi Square Value (0.05)						136.1
122	Adjusted Level of Significance				0.0459	Adjusted Chi Square Value						135.5
123												
124	**Assuming Gamma Distribution**											
125	95% Approximate Gamma UCL (use when n>=50))				0.689	95% Adjusted Gamma UCL (use when n<50)						0.693
126												
127	**Lognormal GOF Test**											
128	Shapiro Wilk Test Statistic				0.894	**Shapiro Wilk Lognormal GOF Test**						
129	5% Shapiro Wilk P Value				2.7516E-5	Data Not Lognormal at 5% Significance Level						
130	Lilliefors Test Statistic				0.131	**Lilliefors Lognormal GOF Test**						
131	5% Lilliefors Critical Value				0.116	Data Not Lognormal at 5% Significance Level						
132	**Data Not Lognormal at 5% Significance Level**											
133												
134	**Lognormal Statistics**											
135	Minimum of Logged Data				-2.12	Mean of logged Data						-0.936
136	Maximum of Logged Data				1.974	SD of logged Data						0.693
137												
138	**Assuming Lognormal Distribution**											
139	95% H-UCL				0.601	90% Chebyshev (MVUE) UCL						0.644
140	95% Chebyshev (MVUE) UCL				0.711	97.5% Chebyshev (MVUE) UCL						0.805
141	99% Chebyshev (MVUE) UCL				0.988							
142												
143	**Nonparametric Distribution Free UCL Statistics**											
144	**Data do not follow a Discernible Distribution (0.05)**											
145												
146	**Nonparametric Distribution Free UCLs**											
147	95% CLT UCL				0.778	95% Jackknife UCL						0.781
148	95% Standard Bootstrap UCL				0.776	95% Bootstrap-t UCL						1.27
149	95% Hall's Bootstrap UCL				1.534	95% Percentile Bootstrap UCL						0.785
150	95% BCA Bootstrap UCL				0.938							
151	90% Chebyshev(Mean, Sd) UCL				0.949	95% Chebyshev(Mean, Sd) UCL						1.121
152	97.5% Chebyshev(Mean, Sd) UCL				1.36	99% Chebyshev(Mean, Sd) UCL						1.829
153												
154	**Suggested UCL to Use**											
155	95% Chebyshev (Mean, Sd) UCL				1.121							
156												
157	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
158	Recommendations are based upon data size, data distribution, and skewness.											
159	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
160	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
161												
162												

163	**Arsenic**											
164												
165	**General Statistics**											
166						Total Number of Observations	58			Number of Distinct Observations	41	
167										Number of Missing Observations	0	
168						Minimum	8.2			Mean	140.1	
169						Maximum	550			Median	97.75	
170						SD	131.3			Std. Error of Mean	17.24	
171						Coefficient of Variation	0.937			Skewness	1.422	
172												
173	**Normal GOF Test**											
174						Shapiro Wilk Test Statistic	0.834			**Shapiro Wilk GOF Test**		
175						5% Shapiro Wilk P Value	1.5279E-8			Data Not Normal at 5% Significance Level		
176						Lilliefors Test Statistic	0.176			**Lilliefors GOF Test**		
177						5% Lilliefors Critical Value	0.116			Data Not Normal at 5% Significance Level		
178	**Data Not Normal at 5% Significance Level**											
179												
180	**Assuming Normal Distribution**											
181						**95% Normal UCL**				**95% UCLs (Adjusted for Skewness)**		
182						95% Student's-t UCL	168.9			95% Adjusted-CLT UCL (Chen-1995)	171.9	
183										95% Modified-t UCL (Johnson-1978)	169.5	
184												
185	**Gamma GOF Test**											
186						A-D Test Statistic	0.47			**Anderson-Darling Gamma GOF Test**		
187						5% A-D Critical Value	0.775			Detected data appear Gamma Distributed at 5% Significance Level		
188						K-S Test Statistic	0.106			**Kolmogorov-Smirnov Gamma GOF Test**		
189						5% K-S Critical Value	0.12			Detected data appear Gamma Distributed at 5% Significance Level		
190	**Detected data appear Gamma Distributed at 5% Significance Level**											
191												
192	**Gamma Statistics**											
193						k hat (MLE)	1.204			k star (bias corrected MLE)	1.153	
194						Theta hat (MLE)	116.4			Theta star (bias corrected MLE)	121.5	
195						nu hat (MLE)	139.7			nu star (bias corrected)	133.8	
196						MLE Mean (bias corrected)	140.1			MLE Sd (bias corrected)	130.5	
197										Approximate Chi Square Value (0.05)	108.1	
198						Adjusted Level of Significance	0.0459			Adjusted Chi Square Value	107.5	
199												
200	**Assuming Gamma Distribution**											
201						95% Approximate Gamma UCL (use when n>=50)	173.5			95% Adjusted Gamma UCL (use when n<50)	174.4	
202												
203	**Lognormal GOF Test**											
204						Shapiro Wilk Test Statistic	0.963			**Shapiro Wilk Lognormal GOF Test**		
205						5% Shapiro Wilk P Value	0.162			Data appear Lognormal at 5% Significance Level		
206						Lilliefors Test Statistic	0.0772			**Lilliefors Lognormal GOF Test**		
207						5% Lilliefors Critical Value	0.116			Data appear Lognormal at 5% Significance Level		
208	**Data appear Lognormal at 5% Significance Level**											
209												
210	**Lognormal Statistics**											
211						Minimum of Logged Data	2.104			Mean of logged Data	4.473	
212						Maximum of Logged Data	6.31			SD of logged Data	1.05	
213												
214	**Assuming Lognormal Distribution**											
215						95% H-UCL	212.8			90% Chebyshev (MVUE) UCL	224.2	
216						95% Chebyshev (MVUE) UCL	257.8			97.5% Chebyshev (MVUE) UCL	304.5	

217				99% Chebyshev (MVUE) UCL		396.2						
218												
219	**Nonparametric Distribution Free UCL Statistics**											
220	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
221												
222	**Nonparametric Distribution Free UCLs**											
223				95% CLT UCL		168.5				95% Jackknife UCL		168.9
224				95% Standard Bootstrap UCL		168.6				95% Bootstrap-t UCL		173.6
225				95% Hall's Bootstrap UCL		172.7				95% Percentile Bootstrap UCL		167.4
226				95% BCA Bootstrap UCL		173						
227				90% Chebyshev(Mean, Sd) UCL		191.8				95% Chebyshev(Mean, Sd) UCL		215.3
228				97.5% Chebyshev(Mean, Sd) UCL		247.8				99% Chebyshev(Mean, Sd) UCL		311.7
229												
230	**Suggested UCL to Use**											
231				95% Approximate Gamma UCL		173.5						
232												
233	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
234	Recommendations are based upon data size, data distribution, and skewness.											
235	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
236	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
237												
238												
239	**Cadmium**											
240												
241	**General Statistics**											
242				Total Number of Observations		58				Number of Distinct Observations		43
243										Number of Missing Observations		0
244				Minimum		0.13				Mean		0.695
245				Maximum		2.4				Median		0.618
246				SD		0.417				Std. Error of Mean		0.0548
247				Coefficient of Variation		0.6				Skewness		2.171
248												
249	**Normal GOF Test**											
250				Shapiro Wilk Test Statistic		0.812				**Shapiro Wilk GOF Test**		
251				5% Shapiro Wilk P Value		1.0773E-9				Data Not Normal at 5% Significance Level		
252				Lilliefors Test Statistic		0.17				**Lilliefors GOF Test**		
253				5% Lilliefors Critical Value		0.116				Data Not Normal at 5% Significance Level		
254	**Data Not Normal at 5% Significance Level**											
255												
256	**Assuming Normal Distribution**											
257	**95% Normal UCL**									**95% UCLs (Adjusted for Skewness)**		
258				95% Student's-t UCL		0.786				95% Adjusted-CLT UCL (Chen-1995)		0.801
259										95% Modified-t UCL (Johnson-1978)		0.789
260												
261	**Gamma GOF Test**											
262				A-D Test Statistic		0.717				**Anderson-Darling Gamma GOF Test**		
263				5% A-D Critical Value		0.755				Detected data appear Gamma Distributed at 5% Significance Level		
264				K-S Test Statistic		0.0955				**Kolmogorov-Smirnov Gamma GOF Test**		
265				5% K-S Critical Value		0.117				Detected data appear Gamma Distributed at 5% Significance Level		
266	**Detected data appear Gamma Distributed at 5% Significance Level**											
267												
268	**Gamma Statistics**											
269				k hat (MLE)		3.69				k star (bias corrected MLE)		3.51
270				Theta hat (MLE)		0.188				Theta star (bias corrected MLE)		0.198

271					nu hat (MLE)	428				nu star (bias corrected)		407.2
272					MLE Mean (bias corrected)	0.695				MLE Sd (bias corrected)		0.371
273										Approximate Chi Square Value (0.05)		361.4
274					Adjusted Level of Significance	0.0459				Adjusted Chi Square Value		360.3
275												
276					**Assuming Gamma Distribution**							
277					95% Approximate Gamma UCL (use when n>=50)	0.783				95% Adjusted Gamma UCL (use when n<50)		0.785
278												
279					**Lognormal GOF Test**							
280					Shapiro Wilk Test Statistic	0.985				**Shapiro Wilk Lognormal GOF Test**		
281					5% Shapiro Wilk P Value	0.857				Data appear Lognormal at 5% Significance Level		
282					Lilliefors Test Statistic	0.0649				**Lilliefors Lognormal GOF Test**		
283					5% Lilliefors Critical Value	0.116				Data appear Lognormal at 5% Significance Level		
284					**Data appear Lognormal at 5% Significance Level**							
285												
286					**Lognormal Statistics**							
287					Minimum of Logged Data	-2.04				Mean of logged Data		-0.506
288					Maximum of Logged Data	0.875				SD of logged Data		0.532
289												
290					**Assuming Lognormal Distribution**							
291					95% H-UCL	0.794				90% Chebyshev (MVUE) UCL		0.846
292					95% Chebyshev (MVUE) UCL	0.915				97.5% Chebyshev (MVUE) UCL		1.012
293					99% Chebyshev (MVUE) UCL	1.201						
294												
295					**Nonparametric Distribution Free UCL Statistics**							
296					**Data appear to follow a Discernible Distribution at 5% Significance Level**							
297												
298					**Nonparametric Distribution Free UCLs**							
299					95% CLT UCL	0.785				95% Jackknife UCL		0.786
300					95% Standard Bootstrap UCL	0.786				95% Bootstrap-t UCL		0.8
301					95% Hall's Bootstrap UCL	0.819				95% Percentile Bootstrap UCL		0.792
302					95% BCA Bootstrap UCL	0.806						
303					90% Chebyshev(Mean, Sd) UCL	0.859				95% Chebyshev(Mean, Sd) UCL		0.933
304					97.5% Chebyshev(Mean, Sd) UCL	1.037				99% Chebyshev(Mean, Sd) UCL		1.239
305												
306					**Suggested UCL to Use**							
307					95% Approximate Gamma UCL	0.783						
308												
309	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
310	Recommendations are based upon data size, data distribution, and skewness.											
311	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
312	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
313												
314												
315	**Chromium**											
316												
317					**General Statistics**							
318					Total Number of Observations	58				Number of Distinct Observations		21
319										Number of Missing Observations		0
320					Minimum	6.9				Mean		11.21
321					Maximum	33				Median		11
322					SD	3.391				Std. Error of Mean		0.445
323					Coefficient of Variation	0.303				Skewness		4.748
324												

325	**Normal GOF Test**											
326					Shapiro Wilk Test Statistic	0.599	**Shapiro Wilk GOF Test**					
327					5% Shapiro Wilk P Value	0	Data Not Normal at 5% Significance Level					
328					Lilliefors Test Statistic	0.252	**Lilliefors GOF Test**					
329					5% Lilliefors Critical Value	0.116	Data Not Normal at 5% Significance Level					
330	**Data Not Normal at 5% Significance Level**											
331												
332	**Assuming Normal Distribution**											
333	**95% Normal UCL**						**95% UCLs (Adjusted for Skewness)**					
334					95% Student's-t UCL	11.95	95% Adjusted-CLT UCL (Chen-1995)	12.23				
335							95% Modified-t UCL (Johnson-1978)	12				
336												
337	**Gamma GOF Test**											
338					A-D Test Statistic	3.059	**Anderson-Darling Gamma GOF Test**					
339					5% A-D Critical Value	0.749	Data Not Gamma Distributed at 5% Significance Level					
340					K-S Test Statistic	0.2	**Kolmogorov-Smirnov Gamma GOF Test**					
341					5% K-S Critical Value	0.117	Data Not Gamma Distributed at 5% Significance Level					
342	**Data Not Gamma Distributed at 5% Significance Level**											
343												
344	**Gamma Statistics**											
345					k hat (MLE)	17.63	k star (bias corrected MLE)	16.73				
346					Theta hat (MLE)	0.635	Theta star (bias corrected MLE)	0.67				
347					nu hat (MLE)	2046	nu star (bias corrected)	1941				
348					MLE Mean (bias corrected)	11.21	MLE Sd (bias corrected)	2.739				
349							Approximate Chi Square Value (0.05)	1840				
350					Adjusted Level of Significance	0.0459	Adjusted Chi Square Value	1837				
351												
352	**Assuming Gamma Distribution**											
353					95% Approximate Gamma UCL (use when n>=50))	11.82	95% Adjusted Gamma UCL (use when n<50)	11.84				
354												
355	**Lognormal GOF Test**											
356					Shapiro Wilk Test Statistic	0.839	**Shapiro Wilk Lognormal GOF Test**					
357					5% Shapiro Wilk P Value	2.6100E-8	Data Not Lognormal at 5% Significance Level					
358					Lilliefors Test Statistic	0.176	**Lilliefors Lognormal GOF Test**					
359					5% Lilliefors Critical Value	0.116	Data Not Lognormal at 5% Significance Level					
360	**Data Not Lognormal at 5% Significance Level**											
361												
362	**Lognormal Statistics**											
363					Minimum of Logged Data	1.932	Mean of logged Data	2.388				
364					Maximum of Logged Data	3.497	SD of logged Data	0.222				
365												
366	**Assuming Lognormal Distribution**											
367					95% H-UCL	11.74	90% Chebyshev (MVUE) UCL	12.14				
368					95% Chebyshev (MVUE) UCL	12.59	97.5% Chebyshev (MVUE) UCL	13.21				
369					99% Chebyshev (MVUE) UCL	14.43						
370												
371	**Nonparametric Distribution Free UCL Statistics**											
372	**Data do not follow a Discernible Distribution (0.05)**											
373												
374	**Nonparametric Distribution Free UCLs**											
375					95% CLT UCL	11.94	95% Jackknife UCL	11.95				
376					95% Standard Bootstrap UCL	11.91	95% Bootstrap-t UCL	12.44				
377					95% Hall's Bootstrap UCL	15.42	95% Percentile Bootstrap UCL	11.97				
378					95% BCA Bootstrap UCL	12.41						

379				90% Chebyshev(Mean, Sd) UCL		12.54				95% Chebyshev(Mean, Sd) UCL		13.15
380				97.5% Chebyshev(Mean, Sd) UCL		13.99				99% Chebyshev(Mean, Sd) UCL		15.64
381												
382						**Suggested UCL to Use**							
383				95% Student's-t UCL		11.95				or 95% Modified-t UCL		12
384												
385						Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.							
386						Recommendations are based upon data size, data distribution, and skewness.							
387						These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).							
388						However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.							
389												
390												
391	**Cobalt**											
392												
393						**General Statistics**							
394				Total Number of Observations		58				Number of Distinct Observations		35
395										Number of Missing Observations		0
396				Minimum		4.2				Mean		8.099
397				Maximum		16				Median		7.9
398				SD		2.421				Std. Error of Mean		0.318
399				Coefficient of Variation		0.299				Skewness		1.158
400												
401						**Normal GOF Test**							
402				Shapiro Wilk Test Statistic		0.908				**Shapiro Wilk GOF Test**		
403				5% Shapiro Wilk P Value		1.5874E-4				Data Not Normal at 5% Significance Level		
404				Lilliefors Test Statistic		0.15				**Lilliefors GOF Test**		
405				5% Lilliefors Critical Value		0.116				Data Not Normal at 5% Significance Level		
406						**Data Not Normal at 5% Significance Level**							
407												
408						**Assuming Normal Distribution**							
409						**95% Normal UCL**						**95% UCLs (Adjusted for Skewness)**	
410				95% Student's-t UCL		8.631				95% Adjusted-CLT UCL (Chen-1995)		8.674
411										95% Modified-t UCL (Johnson-1978)		8.639
412												
413						**Gamma GOF Test**							
414				A-D Test Statistic		0.85				**Anderson-Darling Gamma GOF Test**		
415				5% A-D Critical Value		0.75				Data Not Gamma Distributed at 5% Significance Level		
416				K-S Test Statistic		0.113				**Kolmogorov-Smirnov Gamma GOF Test**		
417				5% K-S Critical Value		0.117				Detected data appear Gamma Distributed at 5% Significance Level		
418						**Detected data follow Appr. Gamma Distribution at 5% Significance Level**							
419												
420						**Gamma Statistics**							
421				k hat (MLE)		12.67				k star (bias corrected MLE)		12.02
422				Theta hat (MLE)		0.639				Theta star (bias corrected MLE)		0.674
423				nu hat (MLE)		1470				nu star (bias corrected)		1395
424				MLE Mean (bias corrected)		8.099				MLE Sd (bias corrected)		2.336
425										Approximate Chi Square Value (0.05)		1309
426				Adjusted Level of Significance		0.0459				Adjusted Chi Square Value		1307
427												
428						**Assuming Gamma Distribution**							
429				95% Approximate Gamma UCL (use when n>=50)		8.629				95% Adjusted Gamma UCL (use when n<50)		8.643
430												
431						**Lognormal GOF Test**							
432				Shapiro Wilk Test Statistic		0.969				**Shapiro Wilk Lognormal GOF Test**		

433	5% Shapiro Wilk P Value				0.296	Data appear Lognormal at 5% Significance Level						
434	Lilliefors Test Statistic				0.0993	**Lilliefors Lognormal GOF Test**						
435	5% Lilliefors Critical Value				0.116	Data appear Lognormal at 5% Significance Level						
436	**Data appear Lognormal at 5% Significance Level**											
437												
438	**Lognormal Statistics**											
439	Minimum of Logged Data				1.435	Mean of logged Data					2.052	
440	Maximum of Logged Data				2.773	SD of logged Data					0.281	
441												
442	**Assuming Lognormal Distribution**											
443	95% H-UCL				8.625	90% Chebyshev (MVUE) UCL					9.001	
444	95% Chebyshev (MVUE) UCL				9.414	97.5% Chebyshev (MVUE) UCL					9.987	
445	99% Chebyshev (MVUE) UCL				11.11							
446												
447	**Nonparametric Distribution Free UCL Statistics**											
448	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
449												
450	**Nonparametric Distribution Free UCLs**											
451	95% CLT UCL				8.622	95% Jackknife UCL					8.631	
452	95% Standard Bootstrap UCL				8.625	95% Bootstrap-t UCL					8.702	
453	95% Hall's Bootstrap UCL				8.726	95% Percentile Bootstrap UCL					8.63	
454	95% BCA Bootstrap UCL				8.664							
455	90% Chebyshev(Mean, Sd) UCL				9.053	95% Chebyshev(Mean, Sd) UCL					9.485	
456	97.5% Chebyshev(Mean, Sd) UCL				10.08	99% Chebyshev(Mean, Sd) UCL					11.26	
457												
458	**Suggested UCL to Use**											
459	95% Approximate Gamma UCL				8.629							
460												
461	When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test											
462	When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL											
463												
464	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
465	Recommendations are based upon data size, data distribution, and skewness.											
466	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
467	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
468												
469												
470	**Copper**											
471												
472	**General Statistics**											
473	Total Number of Observations				58	Number of Distinct Observations					18	
474						Number of Missing Observations					0	
475	Minimum				7.3	Mean					80.9	
476	Maximum				3800	Median					14	
477	SD				497	Std. Error of Mean					65.25	
478	Coefficient of Variation				6.143	Skewness					7.614	
479												
480	**Normal GOF Test**											
481	Shapiro Wilk Test Statistic				0.14	**Shapiro Wilk GOF Test**						
482	5% Shapiro Wilk P Value				0	Data Not Normal at 5% Significance Level						
483	Lilliefors Test Statistic				0.509	**Lilliefors GOF Test**						
484	5% Lilliefors Critical Value				0.116	Data Not Normal at 5% Significance Level						
485	**Data Not Normal at 5% Significance Level**											
486												

487	**Assuming Normal Distribution**											
488	**95% Normal UCL**						**95% UCLs (Adjusted for Skewness)**					
489				95% Student's-t UCL	190				95% Adjusted-CLT UCL (Chen-1995)	257.9		
490									95% Modified-t UCL (Johnson-1978)	200.9		
491												
492	**Gamma GOF Test**											
493				A-D Test Statistic	19.34		**Anderson-Darling Gamma GOF Test**					
494				5% A-D Critical Value	0.837		Data Not Gamma Distributed at 5% Significance Level					
495				K-S Test Statistic	0.485		**Kolmogorov-Smirnov Gamma GOF Test**					
496				5% K-S Critical Value	0.125		Data Not Gamma Distributed at 5% Significance Level					
497	**Data Not Gamma Distributed at 5% Significance Level**											
498												
499	**Gamma Statistics**											
500				k hat (MLE)	0.409				k star (bias corrected MLE)	0.4		
501				Theta hat (MLE)	197.6				Theta star (bias corrected MLE)	202.4		
502				nu hat (MLE)	47.48				nu star (bias corrected)	46.36		
503				MLE Mean (bias corrected)	80.9				MLE Sd (bias corrected)	128		
504									Approximate Chi Square Value (0.05)	31.74		
505				Adjusted Level of Significance	0.0459				Adjusted Chi Square Value	31.43		
506												
507	**Assuming Gamma Distribution**											
508			95% Approximate Gamma UCL (use when n>=50))		118.2				95% Adjusted Gamma UCL (use when n<50)	119.3		
509												
510	**Lognormal GOF Test**											
511				Shapiro Wilk Test Statistic	0.433		**Shapiro Wilk Lognormal GOF Test**					
512				5% Shapiro Wilk P Value	0		Data Not Lognormal at 5% Significance Level					
513				Lilliefors Test Statistic	0.312		**Lilliefors Lognormal GOF Test**					
514				5% Lilliefors Critical Value	0.116		Data Not Lognormal at 5% Significance Level					
515	**Data Not Lognormal at 5% Significance Level**											
516												
517	**Lognormal Statistics**											
518				Minimum of Logged Data	1.988				Mean of logged Data	2.791		
519				Maximum of Logged Data	8.243				SD of logged Data	0.788		
520												
521	**Assuming Lognormal Distribution**											
522				95% H-UCL	27.74				90% Chebyshev (MVUE) UCL	29.77		
523				95% Chebyshev (MVUE) UCL	33.25				97.5% Chebyshev (MVUE) UCL	38.08		
524				99% Chebyshev (MVUE) UCL	47.57							
525												
526	**Nonparametric Distribution Free UCL Statistics**											
527	**Data do not follow a Discernible Distribution (0.05)**											
528												
529	**Nonparametric Distribution Free UCLs**											
530				95% CLT UCL	188.2				95% Jackknife UCL	190		
531				95% Standard Bootstrap UCL	190.7				95% Bootstrap-t UCL	9578		
532				95% Hall's Bootstrap UCL	3715				95% Percentile Bootstrap UCL	211		
533				95% BCA Bootstrap UCL	341.8							
534				90% Chebyshev(Mean, Sd) UCL	276.7				95% Chebyshev(Mean, Sd) UCL	365.3		
535				97.5% Chebyshev(Mean, Sd) UCL	488.4				99% Chebyshev(Mean, Sd) UCL	730.2		
536												
537	**Suggested UCL to Use**											
538				95% Chebyshev (Mean, Sd) UCL	365.3							
539												
540	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											

541	Recommendations are based upon data size, data distribution, and skewness.											
542	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
543	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
544												
545												
546	**Iron**											
547												
548	**General Statistics**											
549					Total Number of Observations	58			Number of Distinct Observations	26		
550									Number of Missing Observations	0		
551					Minimum	9700			Mean	22483		
552					Maximum	63000			Median	20000		
553					SD	10598			Std. Error of Mean	1392		
554					Coefficient of Variation	0.471			Skewness	1.9		
555												
556	**Normal GOF Test**											
557					Shapiro Wilk Test Statistic	0.818			**Shapiro Wilk GOF Test**			
558					5% Shapiro Wilk P Value	2.1614E-9			Data Not Normal at 5% Significance Level			
559					Lilliefors Test Statistic	0.225			**Lilliefors GOF Test**			
560					5% Lilliefors Critical Value	0.116			Data Not Normal at 5% Significance Level			
561	**Data Not Normal at 5% Significance Level**											
562												
563	**Assuming Normal Distribution**											
564					**95% Normal UCL**				**95% UCLs (Adjusted for Skewness)**			
565					95% Student's-t UCL	24809			95% Adjusted-CLT UCL (Chen-1995)	25143		
566									95% Modified-t UCL (Johnson-1978)	24867		
567												
568	**Gamma GOF Test**											
569					A-D Test Statistic	1.394			**Anderson-Darling Gamma GOF Test**			
570					5% A-D Critical Value	0.753			Data Not Gamma Distributed at 5% Significance Level			
571					K-S Test Statistic	0.174			**Kolmogorov-Smirnov Gamma GOF Test**			
572					5% K-S Critical Value	0.117			Data Not Gamma Distributed at 5% Significance Level			
573	**Data Not Gamma Distributed at 5% Significance Level**											
574												
575	**Gamma Statistics**											
576					k hat (MLE)	6.012			k star (bias corrected MLE)	5.712		
577					Theta hat (MLE)	3740			Theta star (bias corrected MLE)	3936		
578					nu hat (MLE)	697.4			nu star (bias corrected)	662.6		
579					MLE Mean (bias corrected)	22483			MLE Sd (bias corrected)	9407		
580									Approximate Chi Square Value (0.05)	603.9		
581					Adjusted Level of Significance	0.0459			Adjusted Chi Square Value	602.5		
582												
583	**Assuming Gamma Distribution**											
584					95% Approximate Gamma UCL (use when n>=50))	24669			95% Adjusted Gamma UCL (use when n<50)	24727		
585												
586	**Lognormal GOF Test**											
587					Shapiro Wilk Test Statistic	0.956			**Shapiro Wilk Lognormal GOF Test**			
588					5% Shapiro Wilk P Value	0.0686			Data appear Lognormal at 5% Significance Level			
589					Lilliefors Test Statistic	0.143			**Lilliefors Lognormal GOF Test**			
590					5% Lilliefors Critical Value	0.116			Data Not Lognormal at 5% Significance Level			
591	**Data appear Approximate Lognormal at 5% Significance Level**											
592												
593	**Lognormal Statistics**											
594					Minimum of Logged Data	9.18			Mean of logged Data	9.935		

595				Maximum of Logged Data		11.05				SD of logged Data		0.399
596												
597					**Assuming Lognormal Distribution**							
598				95% H-UCL		24611				90% Chebyshev (MVUE) UCL		25949
599				95% Chebyshev (MVUE) UCL		27592				97.5% Chebyshev (MVUE) UCL		29873
600				99% Chebyshev (MVUE) UCL		34354						
601												
602					**Nonparametric Distribution Free UCL Statistics**							
603					**Data appear to follow a Discernible Distribution at 5% Significance Level**							
604												
605					**Nonparametric Distribution Free UCLs**							
606				95% CLT UCL		24772				95% Jackknife UCL		24809
607				95% Standard Bootstrap UCL		24634				95% Bootstrap-t UCL		25398
608				95% Hall's Bootstrap UCL		25389				95% Percentile Bootstrap UCL		24817
609				95% BCA Bootstrap UCL		25074						
610				90% Chebyshev(Mean, Sd) UCL		26657				95% Chebyshev(Mean, Sd) UCL		28548
611				97.5% Chebyshev(Mean, Sd) UCL		31173				99% Chebyshev(Mean, Sd) UCL		36329
612												
613					**Suggested UCL to Use**							
614				95% Student's-t UCL		24809				or 95% Modified-t UCL		24867
615				or 95% H-UCL		24611						
616												
617					Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.							
618					Recommendations are based upon data size, data distribution, and skewness.							
619					These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).							
620					However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.							
621												
622					**ProUCL computes and outputs H-statistic based UCLs for historical reasons only.**							
623					**H-statistic often results in unstable (both high and low) values of UCL95 as shown in examples in the Technical Guide.**							
624					**It is therefore recommended to avoid the use of H-statistic based 95% UCLs.**							
625					**Use of nonparametric methods are preferred to compute UCL95 for skewed data sets which do not follow a gamma distribution.**							
626												
627												
628	**Lead**											
629												
630					**General Statistics**							
631				Total Number of Observations		58				Number of Distinct Observations		24
632										Number of Missing Observations		0
633				Minimum		5.8				Mean		27.28
634				Maximum		540				Median		17
635				SD		68.95				Std. Error of Mean		9.054
636				Coefficient of Variation		2.528				Skewness		7.466
637												
638					**Normal GOF Test**							
639				Shapiro Wilk Test Statistic		0.207				**Shapiro Wilk GOF Test**		
640				5% Shapiro Wilk P Value		0				Data Not Normal at 5% Significance Level		
641				Lilliefors Test Statistic		0.421				**Lilliefors GOF Test**		
642				5% Lilliefors Critical Value		0.116				Data Not Normal at 5% Significance Level		
643					**Data Not Normal at 5% Significance Level**							
644												
645					**Assuming Normal Distribution**							
646				**95% Normal UCL**						**95% UCLs (Adjusted for Skewness)**		
647				95% Student's-t UCL		42.42				95% Adjusted-CLT UCL (Chen-1995)		51.66
648										95% Modified-t UCL (Johnson-1978)		43.9

