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Site Characterization Report (with Human Health and Screening Level Ecological Risk Assessments)

Verde Central Mine
Voluntary Remediation Program

Near Jerome, Arizona
VRP Site Code: 508483-00

Freeport Minerals Corporation

Project number: 60580510

April 17, 2020

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Project number: 60580510

April 17, 2020

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LIST OF ACRONYMS

ABA	acid base accounting
ADEQ	Arizona Department of Environmental Quality
ADHS	Arizona Department of Health Services
AGP	acid generation potential
ANP	acid neutralization potential
amsl	above mean sea level
ARS	Arizona Revised Statutes
BADCT	best available demonstrated control technology
COPC	chemical of potential concern
COPEC	chemical of potential ecological concern
CSM	conceptual site model
DEUR	declaration of environmental use restriction
EPA or USEPA	United States Environmental Protection Agency
FAQ	frequently asked question
FMC	Freeport Minerals Corporation
GPL	groundwater protection level
GPS	global positioning system
HASP	health and safety plan
HHRA	human health risk assessment
Library	Jerome Public Library
LRL	laboratory reporting limit
LANL	Los Alamos National Laboratory
NNP	net neutralization potential
NPR	neutralization potential ratio
NR-SRL	non-residential soil remediation level
NWQS	Arizona numeric water quality standards for surface water
PAH	polycyclic aromatic hydrocarbon
PBC	Partial Body Contact
PWP	project work plan
R-SRL	residential soil remediation level
SAP	Sampling and Analysis Plan
SCR	Site Characterization Report
SLERA	screening level ecological risk assessment
SMDP	scientific management decision point
SPLP	synthetic precipitation leaching procedure

SS-SRLs	site-specific soil remediation levels
$TCaCO_3/kT$	tons of calcium carbonate equivalent per kiloton
TEC	threshold effect concentration
UCL	upper confidence limit
VOC	volatile organic carbon
VRP	Voluntary Remediation Program

EXECUTIVE SUMMARY

This Site Characterization Report presents the methods and results of field environmental characterization activities, a Human Health Risk Assessment, and a Screening Level Ecological Risk Assessment for the former Verde Central mine (the project) under the Arizona Department of Environmental Quality (ADEQ) Voluntary Remediation Program. The work was performed by AECOM Technical Services, Inc. (AECOM) on behalf of Freeport Minerals Corporation (FMC). This document incorporates suggestions provided by ADEQ during a 2015 meeting with FMC to discuss the site characterization and Human Health Risk Assessment results developed to date and incorporates comments provided by ADEQ in an email on August 8, 2019 and discussed with FMC during a September 13, 2019 meeting.

The project site is a former copper mine site located in central Arizona, approximately 0.7 miles southwest of the Town of Jerome adjacent to Highway 89A (Figure 1). The site is approximately 12 acres in size and located within steep terrain with notable remnants of former mining activity, including waste rock and mine residual stockpiles. The site is accessed from a dirt road off Highway 89A. There is a locked gate at the head of the dirt road with barbed wire fencing along the property adjacent to the road to limit unauthorized access to the site. Several “No Trespassing” signs are posted so as to be visible from the highway.

The overall objectives of the site characterization and risk assessments were to:

- Characterize the exposed rock, tailings, and mill wastes resulting from historical mining and milling operations at the project site;
- Assess the need to remediate the site to acceptable exposure levels for Chemicals of Potential Concern (COPC); and
- Assess compliance with Arizona Numeric Water Quality Standards for surface water.

The suspected COPCs for the site were identified as metals (particularly arsenic), based on site history information and existing data collected from the site.

Samples of various environmental media were collected at the site in accordance with the Sampling and Analysis Plan (URS 2013b) and ADEQ-approved modifications. A total of 63 field original, 7 field duplicates, and 5 equipment blank samples were collected during a total of six discrete sampling events between July 2014 and July 2018. The environmental media sampled included surface soil from the waste rock, tailing, high-grade ore, low-grade ore, and suspected waste concentrate areas as well as sediment and surface water from Hull Canyon Wash, an ephemeral drainage.

Two Exposure Areas (Figure 2) were developed for evaluating potential risk based on historical site use, current habitat conditions and environmental setting, and potential future site use. Exposure Area 1 comprises the steep slopes of the waste rock stockpiles and the low-grade ore rock stockpiles and several small tailing piles. Exposure Area 2 consists of the former building foundations, small areas of high-grade ore, suspected waste concentrate, and adjacent tailing piles.

- In the Human Health Risk Assessment, analytical results from Exposure Areas 1 and 2 soil samples and Hull Canyon Wash sediment samples were compared to site-specific background soil levels and nonresidential soil remediation levels (SRLs) as listed in Appendix A of AAC Title 18, Chapter 7 (AAC 2009a.)

Soil and sediment leachate testing results were compared to groundwater protection levels (GPLs) as listed in A Screening Method To Determine Soil Concentrations Protective of Groundwater Quality, Arizona Dept. of Environmental Quality (ADEQ 1996). Analytical results for Hull Wash surface water samples were compared to the Arizona numeric water quality standards for surface water for Partial Body Contact. These comparisons were used to help identify areas and/or COPCs requiring further evaluation. Arsenic concentrations exceeded the nonresidential SRL in Exposure Area 1 and Hull Canyon Wash, and arsenic and lead concentrations exceeded the nonresidential SRL in Exposure Area 2. Adolescent trespasser site-specific SRLs were developed for direct contact with soil and sediment; COPCs included antimony, arsenic, cadmium, copper, and lead. The site-specific SRLs were based on a target cancer risk level of 1×10^{-5} and a target Hazard Quotient of 1. None of the COPC concentrations in soil or sediment exceeded the site-specific SRLs.

A Screening Level Ecological Risk Assessment was also conducted, per ADEQ's recommendation, to evaluate whether historical site activities potentially impacted site soil and Hull Canyon Wash sediment and surface water at concentrations that may pose potential risk to ecological receptors. The analytical results were compared to conservative ecological screening level benchmarks that are protective of ecological receptors. Chemicals of Potential Ecological Concern (COPECs) were selected by comparing maximum detected concentrations to the lowest screening benchmark available for soil invertebrates, terrestrial plants, avian wildlife, and mammalian wildlife. Following this initial screen, a comprehensive risk evaluation of the remaining COPECs was conducted by focusing on representative receptors and using chemical- and site-specific input factors.

Based on the overall findings of the Site Characterization Study, Human Health Risk Assessment, and Screening Level Ecological Risk Assessment, the following is concluded:

- COPCs in soil in Exposure Area 1 and Exposure Area 2 as well as in sediment and surface water in the Hull Canyon Wash are detected at concentrations that are unlikely to contribute to adverse human health risks based on the adolescent trespasser exposure scenario.
- Although the potential for unacceptable risks from exposure to COPECs in soil in Exposure Areas 1 and 2 cannot be excluded for all wildlife receptors, uncertainties in conjunction with the availability of nearby quality habitat result in an overestimation of the potential risk. While the potential for localized risk cannot be discounted from exposure to COPECs, risks to plant and invertebrate communities as a whole are expected to be minimal.
- Concentrations of several metals slightly exceed conservative screening benchmarks in both surface water and sediment/soil in Hull Canyon Wash. However, given the ephemeral nature of the Wash, exposure to terrestrial biota particularly in surface water is expected to be minimal.
- The overall slightly elevated acid mine drainage potential is not appreciably impacting surface water at the site.

Based on the information presented in this Site Characterization Report and the conclusions summarized above, FMC recommends a Declaration of Environmental Use Restriction (DEUR) to the property to restrict future land uses to those that minimize human health exposure to COPCs. FMC has no plans to use, develop, or sell this small roadside site, and will continue to limit access by the gate, fencing, and signage. The DEUR will prohibit residential and recreational use and require that property access restrictions are continued to limit potential trespassers.

1.0 INTRODUCTION

This Site Characterization Report (SCR) presents the methods and results of field environmental characterization activities, Human Health Risk Assessment (HHRA) and Screening-Level Ecological Risk Assessment (SLERA) performed in support of the Verde Central Voluntary Remediation Program (VRP) project (VRP Site Code: 508483-00; the project). The work was performed by AECOM Technical Services, Inc. (AECOM; formerly URS Corporation) for Freeport Minerals Corporation (FMC), formerly known as Phelps Dodge Corporation.

The field activities summarized within this SCR were generally performed in accordance with the requirements and procedures outlined in the *Revised Sampling and Analysis Plan, Verde Central Mine Voluntary Remediation Project* (URS, 2013a). The Sampling and Analysis Plan (SAP) is a companion document to the *Revised Project Work Plan* [PWP]*, Verde Central Mine Voluntary Remediation Project* (URS, 2013b) prepared to address Voluntary Remediation Program (VRP) requirements identified in Arizona Revised Statutes (ARS) §49-175 and §49-176. The SAP includes quality assurance, field sampling, and analytical program information for field activities as well as information regarding how project data are to be reviewed, evaluated and reported.

Sampling and analysis activities associated with the approved plans were implemented in 2015, and a draft SCR, dated August 18, 2015, was prepared summarizing the analytical results. The draft SCR included development of site-specific Soil Remediation Levels (SS-SRLs) based on HHRA for a trespasser exposure scenario.

Concurrent with FMC review of the draft SCR, FMC and AECOM personnel (Barbara Nielsen and Janet Workman) met with Arizona Department of Environmental Quality (ADEQ) VRP representative Joey Pace to discuss the approach to risk assessment. The site characterization data and risk assessment results were informally presented to ADEQ during that meeting to provide a basis for discussion. Based on the meeting and a follow-up telephone call, ADEQ noted and/or suggested the following:

- Redefinition of the project boundary such that background sample locations in undisturbed areas would be external to the VRP project area. Note that background sample locations had been previously approved by ADEQ at the time that the plans were approved.
- If the soil samples contained contaminant concentrations greater than calculated SS-SRLs, then horizontal and vertical delineation of soil impacts would be performed.
- The use of human health risk assessment is acceptable for evaluating SS-SRLs.
- Ecological risks should also be evaluated on a screening level basis.
- Rather than evaluating each material type separately with respect to human health and ecological risk, the project site may be divided into two areas of exposure consisting of: 1) areas containing Waste Rock, Low Grade Ore, and Tailing; and 2) the area around the building remnants including High Grade Ore and Suspected Waste Concentrate.

Subsequent to the meeting with ADEQ, AECOM performed supplemental field sampling to provide characterization of surface soil within the area around the building remnants. An amended SAP was not submitted for ADEQ approval prior to the 2018 field work, however, the sampling was substantively similar to the previous site work and was performed in accordance with the procedures outlined in the SAP.

The results of the supplemental sampling are incorporated with the previously collected site data and presented in this SCR. Also presented are the results of the HHRA performed for the purpose of calculating SS-SRLs as well as conclusions and recommendations for both the HHRA and SLERA.

1.1 BACKGROUND

As documented in the PWP, the project area is a former copper mine site located in central Arizona, approximately 0.7 miles southwest of the Town of Jerome (Figure 1). The cadastral location of the project area is Section 27 of Township 16 North, Range 2 East, Gila and Salt River Meridian, which is mapped on the Cottonwood, Arizona, U.S. Geological Survey 7.5 minute topographic quadrangle. The site is approximately 12 acres in size and is located adjacent to and on the south side of State Highway 89A. From the highway, the site can be described as a steep hillside with notable remnants of former mining activity, including waste rock and mine residual stockpiles.

The project area (Figure 2) includes a mine rock stockpile comprised of Waste Rock and Low-Grade Ore, miscellaneous mining residual materials (High Grade Ore, Tailing and Suspected Waste Concentrate from milling operations), multiple closed mine shafts/adits, and the foundation of a former mill. The project area is limited to areas impacted by mining and milling operations, which occurred from 1928 to 1930, including the aforementioned stockpiles, and an area where foundations of the former mine and mill support facilities are located. The site is currently inactive and vehicle access is via an unpaved four-wheel drive road on the south side of Highway 89A. Site access is controlled by a locked metal gate. The site is accessed from a dirt road off Highway 89A. There is a locked gate at the head of the dirt road with barbed wire fencing along the property adjacent to the road to inhibit unauthorized access to the site. Several “No Trespassing” signs are posted visibly from the highway. FMC has no plans to use, develop, or sell this small roadside site, and will continue to limit access by the gate, fencing, and signage.

The project area is located in Hull Canyon, a steep, rocky canyon with relatively minimal soil development and difficult access. The elevation of the project varies from approximately 5,350 feet above mean sea level (amsl) at the lowest point in Hull Canyon, to 5,520 feet amsl at the highest elevations of the remnant building foundations. An unnamed ephemeral streambed exists at the base of the canyon and toe of the rock stockpile located within the project area. This streambed is referred to in the PWP as Hull Canyon Wash. A draft Jurisdictional Delineation was prepared by URS (2013c), but it has since expired. It was concluded that the non-wetland waters of the unnamed ephemeral drainage that flows through the project area (Hull Canyon Wash) would be considered a jurisdictional waterway. This jurisdiction area consisted of 1.1 acres and the observed ephemeral drainage ranges in width from 8 feet to 12 feet and has a length of 2,257 feet. Flow in the wash, when present, is from southwest to northeast across the project area; flow is generally only present in response to precipitation events. Additional site description and history information are presented in the PWP.

1.2 PROJECT OBJECTIVES

The overall objectives of the site characterization and risk assessments were to:

- Characterize the exposed rock, tailings, and mill wastes resulting from historical mining and milling operations at the project site;
- Assess the need to remediate the site to acceptable exposure levels for Chemicals of Potential Concern (COPC); and

- Assess compliance with the Arizona Numeric Water Quality Standards (NWQS) for surface water.

The suspected COPCs for the site are metals (particularly arsenic), based on site history information and existing data collected from the site (see Section 2.0 of the PWP).

1.3 REPORT ORGANIZATION

The SCR is organized as follows:

Section 2 – Site Characterization describes the community involvement and field activities, field sampling and analytical testing methodologies.

Section 3 – Analytical Results summarizes the analytical results for background samples and samples collected in Exposure Area 1, Exposure Area 2 and Hull Canyon Wash and data verification procedures.

Section 4 – Risk Assessments summarize the HHRA and SLERA, which are included in more detail in Appendix G and Appendix H, respectively.

Section 5 – Conclusions and Recommendations are presented.

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2.0 SITE CHARACTERIZATION

2.1 COMMUNITY INVOLVEMENT SUPPORT

As indicated in the PWP, FMC conducted community involvement activities and notified the general public of site characterization sampling activities in advance of performing site work. URS published a notification for a public meeting in the Verde Valley Independent on June 25, 2014 and July 4, 2014. The notice advertised a public meeting to be held on July 7, 2014, at the Lawrence Memorial Hall on Hull Ave. in Jerome from 4:00 to 6:00 pm. The public meeting notice was also posted on a notice board at the Jerome U.S. Post Office.

The public meeting was held, as advertised, at Lawrence Memorial Hall between 4:00 and 6:00 pm on July 7, 2014. The project team consisting of FMC Project Manager, Barbara Nielsen, AECOM Project Director Patrick Gorman, AECOM Project Manager Janet Workman, and several FMC employees were available to the public to answer questions regarding the project. The project team made available copies of project documents at the meeting, including the Frequently Asked Questions (FAQ) sheet; the Project Fact Sheet, the PWP and the SAP. These documents were also provided in hardcopy to the Jerome Public Library (library) on July 7, 2014. An additional set of the project documents were provided to the library via mail on July 24, 2014 (Appendix A).

2.2 FIELD ACTIVITIES

2.2.1 Site-Specific Health and Safety Plan

AECOM prepared a site-specific Health and Safety Plan (HASP) for the initial site characterization activities in April 2008. The HASP was updated on July 18, 2014 and August 1, 2018 to govern the field work activities for sample collection at the site.

2.2.2 Utility Location and Site Survey

Based on information provided by Duff Sorells, FMC Site Manager, Northern Arizona on July 22, 2014, it was determined that the only active utility on the project site was the Town of Jerome water supply main, which is above ground at the site. No additional utility location services were used prior to collection of the surface soil, suspected waste concentrate, sediment and water samples.

In preparation for the field sampling efforts, AECOM loaded the coordinates of all proposed sample locations into a handheld global positioning system (GPS) unit (Trimble GeoExplorer 6000 XH with a horizontal accuracy of ± 2 feet) to aid in identifying the proposed sample locations in the field. Coordinates for the mining residual materials and the locations of fixed points were also loaded into the GPS unit for cross-referencing in the field.

If the actual sample location differed from the proposed sample location, the GPS unit was used to record the actual location. If the actual sampling location was identical to the proposed sampling location as entered into the GPS unit, the sampling point was not recorded.

2.2.3 Site Characterization Sample Collection

Samples of various environmental media were collected at the site using sampling procedures detailed in the SAP. A total of 63 field original, 7 field duplicates, and 5 equipment blank samples, as summarized in

Table 1, were collected during a total of six discrete sampling events. Two rounds of sampling included collection of solid samples. Background soil, Waste Rock, Tailing, High-Grade Ore, Low-Grade Ore, Suspected Waste Concentrate, and Hull Canyon Wash sediment samples were collected between July 22, 2014 and July 25, 2014; Surface Soil samples in the vicinity of former mine and mill support buildings were collected on July 11, 2018. Surface water samples from the ephemeral drainage within Hull Canyon Wash were collected during four rounds of sampling on September 16, 2014, October 2, 2014, December 4, 2014 and May 20, 2015. Samples were identified with a string of characters as follows:

- SC (for Site Characterization);
- A location reference (WR = Waste Rock, LGO = Low-Grade Ore, HGO = High-Grade Ore, T = Tailing, SWC = Suspected Waste Concentrate, SS = Surface Soil, HCW = Hull Canyon Wash, and B = Background); and
- A sample number (i.e., 1, 2, 3, etc.).

Sediment samples and surface water samples collected from within Hull Canyon Wash were further identified with an “S” or a “W” to indicate the matrix collected at a given location. Location references are used throughout this report without the leading characters SC.

Notable variations between proposed and actual sampling locations for the various media are summarized below:

- Sample locations within the Waste Rock were adjusted to allow samples to be collected in a safe manner;
- Several Background sample locations were adjusted due to safety concerns to allow samples to be collected from less steep terrain (note that this modification was verbally approved by ADEQ VRP staff who were conducting a site visit during sample collection);
- The High-Grade Ore sample location was modified based on visual indicators (i.e., the GPS coordinate for the proposed location did not coincide with the actual location of the High Grade Ore as determined visually);
- The Suspected Waste Concentrate sample locations were modified based on visual indicators (i.e., the GPS coordinates for the Suspected Waste Concentrate did not coincide with the actual location of Suspected Waste Concentrate as determined visually); and
- Two of the Tailing sample locations were modified based on visual indicators (i.e., the GPS coordinates for proposed Tailing samples did not coincide with the visually observed locations of Tailing).

Copies of the field notes are included in Appendix B.

2.2.3.1 Solids Sampling

AECOM representatives mobilized to the site on July 22, 2014 to initiate the sampling activities. AECOM met with Duff Sorrels in the FMC Jerome office to obtain site-specific health and safety training and then mobilized to the Verde Central Mine. Between July 22, 2014 and July 25, 2014, AECOM collected 40 field original samples which included site characterization background samples SC-B-1 through SC-B-10 (Figure 2), Waste Rock samples SC-WR-1 through SC-WR-10 (Figure 3), Low-Grade Ore samples

SC-LGO-1 through SC-LGO-10 (Figure 3), High-Grade Ore sample SC-HGO-1 (Figure 4), Suspected Waste Concentrate samples SC-SWC-1 and SC-SWC-2 (Figure 4), Tailing samples SC-T-1 through SC-T-3 (Figures 3 and 4), and stream sediment samples SC-HCW-S-1 through SC-HCW-S-4 (Figures 3 and 4). In addition, four field duplicate samples and five equipment rinsate blank samples were also collected.

AECOM representatives mobilized to the site on July 11, 2018 to collect Surface Soil samples from the area around the building footprint. AECOM collected 10 field original samples which included site characterization Suspected Waste Concentrate Sample SC-SWC-3 (Figure 4), Tailing samples SC-T-4 and SC-T-5 (Figure 4), and Surface Soil samples SC-SS-1 through SC-SS-7 (Figure 4). In addition, two field duplicate samples were collected.

2.2.3.2 Surface Water Sampling

AECOM representatives returned to the site on September 16, October 2 and December 4, 2014 and May 20, 2015 to collect additional rounds of water samples from the four locations within the Hull Canyon Wash (Figures 3 and 4). AECOM representative returned to the site again on July 11 and July 26, 2018 to collect additional rounds of water samples from the Hull Canyon Wash, however sufficient quantities of water were not present within the Wash on those occasions so additional surface water samples were not collected.

2.2.4 Sampling Methodology

Soil/Sediment

Samples were collected using a rock hammer (to break up hard, dry soil) and trowel. All solid samples were collected at a depth of zero to four inches. This was a minor deviation from the SAP which specified that samples be collected from at a depth from zero to six inches. Samples that were not analyzed for volatile organic compounds (VOCs) by United States Environmental Protection Agency (EPA) Method 8260B (e.g., all samples with the exception of Suspected Waste Concentrate) were screened and placed in a stainless sample container. Field duplicates were collected from the same material within the mixing bowl. Equipment rinsate blank samples were collected by pouring de-ionized water over the rock hammer and trowel and collecting steel bowl for homogenization prior to being placed in the appropriate laboratory-supplied the runoff in sample containers.

Surface Water

Surface water samplers were installed at four locations within the Hull Canyon Wash (Figures 3 and 4) on August 7, 2014. The samplers were deployed at the same locations at which sediment samples had been collected in July 2014 (HCW-1, HCW-2, HCW-3, and HCW-4). [Please note that the sample locations do not proceed in sequential order from upstream to downstream.] Each sampler consisted of a 5-foot section of 2-inch poly vinyl chloride (PVC) pipe with a PVC cap attached at one end and ¼-inch screen placed across the opposite end. The samplers were placed with the screened end facing upstream to allow water to enter the pipe under flow conditions in the wash. Each sampler was anchored in place with rocks and additionally secured using nylon rope attached to spikes on the side of the wash. Prior to installation, each sampler was decontaminated utilizing Alconox® powder detergent and distilled water. One equipment blank was collected from the sampler deployed at the HCW-4 location by pouring distilled water into the decontaminated sampler and then pouring the water from the sampler into sample containers provided by the laboratory.

After installation of samplers, AECOM returned to the site to collect surface water samples when water in Hull Canyon Wash was flowing in response to precipitation events. Surface water samples were collected on September 16, October 2, and December 4, 2014 and on May 10, 2015. Samples were collected from HCW-1, HCW-3 and HCW-4 during each sampling event; sufficient water was only present to allow sample collection from HCW-2 during one sampling event (May 10, 2015).

Samples were collected by retrieving the sampler and pouring the contents into laboratory supplied sample containers. Field measurements of pH were performed on water samples using a calibrated Hanna model HI991300.

During the September 2014 sampling event, the limited quantity of water available in the HCW-3 and HCW-4 samplers was not sufficient for analysis of total and dissolved metals so only total metals analyses were performed on these samples. The HCW-1 sample was tagged for laboratory filtration of a portion of the sample for dissolved metals analysis.

During the October 2014 sampling event, the HCW-1 sample consisted of only enough water for a field pH measurement, and was not submitted to the laboratory for further analysis. Split samples from locations HCW-3 and HCW-4 were tagged for laboratory filtration of a portion of the sample to allow analysis of dissolved and total metals.

During the December 2014 sampling event, the HCW-3 sampler did not contain sufficient water to analyze for all of the required parameters. Sample splits from locations HCW-1 and HCW-4 were marked for laboratory filtration.

During the May 2015 sampling event, sample splits from each location were marked for laboratory filtration due to the limited quantity of water available in the samplers.

2.2.5 Sample Handling, Labeling, and Transport

Following collection of each sample, the sample container was labeled with the AECOM job number, sample identification number, date and time of sample collection, analysis requested, and the sampler's initials. Samples were immediately placed in a cooler with ice in preparation for transport to the analytical laboratory. Samples were delivered to TestAmerica of Phoenix, Arizona (Arizona Department of Health Services [ADHS] certification number AZ0728) for analysis.

2.3 ANALYTICAL TESTING METHODOLOGY

Solid samples were analyzed for VOCs by EPA Method 8260B, polycyclic aromatic hydrocarbons (PAHs) by EPA Method 8310, total metals by EPA Method 6010B/7471A, Synthetic Precipitation Leaching Procedure (SPLP) by EPA Method 6010B/6020, acid base accounting (ABA) by the Modified Sobek Method, and paste pH by EPA Method 600/2-78-054. Aqueous samples including equipment blanks were analyzed for VOCs by EPA Method 8260B, PAHs by EPA Method 8310, and metals by EPA Methods 200.7, 200.8, and 245.1. The analysis for ABA and paste pH was performed by SVL Analytical of Kellogg, Idaho (ADHS number AZ0538) as a subcontractor to TestAmerica. Table 2 summarizes the samples collected and the corresponding analysis requested for each. The analytical data provided by the laboratory are included in Appendix C.

3.0 ANALYTICAL RESULTS

This section summarizes the analytical results for background samples and samples collected in Exposure Area 1, Exposure Area 2 (defined below) and Hull Canyon Wash, and data verification procedures. Screening-level comparisons between detected concentrations of priority pollutant metals (plus barium and manganese) and non-residential SRLs (NR-SRLs), background levels and GPLs (where GPLs are available, ADEQ, 1996) are also presented. NR-SRLs rather than residential SRLs (R-SRLs) were used because FMC indicated that recording a Declaration of Environmental Use Restriction (DEUR) could be considered for the project. The screening against NR-SRLs was used to help identify areas and/or contaminants that may require further attention. Screening against the NR-SRL indicated that detected concentrations of arsenic and lead exceeded their respective NR-SRLs. These findings do not constitute a conclusion that remedial action is necessary, only that further evaluation of the potential risks is appropriate. As such, a HHRA and a SLERA were performed for the project and the results are presented in Section 4 of this report.

3.1 BACKGROUND SOIL ANALYTICAL RESULTS

Background samples include a total of ten field original samples and one field duplicate sample. Background sample locations are shown on Figure 2; the analytical results are summarized in Tables 3a through 3c, and the analytical laboratory reports are included in Appendix C. In accordance with the SAP, mean background concentrations for surface soils were estimated by calculating the 95% upper confidence limit (UCL) of the mean for each metal using EPA ProUCL v. 5.1(EPA, 2016). Per the SAP, background concentrations were developed in accordance with Arizona Administrative Code (AAC) R18-7-204. ProUCL output for the background dataset is included in Appendix D. For the background statistics, the background data were reduced prior to uploading in ProUCL to account for duplicate samples by conservatively selecting the lower concentration of the duplicate and normal (primary) background sample to avoid underestimation of sample variance and the 95% UCL. The 95%UCLs were calculated only for only those analytes that met the minimum criterion for development: where the number of samples (n) ≥10, and number of detections is n≥5.

Arsenic was the only metal in background samples detected above its NR-SRL (Table 3a; Arizona Administrative Code [AAC], 2009a) of 10 milligrams per kilogram (mg/kg). Arsenic was detected above the NR-SRL in 9 of 10 field original background samples and the field duplicate sample with concentrations ranging from 5 to 36 mg/kg. The highest detectable concentration of arsenic (36 mg/kg) in a background sample was reported in sample SC-B-11, which is a duplicate of SC-B-5 (31 mg/kg). The estimated upper 95% UCL of the mean for arsenic in background samples (24.71 mg/kg) was also above the NR-SRL.

Three background samples with high total metals concentrations, as determined by the total metals analyses, were further analyzed by the SPLP to evaluate leaching potential (Table 3b). Lead was the only metal detected in the SPLP leachates at concentrations above the corresponding NWQS based on human exposure (i.e., partial body contact) of 0.015 mg/L total recoverable lead. Lead was detected above the NWQS in leachate from each of the three SPLP tests with concentrations ranging from 0.033 mg/L to 0.059 mg/L.

Paste pH was measured in all ten background soil samples and the single duplicate background soil sample (SC-B-11). Results ranged from 5.40 to 8.79 standard pH units (Table 3c). Based on the paste pH

results, three samples with near neutral pH (7.0 pH units) were further evaluated using ABA with sulfur forms, as described in the SAP. The three samples had ABA pyritic (sulfide) sulfur contents less than the laboratory reporting limit (LRL; < 0.01 percent by mass) and an acid generation potential (AGP) of each sample was less than the LRL (< 0.3 tons of calcium carbonate equivalent per kiloton [$TCaCO_3$/kT]) (Table 3c). Acid neutralization potential (ANP) and net neutralization potential (NNP, referred to as ABA in results tables) for the three samples ranged from 5.2 to 13 $TCaCO_3$/kT. Neutralization potential ratios (NPRs) ranged from 17 to 43. Although classified as having uncertain acidification potential (based on NNP) to non-acid generating (based on NPR) using best available demonstrated control technology (BADCT) guidance (ADEQ, 2004), the lack of pyritic (sulfide) sulfur in the background soils indicates that they have not been impacted by the former mining operations and are not susceptible to acidification via sulfide mineral oxidation.

3.2 EXPOSURE AREAS

The Site was divided into two Exposure Areas based on historical site use, current habitat conditions and environmental setting, and potential future site use for the purposes of determining COPCs and evaluating potential risk. For the purpose of clarity, the analytical results summarized in this section are organized by Exposure Area. The sediments and surface water within Hull Canyon Wash constitute a distinct exposure potential for both human and ecological receptors and are discussed separately from Exposure Area 1 and Exposure Area 2, which are defined as follows:

- **Exposure Area 1:** Exposure Area 1 is comprised of the steep slopes of the Waste Rock stockpiles and the Low-Grade Ore rock stockpiles and several small Tailing piles (Figure 3). The Waste Rock stockpile is comprised of gray Waste Rock material from the sinking of the shafts. The Low-Grade Ore stockpile comprises ore that did not contain sufficient copper to warrant processing at the time the mill was in operation and was deposited downhill and west of the Main Verde Central Shaft. The Low-Grade Ore material is visually distinct from the gray waste rock and is rusty red in appearance. The Tailings include sand-sized by-product of the milling and concentrating process. Small amounts of Tailing are present in several locations in the project area, including the mill building foundations, the banks of Hull Canyon Wash at the toe of the rock stockpile, and the hillside west of the unpaved access road approximately 150 feet from Highway 89A. Tailing material is included in both Exposure Area 1 and Exposure Area 2.
- **Exposure Area 2:** Exposure Area 2 is comprised of the former building foundations located south of the Site access road (Figure 4) and includes small areas of High-Grade Ore, Suspected Waste Concentrate and Tailing. Material that appears to be High-Grade Ore is present on the southeast (and uphill) side of the mill building foundations. It is probable that this area was the feed pocket for the ore crushers in the mill building. The rock material is rust-red in appearance, even more so than the Low-Grade Ore in Exposure Area 1. The High-Grade ore can be distinguished visually by its deep rust/red coloration. A pile of black sandy Waste Concentrate material is present west and downhill of the mill building foundations. The material has the appearance of asphalt from afar; however, closer visual examination reveals a sand-sized black material with metallic bits that appear to be iron sulfides. Fragments of rock, metal, and other materials are also present in the Suspected Waste Concentrate pile. Based upon this observation and the proximity of the pile to the mill, the material is suspected to be Waste Concentrate and floor sweepings from the former mill. Small amounts of Tailing are also present in Exposure Area 2, to the north of the building foundations.

3.3 EXPOSURE AREA 1 ANALYTICAL RESULTS

Exposure Area 1 samples include a total of ten Waste Rock samples, ten Low Grade Ore samples, two Tailing samples, and two field duplicate samples. The metals analytical results are summarized in Table 4a along with the 95% UCL of the mean calculated per EPA ProUCL v. 5.1 (EPA, 2016), the 95% UCL of the background mean, the NR-SRL and the minimum GPLs for each metal. For all exposures areas (Exposure Areas 1 and 2, and Hull Canyon Wash, site data were reduced prior to running statistics in ProUCL by conservatively selecting the maximum of the duplicate and normal sample results to avoid underestimation of sample variance and the 95% UCL. As indicated above in the discussion of background, the 95%UCLs were calculated only for only those analytes that met the minimum criterion for development (samples n≥10, and detections n≥5). Although samples were collected from areas with assumed different source materials (i.e., low grade ore, tailings, and waste rock) in Exposure Area 1 (and Exposure Area 2), the combined data sets, that include multiple potential source materials, do not show evidence of a bi-modal or multi-modal distribution indicating multiple data populations. The combined data sets follow a parametric distribution (normal, gamma, and lognormal) for all metals. This indicates that these various sources may be considered a single population, as combining data from different populations typically results in a non-parametric statistical determination. Further graphical support is provided by a set of normal quantile plots (Appendix D) for each analyte at Exposure Area 1, where data points from most combined data sets follow a straight line (except in cases where there are many non-detects) for their raw values or parametrically transformed values.

The SPLP metals analytical results are summarized in Table 4b with the NWQS for Partial Body Contact, (PBC; AAC, 2009), and the paste pH and ABA accounting analytical results are summarized in Table 4c through 4e. The analytical laboratory reports are included in Appendix C. Figure 5 presents the spatial distribution of select metals in Exposure Area 1.

Exposure Area 1 includes a total of twenty-two field original samples and two field duplicate samples. Arsenic was the only metal detected above its respective NR-SRL of 10 mg/kg (Table 4a). Arsenic was detected above the NR-SRL in all field original Exposure Area 1 samples and in the field duplicate samples with concentrations ranging from 19 mg/kg to 250 mg/kg. The highest detectable concentrations of arsenic were generally found in the Low Grade Ore samples, where concentrations ranged from 36 mg/kg to 250 mg/kg; generally lower arsenic concentrations were detected in the Tailing samples (120 mg/kg to 180 mg/kg) and in the Waste Rock samples (19 mg/kg to 120 mg/kg). The 95% UCL of the mean for arsenic in Exposure Area 1 (139.1 mg/kg) is above the background value (24.71 mg/kg) and the NR-SRL. All results for metals concentrations in the samples were below their respective GPLs; however, it is noted that there are no minimum GPLs established for copper, manganese, silver or zinc.

Two to three Exposure Area 1 samples from each media (Low Grade Ore, Waste Rock, Tailing) with high total metals concentrations, as determined by the total metals analyses, were further analyzed by the SPLP to evaluate leaching potential (Table 4b). Arsenic in sample SC-T-1 (0.54 mg/L), copper in samples SC-LGO-3 (12 mg/L) and SC-T-1 (2.2 mg/l) and lead in sample SC-T-1 (0.047 mg/L) were detected in the SPLP leachates at concentrations above the corresponding NWQS based on human exposure (i.e., partial body contact) of 0.280 mg/L total recoverable arsenic, 1.3 mg/L total recoverable copper and 0.015 mg/L total recoverable lead.

Because the potential for generating acid rock drainage is specific to the type of mine residuals, acid base accounting analyses are presented and discussed separately for the Waste Rock, Low-Grade Ore and Tailing samples in Exposure Area 1. It should be noted that one Tailing sample (SC-T-3) for which acid

base accounting analyses were performed is now included in Exposure Area 2. Because acid base accounting analyses were only performed on a single Tailings sample in Exposure Area 2, the results for this sample are discussed with the Exposure Area 1 Tailing samples.

Paste pH was measured in all ten Waste Rock samples and one duplicate sample (Table 4c). Results ranged from 7.38 to 8.48 standard pH units. Based on the paste pH results, three samples with near neutral pH (7.0 pH units) were further evaluated using ABA with sulfur forms. Pyritic (sulfide) sulfur content in the three waste rock samples subjected to ABA analysis ranged from 0.22 to 0.43 percent, resulting in AGPs of 7.0 to 13.3 $TCaCO_3$/kT, respectively. ANP ranged from 19.7 to 28 $TCaCO_3$/kT. NNP results (referred to as ABA in the results tables) for the three samples ranged from 8.3 to 14.7 $TCaCO_3$/kT and the NPRs ranged from 1.7 to 2.8, which classifies them as having uncertain acidification potential according to the BADCT guidance (ADEQ 2004). The pyritic (sulfide) sulfur contents (0.22 to 0.43 percent) indicate that sulfide minerals remain in the waste rock and are susceptible to oxidation, however, they have been partially oxidized as evidenced by the sulfate sulfur contents (0.11 to 0.22 percent).

Paste pH was measured for all ten samples from the Low-Grade Ore area and one duplicate sample (Table 4d). The paste pH results ranged from 3.68 to 4.37 standard pH units. ABA analysis with sulfur forms was conducted on the three samples with circumneutral paste pH. ABA pyritic (sulfide) sulfur contents ranged from 0.13 to 0.95 percent by mass, with a corresponding AGP range of 4.1 to 29.7 $TCaCO_3$/kT (Table 4d). ANPs for the samples were less than or near the LRL, and ranged from not detected (< 0.3 $TCaCO_3$/kT) to 0.5 $TCaCO_3$/kT, resulting in NNPs from -3.6 to -29.7 $TCaCO_3$/kT and NPRs from 0.01 to 0.12. These samples would be classified as having uncertain acidification potential to acid generating according to BADCT guidance (ADEQ, 2004). However, all three samples are potentially acid generating as indicated by the pyritic (sulfide) contents, the paste pH results, and the lack of readily available neutralizing capacity. The sulfate sulfur contents (0.06 to 0.31 percent) indicate that the sulfide minerals in the Low Grade Ore have been partially oxidized.

Paste pH results for the Tailing Area samples were 7.61, 4.54 and 4.02 pH units (Table 4e). ABA pyritic (sulfide) sulfur contents ranged from 0.02 to 0.09 percent by mass, with corresponding AGPs from 0.7 to 2.8 $TCaCO_3$/kT. ANP ranged from not detected (< 0.3 $TCaCO_3$/kT) to 4.1 $TCaCO_3$/kT, resulting in NNPs from -2.0 to +3.4 $TCaCO_3$/kT and NPRs from 0.11 to 5.9. The NNP results suggest that the Tailings have uncertain acid generation potential, while the NPR values suggest that two of the Tailings samples are potentially acid generating and one has uncertain acid generation potential. However, the low pyritic (sulfide) sulfur contents and the sulfate sulfur contents (0.05 to 1.09 percent) suggest that the sulfide minerals in the Tailings are mostly oxidized and the observed acidity in the paste pH likely results from hydrous sulfate mineral oxidation products.

3.4 EXPOSURE AREA 2 ANALYTICAL RESULTS

Exposure Area 2 samples include a total of one High Grade Ore sample, three Suspected Waste Concentrate samples, three Tailing samples, seven Surface Soil samples and two field duplicate samples The metals analytical results are summarized in Table 5a along with the 95% UCL of the mean for site data calculated per EPA ProUCL v. 5.1 (EPA, 2016), the 95% UCL of the background mean, the NR-SRL and the minimum GPLs for each metal. Like Exposure Area 1, Exposure Area 2 samples were collected from areas with assumed different source materials (i.e., high grade ore, waste concentrate, tailings, and surface soil), and site data were reduced prior to running statistics in ProUCL by conservatively selecting the maximum of the duplicate and normal sample results to avoid underestimation of sample variance and the 95% UCL. Review of the statistical distribution of source material data indicates that the

combined dataset that includes multiple potential source materials do not show evidence of a bi-modal or multi-modal distribution, but rather follow a parametric distribution for all but two metals (cadmium and zinc) indicating that these various sources may be considered a single population. For cadmium, low detection frequency resulted in skewing of data and a non-parametric determination, and for zinc a single elevated result skews the distribution non-parametric. Further graphical support is provided by a set of normal quantile plots (Appendix D) for each analyte at Exposure Area 2, where data points from most combined data sets follow a straight line (except in cases where there are many non-detects) for their raw values or parametrically transformed values.

The SPLP metals analytical results are summarized in Table 5b with the NWQS for PBC, the paste pH and ABA accounting analytical results are summarized in Table 5c and 5d, the VOC and PAH analytical results are summarized in Tables 5e and 5f, respectively. The analytical laboratory reports are included in Appendix C. Figure 6 presents the spatial distribution of select metals in Exposure Area 2.

Exposure Area 2 includes a total of fourteen field original samples and one field duplicate sample (Table 5a). Arsenic was detected above the NR-SRL of 10 mg/kg in all field original Exposure Area 2 samples and in the field duplicate sample with concentrations ranging from 31 mg/kg to 430 mg/kg. The 95% UCL of the mean for arsenic in Exposure Area 2 (279.6 mg/kg) was above the background value (24.71 mg/kg) and below the GPL of 290 mg/kg. Lead was detected above the NR-SRL of 800 mg/kg in one Exposure Area 2 sample with a concentration of 1,200 mg/kg (in a Suspected Waste Concentrate sample). The 95% UCL of the mean for lead in Exposure Area 2 (438.8 mg/kg) is above the background value (59.43 mg/kg) and below the NR-SRL.

In some instances, detected concentrations of antimony, arsenic, cadmium, lead and mercury were greater than their respective GPLs. The highest antimony concentrations (36 mg/kg to 42 mg/kg) were greater than the GPL in three Exposure Area 2 samples (two Suspected Waste Concentrate samples and one Surface Soil sample). The 95% UCL of the mean for antimony in Exposure Area 2 (21.45 mg/kg) was less than the GPL. The highest arsenic concentrations (300 mg/kg to 430 mg/kg) were greater than the GPL in five Exposure Area 2 samples (two Suspected Waste Concentrate samples and three Surface Soil samples). The 95% UCL of the mean for arsenic in Exposure Area 2 (279.6 mg/kg) was less than the GPL. The highest cadmium concentration (65 mg/kg) was greater than the GPL in one Suspected Waste Concentrate sample in Exposure Area 2. The 95% UCL of the mean for cadmium in Exposure Area 2 (22.9 mg/kg) was less than the GPL. The highest lead concentrations (310 mg/kg to 1,200 mg/kg) were greater than the GPL in four Exposure Area 2 samples (two Suspected Waste Concentrate samples and two Surface Soil samples). The 95% UCL of the mean for lead in Exposure Area 2 (438.8 mg/kg) was greater than the GPL. The highest concentrations of mercury (12 mg/kg and 14 mg/kg) were greater than or equal to the GPL in two Surface Soil samples in Exposure Area 2. The 95% UCL of the mean for mercury in Exposure Area 2 (6.92 mg/kg) was less than the GPL. It is noted that there are no minimum GPLs established for copper, manganese, silver or zinc. In summary, although there were instances of detected metals concentrations (antimony, arsenic, cadmium and lead) exceeding the GPL, the 95% UCL of the mean for was below the GPL for all compounds except lead.

Exposure Area 2 samples from each media (High Grade Ore, Suspected Waste Concentrate, Tailing and Surface Soil) with high total metals concentrations, as determined by the total metals analyses, were further analyzed using the SPLP to evaluate leaching potential (Table 5b).

Copper in samples SC-HGO-1 (4.4 mg/L), SC-SWC-1 (3.5 mg/L), SC-SWC-2 (34 mg/L), and SC-T-3 (1.5 mg/L) and lead in samples SC-SWC-1 (0.021 mg/L) and SC-SWC-2 (0.14 mg/L) were detected in the

SPLP leachates at concentrations above the corresponding NWQS based on human exposure (i.e., partial body contact) of 1.3 mg/L total recoverable copper and 0.015 mg/L total recoverable lead.

Because the potential for generating acid rock drainage is specific to the type of mine residuals, acid base accounting analyses are presented and discussed separately for the Suspected Waste Concentrate and High Grade Ore samples in Exposure Area 2.

Paste pH results for the two Suspected Waste Concentrate samples were 4.86 and 3.68 standard pH units (Table 5c). ABA pyritic (sulfide) sulfur contents were 3.99 and 2.69 percent by mass, with corresponding AGPs of 125 and 84 $TCaCO_3$/kT. NNP and NPR results for the samples were -110 and -84 $TCaCO_3$/kT and 0.12 and 0.004, respectively, classifying them as acid generating (NNP < -20 $TCaCO_3$/kT and NPR < 1) according to BADCT guidance.

Paste pH result for the High-Grade Ore area sample was 3.52 standard pH units (Table 5d). The ABA pyritic (sulfide) sulfur content was 0.70 percent by mass, with a corresponding AGP of 21.9 $TCaCO_3$/kT. ANP was not detected (< 0.3 $TCaCO_3$/kT), resulting in a NNP of -21.9 $CaCO_3$/kT and NPR of 0.01. The paste pH, NNP, and NPR results suggest that the High Grade Ore is potentially acid generating using BADCT guidance. The sulfate sulfur content (0.43 percent) indicates that the sulfide minerals in the High Grade Ore have been partially oxidized. Figure 7 provides a plot of NPR versus NNP by material type for soil collected in Exposure Areas 1 and 2. It is apparent from the plot that the two suspected waste concentrate soil samples have the greatest potential to generate acid of all the material types in Exposure Areas 1 and 2; however, this area if very small.

Two Suspected Waste Concentrate samples in Exposure Area 2 were analyzed for VOCs (EPA Method 8260B) and PAHs (EPA Method 8310), due to the blackish color of the material, as specified in the SAP (URS 2013a). No VOCs were detected above the LRLs (Table 5e). Of the five PAH compounds detected, PAH results were all below their respective NR-SRL concentrations (Table 5f). Because benzo (a) pyrene is the only PAH for which an Aquifer Water Quality Standard has been established (0.0002 mg/L), only benzo (a) pyrene is compared to a minimum GPL. Using the 2013 ADEQ GPL spreadsheet (ADEQ, 2013), a minimum GPL of 1.6 mg/kg was calculated for benzo (a) pyrene (Appendix F). This calculated minimum GPL is based on the calculated saturation concentration for benzo (a) pyrene. Benzo (a) pyrene was not detected in the samples and the LRLs are less than the calculated minimum GPL. Note that Suspected Waste Concentrate sample (SC-SWC-3, collected in July 2018, was not analyzed for VOCs and PAHs based on the results of the 2014 analyses).

3.5 HULL CANYON WASH SEDIMENT ANALYTICAL RESULTS

Results of the Hull Canyon Wash sediment samples are provided in Tables 6a through Table 6c. A total of four field original and one field duplicate sediment samples were collected and submitted to TestAmerica of Phoenix, Arizona for quantification of 13 priority pollutant metals plus barium and manganese, SPLP metals, paste pH, and PAHs. Sample SC-HCW-S-1 (Figure 4) was collected at the southwest (or up-stream) portion of the site, and can be considered a background sample with respect to potential stream sediment impacts related to site operations. Sample SC-HCW-S-4 (Figure 4) was collected near the south end of the site, but downstream of the Suspected Waste Concentrate area, the High-Grade Ore pile, and the former building foundation. Sample SC-HCW-S-3 (Figure 3) was downstream of SC-HCW-S-4, and downstream of the Low-Grade Ore area and adjacent Tailing. Sample SC-HCW-S-2 (Figure 3) is at the northeast corner and downstream of the entire site. Sample SC-HCW-S-5 was a field duplicate sample of SC-HCW-S-4.

Based on the total metals analysis (Table 6a), arsenic concentrations exceeded the NR-SRL (10 mg/kg) in two samples and the sample duplicate, with a maximum concentration of 34 mg/kg in the most downstream location (SC-HCW-S-2), and a concentration of 31 mg/kg (with duplicate of 32 mg/kg) in sample SC-HCW-S-4. These arsenic concentrations in sediments also exceeded the 95% UCL of the mean for background concentrations (24.71 mg/kg arsenic, Table 3a), but showed similar variability to soil background concentrations. No other metals were found at concentrations exceeding their respective NR-SRLs in the sediment samples. None of the metals concentrations in the sediment samples exceeded their respective minimum GPLs.

In general, the downstream sample (SC-HCW-S-2) had higher overall metals concentrations (combined) than the upstream sample (SC-HCW-S-1). This trend appears to have been largely driven by increasing downstream sediment concentrations of copper, manganese and zinc.

Each of the four sediment samples and the sample duplicate were subjected to SPLP analysis (Table 6b). One copper result (3.7 mg/L, SC-HCW-S-2) exceeded the human health PBC screening value (1.3 mg/L). Lead was detected above the human health PBC screening value (0.015 mg/L) in three samples plus the sample duplicate at 0.12 mg/L (HCW-S-4), 0.034 mg/L (HCW-S-3), 0.020 mg/L (HCW-S-2) and 0.090 mg/L (HCW-S-5).

Because PAHs were detected in the Suspected Waste Concentrate area samples, one sediment sample from the adjacent (and downstream) sample location SC-HCW-S-4 was submitted for PAH analysis and compared to human health (Table 6c) screening standards. The estimated concentration for benzo(a)pyrene (0.018 mg/kg) did not exceed the NR-SRL or the calculated minimum GPL. Because no Aquifer Water Quality Standards have been established for the additional PAH compounds analyzed, no minimum GPLs are established for these additional PAH compounds. (It should be noted that PAH results other than benzo(a)pyrene for the SC-HCW-S-4 sample were rejected [see Appendix E.]) Arizona does not provide ecological screening criteria for sediments, and therefore, site concentrations were compared to Consensus Sediment threshold effect concentrations (TECs) (MacDonald et al., 2000). The detected concentration of benzo(a)pyrene did not exceed its TEC of 0.15 mg/kg.