649												
650	**Gamma GOF Test**											
651					A-D Test Statistic	9.114	**Anderson-Darling Gamma GOF Test**					
652					5% A-D Critical Value	0.772	Data Not Gamma Distributed at 5% Significance Level					
653					K-S Test Statistic	0.303	**Kolmogorov-Smirnov Gamma GOF Test**					
654					5% K-S Critical Value	0.119	Data Not Gamma Distributed at 5% Significance Level					
655	**Data Not Gamma Distributed at 5% Significance Level**											
656												
657	**Gamma Statistics**											
658					k hat (MLE)	1.348	k star (bias corrected MLE)	1.29				
659					Theta hat (MLE)	20.24	Theta star (bias corrected MLE)	21.16				
660					nu hat (MLE)	156.3	nu star (bias corrected)	149.6				
661					MLE Mean (bias corrected)	27.28	MLE Sd (bias corrected)	24.02				
662							Approximate Chi Square Value (0.05)	122.3				
663					Adjusted Level of Significance	0.0459	Adjusted Chi Square Value	121.7				
664												
665	**Assuming Gamma Distribution**											
666					95% Approximate Gamma UCL (use when n>=50))	33.36	95% Adjusted Gamma UCL (use when n<50)	33.53				
667												
668	**Lognormal GOF Test**											
669					Shapiro Wilk Test Statistic	0.74	**Shapiro Wilk Lognormal GOF Test**					
670					5% Shapiro Wilk P Value	3.194E-13	Data Not Lognormal at 5% Significance Level					
671					Lilliefors Test Statistic	0.173	**Lilliefors Lognormal GOF Test**					
672					5% Lilliefors Critical Value	0.116	Data Not Lognormal at 5% Significance Level					
673	**Data Not Lognormal at 5% Significance Level**											
674												
675	**Lognormal Statistics**											
676					Minimum of Logged Data	1.758	Mean of logged Data	2.891				
677					Maximum of Logged Data	6.292	SD of logged Data	0.589				
678												
679	**Assuming Lognormal Distribution**											
680					95% H-UCL	24.96	90% Chebyshev (MVUE) UCL	26.67				
681					95% Chebyshev (MVUE) UCL	29.08	97.5% Chebyshev (MVUE) UCL	32.42				
682					99% Chebyshev (MVUE) UCL	38.98						
683												
684	**Nonparametric Distribution Free UCL Statistics**											
685	**Data do not follow a Discernible Distribution (0.05)**											
686												
687	**Nonparametric Distribution Free UCLs**											
688					95% CLT UCL	42.17	95% Jackknife UCL	42.42				
689					95% Standard Bootstrap UCL	41.66	95% Bootstrap-t UCL	141				
690					95% Hall's Bootstrap UCL	101.2	95% Percentile Bootstrap UCL	45.16				
691					95% BCA Bootstrap UCL	56.25						
692					90% Chebyshev(Mean, Sd) UCL	54.44	95% Chebyshev(Mean, Sd) UCL	66.75				
693					97.5% Chebyshev(Mean, Sd) UCL	83.82	99% Chebyshev(Mean, Sd) UCL	117.4				
694												
695	**Suggested UCL to Use**											
696					95% Chebyshev (Mean, Sd) UCL	66.75						
697												
698	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
699	Recommendations are based upon data size, data distribution, and skewness.											
700	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
701	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
702												

	A	B	C	D	E	F	G	H	I	J	K	L
703												
782												
783	**Molybdenum**											
784												
785	**General Statistics**											
786					Total Number of Observations	58			Number of Distinct Observations	48		
787									Number of Missing Observations	0		
788					Minimum	3.5			Mean	128.8		
789					Maximum	680			Median	64.5		
790					SD	143.8			Std. Error of Mean	18.88		
791					Coefficient of Variation	1.116			Skewness	1.764		
792												
793	**Normal GOF Test**											
794					Shapiro Wilk Test Statistic	0.79			**Shapiro Wilk GOF Test**			
795					5% Shapiro Wilk P Value	8.464E-11			Data Not Normal at 5% Significance Level			
796					Lilliefors Test Statistic	0.203			**Lilliefors GOF Test**			
797					5% Lilliefors Critical Value	0.116			Data Not Normal at 5% Significance Level			
798	**Data Not Normal at 5% Significance Level**											
799												
800	**Assuming Normal Distribution**											
801					**95% Normal UCL**				**95% UCLs (Adjusted for Skewness)**			
802					95% Student's-t UCL	160.4			95% Adjusted-CLT UCL (Chen-1995)	164.6		
803									95% Modified-t UCL (Johnson-1978)	161.1		
804												
805	**Gamma GOF Test**											
806					A-D Test Statistic	0.657			**Anderson-Darling Gamma GOF Test**			
807					5% A-D Critical Value	0.785			Detected data appear Gamma Distributed at 5% Significance Level			
808					K-S Test Statistic	0.109			**Kolmogorov-Smirnov Gamma GOF Test**			
809					5% K-S Critical Value	0.121			Detected data appear Gamma Distributed at 5% Significance Level			
810	**Detected data appear Gamma Distributed at 5% Significance Level**											
811												
812	**Gamma Statistics**											
813					k hat (MLE)	0.899			k star (bias corrected MLE)	0.864		
814					Theta hat (MLE)	143.3			Theta star (bias corrected MLE)	149.1		
815					nu hat (MLE)	104.3			nu star (bias corrected)	100.2		
816					MLE Mean (bias corrected)	128.8			MLE Sd (bias corrected)	138.6		
817									Approximate Chi Square Value (0.05)	78.12		
818					Adjusted Level of Significance	0.0459			Adjusted Chi Square Value	77.63		
819												
820	**Assuming Gamma Distribution**											
821					95% Approximate Gamma UCL (use when n>=50)	165.3			95% Adjusted Gamma UCL (use when n<50)	166.3		
822												
823	**Lognormal GOF Test**											
824					Shapiro Wilk Test Statistic	0.967			**Shapiro Wilk Lognormal GOF Test**			
825					5% Shapiro Wilk P Value	0.244			Data appear Lognormal at 5% Significance Level			
826					Lilliefors Test Statistic	0.0942			**Lilliefors Lognormal GOF Test**			
827					5% Lilliefors Critical Value	0.116			Data appear Lognormal at 5% Significance Level			
828	**Data appear Lognormal at 5% Significance Level**											
829												
830	**Lognormal Statistics**											
831					Minimum of Logged Data	1.253			Mean of logged Data	4.208		
832					Maximum of Logged Data	6.522			SD of logged Data	1.254		
833												
834	**Assuming Lognormal Distribution**											

835					95% H-UCL	235.1				90% Chebyshev (MVUE) UCL		234.2
836					95% Chebyshev (MVUE) UCL	275				97.5% Chebyshev (MVUE) UCL		331.6
837					99% Chebyshev (MVUE) UCL	442.7						
838												
839					**Nonparametric Distribution Free UCL Statistics**							
840					**Data appear to follow a Discernible Distribution at 5% Significance Level**							
841												
842					**Nonparametric Distribution Free UCLs**							
843					95% CLT UCL	159.9				95% Jackknife UCL		160.4
844					95% Standard Bootstrap UCL	159.6				95% Bootstrap-t UCL		165.9
845					95% Hall's Bootstrap UCL	166.3				95% Percentile Bootstrap UCL		159.4
846					95% BCA Bootstrap UCL	162.3						
847					90% Chebyshev(Mean, Sd) UCL	185.5				95% Chebyshev(Mean, Sd) UCL		211.1
848					97.5% Chebyshev(Mean, Sd) UCL	246.7				99% Chebyshev(Mean, Sd) UCL		316.7
849												
850					**Suggested UCL to Use**							
851					95% Approximate Gamma UCL	165.3						
852												
853					Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.							
854					Recommendations are based upon data size, data distribution, and skewness.							
855					These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).							
856					However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.							
857												
858												
859	**Selenium**											
860												
861					**General Statistics**							
862					Total Number of Observations	58				Number of Distinct Observations		22
863										Number of Missing Observations		0
864					Minimum	9.3				Mean		17.61
865					Maximum	58				Median		16
866					SD	7.493				Std. Error of Mean		0.984
867					Coefficient of Variation	0.426				Skewness		3.276
868												
869					**Normal GOF Test**							
870					Shapiro Wilk Test Statistic	0.718				**Shapiro Wilk GOF Test**		
871					5% Shapiro Wilk P Value	2.842E-14				Data Not Normal at 5% Significance Level		
872					Lilliefors Test Statistic	0.202				**Lilliefors GOF Test**		
873					5% Lilliefors Critical Value	0.116				Data Not Normal at 5% Significance Level		
874					**Data Not Normal at 5% Significance Level**							
875												
876					**Assuming Normal Distribution**							
877					**95% Normal UCL**					**95% UCLs (Adjusted for Skewness)**		
878					95% Student's-t UCL	19.25				95% Adjusted-CLT UCL (Chen-1995)		19.68
879										95% Modified-t UCL (Johnson-1978)		19.32
880												
881					**Gamma GOF Test**							
882					A-D Test Statistic	1.752				**Anderson-Darling Gamma GOF Test**		
883					5% A-D Critical Value	0.752				Data Not Gamma Distributed at 5% Significance Level		
884					K-S Test Statistic	0.15				**Kolmogorov-Smirnov Gamma GOF Test**		
885					5% K-S Critical Value	0.117				Data Not Gamma Distributed at 5% Significance Level		
886					**Data Not Gamma Distributed at 5% Significance Level**							
887												
888					**Gamma Statistics**							

889					k hat (MLE)	8.57				k star (bias corrected MLE)		8.138
890					Theta hat (MLE)	2.055				Theta star (bias corrected MLE)		2.164
891					nu hat (MLE)	994.1				nu star (bias corrected)		944
892					MLE Mean (bias corrected)	17.61				MLE Sd (bias corrected)		6.173
893										Approximate Chi Square Value (0.05)		873.7
894					Adjusted Level of Significance	0.0459				Adjusted Chi Square Value		872
895												
896	**Assuming Gamma Distribution**											
897				95% Approximate Gamma UCL (use when n>=50))		19.03				95% Adjusted Gamma UCL (use when n<50)		19.06
898												
899	**Lognormal GOF Test**											
900					Shapiro Wilk Test Statistic	0.927				**Shapiro Wilk Lognormal GOF Test**		
901					5% Shapiro Wilk P Value	0.00189				Data Not Lognormal at 5% Significance Level		
902					Lilliefors Test Statistic	0.131				**Lilliefors Lognormal GOF Test**		
903					5% Lilliefors Critical Value	0.116				Data Not Lognormal at 5% Significance Level		
904	**Data Not Lognormal at 5% Significance Level**											
905												
906	**Lognormal Statistics**											
907					Minimum of Logged Data	2.23				Mean of logged Data		2.809
908					Maximum of Logged Data	4.06				SD of logged Data		0.323
909												
910	**Assuming Lognormal Distribution**											
911					95% H-UCL	18.81				90% Chebyshev (MVUE) UCL		19.74
912					95% Chebyshev (MVUE) UCL	20.77				97.5% Chebyshev (MVUE) UCL		22.2
913					99% Chebyshev (MVUE) UCL	25						
914												
915	**Nonparametric Distribution Free UCL Statistics**											
916	**Data do not follow a Discernible Distribution (0.05)**											
917												
918	**Nonparametric Distribution Free UCLs**											
919					95% CLT UCL	19.23				95% Jackknife UCL		19.25
920					95% Standard Bootstrap UCL	19.19				95% Bootstrap-t UCL		19.97
921					95% Hall's Bootstrap UCL	22.4				95% Percentile Bootstrap UCL		19.43
922					95% BCA Bootstrap UCL	19.88						
923					90% Chebyshev(Mean, Sd) UCL	20.56				95% Chebyshev(Mean, Sd) UCL		21.9
924					97.5% Chebyshev(Mean, Sd) UCL	23.75				99% Chebyshev(Mean, Sd) UCL		27.4
925												
926	**Suggested UCL to Use**											
927					95% Student's-t UCL	19.25				or 95% Modified-t UCL		19.32
928												
929	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
930	Recommendations are based upon data size, data distribution, and skewness.											
931	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
932	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
933												
934												
935	**Thallium**											
936												
937	**General Statistics**											
938					Total Number of Observations	58				Number of Distinct Observations		38
939										Number of Missing Observations		0
940					Minimum	0.081				Mean		0.34
941					Maximum	1.8				Median		0.26
942					SD	0.264				Std. Error of Mean		0.0347

943				Coefficient of Variation		0.777					Skewness	3.29
944												
945						**Normal GOF Test**						
946				Shapiro Wilk Test Statistic		0.72		**Shapiro Wilk GOF Test**				
947				5% Shapiro Wilk P Value		3.830E-14		Data Not Normal at 5% Significance Level				
948				Lilliefors Test Statistic		0.163		**Lilliefors GOF Test**				
949				5% Lilliefors Critical Value		0.116		Data Not Normal at 5% Significance Level				
950						**Data Not Normal at 5% Significance Level**						
951												
952						**Assuming Normal Distribution**						
953				**95% Normal UCL**				**95% UCLs (Adjusted for Skewness)**				
954				95% Student's-t UCL		0.398		95% Adjusted-CLT UCL (Chen-1995)				0.413
955								95% Modified-t UCL (Johnson-1978)				0.4
956												
957						**Gamma GOF Test**						
958				A-D Test Statistic		1.014		**Anderson-Darling Gamma GOF Test**				
959				5% A-D Critical Value		0.759		Data Not Gamma Distributed at 5% Significance Level				
960				K-S Test Statistic		0.119		**Kolmogorov-Smirnov Gamma GOF Test**				
961				5% K-S Critical Value		0.118		Data Not Gamma Distributed at 5% Significance Level				
962						**Data Not Gamma Distributed at 5% Significance Level**						
963												
964						**Gamma Statistics**						
965				k hat (MLE)		2.704		k star (bias corrected MLE)				2.575
966				Theta hat (MLE)		0.126		Theta star (bias corrected MLE)				0.132
967				nu hat (MLE)		313.6		nu star (bias corrected)				298.7
968				MLE Mean (bias corrected)		0.34		MLE Sd (bias corrected)				0.212
969								Approximate Chi Square Value (0.05)				259.7
970				Adjusted Level of Significance		0.0459		Adjusted Chi Square Value				258.8
971												
972						**Assuming Gamma Distribution**						
973				95% Approximate Gamma UCL (use when n>=50))		0.391		95% Adjusted Gamma UCL (use when n<50)				0.392
974												
975						**Lognormal GOF Test**						
976				Shapiro Wilk Test Statistic		0.974		**Shapiro Wilk Lognormal GOF Test**				
977				5% Shapiro Wilk P Value		0.448		Data appear Lognormal at 5% Significance Level				
978				Lilliefors Test Statistic		0.107		**Lilliefors Lognormal GOF Test**				
979				5% Lilliefors Critical Value		0.116		Data appear Lognormal at 5% Significance Level				
980						**Data appear Lognormal at 5% Significance Level**						
981												
982						**Lognormal Statistics**						
983				Minimum of Logged Data		-2.513		Mean of logged Data				-1.275
984				Maximum of Logged Data		0.588		SD of logged Data				0.604
985												
986						**Assuming Lognormal Distribution**						
987				95% H-UCL		0.392		90% Chebyshev (MVUE) UCL				0.419
988				95% Chebyshev (MVUE) UCL		0.458		97.5% Chebyshev (MVUE) UCL				0.512
989				99% Chebyshev (MVUE) UCL		0.617						
990												
991						**Nonparametric Distribution Free UCL Statistics**						
992						**Data appear to follow a Discernible Distribution at 5% Significance Level**						
993												
994						**Nonparametric Distribution Free UCLs**						
995				95% CLT UCL		0.397		95% Jackknife UCL				0.398
996				95% Standard Bootstrap UCL		0.396		95% Bootstrap-t UCL				0.427

997				95% Hall's Bootstrap UCL	0.478			95% Percentile Bootstrap UCL			0.4	
998				95% BCA Bootstrap UCL	0.414							
999				90% Chebyshev(Mean, Sd) UCL	0.444			95% Chebyshev(Mean, Sd) UCL			0.491	
1000				97.5% Chebyshev(Mean, Sd) UCL	0.556			99% Chebyshev(Mean, Sd) UCL			0.685	
1001												
1002				**Suggested UCL to Use**								
1003				95% H-UCL	0.392							
1004												
1005	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
1006	Recommendations are based upon data size, data distribution, and skewness.											
1007	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
1008	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
1009												
1010	**ProUCL computes and outputs H-statistic based UCLs for historical reasons only.**											
1011	**H-statistic often results in unstable (both high and low) values of UCL95 as shown in examples in the Technical Guide.**											
1012	**It is therefore recommended to avoid the use of H-statistic based 95% UCLs.**											
1013	**Use of nonparametric methods are preferred to compute UCL95 for skewed data sets which do not follow a gamma distribution.**											
1014												
1015												
1016	**Uranium**											
1017												
1018				**General Statistics**								
1019				Total Number of Observations	58			Number of Distinct Observations			48	
1020								Number of Missing Observations			0	
1021				Minimum	5.9			Mean			211.7	
1022				Maximum	1000			Median			110	
1023				SD	235.1			Std. Error of Mean			30.87	
1024				Coefficient of Variation	1.11			Skewness			1.74	
1025												
1026				**Normal GOF Test**								
1027				Shapiro Wilk Test Statistic	0.779			**Shapiro Wilk GOF Test**				
1028				5% Shapiro Wilk P Value	2.381E-11			Data Not Normal at 5% Significance Level				
1029				Lilliefors Test Statistic	0.219			**Lilliefors GOF Test**				
1030				5% Lilliefors Critical Value	0.116			Data Not Normal at 5% Significance Level				
1031				**Data Not Normal at 5% Significance Level**								
1032												
1033				**Assuming Normal Distribution**								
1034				**95% Normal UCL**				**95% UCLs (Adjusted for Skewness)**				
1035				95% Student's-t UCL	263.3			95% Adjusted-CLT UCL (Chen-1995)			270	
1036								95% Modified-t UCL (Johnson-1978)			264.5	
1037												
1038				**Gamma GOF Test**								
1039				A-D Test Statistic	0.542			**Anderson-Darling Gamma GOF Test**				
1040				5% A-D Critical Value	0.783			Detected data appear Gamma Distributed at 5% Significance Level				
1041				K-S Test Statistic	0.131			**Kolmogorov-Smirnov Gamma GOF Test**				
1042				5% K-S Critical Value	0.121			Data Not Gamma Distributed at 5% Significance Level				
1043				**Detected data follow Appr. Gamma Distribution at 5% Significance Level**								
1044												
1045				**Gamma Statistics**								
1046				k hat (MLE)	0.92			k star (bias corrected MLE)			0.884	
1047				Theta hat (MLE)	230.1			Theta star (bias corrected MLE)			239.5	
1048				nu hat (MLE)	106.7			nu star (bias corrected)			102.5	
1049				MLE Mean (bias corrected)	211.7			MLE Sd (bias corrected)			225.1	
1050								Approximate Chi Square Value (0.05)			80.18	

1051					Adjusted Level of Significance	0.0459					Adjusted Chi Square Value	79.67
1052												
1053					**Assuming Gamma Distribution**							
1054					95% Approximate Gamma UCL (use when n>=50)	270.7					95% Adjusted Gamma UCL (use when n<50)	272.4
1055												
1056					**Lognormal GOF Test**							
1057					Shapiro Wilk Test Statistic	0.968					**Shapiro Wilk Lognormal GOF Test**	
1058					5% Shapiro Wilk P Value	0.271					Data appear Lognormal at 5% Significance Level	
1059					Lilliefors Test Statistic	0.0739					**Lilliefors Lognormal GOF Test**	
1060					5% Lilliefors Critical Value	0.116					Data appear Lognormal at 5% Significance Level	
1061					**Data appear Lognormal at 5% Significance Level**							
1062												
1063					**Lognormal Statistics**							
1064					Minimum of Logged Data	1.775					Mean of logged Data	4.721
1065					Maximum of Logged Data	6.908					SD of logged Data	1.239
1066												
1067					**Assuming Lognormal Distribution**							
1068					95% H-UCL	381					90% Chebyshev (MVUE) UCL	381.8
1069					95% Chebyshev (MVUE) UCL	447.5					97.5% Chebyshev (MVUE) UCL	538.8
1070					99% Chebyshev (MVUE) UCL	718.2						
1071												
1072					**Nonparametric Distribution Free UCL Statistics**							
1073					**Data appear to follow a Discernible Distribution at 5% Significance Level**							
1074												
1075					**Nonparametric Distribution Free UCLs**							
1076					95% CLT UCL	262.4					95% Jackknife UCL	263.3
1077					95% Standard Bootstrap UCL	261					95% Bootstrap-t UCL	275.4
1078					95% Hall's Bootstrap UCL	270.9					95% Percentile Bootstrap UCL	264.2
1079					95% BCA Bootstrap UCL	273.6						
1080					90% Chebyshev(Mean, Sd) UCL	304.3					95% Chebyshev(Mean, Sd) UCL	346.2
1081					97.5% Chebyshev(Mean, Sd) UCL	404.4					99% Chebyshev(Mean, Sd) UCL	518.8
1082												
1083					**Suggested UCL to Use**							
1084					95% Approximate Gamma UCL	270.7						
1085												
1086					When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test							
1087					When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL							
1088												
1089					Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.							
1090					Recommendations are based upon data size, data distribution, and skewness.							
1091					These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).							
1092					However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.							
1093												
1094												
1095	**Vanadium**											
1096												
1097					**General Statistics**							
1098					Total Number of Observations	58					Number of Distinct Observations	31
1099											Number of Missing Observations	0
1100					Minimum	12					Mean	26.6
1101					Maximum	54					Median	25
1102					SD	9.873					Std. Error of Mean	1.296
1103					Coefficient of Variation	0.371					Skewness	0.758
1104												

1105	**Normal GOF Test**											
1106					Shapiro Wilk Test Statistic	0.93	**Shapiro Wilk GOF Test**					
1107					5% Shapiro Wilk P Value	0.00292	Data Not Normal at 5% Significance Level					
1108					Lilliefors Test Statistic	0.151	**Lilliefors GOF Test**					
1109					5% Lilliefors Critical Value	0.116	Data Not Normal at 5% Significance Level					
1110	**Data Not Normal at 5% Significance Level**											
1111												
1112	**Assuming Normal Distribution**											
1113	**95% Normal UCL**						**95% UCLs (Adjusted for Skewness)**					
1114					95% Student's-t UCL	28.77	95% Adjusted-CLT UCL (Chen-1995)	28.87				
1115							95% Modified-t UCL (Johnson-1978)	28.79				
1116												
1117	**Gamma GOF Test**											
1118					A-D Test Statistic	0.521	**Anderson-Darling Gamma GOF Test**					
1119					5% A-D Critical Value	0.752	Detected data appear Gamma Distributed at 5% Significance Level					
1120					K-S Test Statistic	0.103	**Kolmogorov-Smirnov Gamma GOF Test**					
1121					5% K-S Critical Value	0.117	Detected data appear Gamma Distributed at 5% Significance Level					
1122	**Detected data appear Gamma Distributed at 5% Significance Level**											
1123												
1124	**Gamma Statistics**											
1125					k hat (MLE)	7.758	k star (bias corrected MLE)	7.368				
1126					Theta hat (MLE)	3.429	Theta star (bias corrected MLE)	3.611				
1127					nu hat (MLE)	899.9	nu star (bias corrected)	854.7				
1128					MLE Mean (bias corrected)	26.6	MLE Sd (bias corrected)	9.801				
1129							Approximate Chi Square Value (0.05)	787.9				
1130					Adjusted Level of Significance	0.0459	Adjusted Chi Square Value	786.2				
1131												
1132	**Assuming Gamma Distribution**											
1133					95% Approximate Gamma UCL (use when n>=50)	28.86	95% Adjusted Gamma UCL (use when n<50)	28.92				
1134												
1135	**Lognormal GOF Test**											
1136					Shapiro Wilk Test Statistic	0.968	**Shapiro Wilk Lognormal GOF Test**					
1137					5% Shapiro Wilk P Value	0.256	Data appear Lognormal at 5% Significance Level					
1138					Lilliefors Test Statistic	0.0817	**Lilliefors Lognormal GOF Test**					
1139					5% Lilliefors Critical Value	0.116	Data appear Lognormal at 5% Significance Level					
1140	**Data appear Lognormal at 5% Significance Level**											
1141												
1142	**Lognormal Statistics**											
1143					Minimum of Logged Data	2.485	Mean of logged Data	3.215				
1144					Maximum of Logged Data	3.989	SD of logged Data	0.367				
1145												
1146	**Assuming Lognormal Distribution**											
1147					95% H-UCL	29.02	90% Chebyshev (MVUE) UCL	30.56				
1148					95% Chebyshev (MVUE) UCL	32.35	97.5% Chebyshev (MVUE) UCL	34.84				
1149					99% Chebyshev (MVUE) UCL	39.72						
1150												
1151	**Nonparametric Distribution Free UCL Statistics**											
1152	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
1153												
1154	**Nonparametric Distribution Free UCLs**											
1155					95% CLT UCL	28.74	95% Jackknife UCL	28.77				
1156					95% Standard Bootstrap UCL	28.67	95% Bootstrap-t UCL	29				
1157					95% Hall's Bootstrap UCL	28.87	95% Percentile Bootstrap UCL	28.82				
1158					95% BCA Bootstrap UCL	28.78						

1159				90% Chebyshev(Mean, Sd) UCL		30.49				95% Chebyshev(Mean, Sd) UCL		32.25
1160				97.5% Chebyshev(Mean, Sd) UCL		34.7				99% Chebyshev(Mean, Sd) UCL		39.5
1161												
1162						**Suggested UCL to Use**							
1163				95% Approximate Gamma UCL		28.86						
1164												
1165						Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.						
1166						Recommendations are based upon data size, data distribution, and skewness.						
1167						These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).						
1168						However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.						
1169												
1170	**Cs137**											
1171												
1172						**General Statistics**						
1173				Total Number of Observations		30				Number of Distinct Observations		28
1174				Number of Detects		2				Number of Non-Detects		28
1175				Number of Distinct Detects		2				Number of Distinct Non-Detects		27
1176				Minimum Detect		0.25				Minimum Non-Detect		0.188
1177				Maximum Detect		0.37				Maximum Non-Detect		1.7
1178				Variance Detects		0.0072				Percent Non-Detects		93.33%
1179				Mean Detects		0.31				SD Detects		0.0849
1180				Median Detects		0.31				CV Detects		0.274
1181				Skewness Detects		N/A				Kurtosis Detects		N/A
1182				Mean of Logged Detects		-1.19				SD of Logged Detects		0.277
1183												
1184						**Warning: Data set has only 2 Detected Values.**							
1185						**This is not enough to compute meaningful or reliable statistics and estimates.**						
1186												
1187												
1188						**Normal GOF Test on Detects Only**							
1189						**Not Enough Data to Perform GOF Test**							
1190												
1191						**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**							
1192				KM Mean		0.244				KM Standard Error of Mean		0.0415
1193				KM SD		0.063				95% KM (BCA) UCL		N/A
1194				95% KM (t) UCL		0.315				95% KM (Percentile Bootstrap) UCL		N/A
1195				95% KM (z) UCL		0.312				95% KM Bootstrap t UCL		N/A
1196				90% KM Chebyshev UCL		0.369				95% KM Chebyshev UCL		0.425
1197				97.5% KM Chebyshev UCL		0.503				99% KM Chebyshev UCL		0.657
1198												
1199						**Gamma GOF Tests on Detected Observations Only**							
1200						**Not Enough Data to Perform GOF Test**							
1201												
1202						**Gamma Statistics on Detected Data Only**							
1203				k hat (MLE)		26.36				k star (bias corrected MLE)		N/A
1204				Theta hat (MLE)		0.0118				Theta star (bias corrected MLE)		N/A
1205				nu hat (MLE)		105.4				nu star (bias corrected)		N/A
1206				Mean (detects)		0.31						
1207												
1208						**Estimates of Gamma Parameters using KM Estimates**							
1209				Mean (KM)		0.244				SD (KM)		0.063
1210				Variance (KM)		0.00397				SE of Mean (KM)		0.0415
1211				k hat (KM)		15.03				k star (KM)		13.55
1212				nu hat (KM)		901.6				nu star (KM)		812.7

1213					theta hat (KM)	0.0162					theta star (KM)	0.018
1214					80% gamma percentile (KM)	0.298					90% gamma percentile (KM)	0.332
1215					95% gamma percentile (KM)	0.363					99% gamma percentile (KM)	0.424
1216												
1217					**Gamma Kaplan-Meier (KM) Statistics**							
1218											Adjusted Level of Significance (β)	0.041
1219					Approximate Chi Square Value (812.73, α)	747.6					Adjusted Chi Square Value (812.73, β)	744
1220					95% Gamma Approximate KM-UCL (use when n>=50)	0.265					95% Gamma Adjusted KM-UCL (use when n<50)	0.267
1221												
1222					**Lognormal GOF Test on Detected Observations Only**							
1223					**Not Enough Data to Perform GOF Test**							
1224												
1225					**Lognormal ROS Statistics Using Imputed Non-Detects**							
1226					Mean in Original Scale	0.225					Mean in Log Scale	-1.5
1227					SD in Original Scale	0.0316					SD in Log Scale	0.122
1228					95% t UCL (assumes normality of ROS data)	0.235					95% Percentile Bootstrap UCL	0.235
1229					95% BCA Bootstrap UCL	0.239					95% Bootstrap t UCL	0.242
1230					95% H-UCL (Log ROS)	0.234						
1231												
1232					**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**							
1233					KM Mean (logged)	-1.44					KM Geo Mean	0.237
1234					KM SD (logged)	0.238					95% Critical H Value (KM-Log)	1.773
1235					KM Standard Error of Mean (logged)	0.165					95% H-UCL (KM -Log)	0.264
1236					KM SD (logged)	0.238					95% Critical H Value (KM-Log)	1.773
1237					KM Standard Error of Mean (logged)	0.165						
1238												
1239					**DL/2 Statistics**							
1240					**DL/2 Normal**						**DL/2 Log-Transformed**	
1241					Mean in Original Scale	0.391					Mean in Log Scale	-1.047
1242					SD in Original Scale	0.183					SD in Log Scale	0.484
1243					95% t UCL (Assumes normality)	0.447					95% H-Stat UCL	0.47
1244					**DL/2 is not a recommended method, provided for comparisons and historical reasons**							
1245												
1246					**Nonparametric Distribution Free UCL Statistics**							
1247					**Data do not follow a Discernible Distribution at 5% Significance Level**							
1248												
1249					**Suggested UCL to Use**							
1250					95% KM (t) UCL	0.315					KM H-UCL	0.264
1251					95% KM (BCA) UCL	N/A						
1252					**Warning: One or more Recommended UCL(s) not available!**							
1253												
1254					Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.							
1255					Recommendations are based upon data size, data distribution, and skewness.							
1256					These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).							
1257					However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.							
1258												
1259	**K40**											
1260												
1261					**General Statistics**							
1262					Total Number of Observations	30					Number of Distinct Observations	27
1263					Number of Detects	28					Number of Non-Detects	2
1264					Number of Distinct Detects	27					Number of Distinct Non-Detects	2
1265					Minimum Detect	9.5					Minimum Non-Detect	11.3
1266					Maximum Detect	23.9					Maximum Non-Detect	11.9