3.6 HULL CANYON WASH SURFACE WATER ANALYTICAL RESULTS

Results of the Hull Canyon Wash water samples are provided in Tables 7a through 7b. A total of 13 field samples (plus one field duplicate) were collected from the sampling locations over four field mobilizations during period September 16, 2014 through May 20, 2015, as described in Section 2.4. The analyses requested for each sampling event varied due to the quantity of water available in the sampling devices. The samples were submitted to TestAmerica of Phoenix, Arizona to analyze for the 13 priority pollutant metals (total) plus barium and manganese. The laboratory also conducted analysis of magnesium and calcium for the samples collected on December 4, 2014 and May 20, 2015, although it was not requested. At least one split sample was provided from each sample event, based on availability of sufficient volume collected in the samplers, for laboratory filtration and analysis of dissolved metals. Two samples from HCW-4-W (September 16, 2014 and December 4, 2014 sampling events) were also analyzed for PAHs to correspond with the sediment sample at the same location that was analyzed for PAHs. All samples were also run for hardness (as $CaCO_3$), with the exception of samples collected on October 2, 2014 from HCW-3-W and HCW-4-W.

Total metals in surface water were compared to the NWQS for the PBC standard associated with recreational use of surface waters (Table 7a). There is not an established PBC value for total chromium. Although the majority of total chromium in nature is assumed to be trivalent chromium and no historical activities associated with the production or use of hexavalent chromium occurred at the Site, the hexavalent chromium (chromium VI) PBC value was requested by ADEQ to be conservatively used as a screening surrogate.

The PBC standard for total copper (1.3 mg/L) was equaled in the unfiltered sample collected from location HCW-4-W on September 16, 2014. In addition, the PBC standard for total lead (0.015 mg/L) was exceeded in unfiltered samples collected from locations HCW-3-W (0.05 and 0.022 mg/L on September 16 and October 2, 2014, respectively) and HCW-4-W (0.12 and 0.090 mg/L on September 16 and October 2, 2014, respectively). On both dates, the upstream total lead and copper concentrations (HCW-4-W) exceeded the downstream (HCW-3-W) concentrations, indicating that impacts to the ephemeral stream were reducing in the downstream direction. The downstream-most sampling location (SC-HCW-2-W) was dry on both occasions, so there were no surface water discharges in the Hull Canyon Wash with exceedances during these runoff events, and it's concluded that larger precipitation events are needed to result in a surface flow event in the Hull Canyon Wash at the downstream extent of the site.

Two surface water samples from location HCW-4-W, collected on September 16 and December 4, 2014, were run for PAH analysis (Table 7b). No detected PAH compounds were found above their respective NWQS for PBC in the September sample. None of the PAH compounds were detected in the December sample.

In the September sample two PAH compounds, anthracene and benzo(a)pyrene, were detected at concentrations of 0.065 and 0.11 µg/L, respectively. None of the PAH compounds were detected in the December sample. A&We Acute standards are not available for PAHs. Therefore, Tier II Secondary Acute Values (Suter and Tsao, 1996) were used, as available, for comparison to site concentrations. Neither the anthracene nor benzo(a)pyrene site concentration exceed the associated Secondary Acute Value (13 and 0.24 µg/L, respectively. Therefore, PAHs in ephemeral surface water at the site are not likely to present a significant ecological risk.

3.7 DATA VERIFICATION

The analytical results were reviewed for data verification in accordance with the EPA documents: National Functional Guidelines for Superfund Inorganic Methods Data Review (August 2014) and the National Functional Guidelines for Superfund Organic Methods Data Review (January 2010). The data verification concluded that the data are acceptable in all areas of review and are usable for their intended purpose with noted qualifications. For sample SC-HCW-S-4, analyzed for PAHs, concentration data for all compounds were rejected with the exception of benzo(a)pyrene, which was qualified as estimated. Data Verification Memos are provided in Appendix E and provides details and qualifications of the data verification.

4.0 RISK ASSESSMENTS

Analytical results from Exposure Area 1 and Exposure Area 2 soil samples, Hull Canyon Wash sediment samples and Hull Canyon Wash surface water samples were screened against background levels, NR-SRLs and GPLs to help identify areas and/or contaminants requiring further evaluation, as discussed in Section 3. Because the screening results indicated that detected concentrations of arsenic exceeded the NR-SRL in Exposure Area 1 and Hull Canyon Wash and detected concentrations of arsenic and lead exceeded the NR-SRL in Exposure Area 2, a Human Health Risk Assessment was conducted to evaluate SS-SRLs. A Screening Level Ecological Risk Assessment was also conducted per the recommendation from ADEQ. A summary of the HHRA and ERA are presented in Sections 4.1 and 4.2, respectively. The reader is directed to the more detailed risk assessments in Appendix G (HHRA) and H (SLERA).

4.1 HUMAN HEALTH RISK ASSESSMENT

The primary objective of the HHRA is to evaluate whether activities at the site have potentially impacted the soil, sediment and surface water at concentrations that exceed applicable remediation standards. This assessment was conducted through the collection and evaluation of data for the Site as described in the Revised Project Work Plan (URS 2013) and summarized in Section 3. Data obtained during the field investigation activities conducted in 2014, 2015 and 2018 are used in the HHRA to make recommendations as to whether any remedial actions are recommended for the Site.

The CSM developed for the HHRA represents the connection between contaminant sources, exposure pathways and current/future receptors. It is used to guide the evaluation of potential exposures for human health so that relevant pathways and exposure routes can be evaluated in the HHRA The fate and transport pathways identified in the CSM include direct contact and leaching. The exposure routes are defined by the manner in which a chemical enters the human body and include ingestion, dermal contact, and inhalation. Only potentially complete exposure pathways were evaluated quantitatively in the HHRA, consistent with USEPA guidance (USEPA 1989). Discussion of incomplete exposure pathways that were eliminated from consideration is included in Appendix G. The following potentially complete exposure pathways were evaluated quantitatively:

- *Surface Soil (0—4 inches bgs)*. Incidental ingestion, dermal contact, and inhalation of particulates in surface soil are considered potentially complete exposure pathways for the current/future adolescent trespasser.
- *Sediment*. Incidental ingestion, dermal contact, and inhalation of particulates in sediment are considered potentially complete exposure pathways for the current/future adolescent trespasser.
- *Surface Water.* Incidental ingestion and dermal contact of surface water is considered potentially complete exposure pathway for the current/future adolescent trespasser.

As described in Section 3.2, the site has been subdivided into two Exposure Areas based on current/reasonably anticipated activity patterns for the purposes of determining COPCs and evaluating potential risk. The sediment and surface water samples within Hull Canyon Wash are present in both Exposure Areas but are distinct due to their location within the wash and the expected activity patterns by potential receptors, therefore the risk posed by these media were evaluated separately from Exposure Area 1 and Exposure Area 2. The adolescent trespasser is assumed to have access to and be exposed to Site media in both exposure areas.

4.1.1 Identification of COPCs

The process for developing COPCs is a step-wise approach that evaluates data from Site media and compares these data to conservative default screening levels that are, according to the USEPA and/or ADHS (ADHS 2003), protective of human health and the environment. In general, COPCs are defined as any chemical with a maximum detected concentration (MDC) that exceeds selected screening levels. Those COPCs retained following the screening are then evaluated in more detail which serves to focus the HHRA on those COPCs most likely to contribute to Site risks. For detected analytes, the MDC was used for comparison to the screening level. For non-detected analytes, the minimum reporting limit (MRL) concentration was used for comparison to the screening level. For soil, the screening of COPCs was performed for each exposure area. The screening of COPCs for sediment and surface water was based on all results collected from the Hull Canyon Wash Area, without regard to boundaries of Exposure Areas 1 or 2.

The default screening values used to identify COPCs represent the concentrations below which no adverse health effects are likely to occur for direct contact (e.g., incidental ingestion and dermal contact) exposure pathways. The default screening values for soil use conservative assumptions based on residential exposure that overestimate the types of exposure expected at this site. For example, residential exposure assumes a human receptor is potentially exposed to Site media, e.g., soil, for 350 days per year for 26 years.

The following screening levels were used to identify direct contact COPCs in soil, sediment and surface water:

- Surface Soil (0-4 inches) and Sediment: R-SRLs as listed in Appendix A of AAC Title 18, Chapter 7 (AAC 2009a)
- Surface Water: Partial Body Contact (PBC) - Numeric Water Quality Standards (NWQS) as listed in Table 1 of Appendix A of AAC Title 18, Chapter 11 (AAC 2009b)

The following screening levels were used to identify soil-to-groundwater leaching COPCs in soil and sediment:

- Surface Soil (0-4 inches) and Sediment: Groundwater Protection Limits (GPLs) for metals as listed in A Screening Method to Determine Soil Concentrations Protective of Groundwater Quality, Arizona Dept. of Environmental Quality (ADEQ 1996). GPLs for organics as listed in the ADEQ 2013 GPL spreadsheet.
- Surface Soil and Sediment Synthetic Precipitation Leaching Procedure (SPLP) Results: PBC-NWQC (AAC 2009b)

In addition to the screening values listed above, soil results were compared to the 95% UCL of the mean for the site-specific background to evaluate whether detected concentrations of are consistent with naturally occurring concentrations.

EXPOSURE AREA 1

Descriptive statistics and identified COPCs for Exposure Area 1 are presented in Tables 8a and 8b and discussed below.

Soil - Direct Contact COPCs

In Exposure Area 1, arsenic and copper concentrations exceeded their R-SRLs; these metals are identified as COPCs for direct soil contact. In Exposure Area 1, arsenic concentrations ranged from 19 mg/kg to 250 mg/kg. The MDC of arsenic (250 mg/kg) exceeded the R-SRL of 10 mg/kg and the 95% UCL of the mean background concentration of 24.71 mg/kg. In Exposure Area 1, copper concentrations ranged from 240 mg/kg to 22,000 mg/kg. The MDC of copper (22,000 mg/kg) exceeded the R-SRL of 3,100 mg/kg and the 95% UCL of the mean background concentration of 348.5 mg/kg.

Soil – Leaching to Groundwater COPCs

In Exposure Area 1, no analytes detected in surface soil samples exceeded their respective minimum GPLs.

Copper does not have an established GPL. In Exposure Area 1, copper is detected at concentrations ranging from 240 mg/kg to 24,000 mg/kg, some of which are above the 95% UCL of the mean background value of 348.5 mg/kg. Therefore, the soil SPLP results for copper were compared to the PBC-NWQC to confirm whether copper may be leaching to groundwater at concentrations that may be harmful to human health. Exposure Area 1 soil SPLP results were evaluated for the potential migration of soil contaminants to surface water via runoff of leachate. The MDC of SPLP for copper in soil in Exposure Area 1 exceeded the PCB-NWQS for copper. Consequently, copper was retained for further evaluation as a leaching to groundwater COPC.

EXPOSURE AREA 2

Descriptive statistics and identified COPCs for Exposure Area 2 are presented in Tables 9a and 9b and discussed below.

Soil – Direct Contact

In Exposure Area 2, antimony, arsenic, cadmium, copper and lead concentrations exceeded their respective R-SRLs; these metals are identified as COPCs for direct soil contact.

Exposure Area 2 antimony concentrations ranged from 5.3 milligram per kilogram (mg/kg) to 42 mg/kg. The MDC of antimony (42 mg/kg) exceeded the R-SRL of 31 mg/kg. No background value is available for antimony.

Exposure Area 2 arsenic concentration ranged from 31 mg/kg to 430 mg/kg. The MDC of arsenic (430 mg/kg) exceeded the R-SRL of 10 mg/kg and the 95% UCL of the mean background concentration of 24.71 mg/kg.

Exposure Area 2 cadmium concentrations ranged from 0.67 mg/kg to 65 mg/kg. The MDC of cadmium (65 mg/kg) exceeded the R-SRL of 39 mg/kg and the 95% UCL of the mean background concentration of 3.518 mg/kg.

Exposure Area 2 copper concentrations ranged from 880 mg/kg to 24,000 mg/kg. The MDC of copper (24,000 mg/kg) exceeded the R-SRL of 3,100 mg/kg and the 95% UCL of the mean background concentration of 348.5 mg/kg.

Exposure Area 2 lead concentrations ranged from 18 mg/kg to 1,200 mg/kg. The MDC of lead (1,200 mg/kg) exceeded the R-SRL of 400 mg/kg and the 95% UCL of the mean background value of 59.43 mg/kg.

Soil – Leaching to Groundwater

In Exposure Area 2, antimony, arsenic, cadmium, lead and mercury concentrations exceeded their respective GPLs; these metal are identified as COPCs for leaching to groundwater.
In Exposure Area 2, the MDC of antimony (42 mg/kg) exceeded the minimum GPL of 35 mg/kg. No background value is available for antimony.

In Exposure Area 2, the MDC of arsenic (430 mg/kg) exceeded the GPL of 290 mg/kg and the 95% UCL of the mean background value of 24.71 mg/kg.

In Exposure Area 2, the MDC of cadmium (65 mg/kg) exceeded the GPL of 29 mg/kg and the 95% UCL of the mean background value of 3.518 mg/kg.

Copper does not have an established GPL. In Exposure Area 2, copper was detected at concentrations ranging from 880 mg/kg to 24,000 mg/kg, which are above the 95% UCL of the mean background value of 348.5 mg/kg. Therefore, the soil SPLP results for copper were compared to the PBC-NWQC to confirm whether copper may be leaching to groundwater at concentrations that may be harmful to human health. Exposure Area 2 soil SPLP results were evaluated for the potential migration of soil contaminants to surface water via runoff of leachate. The MDC of SPLP for copper in soil in Exposure Area 2 exceeded the PCB-NWQS for copper. Consequently, copper was retained for further evaluation as a leaching to groundwater COPC.

In Exposure Area 2, the MDC of lead (1200 mg/kg) exceeded the GPL of 290 mg/kg and the 95% UCL of the mean background value of 59.43 mg/kg.

In Exposure Area 2, the MDC of mercury (14 mg/kg) exceeded the GPL of 12 mg/kg and the 95% UCL of the mean background value of 0.166 mg/kg.

HULL CANYON WASH

Descriptive statistics and identified COPCs for Hull Canyon Wash sediment and surface water samples are presented in Tables 10a through 10c and discussed below.

Sediment Direct Contact COPCs

In Hull Canyon Wash sediment samples, arsenic concentrations exceeded the R-SRLs; arsenic is identified as a COPC for sediment direct contact. Arsenic concentrations in sediment samples ranged from 8.7 mg/kg to 34 mg/kg. The MDC of arsenic in sediment (34 mg/kg) exceeded the R-SRL of 10 mg/kg.

Sediment Leaching to Groundwater COPCs

No analytes were present in sediment samples at concentrations exceeding minimum GPLs.

Surface Water Direct Contact COPCs

In Hull Canyon Wash surface water samples, lead concentrations exceeded its PBC NWQS. Lead concentrations in surface water samples ranged from 0.022 mg/L to 0.12 mg/L, exceeded the PBC NWQS of 0.015 mg/L at two locations (HCW-3 and HCW-4).

For lead, the PBC NWQC is based on the lead action level of 0.015 mg/L, which is designed to be protective of exposures to lead in drinking water. Because the Hull Canyon Wash is an ephemeral streambed that is often dry, it is likely that exposure to surface water is intermittent, minimal and of short duration.

In addition, the samples with lead PBC NWQS exceedances were collected in September and October 2014. Subsequent samples collected from the same locations in May 2015 were reported as non-detections. Additional surface water sample collection was attempted in July 2018; however, the streambed was dry and no surface water could be collected at these locations.

The magnitude of exceedance of the drinking water action level for lead are less than an order of magnitude, ranging from slightly less than a factor of 2 (0.022 mg/L at HCW-3), to a factor of 8 (0.12 mg/L at HCW-4). Lead concentrations in surface water over the screening level are not significant enough to warrant concern for the brief and limited exposure to surface water that could occur at the Site. Levels of exposure to surface water in the wash are significantly less than the level of exposure to drinking water sources. Specifically, exposure is expected to be limited to minimal dermal contact, only a few days per year (after a precipitation event). Therefore, the lead exceedances of the PBC-NWQS are not considered to represent a potential risk to human health. Consequently, lead was not retained as a COPC and no further evaluation of lead in surface water is warranted.

Summary

Antimony, arsenic, cadmium, copper, and lead are direct contact surface soil and/or sediment COPCs retained for further evaluation which includes the development of SS- SRLs (Section 4.1.2).

Antimony, arsenic, cadmium, lead and mercury are soil leaching to groundwater COPCs retained for further evaluation which includes the development of alternate GPLs (Section 4.1.5). Copper was also retained for further evaluation for the leaching to groundwater pathway based on SPLP results that exceeded the PBC-NWQS.

Lead was identified as a surface water direct contact COPC; however, based on lines of evidence provided, no further evaluation of lead in surface water is warranted.

4.1.2 Site-Specific Soil Remediation Levels

Antimony, arsenic, cadmium, copper and lead were identified as soil and/or sediment direct contact COPCs and retained for further evaluation. As indicated in the Section 4.1.1, the generic screening values that were used to identify COPCs in soil (R-SRLs) use conservative assumptions that overestimate the types of exposure expected at the Site. As described in USEPA guidance, risk-based screening levels are used to identify those compounds that require further evaluation. Chemicals that do not exceed generic risk-based screening levels in any sample are not present in concentrations that represent a health concern and can be eliminated from further evaluation. However, the reverse is not necessarily true. An

exceedance over risk-based screening levels does not indicate unacceptable risk at the site, but rather that further evaluation of the site's chemical concentrations and potential exposure pathways is necessary. This section discusses the types of exposure expected at this site and, where indicated, derives SS-SRLs to determine whether any of the identified COPCs are present in concentrations indicative of unacceptable human health risk.

The project area is located in Hull Canyon, a steep, rocky canyon with relatively minimal soil development and difficult access. Vehicle access to the site is limited to an unpaved four-wheel drive road on the south side of Highway 89A (Figure 2) and a locked metal gate controls site access. Exposure Area 1 is approximately 6 acres in size on steep slopes and is covered by large rocky material and sand-like material. A 6-foot high chain link fence controls access to Exposure Area 2. Given the remote nature and limited access of the project area, the trespasser exposure scenario is the most likely exposure scenario, with the most sensitive receptor being adolescent trespassers between the ages of 7 to 16 years of age.

The two exposure areas were described in Section 3.2. Exposure Area 1 is on sloped areas that make up the majority of the site. These slopes are steep and difficult to climb. Exposure Area 2 is much smaller (approximately 2 acres) such that trespassers are not expected to spend a significant amount of time at these exposure areas. The Hull Canyon Wash likely represents the most attractive area to trespassers due to the relative ease with which they could walk along the wash. Thus it is assumed that an adolescent trespasser may be exposed to soil and/or sediments as they explore the site. The exposure pathways for this scenario include: incidental ingestion, dermal contact, and dust inhalation.

Site–specific adolescent trespasser SRLs are developed for the soil and sediment direct contact COPCs (antimony, arsenic, cadmium, copper, and lead). The SS-SRLs are based on a target cancer risk level of 1×10^{-5} and a target hazard quotient (HQ) of 1. Site-specific adolescent trespasser SRLs were derived using USEPA guidance, bioavailability literature, and site-specific information.

USEPA guidance, site-specific information, and professional judgment were used to derive reasonable maximum exposure (RME) exposure assumptions for the adolescent trespasser. The RME is estimated by selecting values for exposure variables so that the combination of all variables results in the maximum exposure that can reasonably be expected to occur at the property.

The following summarizes the site-specific exposure assumptions (Table 11) used in the derivation of site-specific adolescent trespasser SRLs:

- **Body Weight:** The average body weight of 46 kg for adolescents 7 to 16 years of age was used (USEPA, 2011).
- **Averaging Time:** The averaging time used to calculate cancer risk was for a 70-year lifetime (25,550 days; USEPA, 1991, 2014). The averaging time used to calculate non-cancer hazard was for the 10-year exposure duration (3,650 days) (USEPA, 1991).
- **Exposure Frequency:** Due to the remoteness of the site and restricted access, it was assumed that trespassers would visit the site infrequently (15 days per year). Note that this exposure frequency differs from the 10 days proposed in the Work Plan and provides a more conservative site-specific remediation level.
- **Exposure Duration:** The maximum exposure duration of 10 years was used for youth 7 to 16 years of age.

- **Body Surface Area (Surface Soil/Sediment Exposure):** Recommended RME value of 6,032 cm^2 was derived for an adult resident assuming complete contact with exposed skin (USEPA, 2011, 2014).
- **Adherence Factor:** The USEPA RME default value for residential exposures to soil of 0.07 mg/cm^2 was used (USEPA, 2014).
- **Soil Ingestion Rate:** It was assumed that one-fourth of the default RME soil ingestion rate for adult residents of 100 mg/day (USEPA, 2014) could occur during the 2 hours that youth trespass on the property. The soil ingestion rate used was 25 mg/day.
- **Exposure Time:** Due the property's small size and restricted access, it was assumed that trespassers would only spend a small portion of their day (about 2 hours) at the site.

These site-specific exposure factors were combined with toxicity values (Table 13) and target risk levels to derive a site-specific adolescent SRLs. The toxicity values were obtained from USEPA's April 2019 Regional Screening Levels Table (USEPA, 2019). The site-specific SRLs are based on target cancer risk levels of 1×10^{-4}, 1×10^{-5}, $1 \text{ X } 10^{-6}$ and a target HQ of 1. The site-specific SRL based on a target cancer risk level of 1×10^{-5} is used for comparison to concentrations of COPCs in soil and sediment, in accordance with the Arizona VRP. Table 14 presents the site-specific SRLs for the COPCs in soil and sediment.

The site-specific adolescent trespasser SRLs developed as summarized above and described in detail in the HHRA (Appendix G) are:

- Antimony: 18,000 mg/kg, based on the non-carcinogenic end point;
- Arsenic: 2,300 mg/kg, based on the 1×10^{-5} carcinogenic end point;
- Cadmium: 27,000 mg/kg, based on the non-carcinogenic end point; and
- Copper: 1,800,000 mg/kg, based on the non-carcinogenic end point.

4.1.3 Risk Evaluation of COPCs

This section presents the comparison of site-specific SRLs to COPC concentrations. Lead is evaluated differently than other chemicals and is discussed separately.

Table 15 provides a comparison of the SS-SRLs for direct contact with soil/sediment in Exposure Area 1, Exposure Area 2 and Hull Canyon Wash. Because the adolescent trespasser is expected to move around the Site rather than spend all of their time at one location, the comparison of the 95 percent UCL of the mean (Table 12) to the site-specific SRL is a more realistic evaluation of exposure. The MDCs and 95 percent UCLs of antimony, arsenic, cadmium, and copper in each exposure area were well below the site-specific adolescent trespasser SRLs, suggesting that concentrations of these chemicals are unlikely to cause adverse health effects to the adolescent trespasser who may be intermittently exposed to Site soil. Consequently, no further evaluation of antimony, arsenic, cadmium and copper with regard to direct contact exposure to soil is warranted.

4.1.4 Lead Evaluation

Lead was identified as a direct contact COPC; the MDC of lead in Exposure Area 2 (1,200 mg/kg) exceeded the R-SRL of 400 mg/kg. The evaluation of lead is conducted differently from other constituents because of lead's unique toxicological properties. The most sensitive receptors to lead exposures are children and pregnant women (developing fetus). The USEPA and the Centers for Disease Control and Prevention (CDC) have determined that the childhood blood-lead (PbB) concentrations at or above 10 micrograms per deciliter (µg/dL) of blood present risks to children's health. The generally accepted methodology is to estimate PbB levels based on soil exposures and to compare the estimated PbB levels to PbB levels considered to be protective of adverse health effects. For this evaluation, USEPA's Adult Lead Model (ALM) (USEPA 2003b, 2017) was used to estimate PbB levels for the adolescent trespasser.