1267					Variance Detects	10.71					Percent Non-Detects	6.667%
1268					Mean Detects	15.55					SD Detects	3.273
1269					Median Detects	15.85					CV Detects	0.21
1270					Skewness Detects	0.337					Kurtosis Detects	0.267
1271					Mean of Logged Detects	2.722					SD of Logged Detects	0.214
1272												
1273	**Normal GOF Test on Detects Only**											
1274					Shapiro Wilk Test Statistic	0.975	**Shapiro Wilk GOF Test**					
1275					5% Shapiro Wilk Critical Value	0.924	Detected Data appear Normal at 5% Significance Level					
1276					Lilliefors Test Statistic	0.0821	**Lilliefors GOF Test**					
1277					5% Lilliefors Critical Value	0.164	Detected Data appear Normal at 5% Significance Level					
1278	**Detected Data appear Normal at 5% Significance Level**											
1279												
1280	**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**											
1281					KM Mean	15.21					KM Standard Error of Mean	0.627
1282					KM SD	3.361					95% KM (BCA) UCL	16.27
1283					95% KM (t) UCL	16.28					95% KM (Percentile Bootstrap) UCL	16.24
1284					95% KM (z) UCL	16.24					95% KM Bootstrap t UCL	16.35
1285					90% KM Chebyshev UCL	17.09					95% KM Chebyshev UCL	17.94
1286					97.5% KM Chebyshev UCL	19.12					99% KM Chebyshev UCL	21.45
1287												
1288	**Gamma GOF Tests on Detected Observations Only**											
1289					A-D Test Statistic	0.307	**Anderson-Darling GOF Test**					
1290					5% A-D Critical Value	0.744	Detected data appear Gamma Distributed at 5% Significance Level					
1291					K-S Test Statistic	0.105	**Kolmogorov-Smirnov GOF**					
1292					5% K-S Critical Value	0.165	Detected data appear Gamma Distributed at 5% Significance Level					
1293	**Detected data appear Gamma Distributed at 5% Significance Level**											
1294												
1295	**Gamma Statistics on Detected Data Only**											
1296					k hat (MLE)	23.21					k star (bias corrected MLE)	20.75
1297					Theta hat (MLE)	0.67					Theta star (bias corrected MLE)	0.749
1298					nu hat (MLE)	1300					nu star (bias corrected)	1162
1299					Mean (detects)	15.55						
1300												
1301	**Gamma ROS Statistics using Imputed Non-Detects**											
1302	GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs											
1303	GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)											
1304	For such situations, GROS method may yield incorrect values of UCLs and BTVs											
1305	This is especially true when the sample size is small.											
1306	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates											
1307					Minimum	9.5					Mean	15.2
1308					Maximum	23.9					Median	15.7
1309					SD	3.423					CV	0.225
1310					k hat (MLE)	20.28					k star (bias corrected MLE)	18.28
1311					Theta hat (MLE)	0.75					Theta star (bias corrected MLE)	0.832
1312					nu hat (MLE)	1217					nu star (bias corrected)	1097
1313					Adjusted Level of Significance (β)	0.041						
1314					Approximate Chi Square Value (N/A, α)	1021					Adjusted Chi Square Value (N/A, β)	1017
1315					95% Gamma Approximate UCL (use when n>=50)	16.33					95% Gamma Adjusted UCL (use when n<50)	16.4
1316												
1317	**Estimates of Gamma Parameters using KM Estimates**											
1318					Mean (KM)	15.21					SD (KM)	3.361
1319					Variance (KM)	11.29					SE of Mean (KM)	0.627
1320					k hat (KM)	20.49					k star (KM)	18.46

1321					nu hat (KM)	1229					nu star (KM)	1108
1322					theta hat (KM)	0.743					theta star (KM)	0.824
1323					80% gamma percentile (KM)	18.08					90% gamma percentile (KM)	19.89
1324					95% gamma percentile (KM)	21.46					99% gamma percentile (KM)	24.63
1325												
1326					**Gamma Kaplan-Meier (KM) Statistics**							
1327					Approximate Chi Square Value (N/A, α)	1031					Adjusted Chi Square Value (N/A, β)	1027
1328					95% Gamma Approximate KM-UCL (use when n>=50)	16.34					95% Gamma Adjusted KM-UCL (use when n<50)	16.4
1329												
1330					**Lognormal GOF Test on Detected Observations Only**							
1331					Shapiro Wilk Test Statistic	0.978					**Shapiro Wilk GOF Test**	
1332					5% Shapiro Wilk Critical Value	0.924					Detected Data appear Lognormal at 5% Significance Level	
1333					Lilliefors Test Statistic	0.118					**Lilliefors GOF Test**	
1334					5% Lilliefors Critical Value	0.164					Detected Data appear Lognormal at 5% Significance Level	
1335					**Detected Data appear Lognormal at 5% Significance Level**							
1336												
1337					**Lognormal ROS Statistics Using Imputed Non-Detects**							
1338					Mean in Original Scale	15.22					Mean in Log Scale	2.698
1339					SD in Original Scale	3.403					SD in Log Scale	0.226
1340					95% t UCL (assumes normality of ROS data)	16.27					95% Percentile Bootstrap UCL	16.31
1341					95% BCA Bootstrap UCL	16.27					95% Bootstrap t UCL	16.33
1342					95% H-UCL (Log ROS)	16.41						
1343												
1344					**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**							
1345					KM Mean (logged)	2.697					KM Geo Mean	14.84
1346					KM SD (logged)	0.225					95% Critical H Value (KM-Log)	1.766
1347					KM Standard Error of Mean (logged)	0.042					95% H-UCL (KM -Log)	16.38
1348					KM SD (logged)	0.225					95% Critical H Value (KM-Log)	1.766
1349					KM Standard Error of Mean (logged)	0.042						
1350												
1351					**DL/2 Statistics**							
1352					**DL/2 Normal**						**DL/2 Log-Transformed**	
1353					Mean in Original Scale	14.9					Mean in Log Scale	2.658
1354					SD in Original Scale	4.012					SD in Log Scale	0.32
1355					95% t UCL (Assumes normality)	16.14					95% H-Stat UCL	16.74
1356					**DL/2 is not a recommended method, provided for comparisons and historical reasons**							
1357												
1358					**Nonparametric Distribution Free UCL Statistics**							
1359					**Detected Data appear Normal Distributed at 5% Significance Level**							
1360												
1361					**Suggested UCL to Use**							
1362					95% KM (t) UCL	16.28						
1363												
1364					Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.							
1365					Recommendations are based upon data size, data distribution, and skewness.							
1366					These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).							
1367					However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.							
1368												
1369												
1370	**Pb210**											
1371												
1372					**General Statistics**							
1373					Total Number of Observations	30					Number of Distinct Observations	28
1374											Number of Missing Observations	0

1375					Minimum	2.82					Mean	40.28
1376					Maximum	194					Median	26.83
1377					SD	40.87					Std. Error of Mean	7.462
1378					Coefficient of Variation	1.015					Skewness	2.244
1379												
1380	**Normal GOF Test**											
1381					Shapiro Wilk Test Statistic	0.767	**Shapiro Wilk GOF Test**					
1382					5% Shapiro Wilk Critical Value	0.927	Data Not Normal at 5% Significance Level					
1383					Lilliefors Test Statistic	0.231	**Lilliefors GOF Test**					
1384					5% Lilliefors Critical Value	0.159	Data Not Normal at 5% Significance Level					
1385	**Data Not Normal at 5% Significance Level**											
1386												
1387	**Assuming Normal Distribution**											
1388	**95% Normal UCL**						**95% UCLs (Adjusted for Skewness)**					
1389					95% Student's-t UCL	52.96					95% Adjusted-CLT UCL (Chen-1995)	55.82
1390											95% Modified-t UCL (Johnson-1978)	53.47
1391												
1392	**Gamma GOF Test**											
1393					A-D Test Statistic	0.358	**Anderson-Darling Gamma GOF Test**					
1394					5% A-D Critical Value	0.767	Detected data appear Gamma Distributed at 5% Significance Level					
1395					K-S Test Statistic	0.129	**Kolmogorov-Smirnov Gamma GOF Test**					
1396					5% K-S Critical Value	0.163	Detected data appear Gamma Distributed at 5% Significance Level					
1397	**Detected data appear Gamma Distributed at 5% Significance Level**											
1398												
1399	**Gamma Statistics**											
1400					k hat (MLE)	1.337					k star (bias corrected MLE)	1.226
1401					Theta hat (MLE)	30.12					Theta star (bias corrected MLE)	32.86
1402					nu hat (MLE)	80.24					nu star (bias corrected)	73.55
1403					MLE Mean (bias corrected)	40.28					MLE Sd (bias corrected)	36.38
1404											Approximate Chi Square Value (0.05)	54.8
1405					Adjusted Level of Significance	0.041					Adjusted Chi Square Value	53.86
1406												
1407	**Assuming Gamma Distribution**											
1408					95% Approximate Gamma UCL (use when n>=50)	54.07					95% Adjusted Gamma UCL (use when n<50)	55
1409												
1410	**Lognormal GOF Test**											
1411					Shapiro Wilk Test Statistic	0.993	**Shapiro Wilk Lognormal GOF Test**					
1412					5% Shapiro Wilk Critical Value	0.927	Data appear Lognormal at 5% Significance Level					
1413					Lilliefors Test Statistic	0.0674	**Lilliefors Lognormal GOF Test**					
1414					5% Lilliefors Critical Value	0.159	Data appear Lognormal at 5% Significance Level					
1415	**Data appear Lognormal at 5% Significance Level**											
1416												
1417	**Lognormal Statistics**											
1418					Minimum of Logged Data	1.037					Mean of logged Data	3.278
1419					Maximum of Logged Data	5.268					SD of logged Data	0.954
1420												
1421	**Assuming Lognormal Distribution**											
1422					95% H-UCL	64.2					90% Chebyshev (MVUE) UCL	65.27
1423					95% Chebyshev (MVUE) UCL	76.3					97.5% Chebyshev (MVUE) UCL	91.61
1424					99% Chebyshev (MVUE) UCL	121.7						
1425												
1426	**Nonparametric Distribution Free UCL Statistics**											
1427	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
1428												

1429	**Nonparametric Distribution Free UCLs**											
1430					95% CLT UCL	52.56				95% Jackknife UCL	52.96	
1431					95% Standard Bootstrap UCL	52.62				95% Bootstrap-t UCL	57.26	
1432					95% Hall's Bootstrap UCL	64.01				95% Percentile Bootstrap UCL	52.27	
1433					95% BCA Bootstrap UCL	57.2						
1434					90% Chebyshev(Mean, Sd) UCL	62.67				95% Chebyshev(Mean, Sd) UCL	72.81	
1435					97.5% Chebyshev(Mean, Sd) UCL	86.88				99% Chebyshev(Mean, Sd) UCL	114.5	
1436												
1437	**Suggested UCL to Use**											
1438					95% Adjusted Gamma UCL	55						
1439												
1440	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
1441	Recommendations are based upon data size, data distribution, and skewness.											
1442	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
1443	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
1444												
1445												
1446	**Po210**											
1447												
1448	**General Statistics**											
1449					Total Number of Observations	30				Number of Distinct Observations	29	
1450										Number of Missing Observations	0	
1451					Minimum	2.88				Mean	41.87	
1452					Maximum	192				Median	29.93	
1453					SD	41.14				Std. Error of Mean	7.51	
1454					Coefficient of Variation	0.983				Skewness	2.111	
1455												
1456	**Normal GOF Test**											
1457					Shapiro Wilk Test Statistic	0.781				**Shapiro Wilk GOF Test**		
1458					5% Shapiro Wilk Critical Value	0.927				Data Not Normal at 5% Significance Level		
1459					Lilliefors Test Statistic	0.195				**Lilliefors GOF Test**		
1460					5% Lilliefors Critical Value	0.159				Data Not Normal at 5% Significance Level		
1461	**Data Not Normal at 5% Significance Level**											
1462												
1463	**Assuming Normal Distribution**											
1464					**95% Normal UCL**					**95% UCLs (Adjusted for Skewness)**		
1465					95% Student's-t UCL	54.63				95% Adjusted-CLT UCL (Chen-1995)	57.31	
1466										95% Modified-t UCL (Johnson-1978)	55.11	
1467												
1468	**Gamma GOF Test**											
1469					A-D Test Statistic	0.379				**Anderson-Darling Gamma GOF Test**		
1470					5% A-D Critical Value	0.766				Detected data appear Gamma Distributed at 5% Significance Level		
1471					K-S Test Statistic	0.105				**Kolmogorov-Smirnov Gamma GOF Test**		
1472					5% K-S Critical Value	0.163				Detected data appear Gamma Distributed at 5% Significance Level		
1473	**Detected data appear Gamma Distributed at 5% Significance Level**											
1474												
1475	**Gamma Statistics**											
1476					k hat (MLE)	1.37				k star (bias corrected MLE)	1.255	
1477					Theta hat (MLE)	30.57				Theta star (bias corrected MLE)	33.36	
1478					nu hat (MLE)	82.19				nu star (bias corrected)	75.3	
1479					MLE Mean (bias corrected)	41.87				MLE Sd (bias corrected)	37.37	
1480										Approximate Chi Square Value (0.05)	56.31	
1481					Adjusted Level of Significance	0.041				Adjusted Chi Square Value	55.37	
1482												

1483	**Assuming Gamma Distribution**											
1484					95% Approximate Gamma UCL (use when n>=50)		55.98			95% Adjusted Gamma UCL (use when n<50)		56.94
1485												
1486	**Lognormal GOF Test**											
1487					Shapiro Wilk Test Statistic		0.988			**Shapiro Wilk Lognormal GOF Test**		
1488					5% Shapiro Wilk Critical Value		0.927			Data appear Lognormal at 5% Significance Level		
1489					Lilliefors Test Statistic		0.0828			**Lilliefors Lognormal GOF Test**		
1490					5% Lilliefors Critical Value		0.159			Data appear Lognormal at 5% Significance Level		
1491	**Data appear Lognormal at 5% Significance Level**											
1492												
1493	**Lognormal Statistics**											
1494					Minimum of Logged Data		1.058			Mean of logged Data		3.327
1495					Maximum of Logged Data		5.257			SD of logged Data		0.949
1496												
1497	**Assuming Lognormal Distribution**											
1498					95% H-UCL		66.91			90% Chebyshev (MVUE) UCL		68.12
1499					95% Chebyshev (MVUE) UCL		79.58			97.5% Chebyshev (MVUE) UCL		95.49
1500					99% Chebyshev (MVUE) UCL		126.7					
1501												
1502	**Nonparametric Distribution Free UCL Statistics**											
1503	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
1504												
1505	**Nonparametric Distribution Free UCLs**											
1506					95% CLT UCL		54.22			95% Jackknife UCL		54.63
1507					95% Standard Bootstrap UCL		54.33			95% Bootstrap-t UCL		59.51
1508					95% Hall's Bootstrap UCL		63.39			95% Percentile Bootstrap UCL		54.8
1509					95% BCA Bootstrap UCL		58.2					
1510					90% Chebyshev(Mean, Sd) UCL		64.4			95% Chebyshev(Mean, Sd) UCL		74.6
1511					97.5% Chebyshev(Mean, Sd) UCL		88.77			99% Chebyshev(Mean, Sd) UCL		116.6
1512												
1513	**Suggested UCL to Use**											
1514					95% Adjusted Gamma UCL		56.94					
1515												
1516	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
1517	Recommendations are based upon data size, data distribution, and skewness.											
1518	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
1519	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
1520												
1521												
1522	**Ra226**											
1523												
1524	**General Statistics**											
1525					Total Number of Observations		30			Number of Distinct Observations		29
1526										Number of Missing Observations		0
1527					Minimum		7.41			Mean		115.6
1528					Maximum		539			Median		72.85
1529					SD		117.8			Std. Error of Mean		21.51
1530					Coefficient of Variation		1.019			Skewness		2.017
1531												
1532	**Normal GOF Test**											
1533					Shapiro Wilk Test Statistic		0.776			**Shapiro Wilk GOF Test**		
1534					5% Shapiro Wilk Critical Value		0.927			Data Not Normal at 5% Significance Level		
1535					Lilliefors Test Statistic		0.219			**Lilliefors GOF Test**		
1536					5% Lilliefors Critical Value		0.159			Data Not Normal at 5% Significance Level		

1537	**Data Not Normal at 5% Significance Level**											
1538												
1539	**Assuming Normal Distribution**											
1540	**95% Normal UCL**						**95% UCLs (Adjusted for Skewness)**					
1541				95% Student's-t UCL	152.2				95% Adjusted-CLT UCL (Chen-1995)	159.5		
1542									95% Modified-t UCL (Johnson-1978)	153.5		
1543												
1544	**Gamma GOF Test**											
1545				A-D Test Statistic	0.597		**Anderson-Darling Gamma GOF Test**					
1546				5% A-D Critical Value	0.769		Detected data appear Gamma Distributed at 5% Significance Level					
1547				K-S Test Statistic	0.133		**Kolmogorov-Smirnov Gamma GOF Test**					
1548				5% K-S Critical Value	0.164		Detected data appear Gamma Distributed at 5% Significance Level					
1549	**Detected data appear Gamma Distributed at 5% Significance Level**											
1550												
1551	**Gamma Statistics**											
1552				k hat (MLE)	1.242				k star (bias corrected MLE)	1.14		
1553				Theta hat (MLE)	93.12				Theta star (bias corrected MLE)	101.5		
1554				nu hat (MLE)	74.51				nu star (bias corrected)	68.39		
1555				MLE Mean (bias corrected)	115.6				MLE Sd (bias corrected)	108.3		
1556									Approximate Chi Square Value (0.05)	50.35		
1557				Adjusted Level of Significance	0.041				Adjusted Chi Square Value	49.46		
1558												
1559	**Assuming Gamma Distribution**											
1560			95% Approximate Gamma UCL (use when n>=50)		157.1				95% Adjusted Gamma UCL (use when n<50)	159.9		
1561												
1562	**Lognormal GOF Test**											
1563				Shapiro Wilk Test Statistic	0.978		**Shapiro Wilk Lognormal GOF Test**					
1564				5% Shapiro Wilk Critical Value	0.927		Data appear Lognormal at 5% Significance Level					
1565				Lilliefors Test Statistic	0.14		**Lilliefors Lognormal GOF Test**					
1566				5% Lilliefors Critical Value	0.159		Data appear Lognormal at 5% Significance Level					
1567	**Data appear Lognormal at 5% Significance Level**											
1568												
1569	**Lognormal Statistics**											
1570				Minimum of Logged Data	2.003				Mean of logged Data	4.297		
1571				Maximum of Logged Data	6.29				SD of logged Data	1.002		
1572												
1573	**Assuming Lognormal Distribution**											
1574				95% H-UCL	192.7				90% Chebyshev (MVUE) UCL	193.3		
1575				95% Chebyshev (MVUE) UCL	227.2				97.5% Chebyshev (MVUE) UCL	274.2		
1576				99% Chebyshev (MVUE) UCL	366.6							
1577												
1578	**Nonparametric Distribution Free UCL Statistics**											
1579	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
1580												
1581	**Nonparametric Distribution Free UCLs**											
1582				95% CLT UCL	151				95% Jackknife UCL	152.2		
1583				95% Standard Bootstrap UCL	150.1				95% Bootstrap-t UCL	168.7		
1584				95% Hall's Bootstrap UCL	176.4				95% Percentile Bootstrap UCL	154.3		
1585				95% BCA Bootstrap UCL	160.3							
1586				90% Chebyshev(Mean, Sd) UCL	180.2				95% Chebyshev(Mean, Sd) UCL	209.4		
1587				97.5% Chebyshev(Mean, Sd) UCL	250				99% Chebyshev(Mean, Sd) UCL	329.6		
1588												
1589	**Suggested UCL to Use**											
1590				95% Adjusted Gamma UCL	159.9							

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.

Ra228

General Statistics

Total Number of Observations	30	Number of Distinct Observations	23
Number of Detects	1	Number of Non-Detects	29
Number of Distinct Detects	1	Number of Distinct Non-Detects	22

Warning: Only one distinct data value was detected! ProUCL (or any other software) should not be used on such a data set!

It is suggested to use alternative site specific values determined by the Project Team to estimate environmental parameters (e.g., EPC, BTV).

The data set for variable Ra228 was not processed!

Th230

General Statistics

Total Number of Observations	30	Number of Distinct Observations	30
		Number of Missing Observations	0
Minimum	5.36	Mean	92.12
Maximum	366	Median	63.5
SD	85.38	Std. Error of Mean	15.59
Coefficient of Variation	0.927	Skewness	1.571

Normal GOF Test

Shapiro Wilk Test Statistic	0.826	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.927	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.199	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.159	Data Not Normal at 5% Significance Level

Data Not Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	118.6	95% Adjusted-CLT UCL (Chen-1995)	122.5
		95% Modified-t UCL (Johnson-1978)	119.4

Gamma GOF Test

A-D Test Statistic	0.487	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.767	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.142	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.164	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	1.326	k star (bias corrected MLE)	1.215
Theta hat (MLE)	69.5	Theta star (bias corrected MLE)	75.81
nu hat (MLE)	79.53	nu star (bias corrected)	72.91
MLE Mean (bias corrected)	92.12	MLE Sd (bias corrected)	83.57

1645											Approximate Chi Square Value (0.05)	54.25
1646					Adjusted Level of Significance	0.041					Adjusted Chi Square Value	53.32
1647												
1648					**Assuming Gamma Distribution**							
1649					95% Approximate Gamma UCL (use when n>=50)	123.8					95% Adjusted Gamma UCL (use when n<50)	126
1650												
1651					**Lognormal GOF Test**							
1652					Shapiro Wilk Test Statistic	0.973					**Shapiro Wilk Lognormal GOF Test**	
1653					5% Shapiro Wilk Critical Value	0.927					Data appear Lognormal at 5% Significance Level	
1654					Lilliefors Test Statistic	0.109					**Lilliefors Lognormal GOF Test**	
1655					5% Lilliefors Critical Value	0.159					Data appear Lognormal at 5% Significance Level	
1656					**Data appear Lognormal at 5% Significance Level**							
1657												
1658					**Lognormal Statistics**							
1659					Minimum of Logged Data	1.679					Mean of logged Data	4.101
1660					Maximum of Logged Data	5.903					SD of logged Data	0.99
1661												
1662					**Assuming Lognormal Distribution**							
1663					95% H-UCL	155					90% Chebyshev (MVUE) UCL	156.1
1664					95% Chebyshev (MVUE) UCL	183.2					97.5% Chebyshev (MVUE) UCL	220.9
1665					99% Chebyshev (MVUE) UCL	294.8						
1666												
1667					**Nonparametric Distribution Free UCL Statistics**							
1668					**Data appear to follow a Discernible Distribution at 5% Significance Level**							
1669												
1670					**Nonparametric Distribution Free UCLs**							
1671					95% CLT UCL	117.8					95% Jackknife UCL	118.6
1672					95% Standard Bootstrap UCL	117.1					95% Bootstrap-t UCL	126.8
1673					95% Hall's Bootstrap UCL	126.9					95% Percentile Bootstrap UCL	117.6
1674					95% BCA Bootstrap UCL	121.8						
1675					90% Chebyshev(Mean, Sd) UCL	138.9					95% Chebyshev(Mean, Sd) UCL	160.1
1676					97.5% Chebyshev(Mean, Sd) UCL	189.5					99% Chebyshev(Mean, Sd) UCL	247.2
1677												
1678					**Suggested UCL to Use**							
1679					95% Adjusted Gamma UCL	126						
1680												
1681					Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.							
1682					Recommendations are based upon data size, data distribution, and skewness.							
1683					These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).							
1684					However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.							
1685												
1686												
1687	**Th232**											
1688												
1689					**General Statistics**							
1690					Total Number of Observations	30					Number of Distinct Observations	26
1691											Number of Missing Observations	0
1692					Minimum	0.44					Mean	1.025
1693					Maximum	1.98					Median	0.96
1694					SD	0.285					Std. Error of Mean	0.0519
1695					Coefficient of Variation	0.277					Skewness	1.278
1696												
1697					**Normal GOF Test**							
1698					Shapiro Wilk Test Statistic	0.905					**Shapiro Wilk GOF Test**	

	A	B	C	D	E	F	G	H	I	J	K	L
1699	5% Shapiro Wilk Critical Value					0.927	Data Not Normal at 5% Significance Level					
1700	Lilliefors Test Statistic					0.146	**Lilliefors GOF Test**					
1701	5% Lilliefors Critical Value					0.159	Data appear Normal at 5% Significance Level					
1702	**Data appear Approximate Normal at 5% Significance Level**											
1703												
1704	**Assuming Normal Distribution**											
1705	**95% Normal UCL**						**95% UCLs (Adjusted for Skewness)**					
1706	95% Student's-t UCL					1.114	95% Adjusted-CLT UCL (Chen-1995)					1.124
1707							95% Modified-t UCL (Johnson-1978)					1.116
1708												
1709	**Gamma GOF Test**											
1710	A-D Test Statistic					0.646	**Anderson-Darling Gamma GOF Test**					
1711	5% A-D Critical Value					0.745	Detected data appear Gamma Distributed at 5% Significance Level					
1712	K-S Test Statistic					0.128	**Kolmogorov-Smirnov Gamma GOF Test**					
1713	5% K-S Critical Value					0.16	Detected data appear Gamma Distributed at 5% Significance Level					
1714	**Detected data appear Gamma Distributed at 5% Significance Level**											
1715												
1716	**Gamma Statistics**											
1717	k hat (MLE)					14.47	k star (bias corrected MLE)					13.04
1718	Theta hat (MLE)					0.0709	Theta star (bias corrected MLE)					0.0786
1719	nu hat (MLE)					867.9	nu star (bias corrected)					782.5
1720	MLE Mean (bias corrected)					1.025	MLE Sd (bias corrected)					0.284
1721							Approximate Chi Square Value (0.05)					718.6
1722	Adjusted Level of Significance					0.041	Adjusted Chi Square Value					715
1723												
1724	**Assuming Gamma Distribution**											
1725	95% Approximate Gamma UCL (use when n>=50))					1.117	95% Adjusted Gamma UCL (use when n<50)					1.122
1726												
1727	**Lognormal GOF Test**											
1728	Shapiro Wilk Test Statistic					0.943	**Shapiro Wilk Lognormal GOF Test**					
1729	5% Shapiro Wilk Critical Value					0.927	Data appear Lognormal at 5% Significance Level					
1730	Lilliefors Test Statistic					0.134	**Lilliefors Lognormal GOF Test**					
1731	5% Lilliefors Critical Value					0.159	Data appear Lognormal at 5% Significance Level					
1732	**Data appear Lognormal at 5% Significance Level**											
1733												
1734	**Lognormal Statistics**											
1735	Minimum of Logged Data					-0.821	Mean of logged Data					-0.00995
1736	Maximum of Logged Data					0.683	SD of logged Data					0.27
1737												
1738	**Assuming Lognormal Distribution**											
1739	95% H-UCL					1.123	90% Chebyshev (MVUE) UCL					1.179
1740	95% Chebyshev (MVUE) UCL					1.248	97.5% Chebyshev (MVUE) UCL					1.345
1741	99% Chebyshev (MVUE) UCL					1.534						
1742												
1743	**Nonparametric Distribution Free UCL Statistics**											
1744	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
1745												
1746	**Nonparametric Distribution Free UCLs**											
1747	95% CLT UCL					1.111	95% Jackknife UCL					1.114
1748	95% Standard Bootstrap UCL					1.107	95% Bootstrap-t UCL					1.13
1749	95% Hall's Bootstrap UCL					1.142	95% Percentile Bootstrap UCL					1.111
1750	95% BCA Bootstrap UCL					1.121						
1751	90% Chebyshev(Mean, Sd) UCL					1.181	95% Chebyshev(Mean, Sd) UCL					1.252
1752	97.5% Chebyshev(Mean, Sd) UCL					1.35	99% Chebyshev(Mean, Sd) UCL					1.542

1753												
1754	**Suggested UCL to Use**											
1755				95% Student's-t UCL		1.114						
1756												
1757	When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test											
1758	When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL											
1759												
1760	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
1761	Recommendations are based upon data size, data distribution, and skewness.											
1762	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
1763	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
1764												
1765												
1766	**U234**											
1767												
1768	**General Statistics**											
1769				Total Number of Observations		30			Number of Distinct Observations		29	
1770									Number of Missing Observations		0	
1771				Minimum		4.87			Mean		83.18	
1772				Maximum		347			Median		39.9	
1773				SD		86.37			Std. Error of Mean		15.77	
1774				Coefficient of Variation		1.038			Skewness		1.546	
1775												
1776	**Normal GOF Test**											
1777				Shapiro Wilk Test Statistic		0.795			**Shapiro Wilk GOF Test**			
1778				5% Shapiro Wilk Critical Value		0.927			Data Not Normal at 5% Significance Level			
1779				Lilliefors Test Statistic		0.248			**Lilliefors GOF Test**			
1780				5% Lilliefors Critical Value		0.159			Data Not Normal at 5% Significance Level			
1781	**Data Not Normal at 5% Significance Level**											
1782												
1783	**Assuming Normal Distribution**											
1784				**95% Normal UCL**					**95% UCLs (Adjusted for Skewness)**			
1785				95% Student's-t UCL		110			95% Adjusted-CLT UCL (Chen-1995)		113.9	
1786									95% Modified-t UCL (Johnson-1978)		110.7	
1787												
1788	**Gamma GOF Test**											
1789				A-D Test Statistic		0.872			**Anderson-Darling Gamma GOF Test**			
1790				5% A-D Critical Value		0.773			Data Not Gamma Distributed at 5% Significance Level			
1791				K-S Test Statistic		0.181			**Kolmogorov-Smirnov Gamma GOF Test**			
1792				5% K-S Critical Value		0.164			Data Not Gamma Distributed at 5% Significance Level			
1793	**Data Not Gamma Distributed at 5% Significance Level**											
1794												
1795	**Gamma Statistics**											
1796				k hat (MLE)		1.082			k star (bias corrected MLE)		0.996	
1797				Theta hat (MLE)		76.9			Theta star (bias corrected MLE)		83.54	
1798				nu hat (MLE)		64.9			nu star (bias corrected)		59.74	
1799				MLE Mean (bias corrected)		83.18			MLE Sd (bias corrected)		83.36	
1800									Approximate Chi Square Value (0.05)		42.97	
1801				Adjusted Level of Significance		0.041			Adjusted Chi Square Value		42.15	
1802												
1803	**Assuming Gamma Distribution**											
1804				95% Approximate Gamma UCL (use when n>=50))		115.6			95% Adjusted Gamma UCL (use when n<50)		117.9	
1805												
1806	**Lognormal GOF Test**											

1807				Shapiro Wilk Test Statistic	0.958	**Shapiro Wilk Lognormal GOF Test**						
1808				5% Shapiro Wilk Critical Value	0.927	Data appear Lognormal at 5% Significance Level						
1809				Lilliefors Test Statistic	0.152	**Lilliefors Lognormal GOF Test**						
1810				5% Lilliefors Critical Value	0.159	Data appear Lognormal at 5% Significance Level						
1811	**Data appear Lognormal at 5% Significance Level**											
1812												
1813	**Lognormal Statistics**											
1814				Minimum of Logged Data	1.583	Mean of logged Data	3.892					
1815				Maximum of Logged Data	5.849	SD of logged Data	1.088					
1816												
1817	**Assuming Lognormal Distribution**											
1818				95% H-UCL	149.4	90% Chebyshev (MVUE) UCL	145.8					
1819				95% Chebyshev (MVUE) UCL	172.9	97.5% Chebyshev (MVUE) UCL	210.6					
1820				99% Chebyshev (MVUE) UCL	284.5							
1821												
1822	**Nonparametric Distribution Free UCL Statistics**											
1823	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
1824												
1825	**Nonparametric Distribution Free UCLs**											
1826				95% CLT UCL	109.1	95% Jackknife UCL	110					
1827				95% Standard Bootstrap UCL	108.5	95% Bootstrap-t UCL	117.2					
1828				95% Hall's Bootstrap UCL	116.8	95% Percentile Bootstrap UCL	110.7					
1829				95% BCA Bootstrap UCL	113							
1830				90% Chebyshev(Mean, Sd) UCL	130.5	95% Chebyshev(Mean, Sd) UCL	151.9					
1831				97.5% Chebyshev(Mean, Sd) UCL	181.7	99% Chebyshev(Mean, Sd) UCL	240.1					
1832												
1833	**Suggested UCL to Use**											
1834				95% H-UCL	149.4							
1835												
1836	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
1837	Recommendations are based upon data size, data distribution, and skewness.											
1838	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
1839	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
1840												
1841	**ProUCL computes and outputs H-statistic based UCLs for historical reasons only.**											
1842	**H-statistic often results in unstable (both high and low) values of UCL95 as shown in examples in the Technical Guide.**											
1843	**It is therefore recommended to avoid the use of H-statistic based 95% UCLs.**											
1844	**Use of nonparametric methods are preferred to compute UCL95 for skewed data sets which do not follow a gamma distribution.**											
1845												
1846												
1847	**U235**											
1848												
1849	**General Statistics**											
1850				Total Number of Observations	30	Number of Distinct Observations	29					
1851						Number of Missing Observations	0					
1852				Minimum	0.23	Mean	4.129					
1853				Maximum	17.2	Median	1.823					
1854				SD	4.323	Std. Error of Mean	0.789					
1855				Coefficient of Variation	1.047	Skewness	1.587					
1856												
1857	**Normal GOF Test**											
1858				Shapiro Wilk Test Statistic	0.789	**Shapiro Wilk GOF Test**						
1859				5% Shapiro Wilk Critical Value	0.927	Data Not Normal at 5% Significance Level						
1860				Lilliefors Test Statistic	0.251	**Lilliefors GOF Test**						