While USEPA's Technical Review Workgroup for Lead has cautioned that lead risk assessments that include non-residential land use should report new toxicity information from USEPA indicating adverse health effects at PbB levels below 10 µg/dL down to 5 µg/dL and possibly lower (USEPA 2010). The USEPA currently considers 10 µg/dL to be the PbB level of concern for fetuses and children. The CDC has replaced its former Level of Concern of 10 µg/dL with a reference value of 5 µg/dL (CDC 2012). Although the new toxicity information for lead has not, as of yet, been incorporated into any USEPA methodologies for evaluating the exposure of children or adults to lead, both thresholds of 5 µg/dL (reference value) and 10 µg/dL (level of concern) were considered herein. In general, the appropriate level for further action is in transition. Although the U.S. Department of Housing and Urban Development adopted new lead action levels in 2017 based on the 5 µg/dL threshold level of lead in the child's blood, to match the more protective guidance of the CDC, this criterion only applies to children living in federally associated housing under the Office of Lead Hazard Control and Healthy Homes' Lead-Based Paint Hazard Control and Lead Hazard Reduction Demonstration Grants.[1] Because of the limited and intermittent amount of lead exposure for the adolescent trespasser considered in this HHRA, although both 5 µg/dL (reference value) and 10 µg/dL (level of concern) scenarios are considered, the final conclusions and recommendations focused on the 10 µg/dL level of concern. This is consistent with the USEPA's risk reduction goal for contaminated sites to limit the probability of a child's PbB concentration exceeding 10 µg/dL to 5 percent or less after cleanup (as described in the 1994 Office of Solid Waste and Emergency Response Directive (USEPA 1994) and is consistent with the underlying assumptions associated with the USEPA soil RSL of 400 mg/kg lead for residential exposure (USEPA 2019).

The ALM was used to evaluate non-child exposure to lead in soil in Exposure Area 2, as detailed in the HHRA (Appendix G). The receptor of concern in the ALM is the fetus of an adult worker and the EPC used in the lead evaluation and is equal to the arithmetic mean concentration of lead in Exposure Area 2 (230 mg/kg). A soil ingestion rate of 25 mg/day was used to evaluate a potential adolescent trespasser which represents the ingestion rate used in the development of site-specific SRLs. A lead absorption fraction of 0.12 was used; this is the default value recommended by the USEPA (2003, 2009). This value is based on experimental studies of the bioavailability of ingested lead in adults with considerations for the following three major sources of variability: 1) effect of food on lead bioavailability, 2) nonlinearity in PbB, and 3) effect of lead form and particle size on bioavailability. The value assumes a relative bioavailability of 0.6 for lead in site-related media as compared to soluble lead, and also assumes an absorption fraction (AF) of 0.2 for soluble lead. Thus, the final AF is 0.12 (i.e., AF = 0.6 x 0.2 = 0.12). The exposure frequency of 15 days per year used for the adolescent trespasser represents a short-term exposure and is incompatible with the use of the ALM, which was not designed to assess exposures less

[1] https://portal.hud.gov/hudportal/HUD?src=/press/press_releases_media_advisories/2017/HUDNo_17-006

than 90 days (USEPA 2016). Consequently, an exposure frequency of 90 days was used in the ALM to represent the minimum number of days to produce a quasi-steady-state blood lead concentration.

Preliminary remediation goals (PRGs) were calculated for the adolescent trespasser in Exposure Area 2 for target fetal PbB concentrations of 5 and 10 µg/dL. The PRG for the adolescent trespasser based on a target fetal blood lead concentration of 5 ug/dL is 5,100 mg/kg. The EPC for lead in Exposure Area 2 (230 mg/kg) is well below this PRG.

The PRG for the adolescent trespasser based on a target fetal blood lead concentration of 10 ug/dL is 12,000 mg/kg. The EPC for lead in Exposure Area 2 (230 mg/kg) is well below this PRG.
No further evaluation of lead with respect to direct contact soil exposure is warranted.

4.1.5 Alternative Groundwater Protection Levels

Antimony, arsenic, cadmium, lead and mercury are soil leaching to groundwater COPCs retained for further evaluation. To further evaluate potential groundwater impacts from these metals, methods outlined in *Screening Method To Determine Soil Concentrations Protective of Groundwater Quality* (ADEQ, 1996) were used to calculate alternate GPLs, as described in the SAP.

Minimum GPLs used in the COPC screening process were calculated based on an assumed leachability ratio 'R' of 20. This ratio represents the resistance of a particular contaminant to partition into leachate and consequently become mobilized from soils to groundwater, and can be calculated as the ratio of the solid phase concentration (mg/kg) to the leachate concentration (mg/L) as determined via SPLP. Therefore, the higher the R value, the lower the particular contaminant's propensity for leaching. The R value is then multiplied by a human health based groundwater standard (e.g., the maximum contaminant level), and a constant value (292.9) that incorporates numerous assumptions about the depth to groundwater, physical mixing of leachate in groundwater via dispersion, well head dilution, etc. (ADEQ 1996).

Site-specific R values calculated for antimony, arsenic, cadmium, copper, lead and mercury for Exposure Area 1, Exposure Area 2 and Hull Canyon Wash are summarized in Table 16 along with alternative GPLs and soil concentrations that exceeded the default GPLs**.** The soil concentrations for antimony, arsenic, cadmium, copper, lead and mercury are all well below their respective alternative GPLs, indicating that these metals are not leaching to groundwater at levels that may cause adverse health effects. No further evaluation of antimony, arsenic, cadmium, copper, lead and mercury with respect to the leaching to groundwater pathway is warranted.

4.1.6 Conclusions – Human Health Risk

Site-specific adolescent trespasser SRLs were developed for soil and sediment direct contact COPCs antimony, arsenic, cadmium, copper, and lead. The site-specific SRLs are based on a target cancer risk level of 1×10^{-5} and a target HQ of 1 and take into consideration site-specific exposure parameters for the adolescent trespasser, e.g., exposure time of 2 hours per day, exposure frequency of 15 days per year, and exposure duration of 10 years. The MDCs and 95 percent UCLs of antimony, arsenic, cadmium, and copper in each exposure area were well below the site-specific adolescent trespasser SRLs, suggesting that concentrations of these chemicals are unlikely to cause adverse health effects to the adolescent trespasser who may be intermittently exposed to Site soil.

Lead was identified as a soil direct contact COPC in Exposure Area 2. A lead PRG was developed based on a target fetal blood lead level of 5 ug/dL (5,100 mg/kg) and 10 ug/dL (12,000 mg/kg). The EPC of lead in Exposure Area 2 is well below these lead PRGs. Consequently, lead concentrations in Site soil are unlikely to cause adverse health effects for the adolescent trespasser.

Alternative GPLs were developed for soil leaching to groundwater COPCs antimony, arsenic, cadmium, copper, lead and mercury. A comparison of the MDCs of these six chemicals in soil to the alternative GPLs shows that Site concentrations of antimony, arsenic, cadmium, copper, lead and mercury are well below the alternative GPLs, indicating that chemicals in soil are not leaching to groundwater at concentrations that would pose unacceptable risk to human health.

Lead was identified as a surface water direct contact COPC; however, based on lines of evidence provided in Section 4.1.4, no further evaluation of lead in surface water is warranted.

4.2 SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT

A streamlined SLERA was conducted to evaluate whether Site soil and Hull Canyon Wash sediment and surface water pose potential risks to ecological receptors, if present on the Site. This assessment was conducted through the collection and evaluation of data for the Site as described in the Revised Project Work Plan (URS 2013a). Data obtained during the field investigation activities conducted in 2014, 2015 and 2018 were included in the SLERA. The chemicals of potential ecological concern (COPEC) screening process and associated risk estimates performed as part of the SLERA are briefly summarized in this section. The reader is directed to the SLERA in Appendix H for a detailed description of the overall assessment, including all relevant assumptions, technical data and calculations.

Steps 1 and 2 of the ecological risk assessment process (USEPA, 1997a), comprise the screening level problem formulation to determine the focus and scope of the SLERA, an ecological effects evaluation, an exposure estimate and the initial screening level risk evaluation to identify COPECs and key receptors to be retained for further evaluation. In the Step 3A refinement per USEPA (2001) guidance, the remaining COPECs from Step 2 are reevaluated using more site-specific information. This Step 3A refinement culminates in a scientific management decision point (SMDP) in which the SLERA conclusions are used to guide risk management decisions.

The problem formulation synthesizes what is known or predicted for the site in order to develop a CSM that guides the SLERA process. The SLERA CSM, presented graphically in Appendix H, integrates ecological fate and transport pathways, key habitats, exposure areas, potential receptors, assessment endpoints and associated measures of effects in order to evaluate potential risk. Ecologically relevant exposure areas, receptors and habitat evaluated in the SLERA include upland terrestrial areas (Exposure Areas 1 and 2) and several point locations along the course of the Hull Canyon Wash (Table 17). Discussion of exposure media and migration pathways that were not considered quantitatively in the SLERA is also included in Appendix H.

The following media and pathways are considered potentially significant for ecological exposure at the Site:

- **Surface soil, direct/indirect contact.** This pathway is potentially complete for terrestrial receptors. Exposure assumes direct contact to surface soil (0–4 inches bgs) and indirect exposure via ingestion of biota (i.e., terrestrial plants, terrestrial invertebrates and /or small mammals).

- **Sediment, direct/indirect contact.** The Hull Canyon Wash is ephemeral and therefore, associated sediments are typically exposed and not saturated. Sediment is thus effectively considered to be soil for the purposes of the SLERA.
- **Surface water, direct contact.** The potential use of water features by area wildlife for drinking water may occur when water is present and thus this pathway is potentially complete. The Hull Canyon Wash is ephemeral for most of the year, which prevents the establishment of an aquatic community.

Exposure Area 1 consists of mine residuals deposited on a relatively steep slope; most of the area is barren, disturbed and ruderal conditions for plant life. Similarly, most of Exposure Area 2 is disturbed and ruderal but with pockets of healthy plant life. Sediment and surface water samples within Hull Canyon Wash are present in both Exposure Areas but are distinct due to their location within the Wash and the expected activity patterns by potential receptors; therefore, the risk posed by surface water and sediment/soil were evaluated separately from Exposure Area 1 and 2 on a point by point basis. The following representative terrestrial receptors are evaluated in this SLERA:

- Terrestrial Plant Community
- Soil Invertebrate Community
- Omnivorous or Insectivorous Wildlife (represented by the horned lark)
- Herbivorous Wildlife (represented by the black-tailed jackrabbit)
- Carnivorous Wildlife (represented by the coyote)

A review of special status species in Yavapai County was conducted as part of the evaluation and selection of representative receptors. Based on current listings of threatened and endangered federal status species (United States Fish and Wildlife Service [USFWS], 2018), and Bureau of Land Management (BLM), Arizona Bureau sensitive species (BLM, 2017), no state and/or federally listed species are expected to occur at or in association with the Site. Given the disturbed nature of the Site and absence of sightings or documented presence of such species, significant site presence is not likely, especially given the presence of nearby undisturbed native habitat.

4.2.1 Risk Estimates

A step-wise approach is used to evaluate Site data for comparison to well established ecological screening levels that are protective of ecological receptors. The COPEC selection process was conducted by comparing MDCs to the lowest screening benchmark available (primarily EPA Eco-SSLs [2007b]) for the four ecological guilds available at the Site: soil invertebrates, terrestrial plants, avian wildlife and mammalian wildlife. For detected analytes, the MDC was used for comparison to the ecological screening levels. For non-detected analytes, the minimum reporting limit (MRL) concentration was used for comparison to the ecological screening levels.

COPECs retained following the initial screen are evaluated in more detail which serves to focus the SLERA on those areas and media most likely to contribute to Site risks. For soil, the screening of COPECs was performed for each exposure area. The screening of COPECs for sediment and surface water was based on all results collected from the Hull Canyon Wash Area, without regard to boundaries of Exposure Areas 1 or 2. Identified COPECs for each area following the initial screen include the following:

- Exposure Area 1: antimony, arsenic, cadmium, copper, lead, manganese, mercury, nickel, selenium, silver and zinc.
- Exposure Area 2: antimony, arsenic, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium, silver and zinc.
- COPECs for the Hull Canyon Wash area included all metals identified for both Exposure Area 1 and 2.

The risk estimation process uses quantitative methods to evaluate the potential for risk, which are presented as Step 2 HQs and Step 3A HQs. Risk estimates are derived for each combination of assessment endpoint and measure of effect focus on each exposure medium and COPEC. An assessment endpoint is an explicit expression of the environmental value to be protected (USEPA, 1997a). The measures of exposure and effect are the ecological characteristic(s) that quantify the assessment endpoint. The measures of effect for wildlife receptors are measurable changes in an attribute of an assessment endpoint, or its surrogate in response to a stressor, and is evaluated by comparing the ingested doses relative to derived toxicity reference values (TRVs) of the receptor population under conservative (Step 2) and site-specific Step 3A assumptions. In Step 2, the evaluation is based on a no observed adverse effect level (NOAEL) TRV based on adverse effects on individuals. The Step 3A evaluation considers not only the NOAEL TRV, but also the lowest observed adverse effect level (LOAEL) TRV that serves as a surrogate for organism population-level effects for consideration by risk managers.

The HQ is an important line of evidence for risk estimation and description when sufficient exposure and toxicity data exist. HQs are unitless ratios calculated by dividing the receptor's estimated exposure by a comparable toxicity benchmark or TRV expressed in the same units of measure. Due to the inherent uncertainties in uptake, toxicity, and exposure terms included in the calculation, the level of mathematical precision of a dose-based HQ is only considered reliable to one significant digit.

An HQ≤1 indicates that a given COPEC-receptor combination may be excluded from further consideration (i.e., potential risk is not likely). If an HQ>1, the potential for a hazard or risk cannot be excluded. However, the magnitude of the HQ is not a measure of the magnitude of a potential hazard and is not comparable across assessment endpoints (i.e., an HQ=10 for one receptor is not necessarily "worse" than an HQ=5 for another), as the underlying dose-response relationship is not linear nor comparable between species.

Step 3A refinements provide more realistic exposure and effects assumptions than in the initial Step 2 screening evaluation. The exposure and toxicity assumptions and ecological effects characterization used for estimating risk to ecological receptors are discussed in detail in the SLERA (Appendix H). Step 3A refinements include:

- **95% UCLs of the mean as estimates of EPCs.** For data with adequate sample size, the 95% UCL of the mean is considered as the EPC. The EPC defaults to the MDC if too few samples are available (as is the case for sediment) to calculate a reliable 95% UCL or if the 95% UCL is skewed higher than the MDC due to small sample size.
- **Receptor-specific exposure.** Applies site-specific or less conservative exposure assumptions for birds and mammals based on typical diet, foraging range, and area use.
- **Bioavailability.** For lead, bioavailability data are available and were applied to exposure estimates.

- **Background.** Metals with Step 3A HQs > 1 were also compared to background values.

PLANT AND INVERTEBRATE SOIL COMMUNITIES

Toxicity screening benchmarks for community level receptors are typically limited to relatively few analytes and based on very conservative laboratory studies and not on locally relevant biota. As such, it is difficult to draw meaningful conclusions regarding potential risk to these communities based on toxicity benchmarks alone. Because of this, the approach taken in this SLERA for community level receptors incorporates 1) comparison to screening benchmarks combined with 2) qualitative field observations (e.g., presence of ground cover, habitat characteristics and suitability for the community, absence of visible signs of stress), and 3) contribution from background concentrations. The methodology, exposure and toxicity assumptions, assessment endpoints and calculations used to estimate risks to plant and invertebrate soil communities are presented in detail in the SLERA (Appendix H)

The Step 2 soil evaluation compares conservative soil benchmarks (primarily EPA Eco-SSLs [2007b]) protective of terrestrial communities to the soil MDC. Appendix H provides comprehensive details on this risk evaluation and the identification of COPECs that are evaluated further in Step 3A. In Step 3A, the evaluation of terrestrial plants and invertebrates compares secondary vegetation and soil/leaf litter invertebrate benchmarks from the Los Alamos National Laboratory (LANL, 2017) as well as background, to area 95% UCL soil concentrations. The results are summarized below.

- **Plant Community -** The potential for risk cannot be excluded for the following COPECs (HQs>1):
  - Exposure Area 1 – arsenic, copper and selenium
  - Exposure Area 2 – arsenic, copper, selenium and zinc
- **Invertebrate Community -** The potential for risk cannot be excluded for the following COPECs (HQs>1):
  - Exposure Area 1 – arsenic, copper and mercury
  - Exposure Area 2 – arsenic, copper, mercury, selenium and zinc

WILDLIFE

An assessment endpoint is an explicit expression of the environmental value to be protected (USEPA, 1997a). The measures of exposure and effect are the ecological characteristic(s) that quantify the assessment endpoint. The measures of effect for wildlife receptors are measurable changes in an attribute of an assessment endpoint, or its surrogate in response to a stressor, and is evaluated by comparing the ingested doses relative to derived TRVs of the receptor population under conservative (Step 2) and site-specific Step 3A assumptions. In Step 2, the evaluation is based on a no observed adverse effect level (NOAEL) TRV based on adverse effects on individuals. The Step 3A evaluation considers not only the NOAEL TRV, but also the lowest observed adverse effect level (LOAEL) TRV that serves as a surrogate for organism population-level effects for consideration by risk managers. The methodology, exposure and toxicity assumptions, assessment endpoints and calculations used to estimate the risks are presented in detail in the SLERA (Appendix H) and the results for Step 3A are summarized below.

Omnivorous/Insectivorous Wildlife

The horned lark was selected as the representative receptor for the protection of omnivorous or insectivorous terrestrial consumers from adverse effects on growth, survival, and reproduction from exposure to site-related COPECs. The following metals were identified as COPECs in Step 3A:

- **Exposure Area 1**: LOAEL HQs are greater than 1 for the following three COPECs: copper, selenium and zinc. NOAEL HQs are greater than 1 for the following six COPECs: cadmium, copper, lead, selenium, silver and zinc.
- **Exposure Area 2**: LOAEL HQs are greater than 1 for the following six COPECs: cadmium, copper, lead, mercury, selenium and zinc. NOAEL HQs are greater than 1 for the following eight COPECs: arsenic, cadmium, copper, lead, mercury, selenium, silver and zinc.

The potential for risk cannot be discounted for omnivorous (or insectivorous) wildlife for the COPECs listed above.

Herbivorous Wildlife

The black-tailed jackrabbit was selected as the representative receptor for the protection of herbivorous terrestrial consumers from adverse effects on growth, survival, and reproduction from exposure to site-related COPECs. The following metals were identified as COPECs in Step 3A:

- **Exposure Area 1**: There are no Step 3A LOAEL- or NOAEL HQs greater than 1.
- **Exposure Area 2**: There are no Step 3A LOAEL HQs greater than 1. Only selenium has a Step 3A NOAEL HQ greater than 1.

Carnivorous Wildlife

The coyote was selected as the representative receptor for the protection of carnivorous terrestrial consumers from adverse effects on growth, survival, and reproduction from exposure to site-related COPECs. The following metals were identified as COPECs in Step 3A:

- **Exposure Area 1**: There are no Step 3A LOAEL- or NOAEL HQs greater than 1.
- **Exposure Area 2**: There are no Step 3A LOAEL- or NOAEL HQs greater than 1.

SEDIMENT

Soil benchmarks rather than sediment benchmarks are used in the sediment evaluation because of the ephemeral nature of the Hull Canyon Wash and the lack of aquatic biota in the vicinity of the Wash. The concentration at each sample location in the Wash is also compared to the MDC in the background dataset and only concentrations that exceed both the screening level and background are retained as final COPECs in sediment. The methodology, exposure and toxicity assumptions, assessment endpoints and calculations used to estimate the risks are presented in detail in the SLERA (Appendix H), the results are summarized below.

- The potential for risk cannot be excluded for the following COPECs that exceed applicable soil screening benchmarks and/or background, listed by sample location:
  - SC-HCW-S-1 – none
  - SC-HCW-S-2 – copper and selenium
  - SC-HCW-S-3 – chromium and nickel
  - SC-HCW-S-4 – copper and selenium
  - SC-HCW-S-5 – copper, mercury and selenium

The results from this sediment evaluation are considered in conjunction with the surface water results since surface water samples were collected in the vicinity of the four sediment/soil sample locations.

SURFACE WATER

Dissolved concentrations in surface water at each of the four sample locations in the ephemeral Hull Canyon Wash were compared to the A&We Acute standards (AAC, 2009). A&We Acute standards apply to an unlisted tributary that is an ephemeral water and are based on acute exposure (AAC, 2009). AAC defines ephemeral water as "a surface water that has a channel that is at all times above the water table and flows only in direct response to precipitation."

It is noted that the dissolved copper concentration at HCW-2-W exceeds the A&We Acute standard; however, given the variation in dissolved copper concentration observed for the three samples collected at HCW-4-W, and the typical absence of water at HCW-2-W, it is difficult to draw a conclusion regarding ecological risk based on a single sample collected at this location. Both sample locations also had relatively high copper concentrations in the collocated sediment/soil samples. Given that the overall area has high copper concentrations in soil, intermittent increases in copper concentrations in Hull Canyon Wash are likely to occur. As previously discussed, there is no evidence of aquatic biota in this ephemeral wash; therefore, the potential ecological risks associated with exposure to copper concentrations in surface water is minimal even for terrestrial receptors that may consume water from the Wash when there is water present.

Comparison to Background

Consideration of naturally occurring background levels for inorganics is an integral part of the risk characterization process and is in accordance with USEPA guidance, Role of Background in the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Cleanup Program (USEPA, 2002b) and Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites (USEPA, 2002a). The presence of naturally occurring concentrations for most metals implies that a greater or smaller part of the reported risk can be due to naturally occurring concentrations, to which the local biota are adapted. As presented in the HQ calculations in the SLERA (Appendix H), site-wide background concentrations for all remaining COPECs were well below their respective EPCs in each area. Based on this comparison, background concentrations of remaining COPECs contribute but do not account for the elevated concentrations found in Exposure Area 1 and Exposure Area 2.

4.2.2 Ecological Risk Characterization Conclusions

The final risk characterization results integrate the Step 2 and Step 3a results with an assessment of uncertainty (lack of knowledge) regarding data, exposure, toxicity, and risk issues. Although risk

assessment follows a structured approach, professional judgment and assumptions or estimates based on limited available information are inherent parts of the risk assessment process. The evaluation of uncertainties is an integral part of the ERA process (USEPA, 1997a) and is described in detail in the SLERA (Appendix H). The following sections provide conclusions regarding the risk results, with consideration for the associated uncertainties. Table 18 presents a summary of the risk results for all representative receptors and media evaluated.

TERRESTRIAL AREAS (EXPOSURE AREAS 1 AND 2)

Plants and Invertebrates

Risks to soil communities are possible from exposure to three COPECs for terrestrial plants and three COPECs for soil invertebrates in Exposure Area 1, and four COPECS for terrestrial plants and five COPECs for soil invertebrates in Exposure Area 2. However, the results reported are based on a screening evaluation using screening benchmarks derived from USEPA, ORNL, and LANL sources. For plants and invertebrates, toxicity endpoints from the USEPA and ORNL studies in particular are based on sensitive seedling growth and germination, and earthworm growth and survival, respectively, and typically use highly soluble chemical forms. The relevance of the screening levels for site-specific vegetation/invertebrates under site-specific soil conditions and constituent form is subject to high uncertainty.

Although physically disturbed areas are evident in association with past mining activities in both Exposure Area 1 and Exposure Area 2, no overt signs of acute or chronic toxicity (e.g., stressed or dead vegetation, absence of biota) have been noted. Risk results based on the Step 2/3A benchmark screen for both plant and invertebrate communities are highly uncertain because they are based on individual species of plants and invertebrates (not populations or communities) and therefore should not be used to infer actual or expected risks for communities of organisms.

In summary, risk results based on the Step 2/Step 3A screen for both plants and invertebrates are highly uncertain and are unlikely to reflect actual risks that may be present at the Site, especially given the notable differences in test versus local species and extrapolation of individual toxicity tests to entire communities. Consideration of additional lines of evidence including soil background conditions and community structure/ site observations indicate the ruderal conditions present primarily are due to physical rather than chemical stressors. While potential for localized hazards and risk cannot be discounted from exposure to the above COPECs, the risks to terrestrial plant and invertebrate communities are expected to be minimal.

Wildlife

Ecological risk for small ranging wildlife receptors with home foraging ranges that imply 100 percent site exposure cannot be excluded. More specifically, risks to omnivorous (insectivorous) wildlife as represented by the horned lark are possible from exposure to three COPECs in EA 1 (copper, selenium and zinc) and six COPECs in EA 2 (cadmium, copper, lead, mercury, selenium and zinc). HQs are generally driven by invertebrate ingestion by the horned lark. Invertebrates account for more than 90 percent of the total ingested dose for all metals except selenium (75 percent invertebrates, 18 percent plants and 7 percent soil) and zinc (88 percent invertebrates, 2 percent plants and 10 percent soil). LOAEL- and NOAEL-based HQs greater than or equal to 1 are discussed in detail in Appendix H.