1861				5% Lilliefors Critical Value		0.159		Data Not Normal at 5% Significance Level				
1862	**Data Not Normal at 5% Significance Level**											
1863												
1864	**Assuming Normal Distribution**											
1865	**95% Normal UCL**						**95% UCLs (Adjusted for Skewness)**					
1866				95% Student's-t UCL		5.47				95% Adjusted-CLT UCL (Chen-1995)		5.672
1867										95% Modified-t UCL (Johnson-1978)		5.508
1868												
1869	**Gamma GOF Test**											
1870				A-D Test Statistic		0.878	**Anderson-Darling Gamma GOF Test**					
1871				5% A-D Critical Value		0.773	Data Not Gamma Distributed at 5% Significance Level					
1872				K-S Test Statistic		0.188	**Kolmogorov-Smirnov Gamma GOF Test**					
1873				5% K-S Critical Value		0.164	Data Not Gamma Distributed at 5% Significance Level					
1874	**Data Not Gamma Distributed at 5% Significance Level**											
1875												
1876	**Gamma Statistics**											
1877				k hat (MLE)		1.085				k star (bias corrected MLE)		0.999
1878				Theta hat (MLE)		3.806				Theta star (bias corrected MLE)		4.135
1879				nu hat (MLE)		65.09				nu star (bias corrected)		59.92
1880				MLE Mean (bias corrected)		4.129				MLE Sd (bias corrected)		4.132
1881										Approximate Chi Square Value (0.05)		43.12
1882				Adjusted Level of Significance		0.041				Adjusted Chi Square Value		42.3
1883												
1884	**Assuming Gamma Distribution**											
1885			95% Approximate Gamma UCL (use when n>=50))			5.738				95% Adjusted Gamma UCL (use when n<50)		5.849
1886												
1887	**Lognormal GOF Test**											
1888				Shapiro Wilk Test Statistic		0.961	**Shapiro Wilk Lognormal GOF Test**					
1889				5% Shapiro Wilk Critical Value		0.927	Data appear Lognormal at 5% Significance Level					
1890				Lilliefors Test Statistic		0.139	**Lilliefors Lognormal GOF Test**					
1891				5% Lilliefors Critical Value		0.159	Data appear Lognormal at 5% Significance Level					
1892	**Data appear Lognormal at 5% Significance Level**											
1893												
1894	**Lognormal Statistics**											
1895				Minimum of Logged Data		-1.47				Mean of logged Data		0.891
1896				Maximum of Logged Data		2.845				SD of logged Data		1.083
1897												
1898	**Assuming Lognormal Distribution**											
1899				95% H-UCL		7.367				90% Chebyshev (MVUE) UCL		7.203
1900				95% Chebyshev (MVUE) UCL		8.539				97.5% Chebyshev (MVUE) UCL		10.39
1901				99% Chebyshev (MVUE) UCL		14.03						
1902												
1903	**Nonparametric Distribution Free UCL Statistics**											
1904	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
1905												
1906	**Nonparametric Distribution Free UCLs**											
1907				95% CLT UCL		5.427				95% Jackknife UCL		5.47
1908				95% Standard Bootstrap UCL		5.377				95% Bootstrap-t UCL		5.78
1909				95% Hall's Bootstrap UCL		5.701				95% Percentile Bootstrap UCL		5.389
1910				95% BCA Bootstrap UCL		5.541						
1911				90% Chebyshev(Mean, Sd) UCL		6.497				95% Chebyshev(Mean, Sd) UCL		7.57
1912				97.5% Chebyshev(Mean, Sd) UCL		9.058				99% Chebyshev(Mean, Sd) UCL		11.98
1913												
1914	**Suggested UCL to Use**											

1915					95% H-UCL	7.367						
1916												
1917	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
1918	Recommendations are based upon data size, data distribution, and skewness.											
1919	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
1920	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
1921												
1922	**ProUCL computes and outputs H-statistic based UCLs for historical reasons only.**											
1923	**H-statistic often results in unstable (both high and low) values of UCL95 as shown in examples in the Technical Guide.**											
1924	**It is therefore recommended to avoid the use of H-statistic based 95% UCLs.**											
1925	**Use of nonparametric methods are preferred to compute UCL95 for skewed data sets which do not follow a gamma distribution.**											
1926												
1927												
1928	**U238**											
1929												
1930	**General Statistics**											
1931	Total Number of Observations					30	Number of Distinct Observations					29
1932							Number of Missing Observations					0
1933	Minimum					4.57	Mean					84.56
1934	Maximum					356	Median					41.98
1935	SD					87.95	Std. Error of Mean					16.06
1936	Coefficient of Variation					1.04	Skewness					1.56
1937												
1938	**Normal GOF Test**											
1939	Shapiro Wilk Test Statistic					0.796	**Shapiro Wilk GOF Test**					
1940	5% Shapiro Wilk Critical Value					0.927	Data Not Normal at 5% Significance Level					
1941	Lilliefors Test Statistic					0.242	**Lilliefors GOF Test**					
1942	5% Lilliefors Critical Value					0.159	Data Not Normal at 5% Significance Level					
1943	**Data Not Normal at 5% Significance Level**											
1944												
1945	**Assuming Normal Distribution**											
1946	**95% Normal UCL**						**95% UCLs (Adjusted for Skewness)**					
1947	95% Student's-t UCL					111.8	95% Adjusted-CLT UCL (Chen-1995)					115.9
1948							95% Modified-t UCL (Johnson-1978)					112.6
1949												
1950	**Gamma GOF Test**											
1951	A-D Test Statistic					0.823	**Anderson-Darling Gamma GOF Test**					
1952	5% A-D Critical Value					0.774	Data Not Gamma Distributed at 5% Significance Level					
1953	K-S Test Statistic					0.163	**Kolmogorov-Smirnov Gamma GOF Test**					
1954	5% K-S Critical Value					0.165	Detected data appear Gamma Distributed at 5% Significance Level					
1955	**Detected data follow Appr. Gamma Distribution at 5% Significance Level**											
1956												
1957	**Gamma Statistics**											
1958	k hat (MLE)					1.075	k star (bias corrected MLE)					0.99
1959	Theta hat (MLE)					78.66	Theta star (bias corrected MLE)					85.44
1960	nu hat (MLE)					64.49	nu star (bias corrected)					59.38
1961	MLE Mean (bias corrected)					84.56	MLE Sd (bias corrected)					85
1962							Approximate Chi Square Value (0.05)					42.66
1963	Adjusted Level of Significance					0.041	Adjusted Chi Square Value					41.84
1964												
1965	**Assuming Gamma Distribution**											
1966	95% Approximate Gamma UCL (use when n>=50)					117.7	95% Adjusted Gamma UCL (use when n<50)					120
1967												
1968	**Lognormal GOF Test**											

1969	Shapiro Wilk Test Statistic					0.961	**Shapiro Wilk Lognormal GOF Test**					
1970	5% Shapiro Wilk Critical Value					0.927	Data appear Lognormal at 5% Significance Level					
1971	Lilliefors Test Statistic					0.153	**Lilliefors Lognormal GOF Test**					
1972	5% Lilliefors Critical Value					0.159	Data appear Lognormal at 5% Significance Level					
1973	**Data appear Lognormal at 5% Significance Level**											
1974												
1975	**Lognormal Statistics**											
1976	Minimum of Logged Data					1.52	Mean of logged Data					3.905
1977	Maximum of Logged Data					5.875	SD of logged Data					1.096
1978												
1979	**Assuming Lognormal Distribution**											
1980	95% H-UCL					153.6	90% Chebyshev (MVUE) UCL					149.5
1981	95% Chebyshev (MVUE) UCL					177.4	97.5% Chebyshev (MVUE) UCL					216.2
1982	99% Chebyshev (MVUE) UCL					292.4						
1983												
1984	**Nonparametric Distribution Free UCL Statistics**											
1985	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
1986												
1987	**Nonparametric Distribution Free UCLs**											
1988	95% CLT UCL					111	95% Jackknife UCL					111.8
1989	95% Standard Bootstrap UCL					110.7	95% Bootstrap-t UCL					118.3
1990	95% Hall's Bootstrap UCL					120.8	95% Percentile Bootstrap UCL					112.3
1991	95% BCA Bootstrap UCL					117						
1992	90% Chebyshev(Mean, Sd) UCL					132.7	95% Chebyshev(Mean, Sd) UCL					154.5
1993	97.5% Chebyshev(Mean, Sd) UCL					184.8	99% Chebyshev(Mean, Sd) UCL					244.3
1994												
1995	**Suggested UCL to Use**											
1996	95% Adjusted Gamma UCL					120						
1997												
1998	When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test											
1999	When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL											
2000												
2001	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
2002	Recommendations are based upon data size, data distribution, and skewness.											
2003	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
2004	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
2005												

UCL Statistics for Data Sets with Non-Detects

User Selected Options	
Date/Time of Computation	ProUCL 5.18/4/2022 1:32:52 PM
From File	PlantTissue_ProUCL_Input.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Aluminum

General Statistics

Total Number of Observations	16	Number of Distinct Observations	14
		Number of Missing Observations	0
Minimum	6.5	Mean	24.28
Maximum	48	Median	23
SD	12.35	Std. Error of Mean	3.087
Coefficient of Variation	0.509	Skewness	0.594

Normal GOF Test

Shapiro Wilk Test Statistic	0.95	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.887	Data appear Normal at 5% Significance Level
Lilliefors Test Statistic	0.132	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.213	Data appear Normal at 5% Significance Level

Data appear Normal at 5% Significance Level

Assuming Normal Distribution

95% Normal UCL		**95% UCLs (Adjusted for Skewness)**	
95% Student's-t UCL	29.69	95% Adjusted-CLT UCL (Chen-1995)	29.85
		95% Modified-t UCL (Johnson-1978)	29.77

Gamma GOF Test

A-D Test Statistic	0.133	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.742	Detected data appear Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.0885	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.216	Detected data appear Gamma Distributed at 5% Significance Level

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	3.878	k star (bias corrected MLE)	3.192
Theta hat (MLE)	6.261	Theta star (bias corrected MLE)	7.606
nu hat (MLE)	124.1	nu star (bias corrected)	102.2
MLE Mean (bias corrected)	24.28	MLE Sd (bias corrected)	13.59
		Approximate Chi Square Value (0.05)	79.84
Adjusted Level of Significance	0.0335	Adjusted Chi Square Value	77.59

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	31.07	95% Adjusted Gamma UCL (use when n<50)	31.97

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.971	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.887	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.119	**Lilliefors Lognormal GOF Test**

55				5% Lilliefors Critical Value		0.213		Data appear Lognormal at 5% Significance Level				
56	**Data appear Lognormal at 5% Significance Level**											
57												
58	**Lognormal Statistics**											
59				Minimum of Logged Data		1.872		Mean of logged Data				3.055
60				Maximum of Logged Data		3.871		SD of logged Data				0.56
61												
62	**Assuming Lognormal Distribution**											
63				95% H-UCL		33.71		90% Chebyshev (MVUE) UCL				35.27
64				95% Chebyshev (MVUE) UCL		40.13		97.5% Chebyshev (MVUE) UCL				46.86
65				99% Chebyshev (MVUE) UCL		60.1						
66												
67	**Nonparametric Distribution Free UCL Statistics**											
68	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
69												
70	**Nonparametric Distribution Free UCLs**											
71				95% CLT UCL		29.36		95% Jackknife UCL				29.69
72				95% Standard Bootstrap UCL		29.27		95% Bootstrap-t UCL				30.36
73				95% Hall's Bootstrap UCL		29.96		95% Percentile Bootstrap UCL				29.38
74				95% BCA Bootstrap UCL		29.88						
75				90% Chebyshev(Mean, Sd) UCL		33.54		95% Chebyshev(Mean, Sd) UCL				37.74
76				97.5% Chebyshev(Mean, Sd) UCL		43.56		99% Chebyshev(Mean, Sd) UCL				55
77												
78	**Suggested UCL to Use**											
79				95% Student's-t UCL		29.69						
80												
81	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
82	Recommendations are based upon data size, data distribution, and skewness.											
83	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
84	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
85												
86	**Antimony**											
87												
88	**General Statistics**											
89				Total Number of Observations		16		Number of Distinct Observations				14
90				Number of Detects		15		Number of Non-Detects				1
91				Number of Distinct Detects		13		Number of Distinct Non-Detects				1
92				Minimum Detect		0.022		Minimum Non-Detect				0.096
93				Maximum Detect		0.069		Maximum Non-Detect				0.096
94				Variance Detects		2.0950E-4		Percent Non-Detects				6.25%
95				Mean Detects		0.0461		SD Detects				0.0145
96				Median Detects		0.053		CV Detects				0.314
97				Skewness Detects		-0.256		Kurtosis Detects				-1.143
98				Mean of Logged Detects		-3.131		SD of Logged Detects				0.351
99												
100	**Normal GOF Test on Detects Only**											
101				Shapiro Wilk Test Statistic		0.938		**Shapiro Wilk GOF Test**				
102				5% Shapiro Wilk Critical Value		0.881		Detected Data appear Normal at 5% Significance Level				
103				Lilliefors Test Statistic		0.217		**Lilliefors GOF Test**				
104				5% Lilliefors Critical Value		0.22		Detected Data appear Normal at 5% Significance Level				
105	**Detected Data appear Normal at 5% Significance Level**											
106												
107	**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**											
108				KM Mean		0.0461		KM Standard Error of Mean				0.00374

109				KM SD	0.014				95% KM (BCA) UCL			0.0516
110				95% KM (t) UCL	0.0526				95% KM (Percentile Bootstrap) UCL			0.0519
111				95% KM (z) UCL	0.0522				95% KM Bootstrap t UCL			0.0521
112				90% KM Chebyshev UCL	0.0573				95% KM Chebyshev UCL			0.0624
113				97.5% KM Chebyshev UCL	0.0694				99% KM Chebyshev UCL			0.0833
114												
115				**Gamma GOF Tests on Detected Observations Only**								
116				A-D Test Statistic	0.585	**Anderson-Darling GOF Test**						
117				5% A-D Critical Value	0.737	Detected data appear Gamma Distributed at 5% Significance Level						
118				K-S Test Statistic	0.242	**Kolmogorov-Smirnov GOF**						
119				5% K-S Critical Value	0.222	Detected Data Not Gamma Distributed at 5% Significance Level						
120				**Detected data follow Appr. Gamma Distribution at 5% Significance Level**								
121												
122				**Gamma Statistics on Detected Data Only**								
123				k hat (MLE)	9.562	k star (bias corrected MLE)						7.694
124				Theta hat (MLE)	0.00482	Theta star (bias corrected MLE)						0.00599
125				nu hat (MLE)	286.8	nu star (bias corrected)						230.8
126				Mean (detects)	0.0461							
127												
128				**Gamma ROS Statistics using Imputed Non-Detects**								
129				GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs								
130				GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)								
131				For such situations, GROS method may yield incorrect values of UCLs and BTVs								
132				This is especially true when the sample size is small.								
133				For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates								
134				Minimum	0.022	Mean						0.046
135				Maximum	0.069	Median						0.0489
136				SD	0.014	CV						0.304
137				k hat (MLE)	10.18	k star (bias corrected MLE)						8.316
138				Theta hat (MLE)	0.00452	Theta star (bias corrected MLE)						0.00553
139				nu hat (MLE)	325.9	nu star (bias corrected)						266.1
140				Adjusted Level of Significance (β)	0.0335							
141				Approximate Chi Square Value (266.12, α)	229.3	Adjusted Chi Square Value (266.12, β)						225.5
142				95% Gamma Approximate UCL (use when n>=50)	0.0534	95% Gamma Adjusted UCL (use when n<50)						0.0543
143												
144				**Estimates of Gamma Parameters using KM Estimates**								
145				Mean (KM)	0.0461	SD (KM)						0.014
146				Variance (KM)	1.9553E-4	SE of Mean (KM)						0.00374
147				k hat (KM)	10.85	k star (KM)						8.86
148				nu hat (KM)	347.3	nu star (KM)						283.5
149				theta hat (KM)	0.00424	theta star (KM)						0.0052
150				80% gamma percentile (KM)	0.0583	90% gamma percentile (KM)						0.0667
151				95% gamma percentile (KM)	0.0741	99% gamma percentile (KM)						0.0895
152												
153				**Gamma Kaplan-Meier (KM) Statistics**								
154				Approximate Chi Square Value (283.52, α)	245.5	Adjusted Chi Square Value (283.52, β)						241.5
155				95% Gamma Approximate KM-UCL (use when n>=50)	0.0532	95% Gamma Adjusted KM-UCL (use when n<50)						0.0541
156												
157				**Lognormal GOF Test on Detected Observations Only**								
158				Shapiro Wilk Test Statistic	0.909	**Shapiro Wilk GOF Test**						
159				5% Shapiro Wilk Critical Value	0.881	Detected Data appear Lognormal at 5% Significance Level						
160				Lilliefors Test Statistic	0.242	**Lilliefors GOF Test**						
161				5% Lilliefors Critical Value	0.22	Detected Data Not Lognormal at 5% Significance Level						
162				**Detected Data appear Approximate Lognormal at 5% Significance Level**								

163												
164	**Lognormal ROS Statistics Using Imputed Non-Detects**											
165				Mean in Original Scale	0.0459			Mean in Log Scale	-3.131			
166				SD in Original Scale	0.014			SD in Log Scale	0.339			
167				95% t UCL (assumes normality of ROS data)	0.0521			95% Percentile Bootstrap UCL	0.0514			
168				95% BCA Bootstrap UCL	0.0512			95% Bootstrap t UCL	0.0519			
169				95% H-UCL (Log ROS)	0.0547							
170												
171	**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**											
172				KM Mean (logged)	-3.131			KM Geo Mean	0.0437			
173				KM SD (logged)	0.339			95% Critical H Value (KM-Log)	1.902			
174				KM Standard Error of Mean (logged)	0.0906			95% H-UCL (KM -Log)	0.0547			
175				KM SD (logged)	0.339			95% Critical H Value (KM-Log)	1.902			
176				KM Standard Error of Mean (logged)	0.0906							
177												
178	**DL/2 Statistics**											
179				**DL/2 Normal**				**DL/2 Log-Transformed**				
180				Mean in Original Scale	0.0462			Mean in Log Scale	-3.125			
181				SD in Original Scale	0.014			SD in Log Scale	0.34			
182				95% t UCL (Assumes normality)	0.0523			95% H-Stat UCL	0.055			
183	**DL/2 is not a recommended method, provided for comparisons and historical reasons**											
184												
185	**Nonparametric Distribution Free UCL Statistics**											
186	**Detected Data appear Normal Distributed at 5% Significance Level**											
187												
188	**Suggested UCL to Use**											
189				95% KM (t) UCL	0.0526							
190												
191	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
192	Recommendations are based upon data size, data distribution, and skewness.											
193	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
194	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
195												
196	**Arsenic**											
197												
198	**General Statistics**											
199				Total Number of Observations	16			Number of Distinct Observations	14			
200				Number of Detects	15			Number of Non-Detects	1			
201				Number of Distinct Detects	13			Number of Distinct Non-Detects	1			
202				Minimum Detect	0.055			Minimum Non-Detect	0.19			
203				Maximum Detect	0.77			Maximum Non-Detect	0.19			
204				Variance Detects	0.0398			Percent Non-Detects	6.25%			
205				Mean Detects	0.291			SD Detects	0.2			
206				Median Detects	0.27			CV Detects	0.686			
207				Skewness Detects	1.072			Kurtosis Detects	0.784			
208				Mean of Logged Detects	-1.466			SD of Logged Detects	0.733			
209												
210	**Normal GOF Test on Detects Only**											
211				Shapiro Wilk Test Statistic	0.895			**Shapiro Wilk GOF Test**				
212				5% Shapiro Wilk Critical Value	0.881			Detected Data appear Normal at 5% Significance Level				
213				Lilliefors Test Statistic	0.178			**Lilliefors GOF Test**				
214				5% Lilliefors Critical Value	0.22			Detected Data appear Normal at 5% Significance Level				
215	**Detected Data appear Normal at 5% Significance Level**											
216												

	A	B	C	D	E	F	G	H	I	J	K	L
217	**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**											
218					KM Mean	0.281				KM Standard Error of Mean		0.0495
219					KM SD	0.191				95% KM (BCA) UCL		0.369
220					95% KM (t) UCL	0.368				95% KM (Percentile Bootstrap) UCL		0.361
221					95% KM (z) UCL	0.363				95% KM Bootstrap t UCL		0.392
222					90% KM Chebyshev UCL	0.43				95% KM Chebyshev UCL		0.497
223					97.5% KM Chebyshev UCL	0.59				99% KM Chebyshev UCL		0.774
224												
225	**Gamma GOF Tests on Detected Observations Only**											
226					A-D Test Statistic	0.266	**Anderson-Darling GOF Test**					
227					5% A-D Critical Value	0.746	Detected data appear Gamma Distributed at 5% Significance Level					
228					K-S Test Statistic	0.14	**Kolmogorov-Smirnov GOF**					
229					5% K-S Critical Value	0.224	Detected data appear Gamma Distributed at 5% Significance Level					
230	**Detected data appear Gamma Distributed at 5% Significance Level**											
231												
232	**Gamma Statistics on Detected Data Only**											
233					k hat (MLE)	2.316				k star (bias corrected MLE)		1.898
234					Theta hat (MLE)	0.126				Theta star (bias corrected MLE)		0.153
235					nu hat (MLE)	69.49				nu star (bias corrected)		56.93
236					Mean (detects)	0.291						
237												
238	**Gamma ROS Statistics using Imputed Non-Detects**											
239	GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs											
240	GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)											
241	For such situations, GROS method may yield incorrect values of UCLs and BTVs											
242	This is especially true when the sample size is small.											
243	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates											
244					Minimum	0.055				Mean		0.281
245					Maximum	0.77				Median		0.225
246					SD	0.197				CV		0.702
247					k hat (MLE)	2.301				k star (bias corrected MLE)		1.911
248					Theta hat (MLE)	0.122				Theta star (bias corrected MLE)		0.147
249					nu hat (MLE)	73.64				nu star (bias corrected)		61.17
250					Adjusted Level of Significance (β)	0.0335						
251					Approximate Chi Square Value (61.17, α)	44.18				Adjusted Chi Square Value (61.17, β)		42.54
252					95% Gamma Approximate UCL (use when n>=50)	0.389				95% Gamma Adjusted UCL (use when n<50)		0.404
253												
254	**Estimates of Gamma Parameters using KM Estimates**											
255					Mean (KM)	0.281				SD (KM)		0.191
256					Variance (KM)	0.0365				SE of Mean (KM)		0.0495
257					k hat (KM)	2.166				k star (KM)		1.802
258					nu hat (KM)	69.32				nu star (KM)		57.66
259					theta hat (KM)	0.13				theta star (KM)		0.156
260					80% gamma percentile (KM)	0.426				90% gamma percentile (KM)		0.56
261					95% gamma percentile (KM)	0.689				99% gamma percentile (KM)		0.977
262												
263	**Gamma Kaplan-Meier (KM) Statistics**											
264					Approximate Chi Square Value (57.66, α)	41.2				Adjusted Chi Square Value (57.66, β)		39.62
265					95% Gamma Approximate KM-UCL (use when n>=50)	0.393				95% Gamma Adjusted KM-UCL (use when n<50)		0.409
266												
267	**Lognormal GOF Test on Detected Observations Only**											
268					Shapiro Wilk Test Statistic	0.97	**Shapiro Wilk GOF Test**					
269					5% Shapiro Wilk Critical Value	0.881	Detected Data appear Lognormal at 5% Significance Level					
270					Lilliefors Test Statistic	0.118	**Lilliefors GOF Test**					

271				5% Lilliefors Critical Value	0.22	Detected Data appear Lognormal at 5% Significance Level						
272	**Detected Data appear Lognormal at 5% Significance Level**											
273												
274	**Lognormal ROS Statistics Using Imputed Non-Detects**											
275				Mean in Original Scale	0.281	Mean in Log Scale	-1.502					
276				SD in Original Scale	0.197	SD in Log Scale	0.723					
277			95% t UCL (assumes normality of ROS data)		0.367	95% Percentile Bootstrap UCL	0.362					
278				95% BCA Bootstrap UCL	0.377	95% Bootstrap t UCL	0.392					
279				95% H-UCL (Log ROS)	0.445							
280												
281	**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**											
282				KM Mean (logged)	-1.505	KM Geo Mean	0.222					
283				KM SD (logged)	0.71	95% Critical H Value (KM-Log)	2.293					
284			KM Standard Error of Mean (logged)		0.186	95% H-UCL (KM -Log)	0.435					
285				KM SD (logged)	0.71	95% Critical H Value (KM-Log)	2.293					
286			KM Standard Error of Mean (logged)		0.186							
287												
288	**DL/2 Statistics**											
289	**DL/2 Normal**					**DL/2 Log-Transformed**						
290				Mean in Original Scale	0.279	Mean in Log Scale	-1.521					
291				SD in Original Scale	0.199	SD in Log Scale	0.742					
292				95% t UCL (Assumes normality)	0.366	95% H-Stat UCL	0.45					
293	**DL/2 is not a recommended method, provided for comparisons and historical reasons**											
294												
295	**Nonparametric Distribution Free UCL Statistics**											
296	**Detected Data appear Normal Distributed at 5% Significance Level**											
297												
298	**Suggested UCL to Use**											
299				95% KM (t) UCL	0.368							
300												
301	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
302	Recommendations are based upon data size, data distribution, and skewness.											
303	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
304	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
305												
306												
307	**Barium**											
308												
309	**General Statistics**											
310				Total Number of Observations	16	Number of Distinct Observations	13					
311						Number of Missing Observations	0					
312				Minimum	3	Mean	19.58					
313				Maximum	36	Median	19.5					
314				SD	9.707	Std. Error of Mean	2.427					
315				Coefficient of Variation	0.496	Skewness	-0.205					
316												
317	**Normal GOF Test**											
318				Shapiro Wilk Test Statistic	0.952	**Shapiro Wilk GOF Test**						
319				5% Shapiro Wilk Critical Value	0.887	Data appear Normal at 5% Significance Level						
320				Lilliefors Test Statistic	0.149	**Lilliefors GOF Test**						
321				5% Lilliefors Critical Value	0.213	Data appear Normal at 5% Significance Level						
322	**Data appear Normal at 5% Significance Level**											
323												
324	**Assuming Normal Distribution**											

325	**95% Normal UCL**						**95% UCLs (Adjusted for Skewness)**					
326				95% Student's-t UCL		23.84				95% Adjusted-CLT UCL (Chen-1995)		23.44
327										95% Modified-t UCL (Johnson-1978)		23.81
328												
329	**Gamma GOF Test**											
330				A-D Test Statistic		0.649	**Anderson-Darling Gamma GOF Test**					
331				5% A-D Critical Value		0.744	Detected data appear Gamma Distributed at 5% Significance Level					
332				K-S Test Statistic		0.184	**Kolmogorov-Smirnov Gamma GOF Test**					
333				5% K-S Critical Value		0.217	Detected data appear Gamma Distributed at 5% Significance Level					
334	**Detected data appear Gamma Distributed at 5% Significance Level**											
335												
336	**Gamma Statistics**											
337				k hat (MLE)		2.999	k star (bias corrected MLE)					2.479
338				Theta hat (MLE)		6.529	Theta star (bias corrected MLE)					7.9
339				nu hat (MLE)		95.97	nu star (bias corrected)					79.31
340				MLE Mean (bias corrected)		19.58	MLE Sd (bias corrected)					12.44
341							Approximate Chi Square Value (0.05)					59.79
342				Adjusted Level of Significance		0.0335	Adjusted Chi Square Value					57.87
343												
344	**Assuming Gamma Distribution**											
345			95% Approximate Gamma UCL (use when n>=50))			25.97	95% Adjusted Gamma UCL (use when n<50)					26.84
346												
347	**Lognormal GOF Test**											
348				Shapiro Wilk Test Statistic		0.862	**Shapiro Wilk Lognormal GOF Test**					
349				5% Shapiro Wilk Critical Value		0.887	Data Not Lognormal at 5% Significance Level					
350				Lilliefors Test Statistic		0.198	**Lilliefors Lognormal GOF Test**					
351				5% Lilliefors Critical Value		0.213	Data appear Lognormal at 5% Significance Level					
352	**Data appear Approximate Lognormal at 5% Significance Level**											
353												
354	**Lognormal Statistics**											
355				Minimum of Logged Data		1.099	Mean of logged Data					2.799
356				Maximum of Logged Data		3.584	SD of logged Data					0.698
357												
358	**Assuming Lognormal Distribution**											
359				95% H-UCL		31.58	90% Chebyshev (MVUE) UCL					31.95
360				95% Chebyshev (MVUE) UCL		37.1	97.5% Chebyshev (MVUE) UCL					44.26
361				99% Chebyshev (MVUE) UCL		58.31						
362												
363	**Nonparametric Distribution Free UCL Statistics**											
364	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
365												
366	**Nonparametric Distribution Free UCLs**											
367				95% CLT UCL		23.57	95% Jackknife UCL					23.84
368				95% Standard Bootstrap UCL		23.35	95% Bootstrap-t UCL					23.73
369				95% Hall's Bootstrap UCL		23.59	95% Percentile Bootstrap UCL					23.44
370				95% BCA Bootstrap UCL		23.5						
371				90% Chebyshev(Mean, Sd) UCL		26.86	95% Chebyshev(Mean, Sd) UCL					30.16
372				97.5% Chebyshev(Mean, Sd) UCL		34.74	99% Chebyshev(Mean, Sd) UCL					43.73
373												
374	**Suggested UCL to Use**											
375				95% Student's-t UCL		23.84						
376												
377	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
378	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.

Note: For highly negatively-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be reliable. Chen's and Johnson's methods provide adjustments for positvely skewed data sets.

Cadmium

General Statistics

Total Number of Observations	16	Number of Distinct Observations	5
Number of Detects	2	Number of Non-Detects	14
Number of Distinct Detects	2	Number of Distinct Non-Detects	3
Minimum Detect	0.032	Minimum Non-Detect	0.18
Maximum Detect	0.036	Maximum Non-Detect	0.2
Variance Detects	8.0000E-6	Percent Non-Detects	87.5%
Mean Detects	0.034	SD Detects	0.00283
Median Detects	0.034	CV Detects	0.0832
Skewness Detects	N/A	Kurtosis Detects	N/A
Mean of Logged Detects	-3.383	SD of Logged Detects	0.0833

Warning: Data set has only 2 Detected Values.

This is not enough to compute meaningful or reliable statistics and estimates.