Key uncertainties regarding wildlife risk results indicate that risk is generally overestimated. In particular, the assumption that most receptors spend all of their time in a specific area likely overestimates risk, especially for receptors with moderate home or feeding ranges such as the horned lark, as the relatively low vegetative cover within physically disturbed/recovering areas of the Site (for example, the waste piles) and attractiveness of adjacent areas within and outside of each EA would likely lead these receptors to forage over wider areas. Although all terrestrial wildlife evaluated are year-round residents, wildlife receptors such as the horned lark may migrate locally due to seasonal factors (e.g., food availability, thermal cover) resulting in wider home ranges and/or altered diets, which may vary from year to year. For omnivorous receptors such as the horned lark that rely on invertebrates for most of their diet, reported risk is likely overestimated, as uptake factors used to model invertebrate (food) concentrations are based on earthworm models; use of earthworm-based uptake factors where earthworms are not expected to be the primary food source is likely to overestimate potential risk.

Although the potential for unacceptable risks from exposure to six COPECs cannot be excluded for small ranging wildlife receptors such as the horned lark, uncertainties result in a likely overestimate of the potential risks. In addition, ecological exposures at the former mining site may be lower than in adjacent undisturbed areas due to degraded habitat resulting from past physical disturbances. These uncertainties coupled with the availability of nearby quality habitat suggest that the likelihood of small- and medium-ranging wildlife receptors being maximally exposed to COPECs within EA 1 or EA 2 is unlikely.

HULL CANYON WASH

Aquatic exposures to surface water in the Hull Canyon Wash was evaluated by comparing sample concentrations to screening levels that are designed to protect aquatic organisms and wildlife in ephemeral waterbodies (AAC, 2009). Only two samples exceeded screening levels at two locations: HCW-2-W (copper) and HCW-4-W (copper). The exceedance for the HCW-4-W sample was not repeated in a separate sample at the same location two months later. Given the ephemeral nature of the Wash, exposure to terrestrial biota in surface water is expected to be minimal.

Sediment (or more appropriately, soil) samples were also collected at the four sample locations within the Wash. These samples were compared to soil benchmarks because of the ephemeral nature of the Wash and the lack of sediment-related biota in the area of the Wash. Copper and selenium exceeded their respective soil benchmarks and background in two samples and chromium and nickel exceeded their respective benchmarks in one other sample. However, with the exception of copper, none of these COPECs were considered a concern in the associated surface water samples. In addition, the soil screening benchmarks are highly conservative resulting in a high level of uncertainty.

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5.0 CONCLUSIONS AND RECOMMENDATIONS

This Site Characterization Report presents the results of field environmental characterization activities performed by AECOM from July 22 2014 through May 20, 2015 and in July 2018 in support of the Verde Central Voluntary Remediation Project. Results of media specific sampling were compared to human health risk-based, site-specific SRLs and in a screening level ecological risk assessment.

5.1 CONCLUSIONS

Sampling activities were conducted with minor changes to the approved Work Plan as described in Section 2.2.3. Data verification was performed (Appendix E) and concluded that the data were acceptable in all areas of review and are usable for their intended purposes. The Site was divided into Exposure Areas based on historical site use, current habitat conditions and environmental setting, and potential future site use for the purposes of determining COPCs and evaluating potential human health and ecological risk.

The human health risk assessment (Section 4.1) included comparisons of the analytical results to background and generic human health screening levels to identify direct contact and leaching to groundwater COPCs in soil, sediments and surface water. Antimony, arsenic, cadmium, copper and lead were identified as COPCs in soil and sediment and site-specific adolescent trespasser SRLs for these metals were developed based on a target cancer risk level of 1×10^{-5} and a target HQ of 1. The MDCs and 95 percent UCLs of antimony, arsenic, cadmium, and copper in each exposure area were well below the site-specific adolescent trespasser SRL, suggesting that concentrations of these chemicals are unlikely to cause adverse health effects to the adolescent trespasser who may be intermittently exposed to Site soil.

Lead was identified as a soil direct contact COPC in Exposure Area 2. A lead PRG was developed based on a target fetal blood lead level of 5 ug/dL (5,100 mg/kg) and 10 ug/dL (12,000 mg/kg). The EPC for lead in Exposure Area 2 (230 mg/kg) is well below these lead PRGs. Consequently, lead concentrations in Site soil are unlikely to cause adverse health effects for the adolescent trespasser. Lead was identified as a surface water direct contact COPC; however, based on lines of evidence provided in Section 4.1.4, no further evaluation of lead in surface water is warranted.

Alternative GPLs were developed for soil leaching to groundwater COPCs antimony, arsenic, cadmium, copper, lead and mercury. A comparison of the MDCs of these six chemicals in soil to the alternative GPLs shows that Site concentrations of antimony, arsenic, cadmium, copper, lead and mercury are well below the alternative GPLs, indicating that chemicals in soil are not leaching to groundwater at concentrations that would pose unacceptable risk to human health.

As discussed in the summary of the SLERA (Section 4.2), risks to terrestrial plant and invertebrate communities cannot be discounted from exposure to three COPECs (arsenic, copper and selenium) for terrestrial plants and three COPECs (arsenic, copper and mercury) for soil invertebrates in Exposure Area 1, and four COPECS (arsenic, copper, selenium and zinc) for terrestrial plants and five COPECs (arsenic, copper, mercury, selenium and zinc) for soil invertebrates in Exposure Area 2. Although physically disturbed areas are evident in association with past mining activities in both Exposure Area 1 and 2, no overt signs of acute or chronic toxicity (e.g., stressed or dead vegetation, absence of biota) have been noted. Consideration of soil background conditions and community structure/site observations indicate

the ruderal conditions present primarily are due to physical rather than chemical stressors. While potential for localized hazards and risk cannot be discounted from exposure to the above COPECs, the risks to soil communities as a whole are expected to be minimal.

Risk to omnivorous (insectivorous) wildlife, as represented by the horned lark, are possible from exposure to three COPECs in Exposure Area 1 (copper, selenium and zinc) and six COPECs in Exposure Area 2 (cadmium, copper, lead, mercury, selenium and zinc). The ecological risks from these COPECs are driven by invertebrate ingestion by the horned lark. Although the potential for unacceptable risks cannot be excluded for small to medium ranging wildlife receptors, uncertainties as discussed in detail in the SLERA (Appendix H) result in a likely overestimate of the potential risks. In addition, ecological exposures at the former mining site may be lower than in adjacent undisturbed areas due to degraded habitat resulting from past physical disturbances. These uncertainties, coupled with the availability of nearby quality habitat, suggest that the likelihood of small ranging wildlife receptors being maximally exposed to COPECs within Exposure Area 1 or 2 is unlikely.

Concentrations of several metals slightly exceed conservative screening benchmarks in both surface water (copper only) and sediment/soil (copper, selenium, chromium and nickel) in Hull Canyon Wash. However, given the ephemeral nature of the Wash, exposure to terrestrial biota particularly in surface water is expected to be minimal.

Low levels of PAHs detected in surface water and/or sediment were compared with commonly used consensus criteria. Site concentrations did not exceed these screening levels, and PAHs in surface water and sediment are not considered to present a significant ecological risk.

To evaluate the potential for acid mine drainage (AMD), surface materials from the background locations and the five primary exposure areas were subjected to ABA analysis with sulfur forms. The ABA results are summarized in Figure 7. Review of Figure 7 shows that all of the background soil, Waste Rock, Tailing, and two of the Low Grade Ore samples fall in a NNP range of -20 to +20 $TCaCO_3$/Kt or NPR range between 1 and 3, which are classified as having uncertain acidification potential (the gray shaded areas) using BADCT guidance.

The Waste Rock and Low Grade Ore, which comprise the largest volume of mining residual materials at the site, would be the largest potential source of AMD if it occurred. However, these materials have been exposed to weathering and oxidation for about 85 years and do not appear to have generated persistent AMD to date. The apparent lack of AMD may be related to limited precipitation infiltration (because of the steep slopes that encourage runoff), limited oxygen diffusion into the mining residual materials (e.g., fine-grained materials) and primary sulfide minerals (because of oxidation rinds), or additional neutralizing capacity that may be provided by other minerals (e.g., chlorite, an abundant mineral in the ore host rocks [Anderson and Creasey 1958]) that are not accounted for in the modified Sobek ABA analyses.

The single High-Grade Ore sample (NNP -21.9 $TCaCO_3$/Kt; NPR 0.01) and one Low Grade Ore sample (NNP -29.7 $TCaCO_3$/Kt; NPR 0.01) fall slightly below this range, and are classified as potentially acid generating using BADCT guidance. The Suspected Waste Concentrate area samples fall well within the acid generation zone (NPP -84 and -110 $TCaCO_3$/kT; NPR 0.004 and 0.12) and appear to have the highest potential for acid generation because these materials have the highest pyritic (sulfide) sulfur contents of all the samples analyzed. Although, the High Grade Ore and Suspected Waste Concentrate appear to have the highest acidification potential, these materials comprise a relatively small volume of the mining residual materials at the site and would likely be a negligible source of AMD if it occurred.

Surface water runoff generated on site following precipitation events primarily flows into Hull Canyon Wash, an ephemeral drainage along the toe of the mining residual materials. Observation of the wash during site reconnaissance and sampling events showed no visual evidence of AMD effects, including acidic seeps or mineral precipitates or staining, including yellow, red, or orange ferric hydroxides (yellow-boy) or white aluminum hydroxides or sulfates. Moreover, direct pH measurements in wet-weather samples from Hull Canyon Wash had a pH range from 6.98 to 8.36 standard pH units, all within both the Acute A&We and the PBC standard range of acceptability (6.5 to 9.0). Therefore, it is concluded that overall slightly elevated AMD potential is not appreciably impacting surface water at the site. `

Erosion and surface water transport of mine material appears to be minimal compared to native soil erosion from the much larger adjacent mountainous area of the watershed. No distinct mine material was identified in the Hull Canyon Wash streambed bottom during the investigation, although small amounts of tailing were believed to be present in the banks. Metals concentrations in wash sediment samples were within the range of background soil samples collected in the higher elevations, except for copper which ranged from 140 to 2,200 mg/kg in Hull Canyon Wash sediment samples downstream of mine material (excluding upstream sample SC-HCW-S-1) compared to 25 to 590 mg/kg in the background soil. The copper concentrations in all background soil and wash sediment samples were below the site-specific human health SRL, but above the ecological soil benchmark values. The potential ecological risks associated with exposure to copper concentrations in surface water is minimal even for terrestrial receptors that may consume water from the Wash when there is water present (Section 4.2.2).

In summary, and based on the overall findings of this Site Characterization Study as well as the Human Health Risk Assessment, it is concluded that concentrations of COPCs in soil in Exposure Area 1 and Exposure Area 2 are below generic and/or site-specific soil remediation levels and are unlikely to contribute to adverse human health effects. In addition, concentrations of COPCs in sediment and surface water in Hull Canyon Wash are detected at concentrations that are unlikely to contribute to adverse human health risks. Consequently, no further evaluation of Site media is warranted with regard to human health risk. Although the potential for unacceptable risks cannot be excluded for all ecological receptors, associated uncertainties result in a likely overestimate of the potential risks. These uncertainties, coupled with the availability of nearby quality habitat, suggest that the likelihood of receptors being maximally exposed to COPECs within Exposure Area 1 or Exposure Area 2 is unlikely. Concentrations of COPECs in sediment and surface water in Hull Canyon Wash pose little or no unacceptable risk to biota that may occasionally visit the Hull Canyon Wash area when surface water is available.

5.2 RECOMMENDATIONS

Based on the information presented in this report and the conclusions summarized above, FMC recommends a Declaration of Environmental Use Restriction for the property to restrict future land uses to those that minimize human health exposure to COPCs. FMC has no plans to use, develop, or sell this small roadside site, and will continue to limit access by the gate, fencing, and signage. The DEUR will prohibit residential and recreational use and require that property access restrictions are continued to limit potential trespassers.

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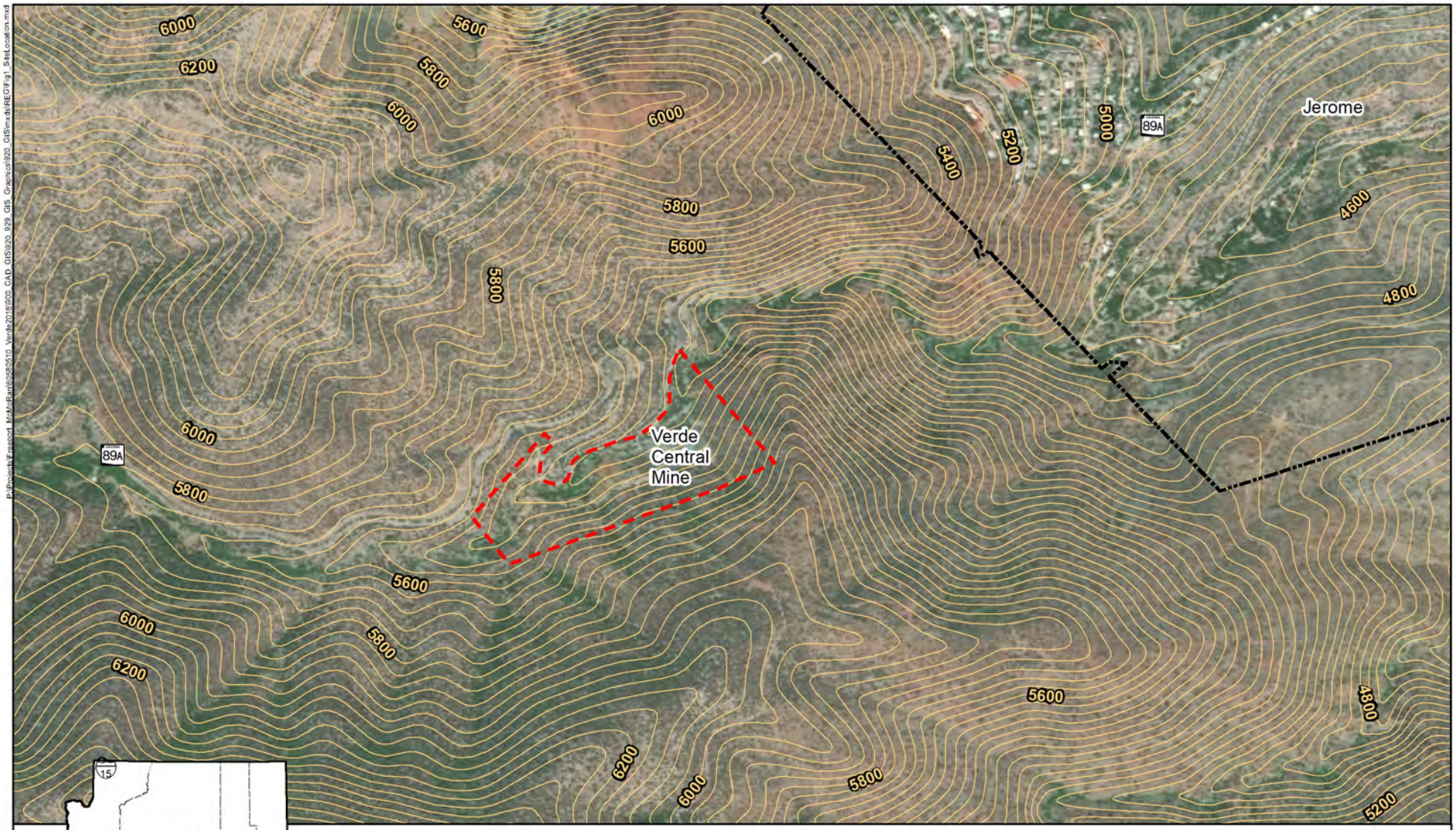
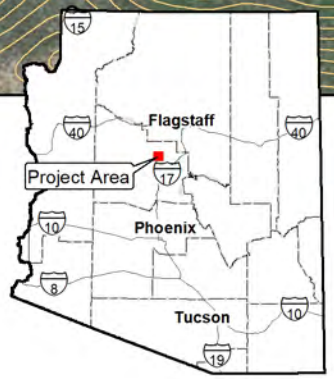
FIGURES





LEGEND

- Verde Central Mine Site
- Town Boundary
- USGS Elevation Contour

Base Map: ALRIS 2016
Project Area: URS 2007
Elevation Contours: U.S. Geologic Survey DEM
Imagery: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

N

0 500 1,000
Feet

Figure 1

Site Location Map

Freeport Minerals Corporation

Updated Site Characterization Report
Verde Central Mine, Near Jerome, Arizona

AECOM

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LEGEND

Mine Features

- Verde Central Voluntary Remediation Site
- Closed Mine Shaft or Adit
- Project Exposure Areas
- Approximate Extent of Waste Rock Stockpile
- Approximate Extent of Low-Grade Ore Rock Stockpile
- Mill Building Foundation
- Tailing[1]
- Waste Concentrate[1]
- High Grade Ore[1]
- USGS Elevation Contour

[1] The extent of tailing, waste concentrate, and high grade ore shown above was estimated during planning stages or the project.

Sample Type

- Background Soil

General Features

- Ephemeral Stream Bed

N

0 100 200
Feet

Hydrology and Mine Features: URS 2008
Elevation Contours: U.S.Geological Survey DEM
Imagery: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 2

Project Area and Background Sample Locations

Freeport Minerals Corporation
Updated Site Characterization Report
Verde Central Mine, Near Jerome, Arizona

AECOM

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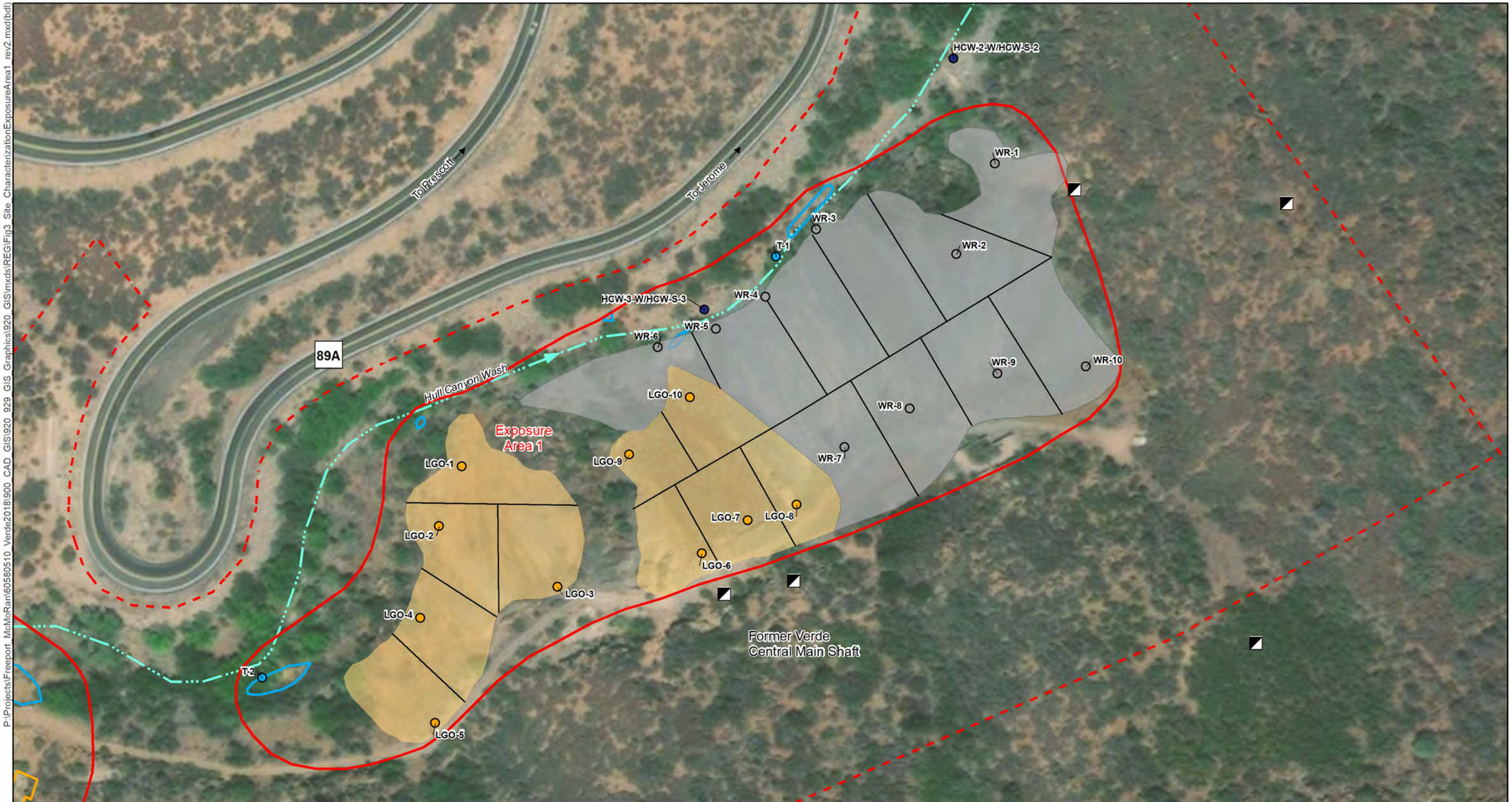

LEGEND

- Verde Central Mine Site
- Project Exposure Areas
- Closed Mine Shaft or Adit
- Approximate Extent of Waste Rock Stockpile
- Approximate Extent of Low-Grade Ore Rock Stockpile
- Mill Building Foundation
- Tailing[1]

Sample Type

- Low Grade Ore Stockpile
- Tailing Stockpile
- Waste Rock Stockpile
- Hull Canyon Wash

General Features

- Ephemeral Stream Bed

N

0 50 100
Feet
1 inch = 100 feet

[1] The extent of tailing shown above was estimated during planning stages of the project. Some sample locations were modified to coincide with tailing observed at the time of the sampling.

Source:
Hydrology and Mine Features: URS 2008
Imagery: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 3

Site Characterization Sample Locations Exposure Area 1

Freeport Minerals Corporation
Updated Site Characterization Report
Verde Central Mine, Near Jerome, Arizona

AECOM

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LEGEND

- Verde Central Mine Site
- Project Exposure Areas

SampleType

- High Grade Ore Stockpile
- Hull Canyon Wash
- Tailing Stockpile
- Waste Concentrate Stockpile
- Soil

- Mill Building Foundation
- Tailing[1]
- Ephemeral Stream Bed

N

0 50 100

Feet
1 inch = 100 feet

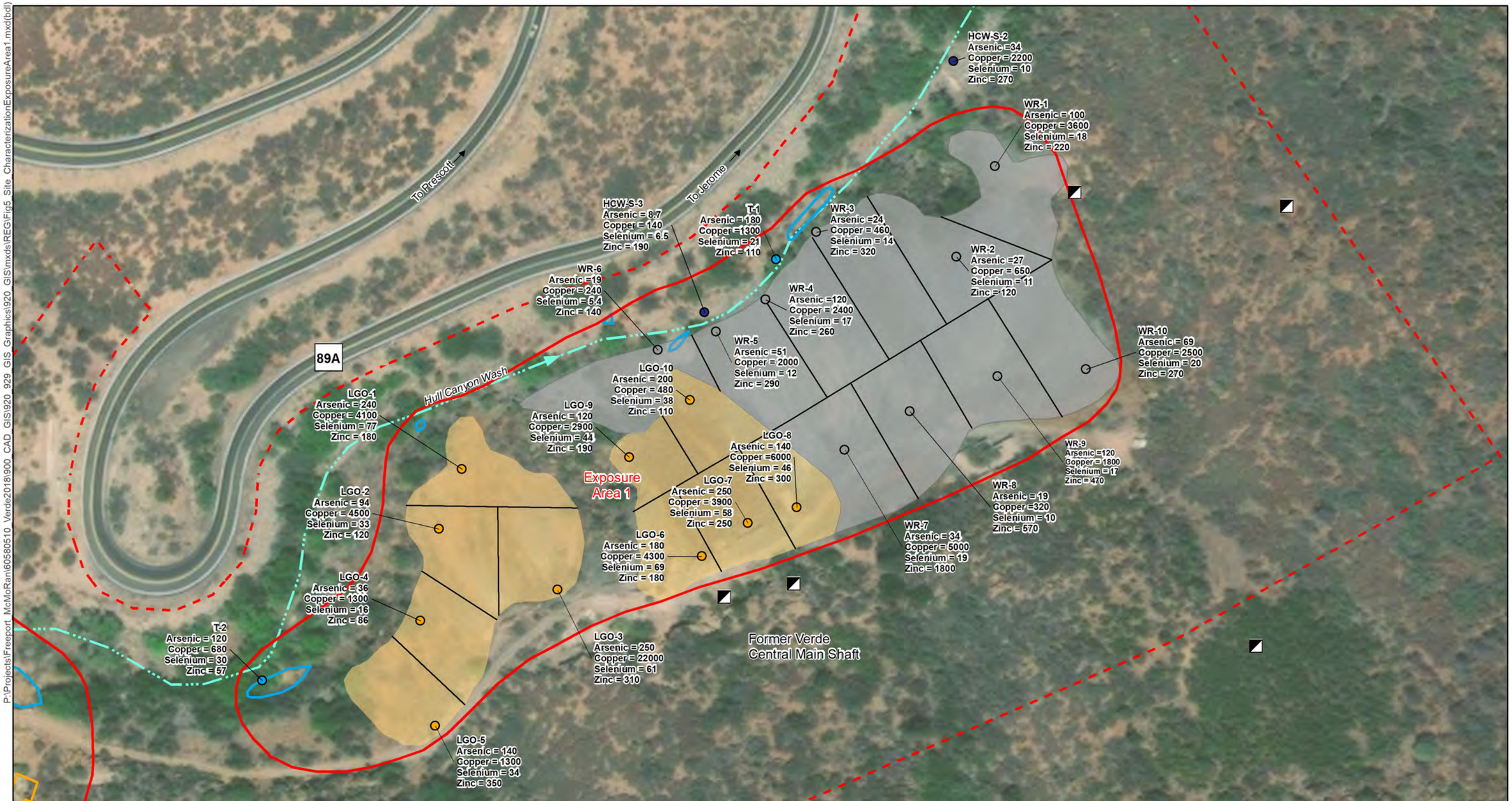
[1]The extent of tailing shown above was estimated during planning stages of the project.
Some sample locations were modified to coincide with tailing observed at the time of the sampling.