Normal GOF Test on Detects Only

Not Enough Data to Perform GOF Test

Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs

KM Mean	0.034	KM Standard Error of Mean	0.002
KM SD	0.002	95% KM (BCA) UCL	N/A
95% KM (t) UCL	0.0375	95% KM (Percentile Bootstrap) UCL	N/A
95% KM (z) UCL	0.0373	95% KM Bootstrap t UCL	N/A
90% KM Chebyshev UCL	0.04	95% KM Chebyshev UCL	0.0427
97.5% KM Chebyshev UCL	0.0465	99% KM Chebyshev UCL	0.0539

Gamma GOF Tests on Detected Observations Only

Not Enough Data to Perform GOF Test

Gamma Statistics on Detected Data Only

k hat (MLE)	288.7	k star (bias corrected MLE)	N/A
Theta hat (MLE)	1.1778E-4	Theta star (bias corrected MLE)	N/A
nu hat (MLE)	1155	nu star (bias corrected)	N/A
Mean (detects)	0.034		

Estimates of Gamma Parameters using KM Estimates

Mean (KM)	0.034	SD (KM)	0.002
Variance (KM)	4.0000E-6	SE of Mean (KM)	0.002
k hat (KM)	289	k star (KM)	234.9
nu hat (KM)	9248	nu star (KM)	7515
theta hat (KM)	1.1765E-4	theta star (KM)	1.4477E-4
80% gamma percentile (KM)	0.0359	90% gamma percentile (KM)	0.0369
95% gamma percentile (KM)	0.0377	99% gamma percentile (KM)	0.0394

Gamma Kaplan-Meier (KM) Statistics

433											Adjusted Level of Significance (β)	0.0335
434				Approximate Chi Square Value (N/A, α)		7315					Adjusted Chi Square Value (N/A, β)	7292
435				95% Gamma Approximate KM-UCL (use when n>=50)		0.0349					95% Gamma Adjusted KM-UCL (use when n<50)	0.035
436												
437						**Lognormal GOF Test on Detected Observations Only**							
438						**Not Enough Data to Perform GOF Test**							
439												
440						**Lognormal ROS Statistics Using Imputed Non-Detects**							
441						Mean in Original Scale	0.0341				Mean in Log Scale	-3.383
442						SD in Original Scale	0.00305				SD in Log Scale	0.0896
443				95% t UCL (assumes normality of ROS data)			0.0354				95% Percentile Bootstrap UCL	0.0353
444						95% BCA Bootstrap UCL	0.0353				95% Bootstrap t UCL	0.0355
445						95% H-UCL (Log ROS)	N/A					
446												
447						**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**							
448						KM Mean (logged)	-3.383				KM Geo Mean	0.0339
449						KM SD (logged)	0.0589				95% Critical H Value (KM-Log)	N/A
450						KM Standard Error of Mean (logged)	0.0589				95% H-UCL (KM -Log)	N/A
451						KM SD (logged)	0.0589				95% Critical H Value (KM-Log)	N/A
452						KM Standard Error of Mean (logged)	0.0589					
453												
454						**DL/2 Statistics**							
455						**DL/2 Normal**					**DL/2 Log-Transformed**	
456						Mean in Original Scale	0.0874				Mean in Log Scale	-2.483
457						SD in Original Scale	0.0212				SD in Log Scale	0.354
458						95% t UCL (Assumes normality)	0.0967				95% H-Stat UCL	0.106
459						**DL/2 is not a recommended method, provided for comparisons and historical reasons**							
460												
461						**Nonparametric Distribution Free UCL Statistics**							
462						**Data do not follow a Discernible Distribution at 5% Significance Level**							
463												
464						**Suggested UCL to Use**							
465						95% KM (t) UCL	0.0375				KM H-UCL	N/A
466						95% KM (BCA) UCL	N/A					
467						**Warning: One or more Recommended UCL(s) not available!**							
468						**Warning: Recommended UCL exceeds the maximum observation**							
469												
470						Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.							
471						Recommendations are based upon data size, data distribution, and skewness.							
472						These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).							
473						However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.							
474												
475	**Cobalt**											
476												
477						**General Statistics**							
478						Total Number of Observations	16				Number of Distinct Observations	9
479						Number of Detects	3				Number of Non-Detects	13
480						Number of Distinct Detects	3				Number of Distinct Non-Detects	6
481						Minimum Detect	0.036				Minimum Non-Detect	0.0495
482						Maximum Detect	0.051				Maximum Non-Detect	0.5
483						Variance Detects	5.7000E-5				Percent Non-Detects	81.25%
484						Mean Detects	0.043				SD Detects	0.00755
485						Median Detects	0.042				CV Detects	0.176
486						Skewness Detects	0.586				Kurtosis Detects	N/A

487				Mean of Logged Detects		-3.157					SD of Logged Detects	0.175
488												
489						**Warning: Data set has only 3 Detected Values.**							
490						**This is not enough to compute meaningful or reliable statistics and estimates.**						
491												
492												
493						**Normal GOF Test on Detects Only**							
494					Shapiro Wilk Test Statistic	0.987			**Shapiro Wilk GOF Test**			
495					5% Shapiro Wilk Critical Value	0.767			Detected Data appear Normal at 5% Significance Level			
496					Lilliefors Test Statistic	0.219			**Lilliefors GOF Test**			
497					5% Lilliefors Critical Value	0.425			Detected Data appear Normal at 5% Significance Level			
498						**Detected Data appear Normal at 5% Significance Level**						
499												
500						**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**						
501					KM Mean	0.042			KM Standard Error of Mean			0.00373
502					KM SD	0.00581			95% KM (BCA) UCL			N/A
503					95% KM (t) UCL	0.0485			95% KM (Percentile Bootstrap) UCL			N/A
504					95% KM (z) UCL	0.0481			95% KM Bootstrap t UCL			N/A
505					90% KM Chebyshev UCL	0.0532			95% KM Chebyshev UCL			0.0583
506					97.5% KM Chebyshev UCL	0.0653			99% KM Chebyshev UCL			0.0791
507												
508						**Gamma GOF Tests on Detected Observations Only**							
509						**Not Enough Data to Perform GOF Test**							
510												
511						**Gamma Statistics on Detected Data Only**							
512					k hat (MLE)	49.21			k star (bias corrected MLE)			N/A
513					Theta hat (MLE)	8.7384E-4			Theta star (bias corrected MLE)			N/A
514					nu hat (MLE)	295.2			nu star (bias corrected)			N/A
515					Mean (detects)	0.043						
516												
517						**Gamma ROS Statistics using Imputed Non-Detects**							
518						GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs							
519						GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)							
520						For such situations, GROS method may yield incorrect values of UCLs and BTVs							
521						This is especially true when the sample size is small.							
522						For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates							
523					Minimum	0.0351			Mean			0.0417
524					Maximum	0.051			Median			0.0415
525					SD	0.00476			CV			0.114
526					k hat (MLE)	83.45			k star (bias corrected MLE)			67.85
527					Theta hat (MLE)	4.9987E-4			Theta star (bias corrected MLE)			6.1485E-4
528					nu hat (MLE)	2670			nu star (bias corrected)			2171
529					Adjusted Level of Significance (β)	0.0335						
530					Approximate Chi Square Value (N/A, α)	2064			Adjusted Chi Square Value (N/A, β)			2052
531					95% Gamma Approximate UCL (use when n>=50)	0.0439			95% Gamma Adjusted UCL (use when n<50)			N/A
532												
533						**Estimates of Gamma Parameters using KM Estimates**							
534					Mean (KM)	0.042			SD (KM)			0.00581
535					Variance (KM)	3.3750E-5			SE of Mean (KM)			0.00373
536					k hat (KM)	52.27			k star (KM)			42.51
537					nu hat (KM)	1673			nu star (KM)			1360
538					theta hat (KM)	8.0357E-4			theta star (KM)			9.8804E-4
539					80% gamma percentile (KM)	0.0473			90% gamma percentile (KM)			0.0504
540					95% gamma percentile (KM)	0.0531			99% gamma percentile (KM)			0.0584

	Gamma Kaplan-Meier (KM) Statistics		
Approximate Chi Square Value (N/A, α)	1276	Adjusted Chi Square Value (N/A, β)	1266
95% Gamma Approximate KM-UCL (use when n>=50)	0.0448	95% Gamma Adjusted KM-UCL (use when n<50)	0.0451
Lognormal GOF Test on Detected Observations Only			
Shapiro Wilk Test Statistic	0.996	**Shapiro Wilk GOF Test**	
5% Shapiro Wilk Critical Value	0.767	Detected Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.197	**Lilliefors GOF Test**	
5% Lilliefors Critical Value	0.425	Detected Data appear Lognormal at 5% Significance Level	
Detected Data appear Lognormal at 5% Significance Level			
Lognormal ROS Statistics Using Imputed Non-Detects			
Mean in Original Scale	0.0416	Mean in Log Scale	-3.185
SD in Original Scale	0.00471	SD in Log Scale	0.112
95% t UCL (assumes normality of ROS data)	0.0437	95% Percentile Bootstrap UCL	0.0435
95% BCA Bootstrap UCL	0.0439	95% Bootstrap t UCL	0.0437
95% H-UCL (Log ROS)	0.0438		
Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution			
KM Mean (logged)	-3.179	KM Geo Mean	0.0416
KM SD (logged)	0.135	95% Critical H Value (KM-Log)	1.761
KM Standard Error of Mean (logged)	0.0876	95% H-UCL (KM -Log)	0.0447
KM SD (logged)	0.135	95% Critical H Value (KM-Log)	1.761
KM Standard Error of Mean (logged)	0.0876		
DL/2 Statistics			
DL/2 Normal		**DL/2 Log-Transformed**	
Mean in Original Scale	0.189	Mean in Log Scale	-1.898
SD in Original Scale	0.09	SD in Log Scale	0.843
95% t UCL (Assumes normality)	0.228	95% H-Stat UCL	0.366
DL/2 is not a recommended method, provided for comparisons and historical reasons			
Nonparametric Distribution Free UCL Statistics			
Detected Data appear Normal Distributed at 5% Significance Level			
Suggested UCL to Use			
95% KM (t) UCL	0.0485		
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.			
Copper			
General Statistics			
Total Number of Observations	16	Number of Distinct Observations	15
		Number of Missing Observations	0
Minimum	0.8	Mean	1.456
Maximum	3.3	Median	1.3
SD	0.639	Std. Error of Mean	0.16
Coefficient of Variation	0.439	Skewness	1.691

595												
596	**Normal GOF Test**											
597					Shapiro Wilk Test Statistic	0.846	**Shapiro Wilk GOF Test**					
598					5% Shapiro Wilk Critical Value	0.887	Data Not Normal at 5% Significance Level					
599					Lilliefors Test Statistic	0.16	**Lilliefors GOF Test**					
600					5% Lilliefors Critical Value	0.213	Data appear Normal at 5% Significance Level					
601	**Data appear Approximate Normal at 5% Significance Level**											
602												
603	**Assuming Normal Distribution**											
604				**95% Normal UCL**			**95% UCLs (Adjusted for Skewness)**					
605					95% Student's-t UCL	1.736	95% Adjusted-CLT UCL (Chen-1995)	1.791				
606							95% Modified-t UCL (Johnson-1978)	1.747				
607												
608	**Gamma GOF Test**											
609					A-D Test Statistic	0.37	**Anderson-Darling Gamma GOF Test**					
610					5% A-D Critical Value	0.74	Detected data appear Gamma Distributed at 5% Significance Level					
611					K-S Test Statistic	0.126	**Kolmogorov-Smirnov Gamma GOF Test**					
612					5% K-S Critical Value	0.216	Detected data appear Gamma Distributed at 5% Significance Level					
613	**Detected data appear Gamma Distributed at 5% Significance Level**											
614												
615	**Gamma Statistics**											
616					k hat (MLE)	6.832	k star (bias corrected MLE)	5.592				
617					Theta hat (MLE)	0.213	Theta star (bias corrected MLE)	0.26				
618					nu hat (MLE)	218.6	nu star (bias corrected)	179				
619					MLE Mean (bias corrected)	1.456	MLE Sd (bias corrected)	0.616				
620							Approximate Chi Square Value (0.05)	149				
621					Adjusted Level of Significance	0.0335	Adjusted Chi Square Value	145.9				
622												
623	**Assuming Gamma Distribution**											
624					95% Approximate Gamma UCL (use when n>=50))	1.748	95% Adjusted Gamma UCL (use when n<50)	1.785				
625												
626	**Lognormal GOF Test**											
627					Shapiro Wilk Test Statistic	0.951	**Shapiro Wilk Lognormal GOF Test**					
628					5% Shapiro Wilk Critical Value	0.887	Data appear Lognormal at 5% Significance Level					
629					Lilliefors Test Statistic	0.124	**Lilliefors Lognormal GOF Test**					
630					5% Lilliefors Critical Value	0.213	Data appear Lognormal at 5% Significance Level					
631	**Data appear Lognormal at 5% Significance Level**											
632												
633	**Lognormal Statistics**											
634					Minimum of Logged Data	-0.223	Mean of logged Data	0.3				
635					Maximum of Logged Data	1.194	SD of logged Data	0.386				
636												
637	**Assuming Lognormal Distribution**											
638					95% H-UCL	1.766	90% Chebyshev (MVUE) UCL	1.875				
639					95% Chebyshev (MVUE) UCL	2.069	97.5% Chebyshev (MVUE) UCL	2.337				
640					99% Chebyshev (MVUE) UCL	2.865						
641												
642	**Nonparametric Distribution Free UCL Statistics**											
643	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
644												
645	**Nonparametric Distribution Free UCLs**											
646					95% CLT UCL	1.718	95% Jackknife UCL	1.736				
647					95% Standard Bootstrap UCL	1.712	95% Bootstrap-t UCL	1.859				
648					95% Hall's Bootstrap UCL	2.025	95% Percentile Bootstrap UCL	1.714				

649				95% BCA Bootstrap UCL	1.779							
650				90% Chebyshev(Mean, Sd) UCL	1.935					95% Chebyshev(Mean, Sd) UCL	2.152	
651				97.5% Chebyshev(Mean, Sd) UCL	2.453					99% Chebyshev(Mean, Sd) UCL	3.045	
652												
653					**Suggested UCL to Use**							
654				95% Student's-t UCL	1.736							
655												
656	When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test											
657	When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL											
658												
659	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
660	Recommendations are based upon data size, data distribution, and skewness.											
661	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
662	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
663												
664												
665	**Iron**											
666												
667					**General Statistics**							
668				Total Number of Observations	16					Number of Distinct Observations	14	
669										Number of Missing Observations	0	
670				Minimum	22					Mean	54	
671				Maximum	100					Median	49	
672				SD	24.69					Std. Error of Mean	6.173	
673				Coefficient of Variation	0.457					Skewness	0.627	
674												
675					**Normal GOF Test**							
676				Shapiro Wilk Test Statistic	0.918					**Shapiro Wilk GOF Test**		
677				5% Shapiro Wilk Critical Value	0.887					Data appear Normal at 5% Significance Level		
678				Lilliefors Test Statistic	0.157					**Lilliefors GOF Test**		
679				5% Lilliefors Critical Value	0.213					Data appear Normal at 5% Significance Level		
680					**Data appear Normal at 5% Significance Level**							
681												
682					**Assuming Normal Distribution**							
683					**95% Normal UCL**					**95% UCLs (Adjusted for Skewness)**		
684				95% Student's-t UCL	64.82					95% Adjusted-CLT UCL (Chen-1995)	65.19	
685										95% Modified-t UCL (Johnson-1978)	64.98	
686												
687					**Gamma GOF Test**							
688				A-D Test Statistic	0.322					**Anderson-Darling Gamma GOF Test**		
689				5% A-D Critical Value	0.741					Detected data appear Gamma Distributed at 5% Significance Level		
690				K-S Test Statistic	0.146					**Kolmogorov-Smirnov Gamma GOF Test**		
691				5% K-S Critical Value	0.216					Detected data appear Gamma Distributed at 5% Significance Level		
692					**Detected data appear Gamma Distributed at 5% Significance Level**							
693												
694					**Gamma Statistics**							
695				k hat (MLE)	5.17					k star (bias corrected MLE)	4.242	
696				Theta hat (MLE)	10.45					Theta star (bias corrected MLE)	12.73	
697				nu hat (MLE)	165.4					nu star (bias corrected)	135.7	
698				MLE Mean (bias corrected)	54					MLE Sd (bias corrected)	26.22	
699										Approximate Chi Square Value (0.05)	109.8	
700				Adjusted Level of Significance	0.0335					Adjusted Chi Square Value	107.2	
701												
702					**Assuming Gamma Distribution**							

703	95% Approximate Gamma UCL (use when n>=50))					66.74	95% Adjusted Gamma UCL (use when n<50)					68.4
704												
705	**Lognormal GOF Test**											
706	Shapiro Wilk Test Statistic					0.956	**Shapiro Wilk Lognormal GOF Test**					
707	5% Shapiro Wilk Critical Value					0.887	Data appear Lognormal at 5% Significance Level					
708	Lilliefors Test Statistic					0.14	**Lilliefors Lognormal GOF Test**					
709	5% Lilliefors Critical Value					0.213	Data appear Lognormal at 5% Significance Level					
710	**Data appear Lognormal at 5% Significance Level**											
711												
712	**Lognormal Statistics**											
713	Minimum of Logged Data					3.091	Mean of logged Data					3.889
714	Maximum of Logged Data					4.605	SD of logged Data					0.467
715												
716	**Assuming Lognormal Distribution**											
717	95% H-UCL					69.5	90% Chebyshev (MVUE) UCL					73.57
718	95% Chebyshev (MVUE) UCL					82.39	97.5% Chebyshev (MVUE) UCL					94.63
719	99% Chebyshev (MVUE) UCL					118.7						
720												
721	**Nonparametric Distribution Free UCL Statistics**											
722	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
723												
724	**Nonparametric Distribution Free UCLs**											
725	95% CLT UCL					64.15	95% Jackknife UCL					64.82
726	95% Standard Bootstrap UCL					63.9	95% Bootstrap-t UCL					66.41
727	95% Hall's Bootstrap UCL					65.17	95% Percentile Bootstrap UCL					63.56
728	95% BCA Bootstrap UCL					64.5						
729	90% Chebyshev(Mean, Sd) UCL					72.52	95% Chebyshev(Mean, Sd) UCL					80.91
730	97.5% Chebyshev(Mean, Sd) UCL					92.55	99% Chebyshev(Mean, Sd) UCL					115.4
731												
732	**Suggested UCL to Use**											
733	95% Student's-t UCL					64.82						
734												
735	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
736	Recommendations are based upon data size, data distribution, and skewness.											
737	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
738	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
739												
740	**Lead**											
741												
742	**General Statistics**											
743	Total Number of Observations					16	Number of Distinct Observations					13
744	Number of Detects					10	Number of Non-Detects					6
745	Number of Distinct Detects					10	Number of Distinct Non-Detects					3
746	Minimum Detect					0.064	Minimum Non-Detect					0.18
747	Maximum Detect					0.14	Maximum Non-Detect					0.2
748	Variance Detects					7.5707E-4	Percent Non-Detects					37.5%
749	Mean Detects					0.0898	SD Detects					0.0275
750	Median Detects					0.0825	CV Detects					0.306
751	Skewness Detects					0.99	Kurtosis Detects					-0.408
752	Mean of Logged Detects					-2.449	SD of Logged Detects					0.286
753												
754	**Normal GOF Test on Detects Only**											
755	Shapiro Wilk Test Statistic					0.847	**Shapiro Wilk GOF Test**					
756	5% Shapiro Wilk Critical Value					0.842	Detected Data appear Normal at 5% Significance Level					

757				Lilliefors Test Statistic		0.255	**Lilliefors GOF Test**					
758				5% Lilliefors Critical Value		0.262	Detected Data appear Normal at 5% Significance Level					
759	**Detected Data appear Normal at 5% Significance Level**											
760												
761	**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**											
762				KM Mean		0.0898	KM Standard Error of Mean					0.0087
763				KM SD		0.0261	95% KM (BCA) UCL					0.105
764				95% KM (t) UCL		0.105	95% KM (Percentile Bootstrap) UCL					0.104
765				95% KM (z) UCL		0.104	95% KM Bootstrap t UCL					0.118
766				90% KM Chebyshev UCL		0.116	95% KM Chebyshev UCL					0.128
767				97.5% KM Chebyshev UCL		0.144	99% KM Chebyshev UCL					0.176
768												
769	**Gamma GOF Tests on Detected Observations Only**											
770				A-D Test Statistic		0.589	**Anderson-Darling GOF Test**					
771				5% A-D Critical Value		0.725	Detected data appear Gamma Distributed at 5% Significance Level					
772				K-S Test Statistic		0.225	**Kolmogorov-Smirnov GOF**					
773				5% K-S Critical Value		0.266	Detected data appear Gamma Distributed at 5% Significance Level					
774	**Detected data appear Gamma Distributed at 5% Significance Level**											
775												
776	**Gamma Statistics on Detected Data Only**											
777				k hat (MLE)		13.16	k star (bias corrected MLE)					9.276
778				Theta hat (MLE)		0.00683	Theta star (bias corrected MLE)					0.00968
779				nu hat (MLE)		263.1	nu star (bias corrected)					185.5
780				Mean (detects)		0.0898						
781												
782	**Gamma ROS Statistics using Imputed Non-Detects**											
783	GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs											
784	GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)											
785	For such situations, GROS method may yield incorrect values of UCLs and BTVs											
786	This is especially true when the sample size is small.											
787	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates											
788				Minimum		0.064	Mean					0.0894
789				Maximum		0.14	Median					0.085
790				SD		0.0232	CV					0.26
791				k hat (MLE)		17.31	k star (bias corrected MLE)					14.11
792				Theta hat (MLE)		0.00516	Theta star (bias corrected MLE)					0.00633
793				nu hat (MLE)		554	nu star (bias corrected)					451.4
794				Adjusted Level of Significance (β)		0.0335						
795				Approximate Chi Square Value (451.44, α)		403.2	Adjusted Chi Square Value (451.44, β)					398
796				95% Gamma Approximate UCL (use when n>=50)		0.1	95% Gamma Adjusted UCL (use when n<50)					0.101
797												
798	**Estimates of Gamma Parameters using KM Estimates**											
799				Mean (KM)		0.0898	SD (KM)					0.0261
800				Variance (KM)		6.8136E-4	SE of Mean (KM)					0.0087
801				k hat (KM)		11.84	k star (KM)					9.658
802				nu hat (KM)		378.7	nu star (KM)					309
803				theta hat (KM)		0.00759	theta star (KM)					0.0093
804				80% gamma percentile (KM)		0.113	90% gamma percentile (KM)					0.128
805				95% gamma percentile (KM)		0.142	99% gamma percentile (KM)					0.17
806												
807	**Gamma Kaplan-Meier (KM) Statistics**											
808				Approximate Chi Square Value (309.05, α)		269.3	Adjusted Chi Square Value (309.05, β)					265.1
809				95% Gamma Approximate KM-UCL (use when n>=50)		0.103	95% Gamma Adjusted KM-UCL (use when n<50)					0.105
810												

811	**Lognormal GOF Test on Detected Observations Only**											
812					Shapiro Wilk Test Statistic	0.882	**Shapiro Wilk GOF Test**					
813					5% Shapiro Wilk Critical Value	0.842	Detected Data appear Lognormal at 5% Significance Level					
814					Lilliefors Test Statistic	0.207	**Lilliefors GOF Test**					
815					5% Lilliefors Critical Value	0.262	Detected Data appear Lognormal at 5% Significance Level					
816	**Detected Data appear Lognormal at 5% Significance Level**											
817												
818	**Lognormal ROS Statistics Using Imputed Non-Detects**											
819					Mean in Original Scale	0.0889	Mean in Log Scale	-2.449				
820					SD in Original Scale	0.0229	SD in Log Scale	0.241				
821					95% t UCL (assumes normality of ROS data)	0.0989	95% Percentile Bootstrap UCL	0.0988				
822					95% BCA Bootstrap UCL	0.0997	95% Bootstrap t UCL	0.102				
823					95% H-UCL (Log ROS)	0.0997						
824												
825	**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**											
826					KM Mean (logged)	-2.449	KM Geo Mean	0.0864				
827					KM SD (logged)	0.271	95% Critical H Value (KM-Log)	1.849				
828					KM Standard Error of Mean (logged)	0.0904	95% H-UCL (KM -Log)	0.102				
829					KM SD (logged)	0.271	95% Critical H Value (KM-Log)	1.849				
830					KM Standard Error of Mean (logged)	0.0904						
831												
832	**DL/2 Statistics**											
833				**DL/2 Normal**			**DL/2 Log-Transformed**					
834					Mean in Original Scale	0.0921	Mean in Log Scale	-2.41				
835					SD in Original Scale	0.0217	SD in Log Scale	0.229				
836					95% t UCL (Assumes normality)	0.102	95% H-Stat UCL	0.103				
837	**DL/2 is not a recommended method, provided for comparisons and historical reasons**											
838												
839	**Nonparametric Distribution Free UCL Statistics**											
840	**Detected Data appear Normal Distributed at 5% Significance Level**											
841												
842	**Suggested UCL to Use**											
843					95% KM (t) UCL	0.105						
844												
845	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
846	Recommendations are based upon data size, data distribution, and skewness.											
847	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
848	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
849												
850												
851	**Manganese**											
852												
853	**General Statistics**											
854					Total Number of Observations	16	Number of Distinct Observations	14				
855							Number of Missing Observations	0				
856					Minimum	10	Mean	49.5				
857					Maximum	110	Median	40.5				
858					SD	32.61	Std. Error of Mean	8.153				
859					Coefficient of Variation	0.659	Skewness	0.607				
860												
861	**Normal GOF Test**											
862					Shapiro Wilk Test Statistic	0.913	**Shapiro Wilk GOF Test**					
863					5% Shapiro Wilk Critical Value	0.887	Data appear Normal at 5% Significance Level					
864					Lilliefors Test Statistic	0.149	**Lilliefors GOF Test**					

865				5% Lilliefors Critical Value		0.213		Data appear Normal at 5% Significance Level				
866	**Data appear Normal at 5% Significance Level**											
867												
868	**Assuming Normal Distribution**											
869	**95% Normal UCL**						**95% UCLs (Adjusted for Skewness)**					
870				95% Student's-t UCL		63.79		95% Adjusted-CLT UCL (Chen-1995)				64.23
871								95% Modified-t UCL (Johnson-1978)				64
872												
873	**Gamma GOF Test**											
874				A-D Test Statistic		0.336	**Anderson-Darling Gamma GOF Test**					
875				5% A-D Critical Value		0.749	Detected data appear Gamma Distributed at 5% Significance Level					
876				K-S Test Statistic		0.129	**Kolmogorov-Smirnov Gamma GOF Test**					
877				5% K-S Critical Value		0.218	Detected data appear Gamma Distributed at 5% Significance Level					
878	**Detected data appear Gamma Distributed at 5% Significance Level**											
879												
880	**Gamma Statistics**											
881				k hat (MLE)		2.203		k star (bias corrected MLE)				1.832
882				Theta hat (MLE)		22.47		Theta star (bias corrected MLE)				27.03
883				nu hat (MLE)		70.5		nu star (bias corrected)				58.61
884				MLE Mean (bias corrected)		49.5		MLE Sd (bias corrected)				36.58
885								Approximate Chi Square Value (0.05)				42.01
886				Adjusted Level of Significance		0.0335		Adjusted Chi Square Value				40.41
887												
888	**Assuming Gamma Distribution**											
889				95% Approximate Gamma UCL (use when n>=50))		69.06		95% Adjusted Gamma UCL (use when n<50)				71.79
890												
891	**Lognormal GOF Test**											
892				Shapiro Wilk Test Statistic		0.937	**Shapiro Wilk Lognormal GOF Test**					
893				5% Shapiro Wilk Critical Value		0.887	Data appear Lognormal at 5% Significance Level					
894				Lilliefors Test Statistic		0.145	**Lilliefors Lognormal GOF Test**					
895				5% Lilliefors Critical Value		0.213	Data appear Lognormal at 5% Significance Level					
896	**Data appear Lognormal at 5% Significance Level**											
897												
898	**Lognormal Statistics**											
899				Minimum of Logged Data		2.303		Mean of logged Data				3.658
900				Maximum of Logged Data		4.7		SD of logged Data				0.767
901												
902	**Assuming Lognormal Distribution**											
903				95% H-UCL		83.16		90% Chebyshev (MVUE) UCL				82.08
904				95% Chebyshev (MVUE) UCL		96.21		97.5% Chebyshev (MVUE) UCL				115.8
905				99% Chebyshev (MVUE) UCL		154.4						
906												
907	**Nonparametric Distribution Free UCL Statistics**											
908	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
909												
910	**Nonparametric Distribution Free UCLs**											
911				95% CLT UCL		62.91		95% Jackknife UCL				63.79
912				95% Standard Bootstrap UCL		62.07		95% Bootstrap-t UCL				65.19
913				95% Hall's Bootstrap UCL		64.76		95% Percentile Bootstrap UCL				63.38
914				95% BCA Bootstrap UCL		64.5						
915				90% Chebyshev(Mean, Sd) UCL		73.96		95% Chebyshev(Mean, Sd) UCL				85.04
916				97.5% Chebyshev(Mean, Sd) UCL		100.4		99% Chebyshev(Mean, Sd) UCL				130.6
917												
918	**Suggested UCL to Use**											

	A	B	C	D	E	F	G	H	I	J	K	L
919					95% Student's-t UCL	63.79						
920												
921	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
922	Recommendations are based upon data size, data distribution, and skewness.											
923	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
924	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
925												
926												
927	**Molybdenum**											
928												
929	**General Statistics**											
930	Total Number of Observations					16	Number of Distinct Observations					16
931							Number of Missing Observations					0
932	Minimum					5	Mean					53.01
933	Maximum					150	Median					41.5
934	SD					43.29	Std. Error of Mean					10.82
935	Coefficient of Variation					0.817	Skewness					1.191
936												
937	**Normal GOF Test**											
938	Shapiro Wilk Test Statistic					0.875	**Shapiro Wilk GOF Test**					
939	5% Shapiro Wilk Critical Value					0.887	Data Not Normal at 5% Significance Level					
940	Lilliefors Test Statistic					0.189	**Lilliefors GOF Test**					
941	5% Lilliefors Critical Value					0.213	Data appear Normal at 5% Significance Level					
942	**Data appear Approximate Normal at 5% Significance Level**											
943												
944	**Assuming Normal Distribution**											
945	**95% Normal UCL**						**95% UCLs (Adjusted for Skewness)**					
946	95% Student's-t UCL					71.98	95% Adjusted-CLT UCL (Chen-1995)					74.25
947							95% Modified-t UCL (Johnson-1978)					72.52
948												
949	**Gamma GOF Test**											
950	A-D Test Statistic					0.263	**Anderson-Darling Gamma GOF Test**					
951	5% A-D Critical Value					0.756	Detected data appear Gamma Distributed at 5% Significance Level					
952	K-S Test Statistic					0.141	**Kolmogorov-Smirnov Gamma GOF Test**					
953	5% K-S Critical Value					0.219	Detected data appear Gamma Distributed at 5% Significance Level					
954	**Detected data appear Gamma Distributed at 5% Significance Level**											
955												
956	**Gamma Statistics**											
957	k hat (MLE)					1.435	k star (bias corrected MLE)					1.207
958	Theta hat (MLE)					36.95	Theta star (bias corrected MLE)					43.9
959	nu hat (MLE)					45.91	nu star (bias corrected)					38.63
960	MLE Mean (bias corrected)					53.01	MLE Sd (bias corrected)					48.24
961							Approximate Chi Square Value (0.05)					25.4
962	Adjusted Level of Significance					0.0335	Adjusted Chi Square Value					24.18
963												
964	**Assuming Gamma Distribution**											
965	95% Approximate Gamma UCL (use when n>=50))					80.63	95% Adjusted Gamma UCL (use when n<50)					84.69
966												
967	**Lognormal GOF Test**											
968	Shapiro Wilk Test Statistic					0.922	**Shapiro Wilk Lognormal GOF Test**					
969	5% Shapiro Wilk Critical Value					0.887	Data appear Lognormal at 5% Significance Level					
970	Lilliefors Test Statistic					0.198	**Lilliefors Lognormal GOF Test**					
971	5% Lilliefors Critical Value					0.213	Data appear Lognormal at 5% Significance Level					
972	**Data appear Lognormal at 5% Significance Level**											

973												
974	**Lognormal Statistics**											
975						Minimum of Logged Data	1.609			Mean of logged Data	3.583	
976						Maximum of Logged Data	5.011			SD of logged Data	1.023	
977												
978	**Assuming Lognormal Distribution**											
979						95% H-UCL	125.3			90% Chebyshev (MVUE) UCL	107.1	
980						95% Chebyshev (MVUE) UCL	129.3			97.5% Chebyshev (MVUE) UCL	160.1	
981						99% Chebyshev (MVUE) UCL	220.7					
982												
983	**Nonparametric Distribution Free UCL Statistics**											
984	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
985												
986	**Nonparametric Distribution Free UCLs**											
987						95% CLT UCL	70.81			95% Jackknife UCL	71.98	
988						95% Standard Bootstrap UCL	70.36			95% Bootstrap-t UCL	78.33	
989						95% Hall's Bootstrap UCL	85.57			95% Percentile Bootstrap UCL	70.95	
990						95% BCA Bootstrap UCL	75.03					
991						90% Chebyshev(Mean, Sd) UCL	85.47			95% Chebyshev(Mean, Sd) UCL	100.2	
992						97.5% Chebyshev(Mean, Sd) UCL	120.6			99% Chebyshev(Mean, Sd) UCL	160.7	
993												
994	**Suggested UCL to Use**											
995						95% Student's-t UCL	71.98					
996												
997	When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test											
998	When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL											
999												
1000	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
1001	Recommendations are based upon data size, data distribution, and skewness.											
1002	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
1003	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
1004												
1005	**Nickel**											
1006												
1007	**General Statistics**											
1008						Total Number of Observations	16			Number of Distinct Observations	4	
1009						Number of Detects	1			Number of Non-Detects	15	
1010						Number of Distinct Detects	1			Number of Distinct Non-Detects	3	
1011												
1012	**Warning: Only one distinct data value was detected! ProUCL (or any other software) should not be used on such a data set!**											
1013	**It is suggested to use alternative site specific values determined by the Project Team to estimate environmental parameters (e.g., EPC, BTV).**											
1014												
1015	**The data set for variable Nickel was not processed!**											
1016												
1017												
1018	**Selenium**											
1019												
1020	**General Statistics**											
1021						Total Number of Observations	16			Number of Distinct Observations	13	
1022						Number of Detects	15			Number of Non-Detects	1	
1023						Number of Distinct Detects	12			Number of Distinct Non-Detects	1	
1024						Minimum Detect	0.33			Minimum Non-Detect	0.98	
1025						Maximum Detect	5.7			Maximum Non-Detect	0.98	
1026						Variance Detects	2.149			Percent Non-Detects	6.25%	

1027					Mean Detects	2.223					SD Detects	1.466
1028					Median Detects	2.8					CV Detects	0.659
1029					Skewness Detects	0.684					Kurtosis Detects	0.601
1030					Mean of Logged Detects	0.532					SD of Logged Detects	0.836
1031												
1032					**Normal GOF Test on Detects Only**							
1033					Shapiro Wilk Test Statistic	0.905			**Shapiro Wilk GOF Test**			
1034					5% Shapiro Wilk Critical Value	0.881			Detected Data appear Normal at 5% Significance Level			
1035					Lilliefors Test Statistic	0.186			**Lilliefors GOF Test**			
1036					5% Lilliefors Critical Value	0.22			Detected Data appear Normal at 5% Significance Level			
1037					**Detected Data appear Normal at 5% Significance Level**							
1038												
1039					**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**							
1040					KM Mean	2.123					KM Standard Error of Mean	0.37
1041					KM SD	1.427					95% KM (BCA) UCL	2.767
1042					95% KM (t) UCL	2.771					95% KM (Percentile Bootstrap) UCL	2.73
1043					95% KM (z) UCL	2.731					95% KM Bootstrap t UCL	2.824
1044					90% KM Chebyshev UCL	3.232					95% KM Chebyshev UCL	3.734
1045					97.5% KM Chebyshev UCL	4.432					99% KM Chebyshev UCL	5.801
1046												
1047					**Gamma GOF Tests on Detected Observations Only**							
1048					A-D Test Statistic	0.573			**Anderson-Darling GOF Test**			
1049					5% A-D Critical Value	0.747			Detected data appear Gamma Distributed at 5% Significance Level			
1050					K-S Test Statistic	0.25			**Kolmogorov-Smirnov GOF**			
1051					5% K-S Critical Value	0.224			Detected Data Not Gamma Distributed at 5% Significance Level			
1052					**Detected data follow Appr. Gamma Distribution at 5% Significance Level**							
1053												
1054					**Gamma Statistics on Detected Data Only**							
1055					k hat (MLE)	2.023					k star (bias corrected MLE)	1.663
1056					Theta hat (MLE)	1.099					Theta star (bias corrected MLE)	1.337
1057					nu hat (MLE)	60.7					nu star (bias corrected)	49.89
1058					Mean (detects)	2.223						
1059												
1060					**Gamma ROS Statistics using Imputed Non-Detects**							
1061					GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs							
1062					GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)							
1063					For such situations, GROS method may yield incorrect values of UCLs and BTVs							
1064					This is especially true when the sample size is small.							
1065					For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates							
1066					Minimum	0.33					Mean	2.128
1067					Maximum	5.7					Median	2.2
1068					SD	1.467					CV	0.69
1069					k hat (MLE)	1.941					k star (bias corrected MLE)	1.619
1070					Theta hat (MLE)	1.096					Theta star (bias corrected MLE)	1.315
1071					nu hat (MLE)	62.1					nu star (bias corrected)	51.79
1072					Adjusted Level of Significance (β)	0.0335						
1073					Approximate Chi Square Value (51.79, α)	36.26					Adjusted Chi Square Value (51.79, β)	34.79
1074					95% Gamma Approximate UCL (use when n>=50)	3.039					95% Gamma Adjusted UCL (use when n<50)	3.168
1075												
1076					**Estimates of Gamma Parameters using KM Estimates**							
1077					Mean (KM)	2.123					SD (KM)	1.427
1078					Variance (KM)	2.037					SE of Mean (KM)	0.37
1079					k hat (KM)	2.212					k star (KM)	1.839
1080					nu hat (KM)	70.8					nu star (KM)	58.85

1081					theta hat (KM)	0.959					theta star (KM)	1.154
1082					80% gamma percentile (KM)	3.209					90% gamma percentile (KM)	4.211
1083					95% gamma percentile (KM)	5.171					99% gamma percentile (KM)	7.312
1084												
1085					**Gamma Kaplan-Meier (KM) Statistics**							
1086					Approximate Chi Square Value (58.85, α)	42.22					Adjusted Chi Square Value (58.85, β)	40.61
1087					95% Gamma Approximate KM-UCL (use when n>=50)	2.959					95% Gamma Adjusted KM-UCL (use when n<50)	3.076
1088												
1089					**Lognormal GOF Test on Detected Observations Only**							
1090					Shapiro Wilk Test Statistic	0.905					**Shapiro Wilk GOF Test**	
1091					5% Shapiro Wilk Critical Value	0.881					Detected Data appear Lognormal at 5% Significance Level	
1092					Lilliefors Test Statistic	0.257					**Lilliefors GOF Test**	
1093					5% Lilliefors Critical Value	0.22					Detected Data Not Lognormal at 5% Significance Level	
1094					**Detected Data appear Approximate Lognormal at 5% Significance Level**							
1095												
1096					**Lognormal ROS Statistics Using Imputed Non-Detects**							
1097					Mean in Original Scale	2.124					Mean in Log Scale	0.471
1098					SD in Original Scale	1.471					SD in Log Scale	0.844
1099					95% t UCL (assumes normality of ROS data)	2.769					95% Percentile Bootstrap UCL	2.759
1100					95% BCA Bootstrap UCL	2.792					95% Bootstrap t UCL	2.844
1101					95% H-UCL (Log ROS)	3.92						
1102												
1103					**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**							
1104					KM Mean (logged)	0.462					KM Geo Mean	1.588
1105					KM SD (logged)	0.835					95% Critical H Value (KM-Log)	2.46
1106					KM Standard Error of Mean (logged)	0.218					95% H-UCL (KM -Log)	3.821
1107					KM SD (logged)	0.835					95% Critical H Value (KM-Log)	2.46
1108					KM Standard Error of Mean (logged)	0.218						
1109												
1110					**DL/2 Statistics**							
1111					**DL/2 Normal**						**DL/2 Log-Transformed**	
1112					Mean in Original Scale	2.115					Mean in Log Scale	0.454
1113					SD in Original Scale	1.481					SD in Log Scale	0.866
1114					95% t UCL (Assumes normality)	2.764					95% H-Stat UCL	4.01
1115					**DL/2 is not a recommended method, provided for comparisons and historical reasons**							
1116												
1117					**Nonparametric Distribution Free UCL Statistics**							
1118					**Detected Data appear Normal Distributed at 5% Significance Level**							
1119												
1120					**Suggested UCL to Use**							
1121					95% KM (t) UCL	2.771						
1122												
1123					Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.							
1124					Recommendations are based upon data size, data distribution, and skewness.							
1125					These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).							
1126					However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.							
1127												
1128	**Thallium**											
1129												
1130					**General Statistics**							
1131					Total Number of Observations	16					Number of Distinct Observations	9
1132					Number of Detects	1					Number of Non-Detects	15
1133					Number of Distinct Detects	1					Number of Distinct Non-Detects	8
1134												

	A	B	C	D	E	F	G	H	I	J	K	L
1135	**Warning: Only one distinct data value was detected! ProUCL (or any other software) should not be used on such a data set!**											
1136	**It is suggested to use alternative site specific values determined by the Project Team to estimate environmental parameters (e.g., EPC, BTV).**											
1137												
1138	**The data set for variable Thallium was not processed!**											
1139												
1140												
1141	**Thorium**											
1142												
1143	**General Statistics**											
1144						Total Number of Observations	16			Number of Distinct Observations	13	
1145						Number of Detects	14			Number of Non-Detects	2	
1146						Number of Distinct Detects	12			Number of Distinct Non-Detects	2	
1147						Minimum Detect	0.0077			Minimum Non-Detect	0.019	
1148						Maximum Detect	0.024			Maximum Non-Detect	0.02	
1149						Variance Detects	2.4615E-5			Percent Non-Detects	12.5%	
1150						Mean Detects	0.0138			SD Detects	0.00496	
1151						Median Detects	0.0125			CV Detects	0.36	
1152						Skewness Detects	0.517			Kurtosis Detects	-0.526	
1153						Mean of Logged Detects	-4.347			SD of Logged Detects	0.364	
1154												
1155	**Normal GOF Test on Detects Only**											
1156						Shapiro Wilk Test Statistic	0.931		**Shapiro Wilk GOF Test**			
1157						5% Shapiro Wilk Critical Value	0.874		Detected Data appear Normal at 5% Significance Level			
1158						Lilliefors Test Statistic	0.14		**Lilliefors GOF Test**			
1159						5% Lilliefors Critical Value	0.226		Detected Data appear Normal at 5% Significance Level			
1160	**Detected Data appear Normal at 5% Significance Level**											
1161												
1162	**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**											
1163						KM Mean	0.0136			KM Standard Error of Mean	0.00127	
1164						KM SD	0.00469			95% KM (BCA) UCL	0.0156	
1165						95% KM (t) UCL	0.0159			95% KM (Percentile Bootstrap) UCL	0.0158	
1166						95% KM (z) UCL	0.0157			95% KM Bootstrap t UCL	0.016	
1167						90% KM Chebyshev UCL	0.0175			95% KM Chebyshev UCL	0.0192	
1168						97.5% KM Chebyshev UCL	0.0216			99% KM Chebyshev UCL	0.0263	
1169												
1170	**Gamma GOF Tests on Detected Observations Only**											
1171						A-D Test Statistic	0.359		**Anderson-Darling GOF Test**			
1172						5% A-D Critical Value	0.736		Detected data appear Gamma Distributed at 5% Significance Level			
1173						K-S Test Statistic	0.141		**Kolmogorov-Smirnov GOF**			
1174						5% K-S Critical Value	0.229		Detected data appear Gamma Distributed at 5% Significance Level			
1175	**Detected data appear Gamma Distributed at 5% Significance Level**											
1176												
1177	**Gamma Statistics on Detected Data Only**											
1178						k hat (MLE)	8.376			k star (bias corrected MLE)	6.629	
1179						Theta hat (MLE)	0.00164			Theta star (bias corrected MLE)	0.00208	
1180						nu hat (MLE)	234.5			nu star (bias corrected)	185.6	
1181						Mean (detects)	0.0138					
1182												
1183	**Gamma ROS Statistics using Imputed Non-Detects**											
1184	GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs											
1185	GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)											
1186	For such situations, GROS method may yield incorrect values of UCLs and BTVs											
1187	This is especially true when the sample size is small.											
1188	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates											

1189					Minimum	0.0077					Mean	0.0136
1190					Maximum	0.024					Median	0.0125
1191					SD	0.00464					CV	0.341
1192					k hat (MLE)	9.458					k star (bias corrected MLE)	7.726
1193					Theta hat (MLE)	0.00144					Theta star (bias corrected MLE)	0.00176
1194					nu hat (MLE)	302.6					nu star (bias corrected)	247.2
1195					Adjusted Level of Significance (β)	0.0335						
1196					Approximate Chi Square Value (247.23, α)	211.8					Adjusted Chi Square Value (247.23, β)	208.1
1197					95% Gamma Approximate UCL (use when n>=50)	0.0159					95% Gamma Adjusted UCL (use when n<50)	0.0162
1198												
1199					**Estimates of Gamma Parameters using KM Estimates**							
1200					Mean (KM)	0.0136					SD (KM)	0.00469
1201					Variance (KM)	2.1991E-5					SE of Mean (KM)	0.00127
1202					k hat (KM)	8.451					k star (KM)	6.908
1203					nu hat (KM)	270.4					nu star (KM)	221.1
1204					theta hat (KM)	0.00161					theta star (KM)	0.00197
1205					80% gamma percentile (KM)	0.0177					90% gamma percentile (KM)	0.0206
1206					95% gamma percentile (KM)	0.0231					99% gamma percentile (KM)	0.0285
1207												
1208					**Gamma Kaplan-Meier (KM) Statistics**							
1209					Approximate Chi Square Value (221.05, α)	187.6					Adjusted Chi Square Value (221.05, β)	184.1
1210					95% Gamma Approximate KM-UCL (use when n>=50)	0.0161					95% Gamma Adjusted KM-UCL (use when n<50)	0.0164
1211												
1212					**Lognormal GOF Test on Detected Observations Only**							
1213					Shapiro Wilk Test Statistic	0.942					**Shapiro Wilk GOF Test**	
1214					5% Shapiro Wilk Critical Value	0.874					Detected Data appear Lognormal at 5% Significance Level	
1215					Lilliefors Test Statistic	0.148					**Lilliefors GOF Test**	
1216					5% Lilliefors Critical Value	0.226					Detected Data appear Lognormal at 5% Significance Level	
1217					**Detected Data appear Lognormal at 5% Significance Level**							
1218												
1219					**Lognormal ROS Statistics Using Imputed Non-Detects**							
1220					Mean in Original Scale	0.0136					Mean in Log Scale	-4.354
1221					SD in Original Scale	0.00465					SD in Log Scale	0.34
1222					95% t UCL (assumes normality of ROS data)	0.0156					95% Percentile Bootstrap UCL	0.0155
1223					95% BCA Bootstrap UCL	0.0156					95% Bootstrap t UCL	0.0159
1224					95% H-UCL (Log ROS)	0.0161						
1225												
1226					**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**							
1227					KM Mean (logged)	-4.355					KM Geo Mean	0.0128
1228					KM SD (logged)	0.347					95% Critical H Value (KM-Log)	1.909
1229					KM Standard Error of Mean (logged)	0.0951					95% H-UCL (KM -Log)	0.0162
1230					KM SD (logged)	0.347					95% Critical H Value (KM-Log)	1.909
1231					KM Standard Error of Mean (logged)	0.0951						
1232												
1233					**DL/2 Statistics**							
1234					**DL/2 Normal**						**DL/2 Log-Transformed**	
1235					Mean in Original Scale	0.0133					Mean in Log Scale	-4.382
1236					SD in Original Scale	0.00482					SD in Log Scale	0.353
1237					95% t UCL (Assumes normality)	0.0154					95% H-Stat UCL	0.0158
1238					**DL/2 is not a recommended method, provided for comparisons and historical reasons**							
1239												
1240					**Nonparametric Distribution Free UCL Statistics**							
1241					**Detected Data appear Normal Distributed at 5% Significance Level**							
1242												

	A	B	C	D	E	F	G	H	I	J	K	L
1243	**Suggested UCL to Use**											
1244					95% KM (t) UCL	0.0159						
1245												
1246	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
1247	Recommendations are based upon data size, data distribution, and skewness.											
1248	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
1249	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
1250												
1251												
1252	**Uranium**											
1253												
1254	**General Statistics**											
1255					Total Number of Observations	16			Number of Distinct Observations			15
1256									Number of Missing Observations			0
1257					Minimum	0.011			Mean			0.0786
1258					Maximum	0.36			Median			0.039
1259					SD	0.107			Std. Error of Mean			0.0266
1260					Coefficient of Variation	1.355			Skewness			2.315
1261												
1262	**Normal GOF Test**											
1263					Shapiro Wilk Test Statistic	0.586			**Shapiro Wilk GOF Test**			
1264					5% Shapiro Wilk Critical Value	0.887			Data Not Normal at 5% Significance Level			
1265					Lilliefors Test Statistic	0.356			**Lilliefors GOF Test**			
1266					5% Lilliefors Critical Value	0.213			Data Not Normal at 5% Significance Level			
1267	**Data Not Normal at 5% Significance Level**											
1268												
1269	**Assuming Normal Distribution**											
1270					**95% Normal UCL**				**95% UCLs (Adjusted for Skewness)**			
1271					95% Student's-t UCL	0.125			95% Adjusted-CLT UCL (Chen-1995)			0.139
1272									95% Modified-t UCL (Johnson-1978)			0.128
1273												
1274	**Gamma GOF Test**											
1275					A-D Test Statistic	1.381			**Anderson-Darling Gamma GOF Test**			
1276					5% A-D Critical Value	0.762			Data Not Gamma Distributed at 5% Significance Level			
1277					K-S Test Statistic	0.291			**Kolmogorov-Smirnov Gamma GOF Test**			
1278					5% K-S Critical Value	0.221			Data Not Gamma Distributed at 5% Significance Level			
1279	**Data Not Gamma Distributed at 5% Significance Level**											
1280												
1281	**Gamma Statistics**											
1282					k hat (MLE)	1.078			k star (bias corrected MLE)			0.918
1283					Theta hat (MLE)	0.0729			Theta star (bias corrected MLE)			0.0857
1284					nu hat (MLE)	34.5			nu star (bias corrected)			29.36
1285					MLE Mean (bias corrected)	0.0786			MLE Sd (bias corrected)			0.0821
1286									Approximate Chi Square Value (0.05)			17.99
1287					Adjusted Level of Significance	0.0335			Adjusted Chi Square Value			16.98
1288												
1289	**Assuming Gamma Distribution**											
1290					95% Approximate Gamma UCL (use when n>=50))	0.128			95% Adjusted Gamma UCL (use when n<50)			0.136
1291												
1292	**Lognormal GOF Test**											
1293					Shapiro Wilk Test Statistic	0.904			**Shapiro Wilk Lognormal GOF Test**			
1294					5% Shapiro Wilk Critical Value	0.887			Data appear Lognormal at 5% Significance Level			
1295					Lilliefors Test Statistic	0.217			**Lilliefors Lognormal GOF Test**			
1296					5% Lilliefors Critical Value	0.213			Data Not Lognormal at 5% Significance Level			

1297	**Data appear Approximate Lognormal at 5% Significance Level**											
1298												
1299	**Lognormal Statistics**											
1300					Minimum of Logged Data	-4.51			Mean of logged Data	-3.074		
1301					Maximum of Logged Data	-1.022			SD of logged Data	0.956		
1302												
1303	**Assuming Lognormal Distribution**											
1304					95% H-UCL	0.14			90% Chebyshev (MVUE) UCL	0.125		
1305					95% Chebyshev (MVUE) UCL	0.15			97.5% Chebyshev (MVUE) UCL	0.185		
1306					99% Chebyshev (MVUE) UCL	0.253						
1307												
1308	**Nonparametric Distribution Free UCL Statistics**											
1309	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
1310												
1311	**Nonparametric Distribution Free UCLs**											
1312					95% CLT UCL	0.122			95% Jackknife UCL	0.125		
1313					95% Standard Bootstrap UCL	0.12			95% Bootstrap-t UCL	0.263		
1314					95% Hall's Bootstrap UCL	0.348			95% Percentile Bootstrap UCL	0.121		
1315					95% BCA Bootstrap UCL	0.137						
1316					90% Chebyshev(Mean, Sd) UCL	0.159			95% Chebyshev(Mean, Sd) UCL	0.195		
1317					97.5% Chebyshev(Mean, Sd) UCL	0.245			99% Chebyshev(Mean, Sd) UCL	0.344		
1318												
1319	**Suggested UCL to Use**											
1320					95% H-UCL	0.14						
1321												
1322	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
1323	Recommendations are based upon data size, data distribution, and skewness.											
1324	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
1325	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
1326												
1327	**ProUCL computes and outputs H-statistic based UCLs for historical reasons only.**											
1328	**H-statistic often results in unstable (both high and low) values of UCL95 as shown in examples in the Technical Guide.**											
1329	**It is therefore recommended to avoid the use of H-statistic based 95% UCLs.**											
1330	**Use of nonparametric methods are preferred to compute UCL95 for skewed data sets which do not follow a gamma distribution.**											
1331												
1332	**Vanadium**											
1333												
1334	**General Statistics**											
1335					Total Number of Observations	16			Number of Distinct Observations	8		
1336					Number of Detects	2			Number of Non-Detects	14		
1337					Number of Distinct Detects	2			Number of Distinct Non-Detects	6		
1338					Minimum Detect	0.13			Minimum Non-Detect	0.45		
1339					Maximum Detect	0.14			Maximum Non-Detect	0.5		
1340					Variance Detects	5.0000E-5			Percent Non-Detects	87.5%		
1341					Mean Detects	0.135			SD Detects	0.00707		
1342					Median Detects	0.135			CV Detects	0.0524		
1343					Skewness Detects	N/A			Kurtosis Detects	N/A		
1344					Mean of Logged Detects	-2.003			SD of Logged Detects	0.0524		
1345												
1346	**Warning: Data set has only 2 Detected Values.**											
1347	**This is not enough to compute meaningful or reliable statistics and estimates.**											
1348												
1349												
1350	**Normal GOF Test on Detects Only**											

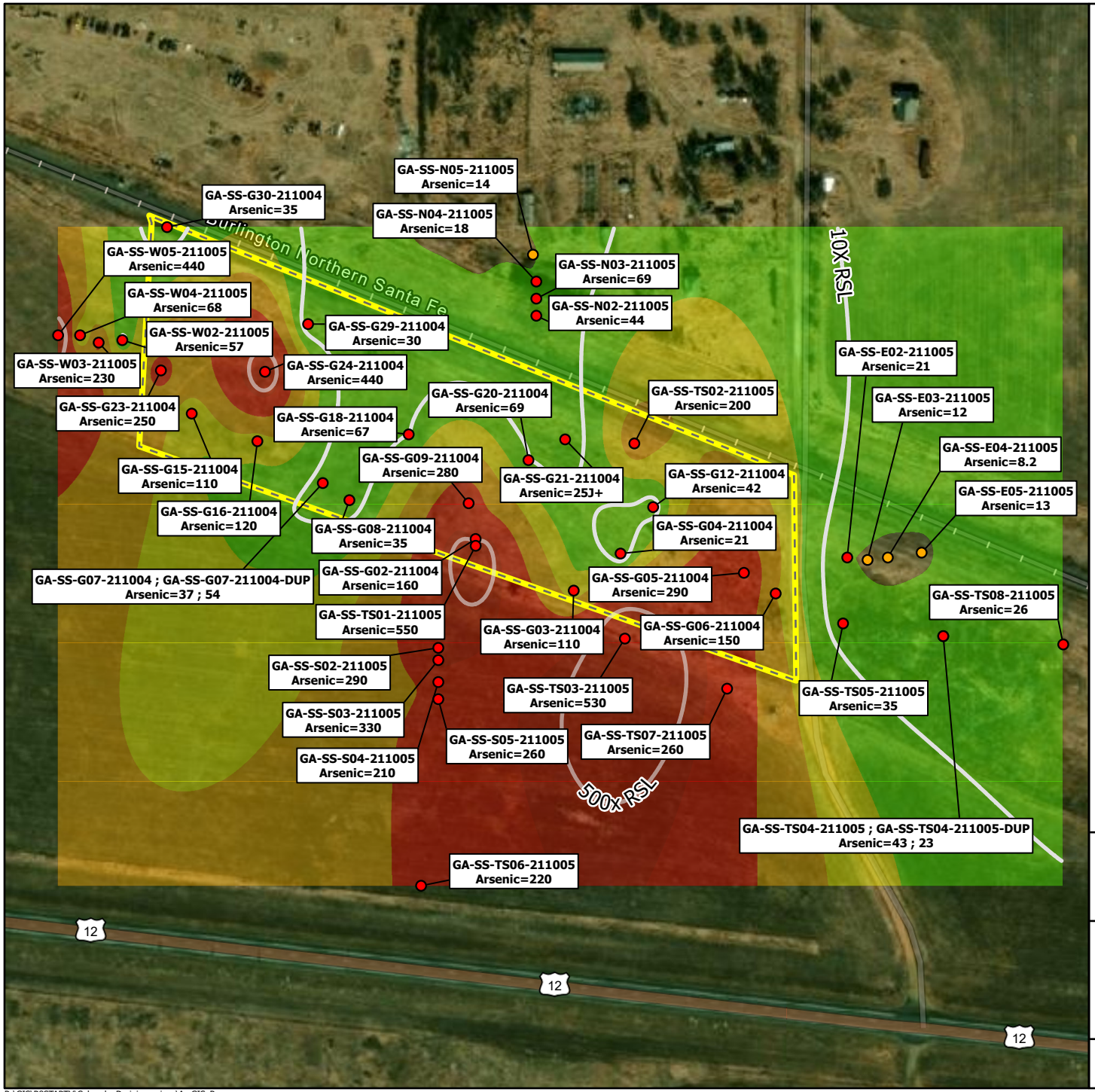
1351	**Not Enough Data to Perform GOF Test**											
1352												
1353	**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**											
1354					KM Mean	0.135			KM Standard Error of Mean	0.005		
1355					KM SD	0.005			95% KM (BCA) UCL	N/A		
1356					95% KM (t) UCL	0.144			95% KM (Percentile Bootstrap) UCL	N/A		
1357					95% KM (z) UCL	0.143			95% KM Bootstrap t UCL	N/A		
1358					90% KM Chebyshev UCL	0.15			95% KM Chebyshev UCL	0.157		
1359					97.5% KM Chebyshev UCL	0.166			99% KM Chebyshev UCL	0.185		
1360												
1361	**Gamma GOF Tests on Detected Observations Only**											
1362	**Not Enough Data to Perform GOF Test**											
1363												
1364	**Gamma Statistics on Detected Data Only**											
1365					k hat (MLE)	728.7			k star (bias corrected MLE)	N/A		
1366					Theta hat (MLE)	1.8527E-4			Theta star (bias corrected MLE)	N/A		
1367					nu hat (MLE)	2915			nu star (bias corrected)	N/A		
1368					Mean (detects)	0.135						
1369												
1370	**Estimates of Gamma Parameters using KM Estimates**											
1371					Mean (KM)	0.135			SD (KM)	0.005		
1372					Variance (KM)	2.5000E-5			SE of Mean (KM)	0.005		
1373					k hat (KM)	729			k star (KM)	592.4		
1374					nu hat (KM)	23328			nu star (KM)	18955		
1375					theta hat (KM)	1.8519E-4			theta star (KM)	2.2790E-4		
1376					80% gamma percentile (KM)	0.14			90% gamma percentile (KM)	0.142		
1377					95% gamma percentile (KM)	0.144			99% gamma percentile (KM)	0.148		
1378												
1379	**Gamma Kaplan-Meier (KM) Statistics**											
1380									Adjusted Level of Significance (β)	0.0335		
1381					Approximate Chi Square Value (N/A, α)	18636			Adjusted Chi Square Value (N/A, β)	18600		
1382					95% Gamma Approximate KM-UCL (use when n>=50)	0.137			95% Gamma Adjusted KM-UCL (use when n<50)	0.138		
1383												
1384	**Lognormal GOF Test on Detected Observations Only**											
1385	**Not Enough Data to Perform GOF Test**											
1386												
1387	**Lognormal ROS Statistics Using Imputed Non-Detects**											
1388					Mean in Original Scale	0.135			Mean in Log Scale	-2.003		
1389					SD in Original Scale	0.00632			SD in Log Scale	0.0468		
1390					95% t UCL (assumes normality of ROS data)	0.138			95% Percentile Bootstrap UCL	0.138		
1391					95% BCA Bootstrap UCL	0.137			95% Bootstrap t UCL	0.138		
1392					95% H-UCL (Log ROS)	N/A						
1393												
1394	**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**											
1395					KM Mean (logged)	-2.003			KM Geo Mean	0.135		
1396					KM SD (logged)	0.0371			95% Critical H Value (KM-Log)	N/A		
1397					KM Standard Error of Mean (logged)	0.0371			95% H-UCL (KM -Log)	N/A		
1398					KM SD (logged)	0.0371			95% Critical H Value (KM-Log)	N/A		
1399					KM Standard Error of Mean (logged)	0.0371						
1400												
1401	**DL/2 Statistics**											
1402	**DL/2 Normal**								**DL/2 Log-Transformed**			
1403					Mean in Original Scale	0.227			Mean in Log Scale	-1.5		
1404					SD in Original Scale	0.0366			SD in Log Scale	0.199		