Figure 4

Site Characterization Sample Locations Exposure Area 2

Freeport Minerals Corporation
Updated Site Characterization Report
Verde Central Mine, Near Jerome, Arizona

AECOM



LEGEND

- Verde Central Mine Site
- Project Exposure Areas
- Closed Mine Shaft or Adit
- Approximate Extent of Waste Rock Stockpile
- Approximate Extent of Low-Grade Ore Rock Stockpile
- Mill Building Foundation
- Tailing[1]

Sample Type

- Low Grade Ore Stockpile
- Tailing Stockpile
- Waste Rock Stockpile
- Hull Canyon Wash

General Features

- Ephemeral Stream Bed

Arsenic = 140
Soil arsenic concentration in mg/kg. If duplicate samples were collected, the highest concentration of the duplicate and primary sample is shown.

N

0 50 100
Feet
1 inch = 100 feet

[1]The extent of tailing shown above was estimated during planning stages of the project. Some sample locations were modified to coincide with tailing observed at the time of the sampling.

Source:
Hydrology and Mine Features: URS 2008
Imagery: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 5

Distribution of Select Analyte Concentrations in Exposure Area 1

Freeport Minerals Corporation
Updated Site Characterization Report
Verde Central Mine, Near Jerome, Arizona

AECOM

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LEGEND

- Verde Central Mine Site
- Project Exposure Areas

SampleType

- High Grade Ore Stockpile
- Hull Canyon Wash
- Tailing Stockpile
- Waste Concentrate Stockpile
- Soil

- Mill Building Foundation
- Tailing[1]
- Ephemeral Stream Bed

Arsenic = 140
Soil arsenic concentration in mg/kg.
If duplicate samples were collected, the highest concentration of the duplicate and primary sample is shown.

N

0 50 100
Feet
1 inch = 100 feet

Figure 6

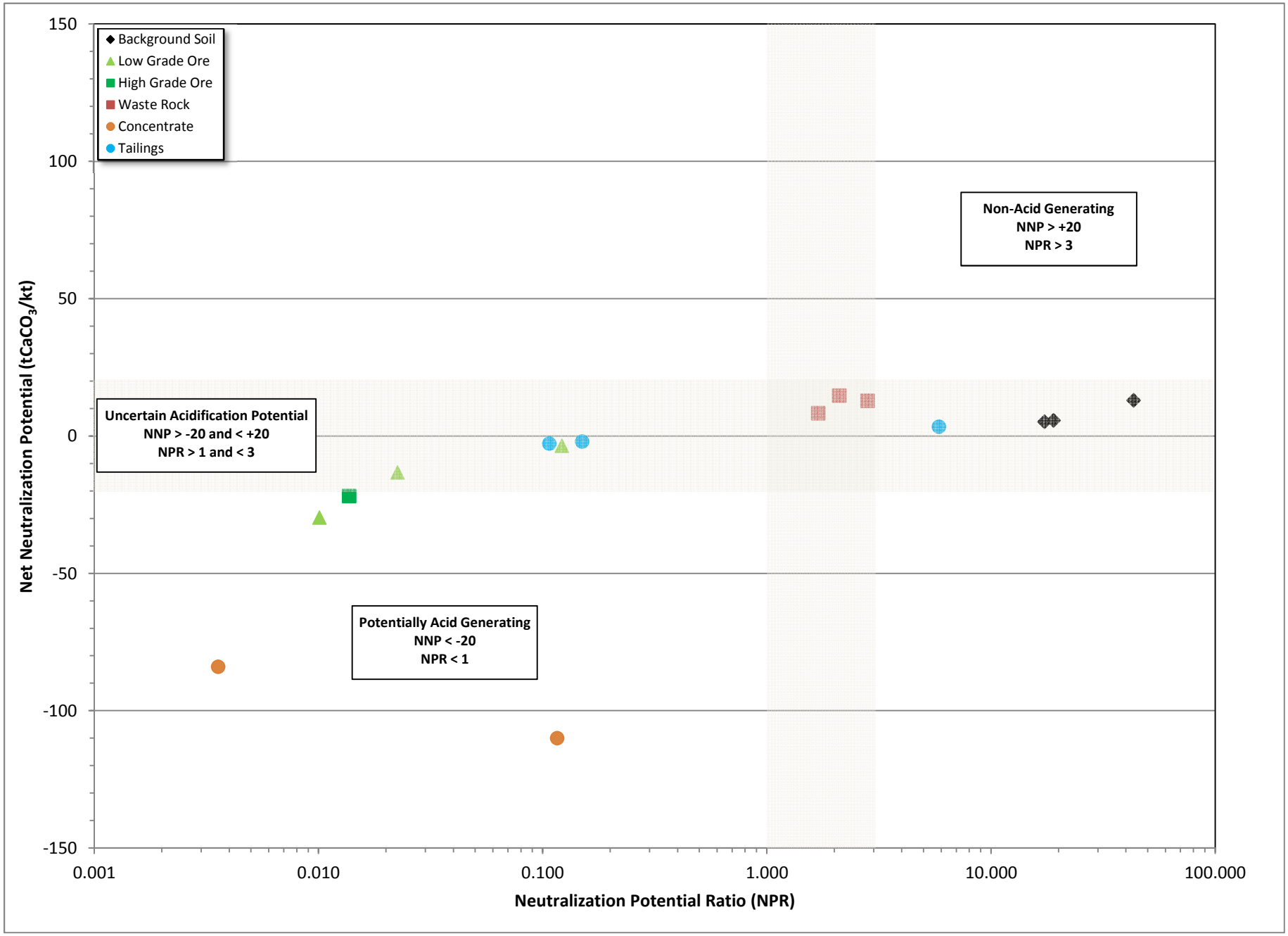
Distribution of Select Analyte Concentrations in Exposure Area 2

Freeport Minerals Corporation
Updated Site Characterization Report
Verde Central Mine, Near Jerome, Arizona

[1]The extent of tailing shown above was estimated during planning stages of the project.
Some sample locations were modified to coincide with tailing observed at the time of the sampling.

AECOM

Figure 7
Acidification Classification (NPR versus NNP) by Material Type



TABLES

Table 1
Sample Summary

Sample Description	Number of Field Original Samples	Original Sample Identification	Number of Field Duplicate Samples	Duplicate Sample Information
Background Soil	10	SC-B-1 through SC-B-10	1	SC-B-11 (duplicate of SC-B-5)
Waste Rock	10	SC-WR-1 through SC-WR-10	1	SC-WR-11 (duplicate of SC-WR-7)
Tailings	5	SC-T-1 through SC-T-5	1	SC-T5-D (duplicate of SC-T-5)
High Grade Ore	1	SC-HGO-1	0	NA
Low Grade Ore	10	SC-LGO-1 through SC-LGO-10	1	SC-LGO-11 (duplicate of SC-LGO-8)
Stream Sediment	4	SC-HCW-S-1 through SC-HCW-S-4	1	SC-HCW-S-5 (duplicate of SC-HCW-S-4)
Surface Soil	7	SC-SS-1 through SC-SS-7	0	NA
Surface Water	13	SC-HCW-1-W (sampled 4 times), SC-HCW-2-W (sampled 1 time), SC-HWC-3-W (sampled 4 times), SC-HCW-4-W (sampled 4 times)	1	SC-HCW-5-Filter/Unfilt (duplicate of SC-HCW-4-Filter/Unfilt)
Suspected Waste Concentrate	3	SC-SWC-1 through SC-SWC-3	0	SC-SWC-3-MS (duplicate of SC-SWC-3)
Equipment Blank	5	EB-1 through EB-5	0	NA
Trip Blank	2	NA	-	NA

Note:
NA = Not Applicable

Table 2
Sample Analyses Requested

Sample Identification	Sample Matrix	Sample Depth (inches)	Analysis Requested					
			VOCs	PAHs	PP Metals	SPLP Metals	ABA	Paste pH
SC-B-1	Solid	0 - 6			x			x
SC-B-2	Solid	0 - 6			x		x	x
SC-B-3	Solid	0 - 6			x		x	x
SC-B-4	Solid	0 - 6			x		x	x
SC-B-5	Solid	0 - 6			x			x
SC-B-6	Solid	0 - 6			x	x		x
SC-B-7	Solid	0 - 6			x	x		x
SC-B-8	Solid	0 - 6			x			x
SC-B-9	Solid	0 - 6			x			x
SC-B-10	Solid	0 - 6			x			x
SC-WR-1	Solid	0 - 6			x	x		x
SC-WR-2	Solid	0 - 6			x			x
SC-WR-3	Solid	0 - 6			x			x
SC-WR-4	Solid	0 - 6			x	x	x	x
SC-WR-5	Solid	0 - 6			x			x
SC-WR-6	Solid	0 - 6			x			x
SC-WR-7	Solid	0 - 6			x	x		x
SC-WR-8	Solid	0 - 6			x		2	x
SC-WR-9	Solid	0 - 6			x			x
SC-WR-10	Solid	0 - 6			x		x	x
SC-T-1	Solid	0 - 6			x	x	x	x
SC-T-2	Solid	0 - 6			x	x	x	x
SC-T-3	Solid	0 - 6			x	x	x	x
SC-T-4	Solid	1 - 6			x			
SC-T-5	Solid	2 - 6			x			
SC-HGO-1	Solid	0 - 6			x	x	x	x
SC-LGO-1	Solid	0 - 6			x			x
SC-LGO-2	Solid	0 - 6			x			x
SC-LGO-3	Solid	0 - 6			x	x		x
SC-LGO-4	Solid	0 - 6			x			x
SC-LGO-5	Solid	0 - 6			x		x	x
SC-LGO-6	Solid	0 - 6			x			x
SC-LGO-7	Solid	0 - 6			x	x	x	x
SC-LGO-8	Solid	0 - 6			x	x	x	x
SC-LGO-9	Solid	0 - 6			x			x
SC-LGO-10	Solid	0 - 6			x			x
SC-HCW-S-1	Solid	NA			x	x		x
SC-HCW-S-2	Solid	NA			x	x		x
SC-HCW-S-3	Solid	NA			x	x		x
SC-HCW-S-4	Solid	NA		x	x	x		x
HCW-1-W*	Aqueous	NA			x			
HCW-2-W	Aqueous	NA						

Table 2
Sample Analyses Requested

Sample Identification	Sample Matrix	Sample Depth (inches)	Analysis Requested					
			VOCs	PAHs	PP Metals	SPLP Metals	ABA	Paste pH
HCW-3-W*	Aqueous	NA			x			
HCW-4-W*	Aqueous	NA		x	x			
SC-SS-1	Solid	0 - 6			x			
SC-SS-2	Solid	0 - 6			x			
SC-SS-3	Solid	0 - 6			x	x		
SC-SS-4	Solid	0 - 6			x			
SC-SS-5	Solid	0 - 6			x	x		
SC-SS-6	Solid	0 - 6			x			
SC-SS-7	Solid	0 - 6			x	x		
SC-SWC-1	Solid	0 - 6	x	x	x	x	x	x
SC-SWC-2	Solid	0 - 6	x	x	x	x	x	x
SC-SWC-3	Solid	1 - 6			x			
EB-1	Aqueous	NA			x			
EB-2	Aqueous	NA			x			
EB-3	Aqueous	NA			x			
EB-4	Aqueous	NA			x			
EB-5	Aqueous	NA	x	x	x			

Notes:

* Surface water samples collected on multiple dates.

VOCs = volatile organic contaminants

PAHs = polycyclic aromatic hydrocarbons

PP = priority pollutant metals plus barium and manganese

SPLP = synthetic precipitation leaching procedure

ABA = acid base accounting plus sulfur forms

Table 3a
Background Soil Samples
Metals

Analyte	SC-B-1	SC-B-2	SC-B-3	SC-B-4	SC-B-5	SC-B-6	SC-B-7	SC-B-8	SC-B-9	SC-B-10	SC-B-11 (DUP SC-B-5)	Background 95% UCL of the Mean (mg/kg)	Non - Residential SRL (mg/kg)
	7/23/2014	7/22/2014	7/22/2014	7/22/2014	7/23/2014	7/23/2014	7/24/2014	7/22/2014	7/22/2014	7/24/2014	7/23/2014		
	13 Priority Pollutant Metals Plus Barium and Manganese EPA Method 6010B and 7471A (mg/kg)												
Antimony	<4.9	<4.9	<4.9	<5.0	<4.9	<5.0	<4.9	<4.9	<4.9	<5.0	<5.0	NA	410
Arsenic	**14**	5.0	**19**	**25**	**31**	**23**	**33**	**13**	**12**	**21**	**36**	**24.71**	10
Barium	100	33	130	39	160	110	100	78	58	73	180	111.3	170,000
Beryllium	<0.49	<0.49	0.77	<0.49	0.67	0.84	0.64	<0.48	0.56	0.73	0.75	0.695	1,900
Cadmium	1.0	<0.49	0.86	2.4	5.9	4.3	5.0	0.87	<0.49	2.0	6.5	3.518	510
Chromium	8.9	2.4	10	10	9.8	12	11	9.4	6.1	14	11	11.21	1,000,000*
Copper	79	29	98	270	510	380	590	190	25	150	590	348.5	41,000
Lead	83	<4.9	8.3	50	85	42	83	16	5.3	20	94	59.43	800
Manganese	330	88	690	230	2,500	910	770	170	170	330	2,800	1,036	32,000
Mercury	0.12	<0.088	<0.10	<0.097	0.16	0.11	0.28	<0.094	<0.092	<0.089	0.24	0.159	310
Nickel	6.9	<2.0	8.3	4.9	8.4	8.8	8.4	8.7	5.1	8.6	9.4	8.35	20,000
Selenium	5.2	<4.9	7.3	<4.9	6.5	7.3	9.3	<4.8	<4.9	7.8	7.7	7.23	5,100
Silver	<2.4	<2.5	<2.5	<2.5	<2.4	<2.4	<2.5	<2.4	<2.4	<2.4	<2.5	NA	5,100
Thallium	<4.9	<4.9	<4.9	<4.9	<5.0	<4.9	<5.0	<4.8	<4.9	<4.9	<4.9	NA	67
Zinc	110	47	140	160	290	130	220	64	71	120	320	178.3	310,000

Notes:
* Non-residential SRL listed for chromium III
EPA = Environmental Protection Agency
mg/kg = milligram per kilogram
UCL = upper confidence limit
DUP = duplicate
Bold = Indicates analyte detected above the non-residential soil remediation level
NA = Not analyzed, or no background value calculated due to lack of detected concentrations.

Table 3b
Background Soil Samples
SPLP Metals

Analyte	SC-B-6	SC-B-7	SC-B-11	NWQS PBC (mg/L)
	41843	41844	41843	
	13 Priority Pollutant Metals Plus Barium and Manganese SPLP by EPA Method 6010B, 6020, and 7470A (mg/L)			
Antimony	<0.015	<0.015	<0.015	0.747 T
Arsenic	0.027	0.026	0.040	0.280 T
Barium	<10	<10	<10	98 T
Beryllium	<0.25	<0.25	<0.25	1.867 T
Cadmium	<0.0050	<0.0050	<0.0050	0.70 T
Chromium	<0.50	<0.50	<0.50	2.8 T**
Copper	0.21 E4	0.17 E4	0.20 E4	1.3 T
Lead	**0.033**	**0.033**	**0.059**	0.015 T
Manganese	0.65	<0.50	1.4	130.7
Mercury	<0.00050	<0.00050	<0.00050	0.28 T
Nickel	<0.50	<0.50	<0.50	28 T
Selenium	0.0052	<0.0050	<0.0050	4.667 T
Silver	<0.0050	<0.0050	<0.0050	4.667 T
Thallium	<0.0050	<0.0050	<0.0050	0.075 T
Zinc	<2.0	<2.0	<2.0	280 T

Notes:

EPA = Environmental Protection Agency

SPLP = Synthetic Precipitation Leaching Procedure

mg/L = milligram per liter

NWQS = Arizona numeric water quality standards for surface water

PBC = Partial Body Contact screening concentration per Arizona Administrative Code (AAC) R18-11 Appendix A (Numeric Water Quality Standards) effective January 31, 2009.

T = total recoverable

E4 = See laboratory reports, Definitions/Glossary section, for QC qualifiers

** PBC listed for Chromium VI

Bold = Result exceeds NWQS PBC

Table 3c
Background Soil Samples
Paste pH and Acid Base Accounting with Sulfur Forms

Analyte	SC-B-1	SC-B-2	SC-B-3	SC-B-4	SC-B-5	SC-B-6	SC-B-7	SC-B-8	SC-B-9	SC-B-10	SC-B-11
	7/23/2014	7/22/2014	7/22/2014	7/22/2014	7/23/2014	7/23/2014	7/24/2014	7/22/2014	7/22/2014	7/24/2014	7/23/2014
	Paste pH by EPA Method 600/2-78-054										
Paste pH	7.95	7.13	6.99	7.06	6.54	5.40	6.91	8.79	6.44	5.89	6.57

Analyte	Units	SC-B-2	SC-B-3	SC-B-4
		7/22/2014	7/22/2014	7/22/2014
	Acid/Base Accounting & Sulfur Forms - Modified Sobek Method			
ABA (NNP)	TCaCO3/kT	13.0	5.2	5.7
AGP	TCaCO3/kT	<0.3	<0.3	<0.3
ANP	TCaCO3/kT	13.0	5.2	5.7
Non-extractable Sulfur	%	<0.01	<0.01	<0.01
Non-Sulfate Sulfur	%	<0.01	<0.01	<0.01
Pyritic (Sulfide) Sulfur	%	<0.01	<0.01	<0.01
Sulfate Sulfur	%	<0.01	<0.01	<0.01
Total Sulfur	%	<0.01	<0.01	<0.01

Notes:
EPA = Environmental Protection Agency
ABA = acid base accounting
AGP = acid generation potential
ANP = acid neutralization potential
NNP = net neutralization potential
TCaCO3/kT = tons of calcium carbonate equivalent per kiloton
Field duplicate of sample SC-B-5 labeled SC-B-11

Table 4a
Exposure Area 1 Soil Samples
Metals - Human Health Screening

Analyte	SC-WR-1	SC-WR-2	SC-WR-3	SC-WR-4	SC-WR-5	SC-WR-6	SC-WR-7	SC-WR-8	SC-WR-9	SC-WR-10	SC-WR-11 (DUP SC-WR-7)	SC-LGO-1	SC-LGO-2	SC-LGO-3	SC-LGO-4	SC-LGO-5	SC-LGO-6	SC-LGO-7	SC-LGO-8	SC-LGO-9	SC-LGO-10	SC-LGO-11 (DUP SC-LGO-8)	SC-T-1	SC-T-2	95 % UCL of the Mean (mg/kg)	Background 95% UCL of the Mean (mg/kg)	Minimum Groundwater Protection Levels (GPLs) (mg/kg)	Non - Residential SRL (mg/kg)
	7/22/2014	7/23/2014	7/23/2014	7/23/2014	7/23/2014	7/23/2014	7/24/2014	7/24/2014	7/24/2014	7/24/2014	7/24/2014	7/24/2014	7/24/2014	7/24/2014	7/24/2014	7/24/2014	7/24/2014	7/24/2014	7/24/2014	7/24/2014	7/24/2014	7/24/2014	7/23/2014	7/23/2014				
13 Priority Pollutant Metals Plus Barium and Manganese by EPA Method 6010B and 7471A (mg/kg)																												
Antimony	<5.0	<4.8	<5.0	<4.9	<4.9	<4.9	<5.0	<4.8	<4.8	<4.9	<5.0	5.3	<5.0	<4.9	<5.0	<4.9	<4.9	6.6	7.1	<4.9	6.0	7.2	<5.0	<4.9	5.43	NA	35	410
Arsenic	**100**	**27** M1 R13	**24**	**120**	**51**	**19**	**34**	**19**	**120**	**69**	**33**	**240**	**94**	**250** M3	**36**	**140**	**180**	**250**	**140**	**120**	**200**	**140**	**180**	**120**	**139.1**	**24.71**	**290**	**10**
Barium	13	7.6	33	20	21	27	40	41	15	50	39	24	64	22 M2	51	25	16	13	39	21	45	38	13	6.7	NA	111.3	12,000	170,000
Beryllium	<0.48	<0.50	<0.49	<0.49	<0.49	<0.49	<0.49	<0.49	<0.49	<0.50	<0.48	<0.48	<0.49	<0.50	<0.49	<0.49	<0.49	<0.50	<0.49	<0.50	<0.49	<0.49	<0.48	<0.50	NA	0.695	23	1,900
Cadmium	0.77	<0.50	1.3	0.75	1.3	<0.49	4.5	1.9	1.7	1.1	6.8	<0.48	<0.49	<0.50	<0.49	<0.49	<0.49	<0.50	0.58	<0.50	<0.49	0.79	<0.48	<0.50	1.98	3.518	29	510
Chromium	<1.9	<2.0	6.3	6.5	<2.0	<2.0	2.0	<2.0	<2.0	<2.0	<1.9	<1.9	5.5	<2.0	6.3	<1.9	<2.0	<2.0	14	<2.0	<2.0	12	2.5	<2.0	NA	11.21	590	1,000,000*
Copper	3,600	650 M3	460	2,400	2,000	240	5,000	320	1,800	2,500	3,000	4,100	4,500	22,000	1,300	1,300	4,300	3,900	6,000	2,900	480	4,500	1,300	680	4932	348.5	NE	41,000
Lead	16	5.7	9.7	13	22	7.9	56	18	14	12	48	59	45	68 M2	22	40	46	68	130	40	60	140	15	18	56.32	59.43	290	800
Manganese	620	390 M3 R13	1,200	1,200	570	250	1,200	880	670	1,100	2,400	300	230	380 M3	230	1,000	330	340	480	400	260	600	220	150	847.8	1,036	NE	32,000
Mercury	0.42	0.14	0.33	0.60	0.49	0.71	1.9	2.2	1.9	1.4	2.1	0.49	0.25	1.1	0.14	2.7	0.65	0.78	1.5	1.0	0.31 M1 R13	2.3	0.46	0.26	1.39	0.159	12	310
Nickel	<1.9	<2.0	3.1	3.7	<2.0	<2.0	7.2	<2.0	<2.0	2.3	5.8	<1.9	3.9	2.2	4.3	<1.9	<2.0	<2.0	14	<2.0	2.1	11	<1.9	<2.0	4.64	8.53	590	20,000
Selenium	18	11	14	17	12	5.4	19	10	17	20	19	77	33	61 M2	16	34	69	58	45	44	38	46	21	30	39.61	7.23	290	5,100
Silver	3.0	<2.5	<2.5	<2.4	<2.5	<2.5	<2.5	<2.4	<2.4	3.5	<2.4	14	5.2	16 M3	<2.4	4.8	11	20	8.7	8.4	3.4	10	4.7	4.9	7.67	NA	NE	5,100
Thallium	<4.8	<5.0	<4.9	<4.9	<4.9	<4.9	<4.9	<4.9	<4.9	<5.0	<4.8	<4.8	<4.9	<5.0 M2	<4.9	<4.9	<4.9	<5.0	<4.9	<5.0	<4.9	<4.9	<4.8	<5.0	NA	NA	12	67
Zinc	220	120 M2 R13	320	260	290	140	1,200	570	470	270	1,800	180	120	310 M3	86	350	180	250	280	190	110	300	110	57	473.1	178.3	NE	310,000