1405				95% t UCL (Assumes normality)		0.243					95% H-Stat UCL	0.25
1406	**DL/2 is not a recommended method, provided for comparisons and historical reasons**											
1407												
1408	**Nonparametric Distribution Free UCL Statistics**											
1409	**Data do not follow a Discernible Distribution at 5% Significance Level**											
1410												
1411	**Suggested UCL to Use**											
1412				95% KM (t) UCL		0.144					KM H-UCL	N/A
1413				95% KM (BCA) UCL		N/A						
1414	**Warning: One or more Recommended UCL(s) not available!**											
1415	**Warning: Recommended UCL exceeds the maximum observation**											
1416												
1417	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
1418	Recommendations are based upon data size, data distribution, and skewness.											
1419	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
1420	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
1421												
1422												
1423	**Zinc**											
1424												
1425	**General Statistics**											
1426				Total Number of Observations		16					Number of Distinct Observations	16
1427											Number of Missing Observations	0
1428				Minimum		4.9					Mean	8.406
1429				Maximum		17					Median	7.5
1430				SD		3.299					Std. Error of Mean	0.825
1431				Coefficient of Variation		0.392					Skewness	1.397
1432												
1433	**Normal GOF Test**											
1434				Shapiro Wilk Test Statistic		0.864					**Shapiro Wilk GOF Test**	
1435				5% Shapiro Wilk Critical Value		0.887					Data Not Normal at 5% Significance Level	
1436				Lilliefors Test Statistic		0.239					**Lilliefors GOF Test**	
1437				5% Lilliefors Critical Value		0.213					Data Not Normal at 5% Significance Level	
1438	**Data Not Normal at 5% Significance Level**											
1439												
1440	**Assuming Normal Distribution**											
1441				**95% Normal UCL**							**95% UCLs (Adjusted for Skewness)**	
1442				95% Student's-t UCL		9.852					95% Adjusted-CLT UCL (Chen-1995)	10.07
1443											95% Modified-t UCL (Johnson-1978)	9.9
1444												
1445	**Gamma GOF Test**											
1446				A-D Test Statistic		0.485					**Anderson-Darling Gamma GOF Test**	
1447				5% A-D Critical Value		0.74					Detected data appear Gamma Distributed at 5% Significance Level	
1448				K-S Test Statistic		0.191					**Kolmogorov-Smirnov Gamma GOF Test**	
1449				5% K-S Critical Value		0.215					Detected data appear Gamma Distributed at 5% Significance Level	
1450	**Detected data appear Gamma Distributed at 5% Significance Level**											
1451												
1452	**Gamma Statistics**											
1453				k hat (MLE)		8.238					k star (bias corrected MLE)	6.735
1454				Theta hat (MLE)		1.02					Theta star (bias corrected MLE)	1.248
1455				nu hat (MLE)		263.6					nu star (bias corrected)	215.5
1456				MLE Mean (bias corrected)		8.406					MLE Sd (bias corrected)	3.239
1457											Approximate Chi Square Value (0.05)	182.5
1458				Adjusted Level of Significance		0.0335					Adjusted Chi Square Value	179.1

1459												
1460	**Assuming Gamma Distribution**											
1461				95% Approximate Gamma UCL (use when n>=50)		9.925		95% Adjusted Gamma UCL (use when n<50)				10.12
1462												
1463	**Lognormal GOF Test**											
1464				Shapiro Wilk Test Statistic		0.946		**Shapiro Wilk Lognormal GOF Test**				
1465				5% Shapiro Wilk Critical Value		0.887		Data appear Lognormal at 5% Significance Level				
1466				Lilliefors Test Statistic		0.168		**Lilliefors Lognormal GOF Test**				
1467				5% Lilliefors Critical Value		0.213		Data appear Lognormal at 5% Significance Level				
1468	**Data appear Lognormal at 5% Significance Level**											
1469												
1470	**Lognormal Statistics**											
1471				Minimum of Logged Data		1.589		Mean of logged Data				2.067
1472				Maximum of Logged Data		2.833		SD of logged Data				0.352
1473												
1474	**Assuming Lognormal Distribution**											
1475				95% H-UCL		10		90% Chebyshev (MVUE) UCL				10.62
1476				95% Chebyshev (MVUE) UCL		11.64		97.5% Chebyshev (MVUE) UCL				13.05
1477				99% Chebyshev (MVUE) UCL		15.82						
1478												
1479	**Nonparametric Distribution Free UCL Statistics**											
1480	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
1481												
1482	**Nonparametric Distribution Free UCLs**											
1483				95% CLT UCL		9.763		95% Jackknife UCL				9.852
1484				95% Standard Bootstrap UCL		9.725		95% Bootstrap-t UCL				10.5
1485				95% Hall's Bootstrap UCL		10.56		95% Percentile Bootstrap UCL				9.775
1486				95% BCA Bootstrap UCL		10.19						
1487				90% Chebyshev(Mean, Sd) UCL		10.88		95% Chebyshev(Mean, Sd) UCL				12
1488				97.5% Chebyshev(Mean, Sd) UCL		13.56		99% Chebyshev(Mean, Sd) UCL				16.61
1489												
1490	**Suggested UCL to Use**											
1491				95% Adjusted Gamma UCL		10.12						
1492												
1493	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
1494	Recommendations are based upon data size, data distribution, and skewness.											
1495	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
1496	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
1497												

APPENDIX C

2D PLUME DIAGRAMS



Griffin Ashing Site

Griffin, Bowman County, North Dakota

Figure
Results- Soil Metals-Arsenic

Arsenic Sampling Points (CAS No. 7440-38-2)
- 0.68-<18 (Above EPA RSL, below Ecological Screening Level)
- >=18 (Above Ecological Screening Level and EPA RSL)

Approximate Site Boundary

Arsenic Contour

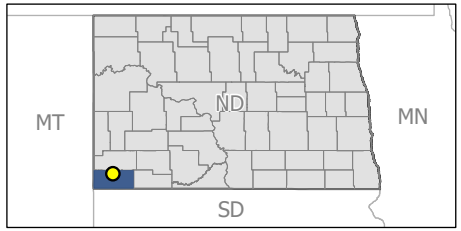
Arsenic Concentration VALUE
- 8-18 mg/kg
- 106 mg/kg
- 150 mg/kg
- 208 mg/kg
- 286 mg/kg
- 390 mg/kg
- 530 mg/kg

Analyte		Arsenic
CAS Number		7440-38-2
Project Action Limits	EPA RSL Residential Soil[a]	0.68
	Ecological Screening Levels[b]	18
	Background Threshold Value	5.5
	Units	mg/kg

Notes
All results and screening levels are in milligram per kilogram (mg/kg)
[a] EPA Regional Screening Levels for Residential Soils (RSL), using a target cancer rate of 1 in 1 million (1E-06) and target hazard quotient=1.0
[b] The lower of EPA Region 4 Ecological Soil Screening Levels (ESL) and toxicological benchmarks for effects on terrestrial plants

CAS: Chemical Abstract Service

0 125 250 500 Feet N



Spatial Reference: WGS 1984 Web Mercator Auxiliary Sphere Coordinate System

Source:
Background: ESRI World Imagery
Sample Locations: EPA Region 8 START V (Tetra Tech)

Prepared For:
US EPA Region 8
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Denver, CO

Prepared By:
Tetra Tech
1560 Broadway Ste 1400
Denver, CO

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Griffin Ashing Site

Griffin, Bowman County, North Dakota

Figure
Results- Soil Metals-Copper

Copper (CAS No. 7440-50-8)
- 0-<18 (Below Ecological Screening Level, below EPA RSL)
- 18-<3100 (Above Ecological Screening Level, below EPA RSL)
- >=3100 (Above Ecological Screening Level and EPA RSL)
- Approximate Site Boundary

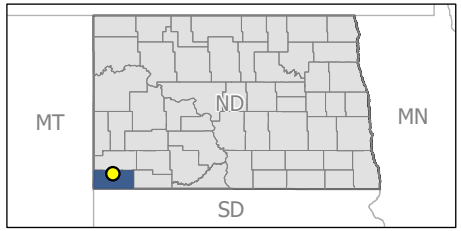
Copper Contour
Copper Concentration
VALUE
- 0.001 - 12.682 mg/kg
- 18 mg/kg
- 295 mg/kg
- 1,591 mg/kg
- 3,100 mg/kg

Analyte		Copper
CAS Number		7440-50-8
Project Action Limits	EPA RSL Residential Soil[a]	3,100
	Ecological Screening Levels[b]	28
	Background Threshold Value	21
	Units	mg/kg

Notes
All results and screening levels are in milligram per kilogram (mg/kg)
[a] EPA Regional Screening Levels for Residential Soils (RSL), using a target cancer rate of 1 in 1 million (1E-06) and target hazard quotient=1.0
[b] The lower of EPA Region 4 Ecological Soil Screening Levels (ESL) and toxicological benchmarks for effects on terrestrial plants

CAS: Chemical Abstract Service

0 125 250 500 Feet N



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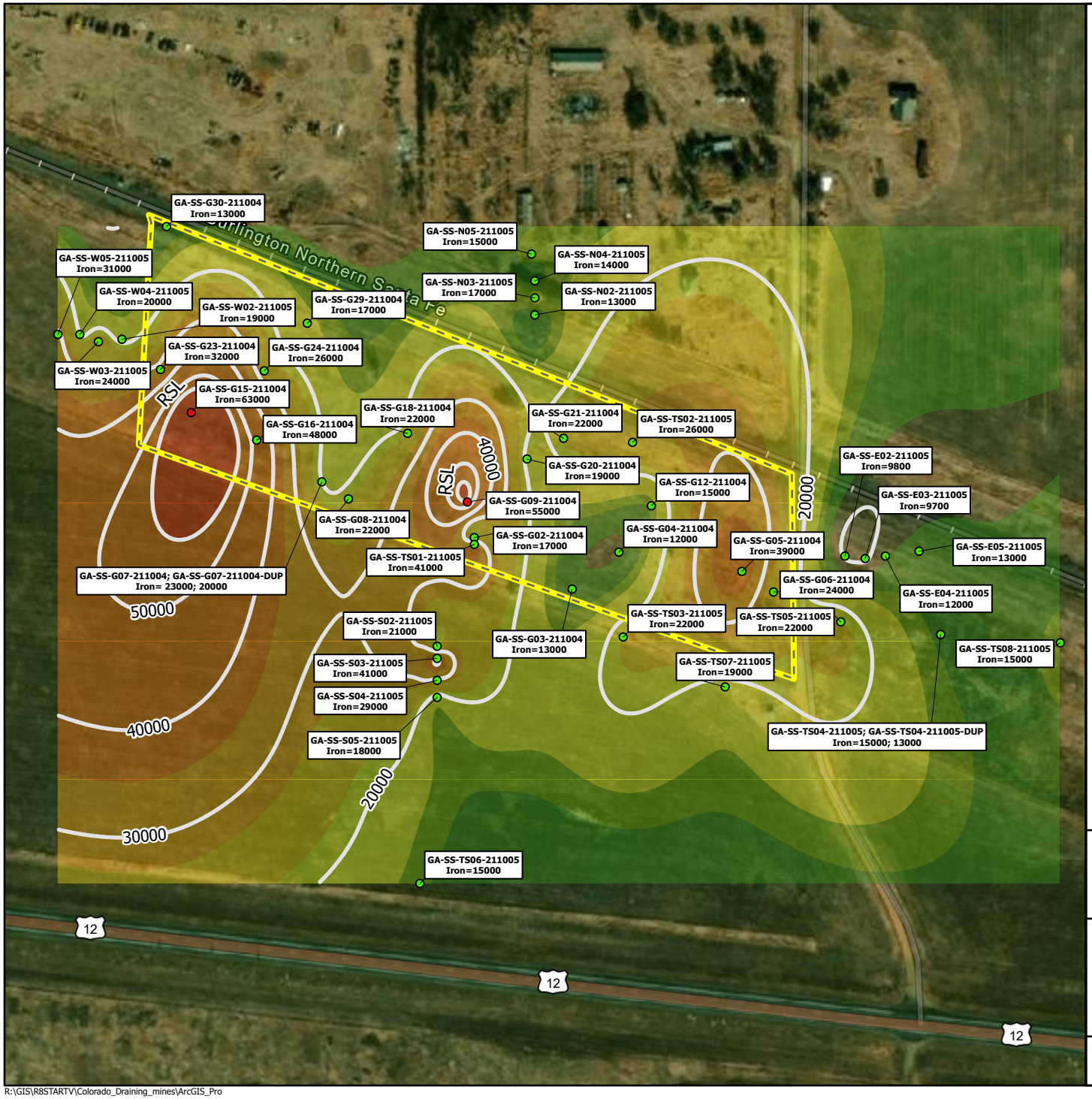


Griffin Ashing Site

Griffin, Bowman County, North Dakota

Figure
Results- Soil Metals-Iron

Soil Metals Sampling Locations

Iron (CAS No. 7439-89-6)
- < 55,000 (0-<18 (Below Ecological Screening Level, below EPA RSL)
- >=55,000 ((Above Ecological Screening Level and EPA RSL))

Approximate Site Boundary

Approximate Site Boundary

Iron Contour

Iron Concentration

VALUE
- 8,801.767 - 12,200
- 12,200.001 - 14,500
- 14,500.001 - 16,000
- 16,000.001 - 22,000
- 22,000.001 - 27,000
- 27,000.001 - 35,000
- 35,000.001 - 55,000
- 55,000.001 - 65,000

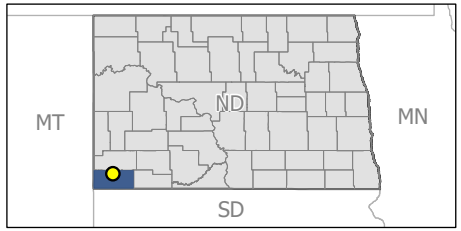
Analyte		Iron
CAS Number		7439-89-6
Project Action Limits	EPA RSL Residential Soil[a]	55,000
	Ecological Screening Levels[b]	NS
	Background Threshold Value	21000
	Units	mg/kg

Notes
All results and screening levels are in milligram per kilogram (mg/kg)
[a] EPA Regional Screening Levels for Residential Soils (RSL), using a target cancer rate of 1 in 1 million (1E-06) and target hazard quotient=1.0
[b] The lower of EPA Region 4 Ecological Soil Screening Levels (ESL) and toxicological benchmarks for effects on terrestrial plants

CAS: Chemical Abstract Service

0 125 250 500 Feet

N



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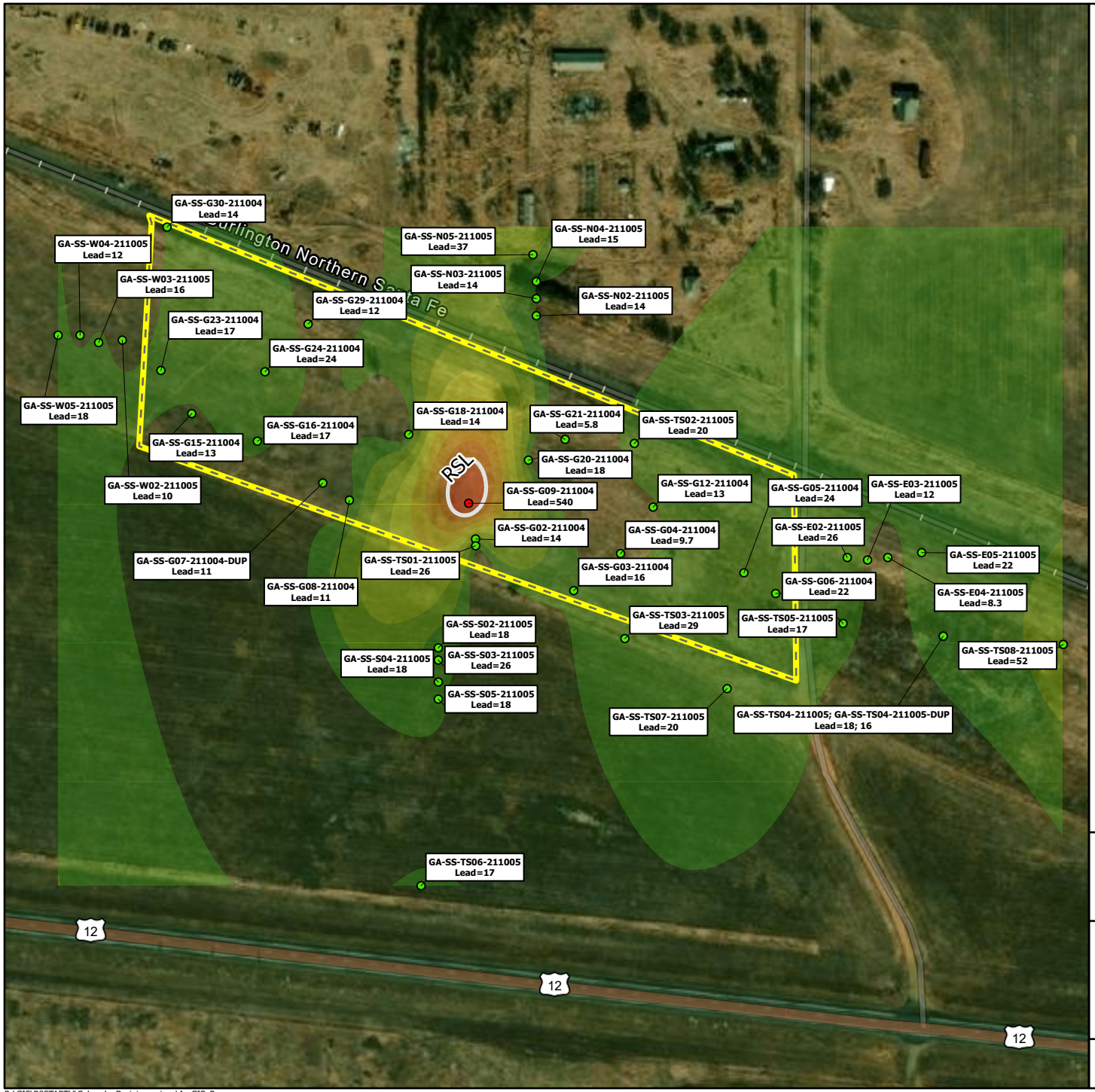


Griffin Ashing Site

Griffin, Bowman County, North Dakota

Figure
Results- Soil Metals-Lead

Lead (CAS No. 7439-92-1)
- <400 (Below Ecological Screening Level, below EPA RSL)
- >=400 (Above Ecological Screening Level and EPA RSL)
- Approximate Site Boundary
- Lead Contour

Lead Concentration

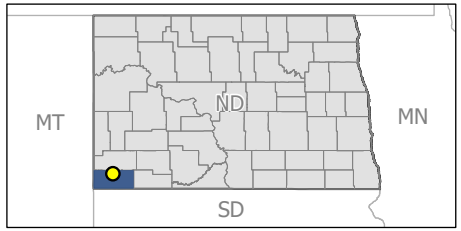
VALUE
- 10.723 - 14 mg/kg
- 34 mg/kg
- 68 mg/kg
- 116 mg/kg
- 177 mg/kg
- 246 mg/kg
- 325 mg/kg
- 415 mg/kg
- 533 mg/kg

Analyte		Lead
CAS Number		7439-92-1
Project Action Limits	EPA RSL Residential Soil[a]	400
	Ecological Screening Levels[b]	NS
	Background Threshold Value	17
	Units	mg/kg

Notes
All results and screening levels are in milligram per kilogram (mg/kg)
[a] EPA Regional Screening Levels for Residential Soils (RSL), using a target cancer rate of 1 in 1 million (1E-06) and target hazard quotient=1.0
[b] The lower of EPA Region 4 Ecological Soil Screening Levels (ESL) and toxicological benchmarks for effects on terrestrial plants

CAS: Chemical Abstract Service

0 125 250 500 Feet N



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Griffin Ashing Site

Griffin, Bowman County, North Dakota

Figure
Results- Soil Metals-Molybdenum

Molybdenum (CAS No. 7439-98-7)
- 2-390 (Above Ecological Screening Level, below EPA RSL)
- >=390 (Above Ecological Screening Level and EPA RSL)
- Approximate Site Boundary
- Molybdenum Contour

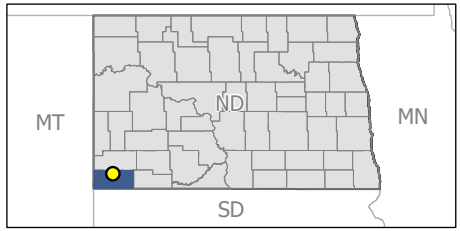
Molybdenum Concentration VALUE
- 0.001 - 2 mg/kg
- 91 mg/kg
- 143 mg/kg
- 190 mg/kg
- 245 mg/kg
- 300 mg/kg
- 400 mg/kg
- 500 mg/kg
- 625 mg/kg

Analyte		Molybdenum
CAS Number		7439-98-7
Project Action Limits	EPA RSL Residential Soil[a]	390
	Ecological Screening Levels[b]	2
	Background Threshold Value	0.85
	Units	mg/kg

Notes
All results and screening levels are in milligram per kilogram (mg/kg)
[a] EPA Regional Screening Levels for Residential Soils (RSL), using a target cancer rate of 1 in 1 million (1E-06) and target hazard quotient=1.0
[b] The lower of EPA Region 4 Ecological Soil Screening Levels (ESL) and toxicological benchmarks for effects on terrestrial plants

CAS: Chemical Abstract Service

0 125 250 500 Feet N



Spatial Reference: WGS 1984 Web Mercator Auxiliary Sphere Coordinate System

Source:
Background: ESRI World Imagery
Sample Locations: EPA Region 8 START V (Tetra Tech)

Prepared For:	Prepared By:
US EPA Region 8 1595 Wynkoop Street Denver, CO	Tetra Tech 1560 Broadway Ste 1400 Denver, CO

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2071-2108-05	68HE0820D0001	9/9/2022

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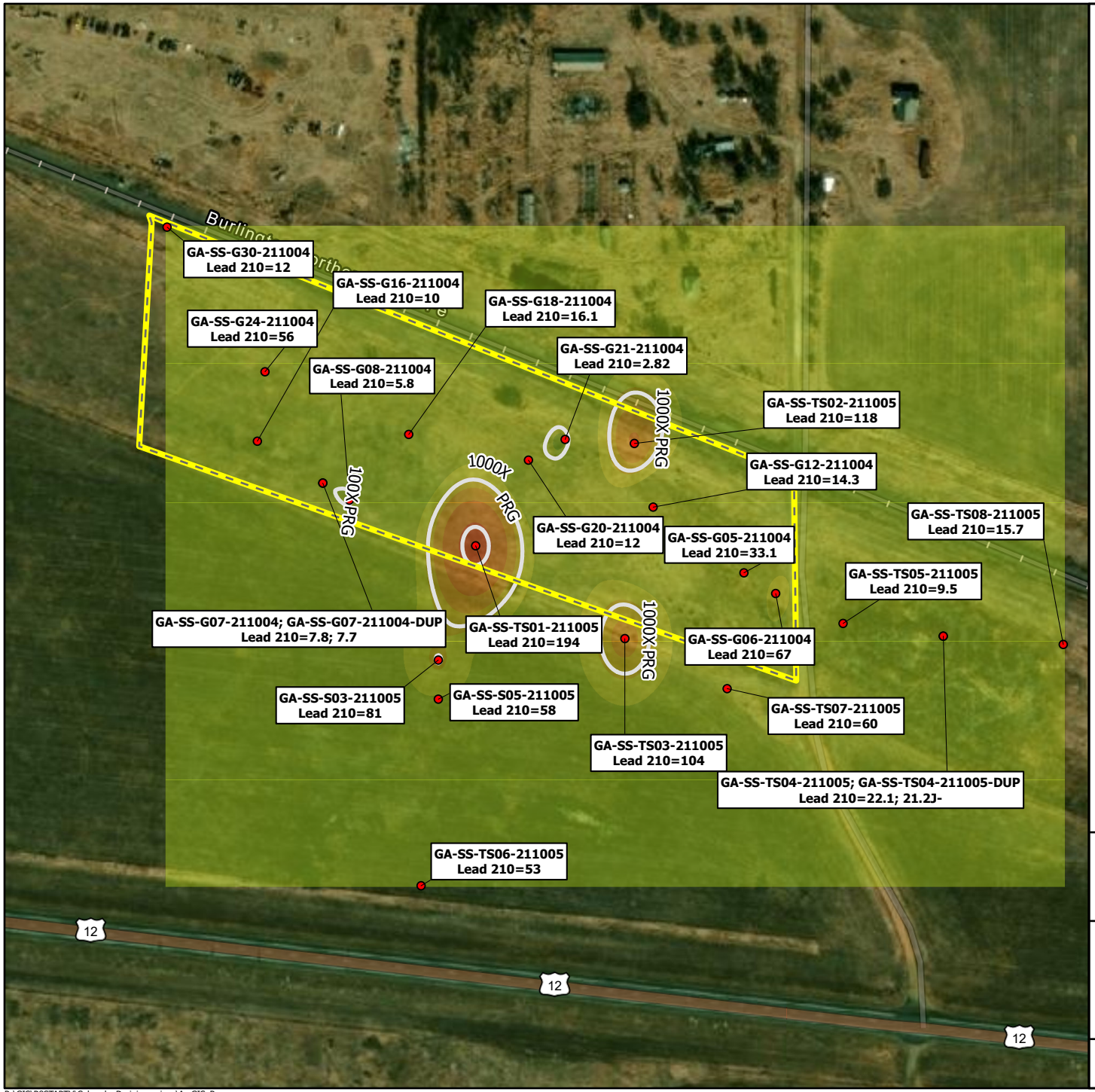

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Griffin Ashing Site

Griffin, Bowman County, North Dakota

Figure
Results- Soil Radiation- Lead-210

Lead 210
- >= .079 (Above PRG for Soil and Farmer Peak PRG)
- Approximate Site Boundary
- Lead 210 Contour

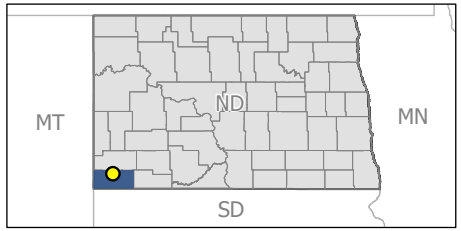
Lead 210 Radiation Concentration
VALUE
- 0.021222 pCi/g (Farmer Peak PRG for Soil)
- 0.078500 pCi/g (Farmer PRG for Soil)
- 5 pCi/g
- 60 pCi/g
- 75 pCi/g
- 90 pCi/g
- 110 pCi/g
- 150 pCi/g
- 200 pCi/g

Analyte		Lead-210
CAS Number		14255-04-0
Project Action Limits	Project Action Limit[a]	5
	Farmer PRG for Soil[b]	0.079
	Farmer Peak PRG for Soil[b]	0.018
	Background Threshold Value	--
	Units	pCi/g

Notes
All results and screening levels are in picocuries per gram (pCi/g)
[a] EPA Preliminary Remediation Goals for Radionuclide Contaminants at Superfund Sites" (PRG) for Farm Workers
[b] Peak Risk Interval PRG for Farm Workers

CAS: Chemical Abstract Service

0 125 250 500 Feet N



Spatial Reference: WGS 1984 Web Mercator Auxiliary Sphere Coordinate System

Source:
Background: ESRI World Imagery
Sample Locations: EPA Region 8 START V (Tetra Tech)

Prepared For:
US EPA Region 8
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Denver, CO

Prepared By:
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1560 Broadway Ste 1400
Denver, CO

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Date: 9/9/2022

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Griffin Ashing Site

Griffin, Bowman County, North Dakota

Figure
Results- Soil Radiation- Polonium-210

Polonium 210
>=0.88 (Above PRG for Soil and Farmer Peak PRG)
Approximate Site Boundary
Polonium Contour

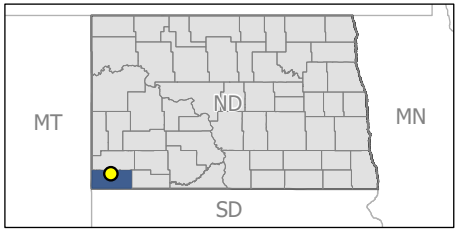
Polonium 210 Radiation Concentration
VALUE
0.022222 - 0.021222 pCi/g
0.878000 pCi/g
5 pCi/g
60 pCi/g
75 pCi/g
100 pCi/g
125 pCi/g
150 pCi/g
200 pCi/g

Analyte		Polonium-210
CAS Number		13981-52-7
Project Action Limits	Project Action Limit[a]	5
	Farmer PRG for Soil[a]	0.012
	Farmer Peak PRG for Soil[b]	0.88
	Background Threshold Value	--
	Units	pCi/g

Notes
All results and screening levels are in picocuries per gram (pCi/g)
[a] EPA Preliminary Remediation Goals for Radionuclide Contaminants at Superfund Sites" (PRG) for Farm Workers
[b] Peak Risk Interval PRG for Farm Workers

CAS: Chemical Abstract Service

0 125 250 500 Feet N



Spatial Reference: WGS 1984 Web Mercator Auxiliary Sphere Coordinate System

Source:
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Sample Locations: EPA Region 8 START V (Tetra Tech)

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Denver, CO

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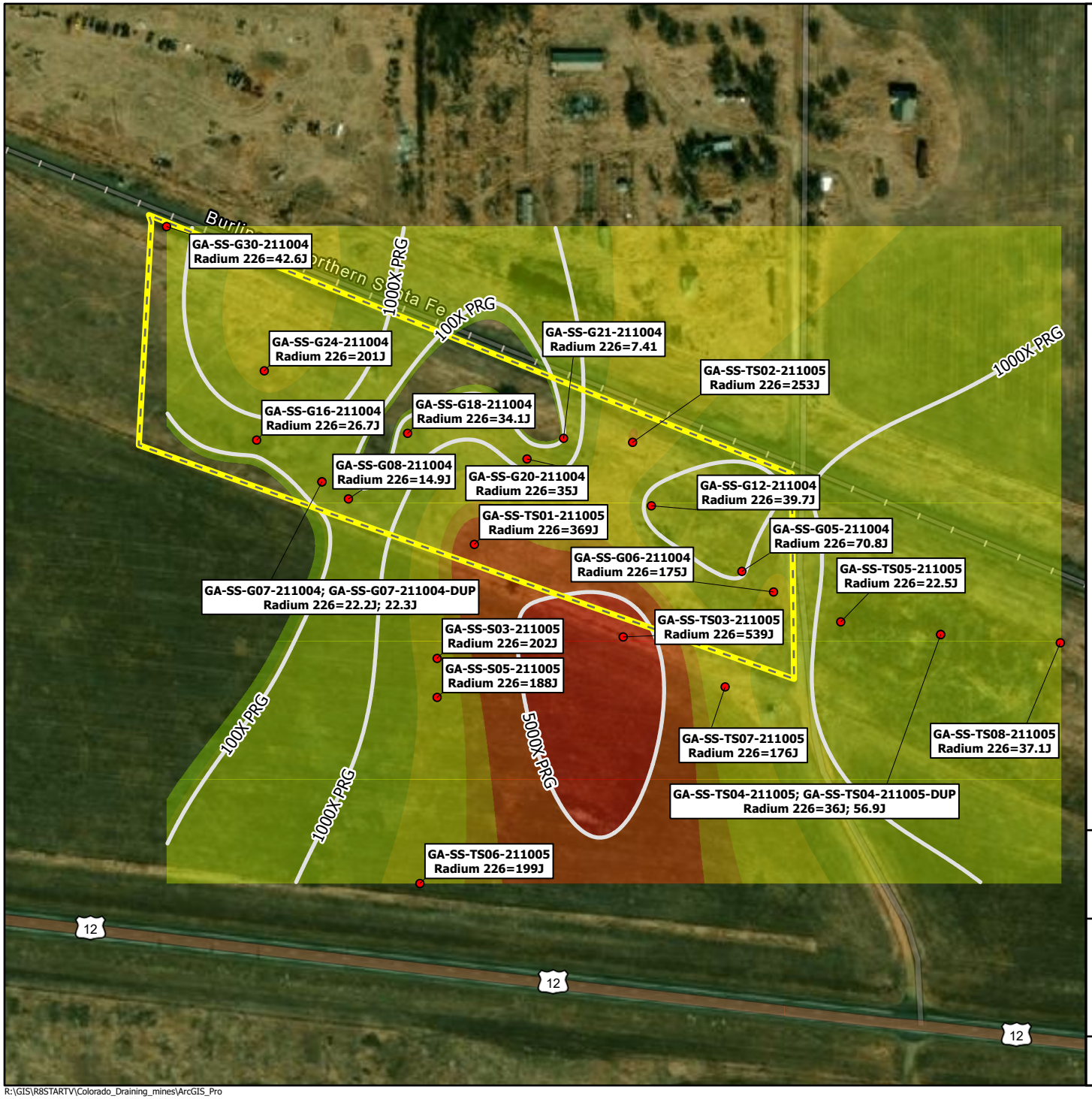