Notes:
EPA = Environmental Protection Agency
mg/kg = milligram per kilogram
UCL = upper confidence level
DUP = duplicate
SRL = Soil Remediation Levels from Appendix A of Chapter 7. Department of Environmental Quality Remedial Action of Title 18. Environmental Quality
Quality, 1996.
NE = Not established
NA = Not analyzed, or no background value calculated due to lack of detected concentrations.
* = SRL for Chromium III
M1, M2, M3, R13 = See laboratory reports, Definitions/Glossary section, for QC qualifiers
Bold = Analyte or mean above non-residential SRL or GPL
= Sample mean (95% UCL) below background level mean (95% UCL)

Table 4b
Exposure Area 1 Soil Samples
SPLP Metals - Human Health Screening

Analyte	SC-WR-1	SC-WR-4	SC-WR-7	SC-LGO-3	SC-LGO-7	SC-LGO-8	SC-T-1	SC-T-2	NWQS PBC (mg/L)
	7/22/2014	7/23/2014	7/24/2014	7/24/2014	7/24/2014	7/24/2014	7/23/2014	7/23/2014	
	13 Priority Pollutant Metals Plus Barium and Manganese SPLP by EPA Method 6010B, 6020, and 7470A (mg/L)								
Antimony	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	0.747 T
Arsenic	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	**0.54**/0.024 (a)	<0.015	0.280 T
Barium	<10	<10	<10	<10	<10	<10	<10	<10	98 T
Beryllium	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	1.867 T
Cadmium	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.70 T
Chromium	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	2.8 T**
Copper	0.070 E4	<0.034	0.29 E4	**12**	0.14 E4	0.17 E4	**2.2**	0.12 E4	1.3 T
Lead	<0.0050	<0.0050	0.014	<0.0050	<0.0050	<0.0050	**0.047**	<0.0050	0.015 T
Manganese	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	130.7
Mercury	<0.00050	<0.00050	0.00051	<0.00050	<0.00050	<0.00050	0.00090	<0.00050	0.28 T
Nickel	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	28 T
Selenium	<0.0050	<0.0050	<0.0050	0.0073	<0.0050	0.0051	<0.0050	<0.0050	4.667 T
Silver	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0071	<0.0050	4.667 T
Thallium	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.075 T
Zinc	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	280 T

Notes:
EPA = Environmental Protection Agency
NWQS = Arizona numeric water quality standards for surface water
SPLP = Synthetic Precipitation Leaching Procedure
mg/L = milligram per liter
PBC = Partial Body Contact screening concentration per Arizona Administrative Code (AAC) R18-11 Appendix A (Numeric Water Quality Standards) effective January 31, 2009.
T = total recoverable
(a) - Reported concentration from Method 6010B and 6020 analyses, respectively
E4 = See laboratory reports, Definitions/Glossary section, for QC qualifiers
** PBC listed for Chromium VI
Bold = Result exceeds NWQS PBC

Table 4c
Exposure Area 1 Waste Rock Area Soil Samples
Paste pH and Acid Base Accounting with Sulfur Forms

Analyte	SC-WR-1	SC-WR-2	SC-WR-3	SC-WR-4	SC-WR-5	SC-WR-6
	7/22/2014	7/23/2014	7/23/2014	7/23/2014	7/23/2014	7/23/2014
	Paste pH by EPA Method 600/2-78-054					
Paste pH	8.23	8.34	8.26	7.94	8.18	8.48

Analyte	SC-WR-7	SC-WR-8	SC-WR-9	SC-WR-10	SC-WR-11 (DUP of SC-WR-7)
	7/24/2014	7/24/2014	7/24/2014	7/24/2014	7/24/2014
	Paste pH by EPA Method 600/2-78-054				
Paste pH	7.61	8.40	7.98	7.38	7.56

Analyte	Units	SC-WR-4	SC-WR-10	SC-WR-11 (DUP of SC-WR-7)
		7/23/2014	7/24/2014	7/24/2014
	Acid/Base Accounting & Sulfur Forms - Modified Sobek Method			
ABA (NNP)	TCaCO3/kT	14.7	12.8	8.3
AGP	TCaCO3/kT	13.3	7.0	11.9
ANP	TCaCO3/kT	28.0	19.7	20.2
Non-extractable Sulfur	%	0.04	0.04	0.09
Non-Sulfate Sulfur	%	0.47	0.26	0.48
Pyritic (Sulfide) Sulfur	%	0.43	0.22	0.38
Sulfate Sulfur	%	0.22	0.14	0.11
Total Sulfur	%	0.69	0.40	0.58

Notes:
ABA = acid base accounting
AGP = acid generation potential
ANP = acid neutralization potential
EPA = Environmental Protection Agency
DUP = duplicate sample
NNP = net neutralization potential
TCaCO3/kT = tons of calcium carbonate equivalent per kiloton
Field duplicate of sample SC-WR-7 labeled SC-WR-11

Table 4d
Exposure Area 1 Low Grade Ore Area Soil Samples
Paste pH and Acid Base Accounting with Sulfur Forms

Analyte	SC-LGO-1	SC-LGO-2	SC-LGO-3	SC-LGO-4	SC-LGO-5	SC-LGO-6
	7/24/2014	7/24/2014	7/24/2014	7/24/2014	7/24/2014	7/24/2014
	Paste pH by EPA Method 600/2-78-054					
Paste pH	3.74	3.96	3.98	3.98	4.35	3.99

Analyte	SC-LGO-7	SC-LGO-8	SC-LGO-9	SC-LGO-10	SC-LGO-11
	7/24/2014	7/24/2014	7/24/2014	7/24/2014	7/24/2014
	Paste pH by EPA Method 600/2-78-054				
Paste pH	4.37	4.34	4.05	3.68	4.15

Analyte	Units	SC-LGO-5	SC-LGO-7	SC-LGO-8
		7/24/2014	7/24/2014	7/24/2014
	Acid/Base Accounting & Sulfur Forms - Modified Sobek Method			
ABA (NNP)	TCaCO3/kT	-3.6	-13.3	-29.7
AGP	TCaCO3/kT	4.1	13.3	29.7
ANP	TCaCO3/kT	0.5	<0.3	<0.3
Non-extractable Sulfur	%	0.10	0.26	0.24
Non-Sulfate Sulfur	%	0.24	0.69	1.19
Pyritic (Sulfide) Sulfur	%	0.13	0.43	0.95
Sulfate Sulfur	%	0.06	0.14	0.31
Total Sulfur	%	0.30	0.83	1.50

Notes:
ABA = acid base accounting
AGP = acid generation potential
ANP = acid neutralization potential
EPA = Environmental Protection Agency
NNP = net neutralization potential
TCaCO3/kT = tons of calcium carbonate equivalent per kiloton
Field duplicate of sample SC-LGO-8 labeled SC-LGO-11

Table 4e
Exposure Area 1 Tailings Area Soil Samples
Paste pH and Acid Base Accounting with Sulfur Forms

Analyte	SC-T-1	SC-T-2	SC-T-3*
	7/23/2014	7/23/2014	7/23/2014
	Paste pH by EPA Method 600/2-78-054		
Paste pH	7.61	4.54	4.02

Analyte	Units	SC-T-1	SC-T-2	SC-T-3*
		7/23/2014	7/23/2014	7/23/2014
	Acid/Base Accounting & Sulfur Forms - Modified Sobek Method			
ABA (NNP)	TCaCO3/kT	3.4	-2.8	-2.0
AGP	TCaCO3/kT	0.7	2.8	2.0
ANP	TCaCO3/kT	4.1	<0.3	<0.3
Non-extractable Sulfur	%	<0.01	0.03	<0.01
Non-Sulfate Sulfur	%	0.02	0.12	0.06
Pyritic (Sulfide) Sulfur	%	0.02	0.09	0.06
Sulfate Sulfur	%	0.05	0.26	1.09
Total Sulfur	%	0.07	0.38	1.15

Notes:

EPA = Environmental Protection Agency

ABA = acid base accounting

AGP = acid generation potential

ANP = acid neutralization potential

NNP = net neutralization potential

TCaCO3/kT = tons of calcium carbonate equivalent per kiloton

Bold = Indicates analyte detected above the minimum laboratory reporting limit (LRL)

* Sample SC-T-3 is located in Exposure Area 2.

Table 5a
Exposure Area 2 Soil Samples
Metals - Human Health Screening

Analyte	SC-HGO-1	SC-SWC-1	SC-SWC-2	SC-SWC-3	SC-SWC-3-MS	SC-T-3	SC-T-4	SC-T-5	SC-T-5-D (DUP of SC-T-5)	SC-SS-1	SC-SS-2	SC-SS-3	SC-SS-4	SC-SS-5	SC-SS-6	SC-SS-7	95 % UCL of the Mean (mg/kg)	Background 95% UCL of the Mean (mg/kg)	Minimum Groundwater Protection Levels (GPLs) (mg/kg)	Non - Residential SRL (mg/kg)
	7/25/2014	7/25/2014	7/25/2014	7/11/2018	7/11/2018	7/23/2014	7/11/2018	7/11/2018	7/11/2018	7/11/2018	7/11/2018	7/11/2018	7/11/2018	7/11/2018	7/11/2018	7/11/2018				
	13 Priority Pollutant Metals Plus Barium and Manganese by EPA Method 6010B and 7471A (mg/kg)																			
Antimony	5.3	**42**	**42**	23	9.5	<5.0	<4.9	<4.9	<5.0	<4.9	<5.0	6.8 J, M2	24	19	<5.0	**36**	21.45	NA	35	410
Arsenic	**410**	**110**	**300**	**86**	**68**	**100**	**130**	**59**	**68** D1	**110**	**31**	**330** D1, M3	**430** D1	**250** D1	**400** D1	**88** D1	**279.6**	24.71	290	10
Barium	6.7	12	26	120	99	<4.9	21	76	74 D1	58	93	140 R13, D1, M2	<99 D1	270 D1	<5.0	74 D1	NA	111.3	12,000	170,000
Beryllium	<0.50	<0.49	<0.50	<0.50	<0.49	<0.49	<0.49	<0.49	<0.50	<0.49	<0.50	<0.49	<0.50	<0.49	<0.50	<0.49	NA	0.697	23	1,900
Cadmium	<0.50	**65**	2.2	1.2	1	<0.49	<0.49	<0.49	<0.50	0.91	ND	1.5	0.67	2.0	<0.50	1.3	22.9	3.518	29	510
Chromium	<2.0	<2.0	2.7	16	11	<2.0	5.3	16	16	8.7	13	14	30	9.4	<2.0	21	14.94	11.21	590	1,000,000*
Copper	4,600	24,000	20,000	6500	5,500	1,000 M3	880	1000	1300	6000	1200	10000 M3	5500	20000	2000	8700	12,873	348.5	NE	41,000
Lead	41	**1,200**	**310**	240	210	18	34	54	57	42	32	240	160	**570**	21	**450**	**438.8**	59.43	290	800
Manganese	260	700	310	210	190	170	120	180	230	610	250	140	240	250	360	250	352.3	1,036	NE	32,000
Mercury	2.0	1.5	1.3	1.1	1.1	0.38	1.2	0.37	0.35	0.46	0.17	**14**	0.55	**12**	0.42	0.31	6.92	0.159	12	310
Nickel	<2.0	22	5.9	12	9	<2.0	3.1	8.0	8.4	8.8	7.4	6.9	21	6.9	<2.0	12	12.44	8.53	590	20,000
Selenium	51	54	59	<5.0	31 D1	32	<4.9	<4.9	<5.0	<4.9	<5.0	<4.9 M2 / 58 R, D1	<5.0	<4.9 / 45 D1	<5.0	<4.9 / 12 D1	40.58	7.23	290	5,100
Silver	11	10	11	3.6	3	4.8	5.9	<2.5	2.5	4.2	<2.5	14	9.9	11	3.7	5.3	NA	NA	NE	5,100
Thallium	<5.0	<4.9	<5.0	<5.0	<4.9	<4.9	<4.9	<4.9	<5.0	<4.9	<5.0	<4.9 U, J, M2	<5.0	<4.9	<5.0	<4.9	NA	NA	12	67
Zinc	140	15,000	480	370	400	67	65	72	83	260	55	280	83	430	160	390	NA	178.3	NE	310,000

Notes:
EPA = Environmental Protection Agency
mg/kg = milligram per kilogram
SRL = Soil Remediation Levels from Appendix A of Chapter 7. Department of Environmental Quality Remedial Action of Title 18. Environmental Quality
GPLs = groundwater protection levels, per A Screening Method To Determine Soil Concentrations Protective of Groundwater Quality, Arizona Dept. of Environmental Quality, 1996.
NE = Not established
* = SRL for Chromium III
(a) - Reported concentration from Method 6010B and 6020 analyses, respectively
D1, M2, M3 = See laboratory reports, Definitions/Glossary section, for QC qualifiers
R, U, J = See Data Verification Report in Appendix E for QC qualifiers
Bold = Result above non-residential SRL or GPL

Table 5b
Exposure Area 2 Soil Samples
SPLP Metals - Human Health Screening

Analyte	SC-HGO-1	SC-SWC-1	SC-SWC-2	SC-T-3	SC-SS-3	SC-SS-5	SC-SS-7	NWQS PBC (mg/L)
	7/25/2014	7/25/2014	7/25/2014	7/23/2014	7/11/2018	7/11/2018	7/11/2018	
	13 Priority Pollutant Metals Plus Barium and Manganese SPLP by EPA Method 6010B, 6020, and 7470A (mg/L)							
Antimony	<0.015	<0.015	<0.015	<0.015	NA	NA	NA	0.747 T
Arsenic	<0.015	<0.015	<0.015	<0.015	NA	NA	NA	0.280 T
Barium	<10	<10	<10	<10	NA	NA	NA	98 T
Beryllium	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	1.867 T
Cadmium	<0.0050	0.0098	0.0051	<0.0050	NA	NA	NA	0.70 T
Chromium	<0.50	<0.50	<0.50	<0.50	NA	NA	NA	2.8 T**
Copper	**4.4**	**3.5**	**34**	**1.5**	1.2	<0.5	<0.5	1.3 T
Lead	<0.0050	**0.021**	**0.14**	<0.0050	NA	NA	NA	0.015 T
Manganese	<0.50	<0.50	**1.1**	<0.50	NA	NA	NA	130.7
Mercury	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.28 T
Nickel	<0.50	<0.50	<0.50	<0.50	NA	NA	NA	28 T
Selenium	<0.0050	0.0057	0.010	0.012	NA	NA	NA	4.667 T
Silver	<0.0050	<0.0050	<0.0050	<0.0050	<0.25	<0.25	<0.25	4.667 T
Thallium	<0.0050	<0.0050	<0.0050	<0.0050	NA	NA	NA	0.075 T
Zinc	<2.0	4.2	<2.0	<2.0	<2.0	<2.0	<2.0	280 T

Notes:
EPA = Environmental Protection Agency
SPLP = Synthetic Precipitation Leaching Procedure
NWQS = Arizona numeric water quality standards for surface water
mg/L = milligram per liter
PBC = Partial Body Contact screening concentration per Arizona Administrative Code (AAC) R18-11 Appendix A (Numeric Water Quality Standards) effective January 31, 2009.
NA = not analyzed
T = total recoverable
** PBC listed for Chromium VI
Bold = Result exceeds NWQS PBC

Table 5c
Exposure Area 2 Suspected Waste Concentrate Area Soil Samples
Paste pH and Acid Base Accounting with Sulfur Forms

Analyte	SC-SWC-1	SC-SWC-2
	7/25/2014	7/25/2014
	Paste pH by EPA Method 600/2-78-054	
Paste pH	4.86	3.68

Analyte	Units	SC-SWC-1	SC-SWC-2
		7/25/2014	7/25/2014
	Acid/Base Accounting & Sulfur Forms - Modified Sobek Method		
ABA (NNP)	TCaCO3/kT	-110.0	-84.0
AGP	TCaCO3/kT	125	84.0
ANP	TCaCO3/kT	14.5	<0.3
Non-extractable Sulfur	%	0.18	0.37
Non-Sulfate Sulfur	%	4.17	3.06
Pyritic (Sulfide) Sulfur	%	3.99	2.69
Sulfate Sulfur	%	1.38	2.24
Total Sulfur	%	5.55	5.30

Notes:
ABA = acid base accounting
AGP = acid generation potential
ANP = acid neutralization potential
EPA = Environmental Protection Agency
NNP = net neutralization potential
TCaCO3/kT = tons of calcium carbonate equivalent per kiloton
above the minimum laboratory

Table 5d
Exposure Area 2 High Grade Ore Area Soil Sample
Paste pH and Acid Base Accounting with Sulfur Forms

Analyte	SC-HGO-1
	7/25/2014
Paste pH by EPA Method 600/2-78-054	
Paste pH	3.52

Analyte	Units	SC-HGO-1
		7/25/2014
Acid/Base Accounting & Sulfur Forms - Modified Sobek method		
ABA (NNP)	TCaCO3/kT	-21.9
AGP	TCaCO3/kT	21.9
ANP	TCaCO3/kT	<0.3
Non-extractable Sulfur	%	0.01
Non-Sulfate Sulfur	%	0.71
Pyritic (Sulfide) Sulfur	%	0.70
Sulfate Sulfur	%	0.43
Total Sulfur	%	1.14

Notes:

EPA = Environmental Protection Agency

ABA = acid base accounting

AGP = acid generation potential

ANP = acid neutralization potential

NNP = net neutralization potential

TCaCO3/kT = tons of calcium carbonate equivalent per kiloton

Table 5e
Exposure Area 2 Suspected Waste Concentrate Area Soil Samples
VOCs - Human Health Screening

Analyte	SC-SWC-1	SC-SWC-2	Non - Residential SRL (mg/kg)	Minimum GPL (mg/kg)
	7/25/2014	7/25/2014		
Volatile Organic Compounds (VOCs) by EPA Method 8260B (mg/kg)				
1,1,1,2-Tetrachloroethane	<2.6	<3.1	73	NE
1,1,1-Trichloroethane	<1.0	<1.2	1,200	0.94
1,1,2,2-Tetrachloroethane	<1.0	<1.2	9.3	NE
1,1,2-Trichloroethane	<1.0	<1.2	16	NE
Acetone	<10	<12	54,000	NE
Benzene	<0.51	<0.61	1.4	0.7
Bromobenzene	<2.6	<3.1	92	NE
Bromochloromethane	<2.6	<3.1	NE	NE
Bromodichloromethane	<1.0	<1.2	18	NE
Bromoform	<2.6	<3.1	2,200	NE
Bromomethane	<2.6	<3.1	13	NE
2-Butanone (MEK)	<5.1	<6.1	34,000	NE
n-Butylbenzene	<2.6	<3.1	240	NE
sec-Butylbenzene	<2.6	<3.1	220	NE
tert-Butylbenzene	<2.6	<3.1	390	NE
Carbon disulfide	<2.6	<3.1	720	NE
Carbon tetrachloride	<2.6	<3.1	5.5	0.95
Chlorobenzene	<0.51	<0.61	530	16.5
Chloroethane	<2.6	<3.1	65	NE
Chloroform	<1.0	<1.2	20	6.8 [1]
Chloromethane	<2.6	<3.1	160	NE
2-Chlorotoluene	<2.6	<3.1	510	NE
4-Chlorotoluene	<2.6	<3.1	NE	NE
Dibromochloromethane	<1.0	<1.2	26	NE
1,2-Dibromo-3-chloropropane	<2.6	<3.1	6.5	NE
1,2-Dibromoethane (EDB)	<0.26	<0.31	0.63	0.0033
Dibromomethane	<1.0	<1.2	230	NE
1,2-Dichlorobenzene	<1.0	<1.2	600	116
1,3-Dichlorobenzene	<1.0	<1.2	600	NE
1,4-Dichlorobenzene	<1.0	<1.2	79	27
Dichlorodifluoromethane	<2.6	<3.1	310	NE
1,1-Dichloroethane	<1.0	<1.2	1,700	NE
1,2-Dichloroethane	<1.0	<1.2	6.0	0.23
1,1-Dichloroethene	<2.6	<3.1	410	0.85
cis-1,2-Dichloroethene	<1.0	<1.2	150	5.3
trans-1,2-Dichloroethene	<1.0	<1.2	230	9.2
1,2-Dichloropropane	<1.0	<1.2	7.4	0.36
1,3-Dichloropropane	<1.0	<1.2	360	NE
2,2-Dichloropropane	<1.0	<1.2	NE	NE
1,1-Dichloropropene	<1.0	<1.2	NE	NE
cis-1,3-Dichloropropene	<1.0	<1.2	NE	NE
trans-1,3-Dichloropropene	<1.0	<1.2	NE	NE
Ethylbenzene	<1.0	<1.2	400	82
Hexachlorobutadiene	<2.6	<3.1	180	NE
2-Hexanone	<5.1	<6.1	NE	NE

Table 5e
Exposure Area 2 Suspected Waste Concentrate Area Soil Samples
VOCs - Human Health Screening

Analyte	SC-SWC-1	SC-SWC-2	Non - Residential SRL (mg/kg)	Minimum GPL (mg/kg)
	7/25/2014	7/25/2014		
Volatile Organic Compounds (VOCs) by EPA Method 8260B (mg/kg)				
Iodomethane	<2.6	<3.1	NE	NE
Isopropylbenzene	<1.0	<1.2	92	NE
p-Isopropyltoluene	<1.0	<1.2	NE	NE
Methylene Chloride	<5.1	<6.1	210	NE
4-Methyl-2-pentanone (MIBK)	<5.1	<6.1	17,000	NE
Methyl-tert-butyl Ether (MTBE)	<0.51	<0.61	710	NE
Naphthalene	<2.6	<3.1	190	NE
n-Propylbenzene	<1.0	<1.2	240	NE
Styrene	<1.0	<1.2	1,500	45
Tetrachloroethene	<1.0	<1.2	13	0.8
Toluene	<1.0	<1.2	650	159
1,2,3-Trichlorobenzene	<2.6	<3.1	NE	NE
1,2,4-Trichlorobenzene	<2.6	<3.1	220	NE
Trichloroethene	<1.0	<1.2	65	0.76
1,2,3-Trichloropropane	<1.0	<1.2	0.11	NE
1,3,5-Trimethylbenzene	<1.0	<1.2	70	NE
Vinyl Acetate	<13	<15	1,400	NE
Vinyl chloride	<0.51	<0.61	0.75	NE
m,p-Xylenes	<1.5	<1.8	NE	NE
o-Xylene	<1.5	<1.8	NE	NE
Xylenes, Total	<3.1	<3.7	420	31

Notes:
EPA = Environmental Protection Agency
mg/kg = milligram per kilogram
SRL = Soil Remediation Levels from Appendix A of Chapter 7. Department of Environmental Quality Remedial Action of Title 18. Environmental Quality 1996, and updates for VOCs per 2013-01 spreadsheet GPL final.xls.
[1] Minimum GPL value for chloroform based on total trihalomethanes
Bold = Indicates analyte detected above the minimum laboratory reporting limit (LRL)
NE = Not established
= Result above non-residential SRL and/or GPL
= laboratory reporting limit above GPL and/or SRL concentration

Table 5f
Exposure Area 2 Suspected Waste Concentrate Area Soil Samples
PAHs - Human Health Screening

Analyte	SC-SWC-1	SC-SWC-2	Non - Residential SRL (mg/kg)	Minimum GPL (mg/kg)
	7/25/2014	7/25/2014		
	Polynuclear Aromatic Hydrocarbons (PAHs) by EPA Method 8310 (mg/kg)			
Naphthalene	<2.0	<2.0	190	NE
Acenaphthylene	<3.0	<3.0	NE	NE
Acenaphthene	<2.0	<2.0	29,000	NE
Fluorene	0.47 C8	1.5 C8	26,000	NE
Phenanthrene	<0.30	2.3	NE	NE
Anthracene	<0.20	<0.20	240,000	NE
Fluoranthene	1.7 C8	1.3 C8	22,000	NE
Pyrene	<0.20	<0.20	29,000	NE
Benzo(a)anthracene	<0.10	1.9 C8	21	NE
Chrysene	1.8	<0.20	2,000	NE
Benzo(b)fluoranthene	<0.20	<0.20	21	NE
Benzo(k)fluoranthene	<0.10	<0.10	210	NE
Benzo(a)pyrene	<0.10	<0.10	2.1	1.6
Dibenz(a,h)anthracene	<0.10	<0.10	2.1	NE
Benzo(g,h,i)perylene	<0.30	<0.30	NE	NE
Indeno(1,2,3-cd)pyrene	<0.10	<0.10	21	NE

Notes:

EPA = Environmental Protection Agency

mg/kg = milligram per kilogram

SRL = Soil Remediation Levels from Appendix A of Chapter 7. Department of Environmental Quality Remedial Action of Title 18. Environmental Quality

GPLs = groundwater protection levels

Minimum GPLs per Arizona Dept. of Environmental Quality 2013 spreadsheet model.