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Griffin Ashing Site

Griffin, Bowman County, North Dakota

Figure
Results- Soil Radiation- Radium-226

Radium 226
- >=.08 (Above PRG for Soil and Farmer Peak PRG)
- Approximate Site Boundary
- Radium 226 Contour

Radium 226 Radiation Concentration

VALUE
- -33.946 - 0.003 pCi/g
- 0.004 - 0.08 pCi/g
- 5 pCi/g
- 150 pCi/g
- 250 pCi/g
- 300 pCi/g
- 400 pCi/g
- 550 pCi/g

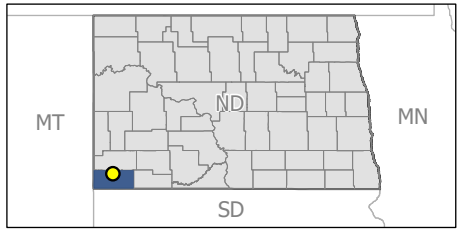
Analyte		Radium-226
CAS Number		13982-63-3
Project Action Limits	Project Action Limit[a]	5
	Farmer PRG for Soil[b]	0.080
	Farmer Peak PRG for Soil[b]	0.0033
	Background Threshold Value	1.4
	Units	pCi/g

Notes
All results and screening levels are in picocuries per gram (pCi/g)
[a] EPA Preliminary Remediation Goals for Radionuclide Contaminants at Superfund Sites" (PRG) for Farm Workers
[b] Peak Risk Interval PRG for Farm Workers

CAS: Chemical Abstract Service

0 125 250 500 Feet

N



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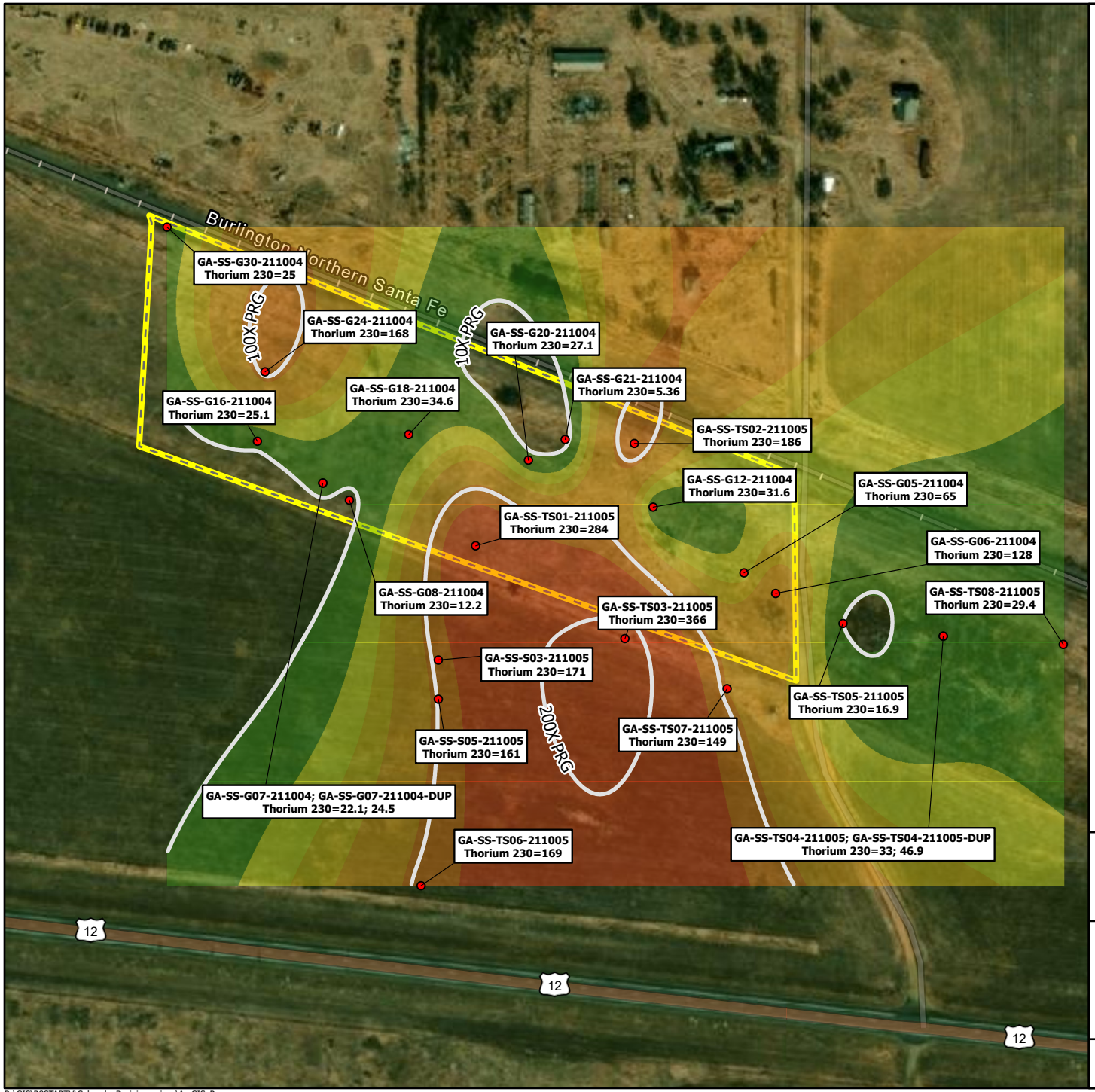


Griffin Ashing Site

Griffin, Bowman County, North Dakota

Figure
Results- Soil Radiation- Thorium-230

Thorium 230
- >=1.6 (Above PRG for Soil and Farmer Peak PRG)
- Approximate Site Boundary
- Thorium 230 Contour

Thorium 230 Radiation Concentration

VALUE
- -29.534 - 15.026 pCi/g
- 50 pCi/g
- 75 pCi/g
- 100 pCi/g
- 150 pCi/g
- 200 pCi/g
- 400 pCi/g

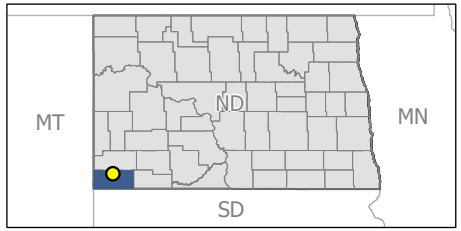
Analyte		Thorium-230
CAS Number		14269-63-7
Project Action Limits	Project Action Limit[a]	5
	Farmer PRG for Soil[b]	1.6
	Farmer Peak PRG for Soil[b]	0.0033
	Background Threshold Value	1.4
	Units	pCi/g

Notes
All results and screening levels are in picocuries per gram (pCi/g)
[a] EPA Preliminary Remediation Goals for Radionuclide Contaminants at Superfund Sites" (PRG) for Farm Workers
[b] Peak Risk Interval PRG for Farm Workers

CAS: Chemical Abstract Service

0 125 250 500 Feet

N



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Griffin Ashing Site

Griffin, Bowman County, North Dakota

Figure
Results- Soil Radiation- Uranium-234

Uranium 234
- >=1.5 (Above PRG for Soil and Farmer Peak PRG)
- Approximate Site Boundary
- Uranium 234 Contour

Uranium 234 Radiation Concentration

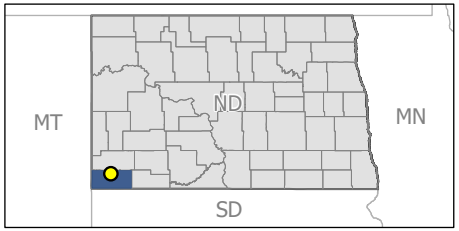
VALUE
- -33.946 - 0.005 pCi/g
- 1.5 pCi/g
- 5 pCi/g
- 50 pCi/g
- 75 pCi/g
- 90 pCi/g
- 125 pCi/g
- 200 pCi/g
- 400 pCi/g

Analyte		Uranium-234
CAS Number		13966-29-5
Project Action Limits	Project Action Limit[a]	5
	Farmer PRG for Soil[b]	1.5
	Farmer Peak PRG for Soil[b]	0.0052
	Background Threshold Value	--
	Units	pCi/g

Notes
All results and screening levels are in picocuries per gram (pCi/g)
[a] EPA Preliminary Remediation Goals for Radionuclide Contaminants at Superfund Sites" (PRG) for Farm Workers
[b] Peak Risk Interval PRG for Farm Workers

CAS: Chemical Abstract Service

0 125 250 500 Feet N



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US EPA Region 8
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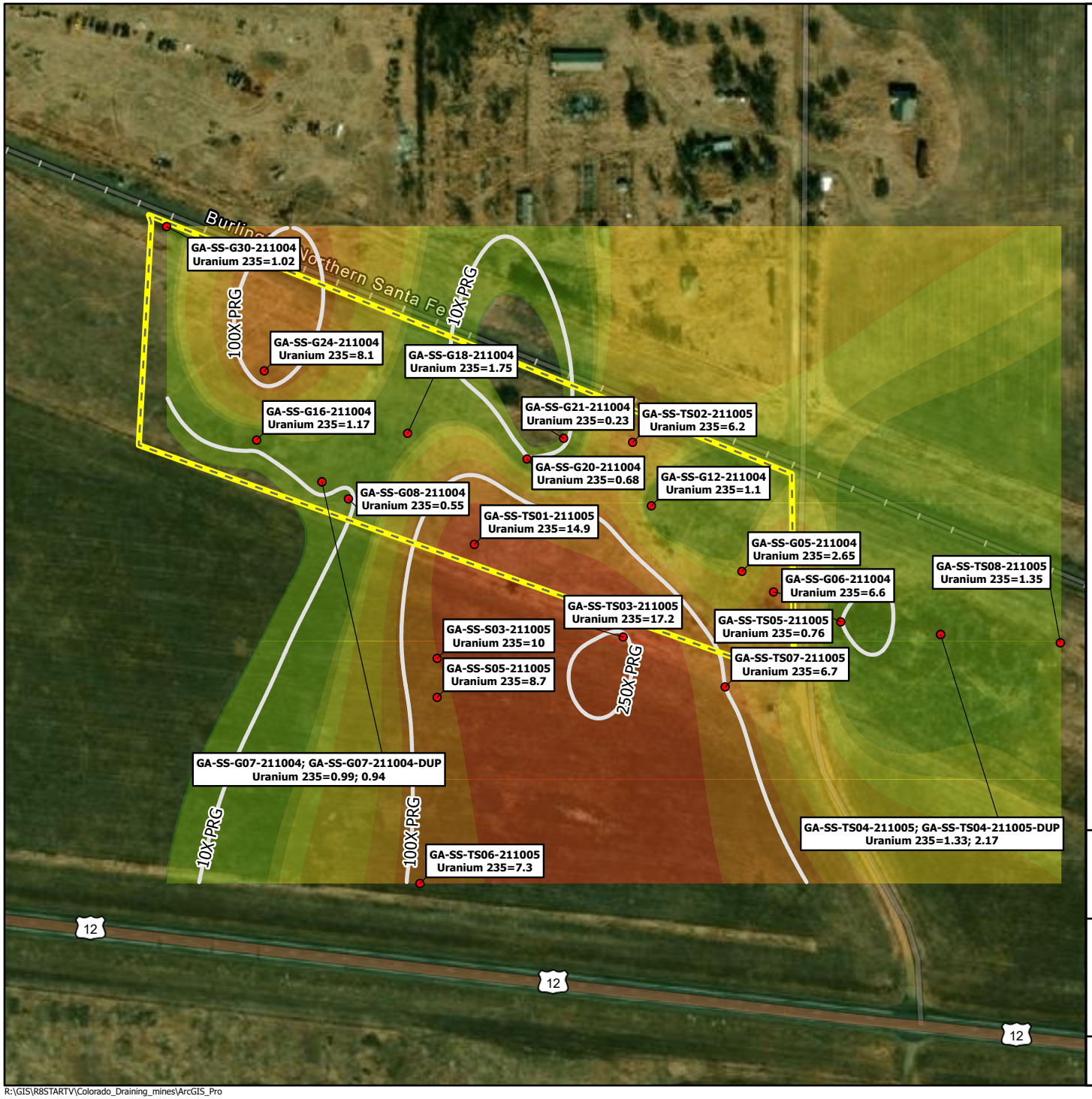


Griffin Ashing Site

Griffin, Bowman County, North Dakota

Figure
Results- Soil Radiation- Uranium-235

Uranium 235
>=.067 (Above PRG for Soil and Farmer Peak PRG)
Approximate Site Boundary
Uranium 234 Contour

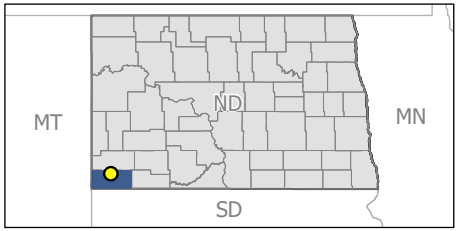
Uranium 234 Radiation Concentration
VALUE
-33.946 - 0.005 pCi/g
1.5 pCi/g
5 pCi/g
50 pCi/g
75 pCi/g
90 pCi/g
125 pCi/g
200 pCi/g
400 pCi/g

Analyte		Uranium-235
CAS Number		15117-96-1
Project Action Limits	Project Action Limit[a]	5
	Farmer PRG for Soil[b]	0.067
	Farmer Peak PRG for Soil[b]	0.014
	Background Threshold Value	--
	Units	pCi/g

Notes
All results and screening levels are in picocuries per gram (pCi/g)
[a] EPA Preliminary Remediation Goals for Radionuclide Contaminants at Superfund Sites" (PRG) for Farm Workers
[b] Peak Risk Interval PRG for Farm Workers

CAS: Chemical Abstract Service

0 125 250 500 Feet N



Spatial Reference: WGS 1984 Web Mercator Auxiliary Sphere Coordinate System

Source:
Background: ESRI World Imagery
Sample Locations: EPA Region 8 START V (Tetra Tech)

Prepared For:
US EPA Region 8
1595 Wynkoop Street
Denver, CO

Prepared By:
Tetra Tech
1560 Broadway Ste 1400
Denver, CO

TETRA TECH

TO/TD: 2071-2108-05
Contract: 68HE0820D0001
Date: 9/9/2022

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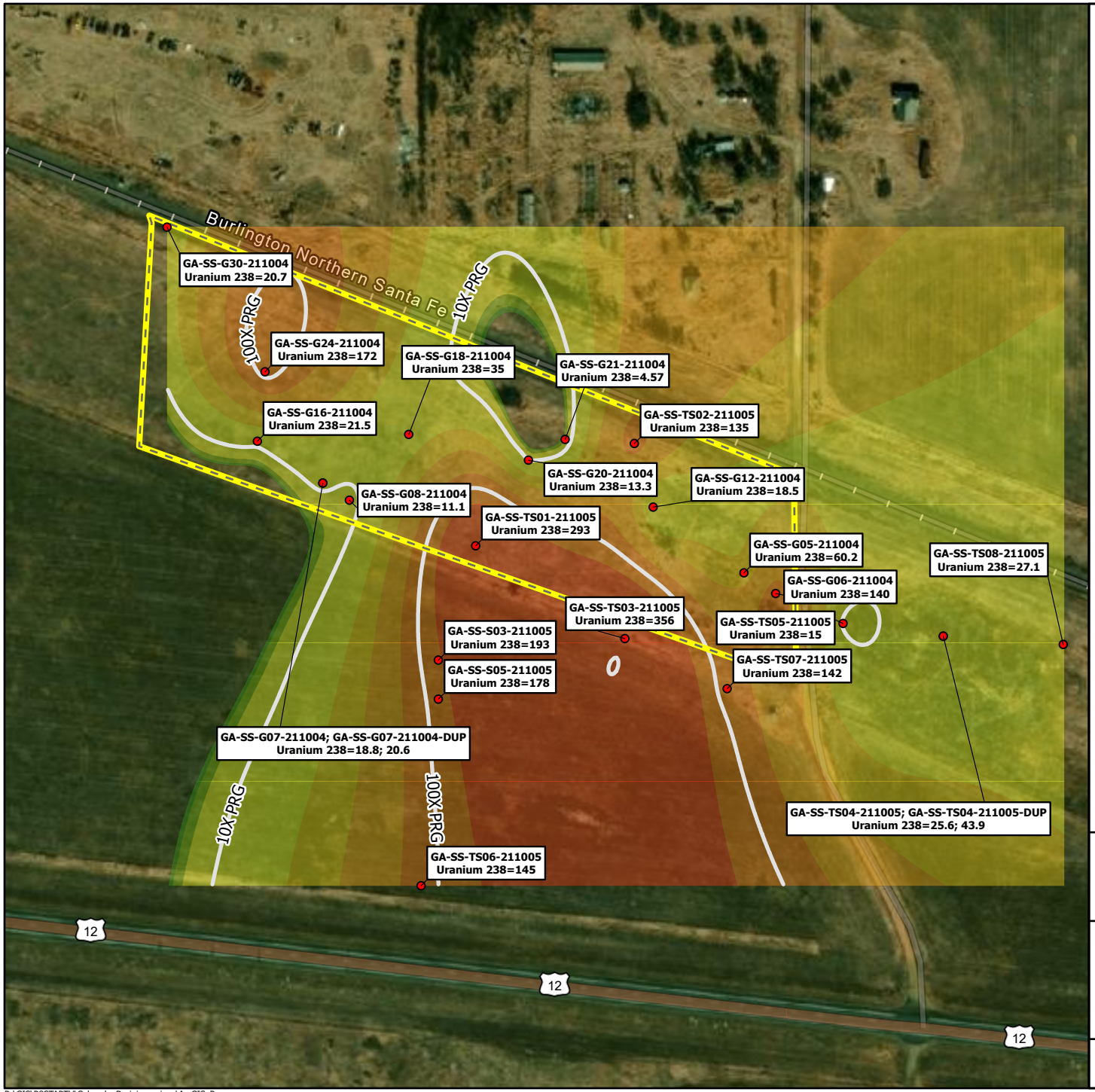


Griffin Ashing Site

Griffin, Bowman County, North Dakota

Figure
Results- Soil Radiation- Uranium-238

Uranium 238
- >=1.6 Above PRG for Soil and Farmer Peak PRG
- Approximate Site Boundary
- Uranium 238 Contour

Uranium 238 Radiation Concentration

VALUE
- -33.946 - 0.003 pCi/g
- 0.004 - 1.61 pCi/g
- 5 pCi/g
- 50 pCi/g
- 80 pCi/g
- 125 pCi/g
- 200 pCi/g
- 400 pCi/g

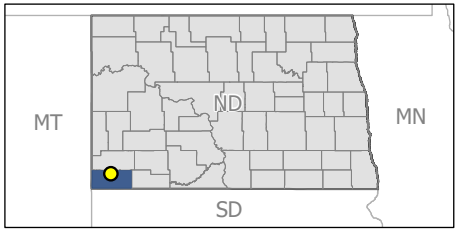
Analyte		Uranium-238
CAS Number		7440-61-1
Project Action Limits	Project Action Limit[a]	5
	Farmer PRG for Soil[b]	1.6
	Farmer Peak PRG for Soil[b]	0.0030
	Background Threshold Value	--
	Units	pCi/g

Notes
All results and screening levels are in picocuries per gram (pCi/g)
[a] EPA Preliminary Remediation Goals for Radionuclide Contaminants at Superfund Sites" (PRG) for Farm Workers
[b] Peak Risk Interval PRG for Farm Workers

CAS: Chemical Abstract Service

0 125 250 500 Feet

N



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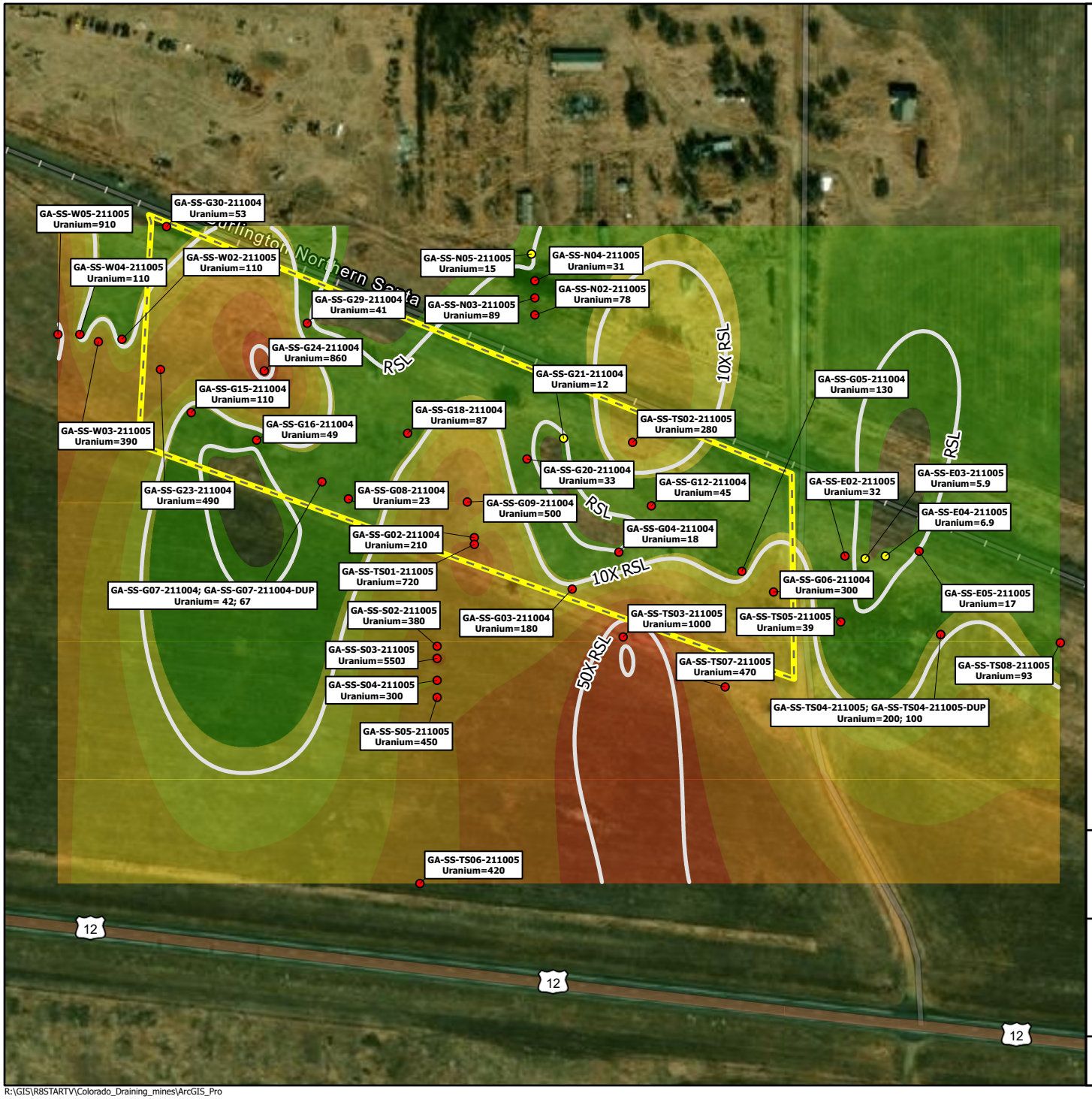

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Griffin Ashing Site

Griffin, Bowman County, North Dakota

Figure
Results- Soil Metals-Uranium

Uranium (CAS No. 7440-61-1)
- 5-<16 (Above Ecological Screening Level, below EPA RSL)
- >=16 (Above Ecological Screening Level and EPA RSL)
- Approximate Site Boundary
- Uranium Contour

Uranium Concentration

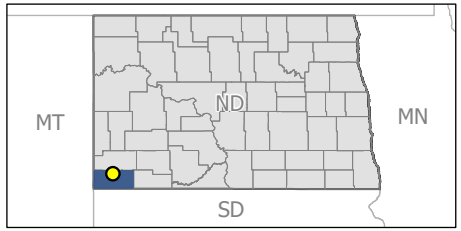
VALUE
- 0.001 - 5 mg/kg
- 16 mg/kg
- 138 mg/kg
- 216 mg/kg
- 329 mg/kg
- 490 mg/kg
- 721 mg/kg
- 1,052 mg/kg

Analyte		Uranium
CAS Number		7440-61-1
Project Action Limits	EPA RSL Residential Soil[a]	16
	Ecological Screening Levels[b]	5
	Background Threshold Value	1.5
	Units	mg/kg

Notes
All results and screening levels are in milligram per kilogram (mg/kg)
[a] EPA Regional Screening Levels for Residential Soils (RSL), using a target cancer rate of 1 in 1 million (1E-06) and target hazard quotient=1.0
[b] The lower of EPA Region 4 Ecological Soil Screening Levels (ESL) and toxicological benchmarks for effects on terrestrial plants

CAS: Chemical Abstract Service

0 125 250 500 Feet N



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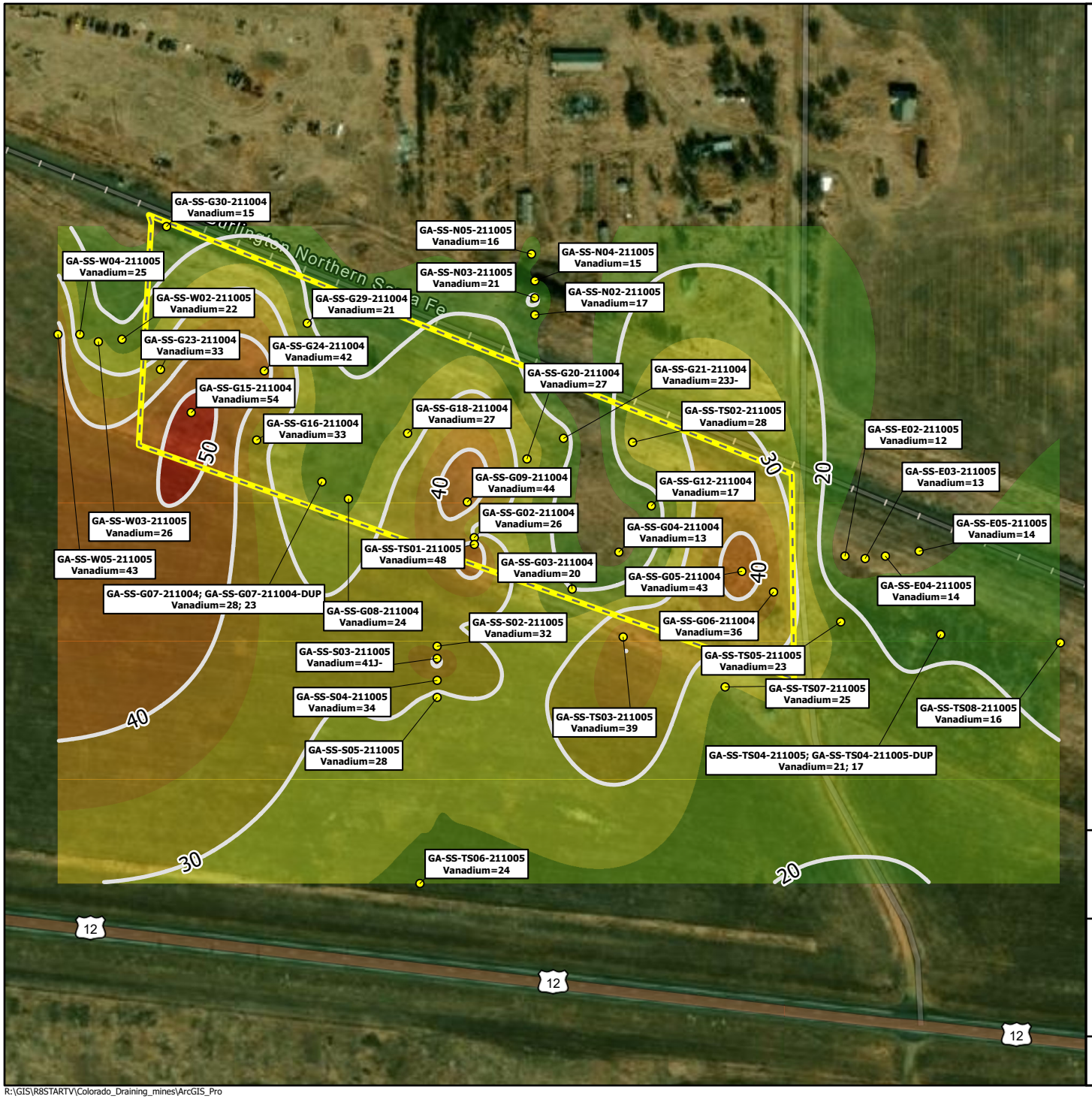


Griffin Ashing Site

Griffin, Bowman County, North Dakota

Figure
Results- Soil Metals-Vanadium

Vanadium (CAS No. 7440-62-2)
- 7.8-<390 (Above Ecological Screening Level, below EPA RSL)
- Approximate Site Boundary
- Vanadium Contour

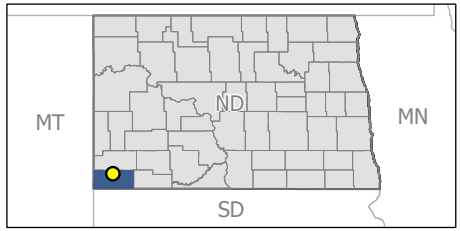
Vandium Concentration
VALUE
- 10.723 - 15 mg/kg
- 20 mg/kg
- 25 mg/kg
- 30 mg/kg
- 35 mg/kg
- 40 mg/kg
- 45 mg/kg
- 50 mg/kg
- 55 mg/kg

Analyte		Vanadium
CAS Number		7440-62-2
Project Action Limits	EPA RSL Residential Soil[a]	390
	Ecological Screening Levels[b]	7.8
	Background Threshold Value	70
	Units	mg/kg

Notes
All results and screening levels are in milligram per kilogram (mg/kg)
[a] EPA Regional Screening Levels for Residential Soils (RSL), using a target cancer rate of 1 in 1 million (1E-06) and target hazard quotient=1.0
[b] The lower of EPA Region 4 Ecological Soil Screening Levels (ESL) and toxicological benchmarks for effects on terrestrial plants

CAS: Chemical Abstract Service

0 125 250 500 Feet N



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