Bold = Indicates analyte detected above the minimum laboratory reporting limit (LRL)

NE = Not established

Table 6a
Hull Canyon Wash Sediment Samples
Metals - Human Health Screening

Analyte	SC-HCW-S-1	SC-HCW-S-4	SC-HCW-S-3	SC-HCW-S-2	SC-HCW-S-5 (DUP of SC-HCW-S-4)	Minimum Groundwater Protection Levels (GPLs) (mg/kg)	Non - Residential SRL (mg/kg)
	7/23/2014	7/25/2014	7/23/2014	7/23/2014	7/25/2014		
	13 Priority Pollutant Metals Plus Barium and Manganese by EPA Method 6010B and 7471A (mg/kg)						
Antimony	<5.0	<4.9	<4.9	<4.8	<5.0	35	410
Arsenic	<4.8	**31**	8.7	**34**	**32**	290	10
Barium	42	32	100	45	34	12,000	170,000
Beryllium	<0.48	<0.48	1.3	<0.50	<0.49	23	1,900
Cadmium	0.73	<0.48	0.60	0.93	0.57	29	510
Chromium	10	8.0	46	11	8.7	590	1,000,000*
Copper	64	910 M3	140	2,200	1,600	NE	41,000
Lead	11	33	25	18	33	290	800
Manganese	120	240 M3	380	690	260	NE	32,000
Mercury	<0.10	0.17	<0.093	0.14	0.89	12	310
Nickel	13	6.8	46	13	6.4	590	20,000
Selenium	<4.8	9.8	6.5	10	12	290	5,100
Silver	<2.4	<2.4	<2.5	<2.5	<2.5	NE	5,100
Thallium	<4.8	<4.8	<5.0	<5.0	<4.9	12	67
Zinc	48	88 M2	190	270	120	NE	310,000

Notes:
= Samples listed in order of upstream (SC-HCW-S-1) to downstream (SC-HCW-S-2)
EPA = Environmental Protection Agency
mg/kg = milligram per kilogram
SRL = Soil Remediation Levels from Appendix A of Chapter 7. Department of Environmental Quality Remedial Action of Title 18. Environmental Quality
GPLs = groundwater protection levels, per A Screening Method To Determine Soil Concentrations Protective of Groundwater Quality, Arizona Dept. of Environmental Quality, 1996.
M3 = See laboratory reports, Definitions/Glossary section, for QC qualifiers
DUP = duplicate
Duplicate of SC-HCW-S-4 was labeled as SC-HCW-S-5
NE = Not established
* = SRL for Chromium III
M2, M3 = See laboratory reports, Definitions/Glossary section, for QC qualifiers
Bold = Result or mean above non-residential SRL

Table 6b
Hull Canyon Wash Sediment Samples
SPLP Metals - Human Health Screening

Analyte	SC-HCW-S-1*	SC-HCW-S-4*	SC-HCW-S-3*	SC-HCW-S-2*	SC-HCW-S-5 (DUP of SC-HCW-S-4)	NWQS PBC (mg/L)
	7/23/2014	7/25/2014	7/23/2014	7/23/2014	7/25/2014	
	13 Priority Pollutant Metals plus Barium and Manganese SPLP by EPA Method 6010B, 6020, and 7470A (mg/L)					
Antimony	<0.015	<0.015	<0.015	<0.015	<0.015	0.747 T
Arsenic	<0.015	0.019	<0.015	<0.015	0.023	0.280 T
Barium	<10	<10	<10	<10	<10	98 T
Beryllium	<0.25	<0.25	<0.25	<0.25	<0.25	1.867 T
Cadmium	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.70 T
Chromium	<0.50	<0.50	<0.50	<0.50	<0.50	2.8 T**
Copper	<0.034 E8	1.1	0.15 E4	**3.7**	0.98	1.3 T
Lead	0.0069	**0.12**	**0.034**	**0.020**	**0.090**	0.015 T
Manganese	<0.50	<0.50	<0.50	<0.50	<0.50	130.7
Mercury	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.28 T
Nickel	<0.50	<0.50	<0.50	<0.50	<0.50	28 T
Selenium	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	4.667 T
Silver	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	4.667 T
Thallium	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.075 T
Zinc	<2.0	<2.0	<2.0	<2.0	<2.0	280 T

Notes:
= Samples listed in order of upstream (SC-HCW-S-1) to downstream (SC-HCW-S-2)
EPA = Environmental Protection Agency
NWQS = Arizona numeric water quality standards for surface water
SPLP = Synthetic Precipitation Leaching Procedure
mg/L = milligram per liter
PBC = Partial Body Contact screening concentration per Arizona Administrative Code (AAC) R18-11 Appendix A (Numeric Water Quality Standards) effective January 31, 2009.
DUP = duplicate
Duplicate of SC-HCW-S-4 was labeled as SC-HCW-S-5
T = total recoverable
E4, E8 = See laboratory reports, Definitions/Glossary section, for QC qualifiers
** PBC listed for Chromium VI
Bold = Result exceeds PBC NWQS

Table 6c
Hull Canyon Wash Sediment Samples
PAHs - Human Health Screening

Analyte	SC-HCW-S-4	Non - Residential SRL (mg/kg)	Minimum GPL (mg/kg)
	7/25/2014		
	Polynuclear Aromatic Hydrocarbons (PAHs) by EPA Method 8310 (mg/kg)		
Naphthalene	<0.20 H4	190	NE
Acenaphthylene	<0.30 H4	NE	NE
Acenaphthene	<0.20 H4	29,000	NE
Fluorene	<0.030 H4	26,000	NE
Phenanthrene	<0.030 H4	NE	NE
Anthracene	<0.020 H4	240,000	NE
Fluoranthene	<0.030 H4 R4	22,000	NE
Pyrene	<0.020 H4 M2 R1	29,000	NE
Benzo(a)anthracene	<0.0099 H4 M2 N1	21	NE
Chrysene	<0.020 H4	2,000	NE
Benzo(b)fluoranthene	<0.020 H4	21	NE
Benzo(k)fluoranthene	<0.0099 H4 M2	210	NE
Benzo(a)pyrene	0.018 H4 M2 R1	2.1	1.6
Dibenz(a,h)anthracene	<0.0099 H4	2.1	NE
Benzo(g,h,i)perylene	<0.030 H4	NE	NE
Indeno(1,2,3-cd)pyrene	<0.0099 H4	21	NE

Notes:

EPA = Environmental Protection Agency

mg/kg = milligram per kilogram

H4, M2, N1, R1, R4 - See laboratory reports, Definitions/Glossary section, for QC qualifiers

SRL = Soil Remediation Levels from Appendix A of Chapter 7. Department of Environmental Quality Remedial Action of Title 18. Environmental Quality

GPLs = groundwater protection levels, per Arizona Dept. of Environmental Quality 2013 spreadsheet model.

NE = Not established

Table 7a
Hull Canyon Wash Surface Water Samples
Metals, pH and Hardness - Human Health Screening

Sample Location	Sample Type	Date	Antimony (mg/L)	Arsenic (mg/L)	Barium (mg/L)	Beryllium (mg/L)	Cadmium (mg/L)	Calcium (mg/L)	Chromium (mg/L)	Copper (mg/L)	Lead (mg/L)	Magnesium (mg/L)	Manganese (mg/L)	Mercury (mg/L)	Nickel (mg/L)	Selenium (mg/L)	Silver (mg/L)	Thallium (mg/L)	Zinc (mg/L)	Hardness*	pH [2]
			13 Priority Pollutant Metals Plus Barium, Manganese, Calcium and Magnesium by EPA Methods 200.7, 200.8, and 245.1 (mg/L)																		
HCW-1-W	Total Recoverable	9/16/2014	<0.0030	<0.0030	0.022	<0.0010	<0.0010	NA	<0.010	0.012	<0.015	NA	0.015	<0.00020	<0.010	<0.0020	<0.010	<0.0010	0.078	390	7.30
	Dissolved	9/16/2014	<0.0030 H6	<0.0030 H6	0.013 H6	<0.0010 H6	<0.0010 H6	NA	<0.010 H6	<0.010 H6	<0.015 H6	NA	<0.010 H6	0.00028 H6	<0.010 H6	<0.0020 H6	<0.010 H6	<0.0010 H6	<0.050 H6	320	-
	Total Recoverable ***	10/2/2014	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	7.32
	Total Recoverable	12/4/2014	<0.0030	<0.0030	0.012	<0.0010	<0.0010	71	<0.010	<0.010	<0.015	39	<0.010	<0.00020	<0.010	<0.0020	<0.010	<0.0010	<0.050	340	8.36
	Dissolved	12/4/2014	<0.0030 H6	<0.0030 H6	0.013 H6	<0.0010	<0.0010 H6	74 H6	<0.010 H6	<0.010 H6	<0.015 H6	41 H6	<0.010 H6	<0.00020 H6	<0.010 H6	0.0023 H6	<0.010 H6 L	<0.0010 H6	<0.050 H6	350	-
	Total Recoverable	5/20/2015	<0.0030	<0.0030	<0.0010	<0.0010	<0.0010	38	<0.010	<0.010	<0.015	31	<0.010	<0.00020	<0.010	<0.0020	<0.010	<0.0010	<0.050	220	8.33
	Dissolved	5/20/2015	<0.0030	<0.0030	<0.0010	<0.0010	<0.0010	37	<0.010	<0.010	<0.015	30	<0.010	<0.00020	<0.010	<0.0020	<0.010	<0.0010	<0.050	220	8.33
HCW-2-W	Total Recoverable	5/20/2015	<0.0030	0.0059	0.016	<0.0010	<0.0010	76	<0.010	0.10	<0.015	38	<0.010	<0.00020	<0.010	0.0093	<0.010	<0.0010	<0.050	350	8.59
	Dissolved	5/20/2015	<0.0030	0.0074	0.016	<0.0010	<0.0010	81	<0.010	0.087	<0.015	41	<0.010	<0.00020	<0.010	0.011	<0.010	<0.0010	<0.050	370	8.59
HCW-3-W	Total Recoverable	9/16/2014	<0.0030	0.011	0.063	<0.0010	<0.0010	NA	0.014	0.065	**0.050**	NA	0.28	<0.00020	0.012	<0.0020	<0.010	<0.0010	0.65	76	7.87
	Total Recoverable	10/2/2014	<0.0030	0.0031	0.028	<0.0010	<0.0010	NA	<0.010	0.058	**0.022**	NA	0.17	<0.00020	<0.010	<0.0020	<0.010	<0.0010	0.11	NA	7.36
	Dissolved	10/2/2014	<0.0030 H6	<0.0030 H6	<0.010 H6	<0.0010 H6	<0.0010 H6	NA	<0.010 H6 B1	0.013 H6	<0.015 H6	NA	0.018 H6	<0.00020 H6	<0.010 H6	<0.0020 H6	<0.010 H6	<0.0010 H6	<0.050 H6	NA	-
	Dissolved****	12/4/2014	<0.030 H6	<0.030 H6	<0.10 H6	<0.010 H6	<0.010 H6	<20 H6	<0.10 H6	<0.10 H6	<0.15 H6	<20 H6	<0.10 H6	<0.00020 H6	<0.10 H6	<0.020 H6	<0.10 H6	<0.010 H6	<0.50 H6	<13	-
	Total Recoverable	5/20/2015	<0.0030	<0.0030	0.018	<0.0010	<0.0010	89	<0.010	0.044	<0.015	29	0.025	<0.00020	<0.010	0.0047	<0.010	<0.0010	<0.050	340	7.88
HCW-4-W	Total Recoverable	9/16/2014	0.0035	0.030	0.13	<0.0010	0.0015	NA	0.014	**1.3**	**0.12**	NA	0.53	0.00068	<0.010	0.0054	<0.010	<0.0010	0.40	110	6.98
	Total Recoverable	10/2/2014	0.0035	0.027	0.099	<0.0010	<0.0010	NA	0.011	0.87	**0.090**	NA	0.40	0.00044	<0.010	0.0050	<0.010	<0.0010	0.27	NA	7.33
	Dissolved	10/2/2014	<0.0030 H6	<0.0030 H6	0.015 H6	<0.0010 H6	<0.0010 H6	NA	<0.010 H6 B1	0.081 H6	<0.015 H6	NA	<0.010 H6	<0.00020 H6	<0.010 H6	0.0020 H6	<0.010 H6	<0.0010 H6	<0.050 H6	NA	-
	Total Recoverable	12/4/2014	<0.0030	<0.0030	0.024	<0.0010	<0.0010	74	<0.010	0.075	<0.015	36	0.066	<0.00020	<0.010	0.0042	<0.010 L5	<0.0010	<0.050	330	6.83
	Dissolved	12/4/2014	<0.0030 H6	<0.0030 H6	0.027 H6	<0.0010 H6	<0.0010 H6	80 H6	<0.010 H6	0.044 H6	<0.015 H6	38 H6	0.026 H6	<0.00020 H6	<0.010 H6	0.0039 H6	<0.010 H6	<0.0010 H6	<0.050 H6	360	-
	Total Recoverable	5/20/2015	<0.0030	<0.0030	0.021	<0.0010	<0.0010	65	<0.010	0.034	<0.015	41	<0.010	<0.00020	<0.010	<0.0020	<0.010	<0.0010	<0.050	330	8.11
	Dissolved	5/20/2015	<0.0030	<0.0030	0.020	<0.0010	<0.0010	66	<0.010	0.03	<0.015	41	<0.010	<0.00020	<0.010	0.002	<0.010	<0.0010	<0.050	330	8.11
HCW-5-W (Dup of HCW-4-W)	Total Recoverable	5/20/2015	<0.0030	<0.0030	0.021	<0.0010	<0.0010	64	<0.010	0.033	<0.015	41	<0.010	<0.00020	<0.010	<0.0020	<0.010	<0.0010	<0.050	330	8.11
	Dissolved	5/20/2015	<0.0030	<0.0030	0.020	<0.0010	<0.0010	65	<0.010	0.029	<0.015	41	<0.010	<0.00020	<0.010	<0.0020	<0.010	<0.0010	<0.050	330	8.11
PBC[1] (mg/L)			0.747 T	0.280 T	98.0 T	1.867 T	0.70 T	NE	2.8 T**	1.3 T	0.015 T	NE	130.7	0.28 T	28 T	4.667 T	4.667 T	0.075 T	280 T	NE	6.5 - 9.0

Notes:
PBC Standards are compared to total recoverable results to determine exceedances. Dissolved sample results are presented for informational purposes only; these results are not compared to the PBC-NWQS.
EPA = Environmental Protection Agency
PBC = Partial Body Contact
T = Total recoverable
mg/L = milligrams per liter
NA = Not analyzed
NE = Not established
NS = Not sampled
[1] = Partial body contact (PBC) standards per Arizona Administrative Code (AAC) R18-11 Appendix A (Numeric Water Quality Standards) effective January 31, 2009. PBCs compared to unfiltered (total recoverable metals).
[2] = pH measurements conducted in field.
* = Total Hardness as Calcium Carbonate ($CaCO_3$) by calculation via Method SM2340B (mg/L)
** PBC listed for Chromium VI
*** The 10/2/14 sample from location SC-HCW-1 only had enough water for a pH reading.
**** The 12/4/14 sample from location SC-HCW-3 had a note on COC of "filter + analyze if possible" due to low sample recovery from the stream sampler.
H6, B1, L5 - See laboratory reports, Definitions/Glossary section, for QC qualifiers
= LRL equals PBC Standard
= Result exceeds Partial Body Contact (PBC) Standard
= Result equals Partial Body Contact (PBC) Standard

Table 7b
Hull Canyon Wash Surface Water Samples
PAHs - Human Health Screening

Analyte	HCW-4*	HCW-4*	NWQS PBC (µg/L)
	9/16/2014	12/4/2014	
	Polynuclear Aromatic Hydrocarbons (PAHs) via EPA Method 8310 (µg/L)		
Acenaphthene	<1.0	<1.0	56,000
Acenaphthylene	<1.0	<1.0	NE
Anthracene	0.065 B4	<0.050	280,000
Benzo(a)anthracene	<0.20	<0.20	0.20
Benzo(a)pyrene	0.11	<0.050	0.20
Benzo(b)fluoranthene	<0.10	<0.10	NE
Benzo(g,h,i)perylene	<0.10	<0.10	NE
Benzo(k)fluoranthene	<0.050	<0.050 B1	1.9
Chrysene	<0.10	<0.10	19
Dibenz(a,h)anthracene	<0.10	<0.10	1.9
Fluoranthene	<0.10	<0.10	37,333
Fluorene	<0.10	<0.10	37,333
Indeno(1,2,3-cd)pyrene	<0.10	<0.10	1.9
Naphthalene	<0.50	<0.50	18,667
Phenanthrene	<0.10	<0.10	NE
Pyrene	<0.10	<0.10	28,000

Notes:

SWQS = Surface Water Quality Standard

EPA = Environmental Protection Agency

PBC = Partial Body Contact screening concentration per Arizona Administrative Code (AAC) R18-11 Appendix A (Numeric Water Quality Standards) effective January 31, 2009.

µg/L = micrograms per Liter

* = sample was unfiltered

B1, B4 - See laboratory reports, Definitions/Glossary section, for QC qualifiers

NE = Not Established

Table 8a
Descriptive Statistics and Soil COPC Determination: Exposure Area 1

ANALYTE	CAS NUMBER	Number of Samples	Number of Detects	Detection Frequency (%)	Median	Mean	Standard Deviation	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)	Minimum Reporting Limit (mg/kg)	Maximum Reporting Limit (mg/kg)	Background 95% UCL (mgkg)	MDC Exceeds Background Value?	Residential Soil Remediation Level (mgkg)	MDC or MRL Exceeds Residential SRL?	Groundwater Protection Limit (mgkg)	MDC or MRL Exceeds GPL?
Antimony	7440-36-0	22	4	18	6.3	6.28	0.814	5.3	7.2	4.8	5	NE	NA	31	No	35	No
Arsenic	7440-38-2	22	22	100	120	115.1	76.61	19	250	4.8	5	24.71	Yes	10	Yes	290	No
Barium	7440-39-3	22	22	100	23	27.6	15.6	6.7	64	4.8	5	111.3	No	15000	No	12000	No
Beryllium	7440-41-7	22	0	0	NA	NA	NA	NA	NA	0.48	0.5	0.695	No	150	No	23	No
Cadmium	7440-43-9	22	9	41	1.3	1.823	1.91	0.75	6.8	0.48	0.5	3.518	Yes	39	No	29	No
Chromium[a]	7440-47-3	22	7	32	6.3	6.157	4	2	14	1.9	2	11.21	Yes	120000	No	590	No
Copper	7440-50-8	22	22	100	2200	3260	4520	240	22000	4.8	50	348.5	Yes	3100	Yes	NE	NA
Lead	7439-92-1	22	22	100	22	36.15	31.21	5.7	140	4.8	5	59.43	Yes	400	No	290	No
Manganese	7439-96-5	22	22	100	395	623.6	519.3	150	2400	1.9	100	1036	Yes	3300	No	NE	NA
Mercury[b]	7439-97-6	22	22	100	0.625	0.942	0.793	0.14	2.7	0.089	0.1	0.159	Yes	23	No	12	No
Nickel	7440-02-0	22	9	41	3.7	4.756	3.805	2.1	14	1.9	2	8.53	Yes	1600	No	590	No
Selenium	7782-49-2	22	22	100	20.5	30.47	20.63	5.4	77	4.8	5	7.23	Yes	390	No	290	No
Silver	7440-22-4	22	13	59	5.2	8.377	5.48	3	20	2.4	2.5	NE	NA	390	No	NE	NA
Thallium	7440-28-0	22	0	0	NA	NA	NA	NA	NA	4.8	240	NE	NA	5.2	No	12	No
Zinc	7440-66-6	22	22	100	235	304.7	356.8	57	1800	9.7	10	178.3	Yes	23000	No	NE	NA

Notes:
Shading indicates soil direct contact COPC and/or leaching to groundwater COPC. COPC determined by comparing the MDC (or the MRL for 100 % nondetected results) to the SRL and GPL.
[a] Chromium assumed to be chromium III.
[b] Mercury assumed to be mercuric chloride.
% = percent
CAS = Chemical Abstract Service
COPC= Chemical of Potential Concern
GPL= groundwater protection limit
MDC = maximum detected concentration
mg/kg = milligrams per kilogram
MRL = minimum reporting limit
NA = not available
NE = not established
SRL = Soil Remediation Level
UCL = Upper Confidence Limit

Table 8b
Descriptive Statistics and Soil SPLP COPC Determination: Exposure Area 1

ANALYTE	CAS NUMBER	Number of Samples	Number of Detects	Detection Frequency (%)	Minimum Detected Concentration (mg/L)	Maximum Detected Concentration (mg/L)	Minimum Reporting Limit (mg/L)	Maximum Reporting Limit (mg/L)	PBC-NWQC mg/L	MDC or MRL Exceeds PBC-NWQC?
Antimony	7440-36-0	2	0	0	NA	NA	0.015	0.015	0.747	No
Arsenic	7440-38-2	4	2	50	0.024	0.54	0.015	0.5	0.28	Yes
Barium	7440-39-3	2	0	0	NA	NA	10	10	98	No
Beryllium	7440-41-7	2	0	0	NA	NA	0.25	0.25	1.867	No
Cadmium	7440-43-9	2	0	0	NA	NA	0.25	0.25	0.7	No
Chromium[a]	7440-47-3	2	0	0	NA	NA	0.5	0.5	2.8	No
Copper	7440-50-8	2	1	50	2.2	2.2	0.5	0.5	1.3	Yes
Lead	7439-92-1	2	0	0	NA	NA	0.5	0.5	0.015	Yes
Manganese	7439-96-5	2	0	0	NA	NA	0.5	0.5	130.7	No
Mercury[b]	7439-97-6	2	1	50	0.0009	0.0009	0.0005	0.0005	0.28	No
Nickel	7440-02-0	2	0	0	NA	NA	0.5	0.5	28	No
Selenium	7782-49-2	2	0	0	NA	NA	0.005	0.005	4.667	No
Silver	7440-22-4	2	0	0	NA	NA	0.25	0.25	4.667	No
Thallium	7440-28-0	2	0	0	NA	NA	0.005	0.005	0.075	No
Zinc	7440-66-6	2	0	0	NA	NA	2	2	280	No

Notes:

Shading indicates soil SPLP COPC. COPC determined by comparing the MDC (or the MRL for 100 % nondetected results) to the PBC-NWQS.

[a] Chromium compared to the PBC for chromium VI.

[b] Mercury assumed to be mercuric chloride.

% = percent

CAS = Chemical Abstract Service

COPC= Chemical of Potential Concern

MDC = maximum detected concentration

mg/L = milligrams per liter

MRL = minimum reporting limit

NA = not available

PBC-NWQC = Partial Body Contact- Numerical Water Quality Criteria

Table 9a
Descriptive Statistics and Soil COPC Determination: Exposure Area 2

ANALYTE	CAS NUMBER	Number of Samples	Number of Detects	Detection Frequency (%)	Median	Mean	Standard Deviation	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)	Minimum Reporting Limit (mg/kg)	Maximum Reporting Limit (mg/kg)	Background 95% UCL (mgkg)	MDC Exceeds Background Value?	Residential Soil Remediation Level (mgkg)	MDC or MRL Exceeds Residential SRL?	Groundwater Protection Limit (mgkg)	MDC or MRL Exceeds GPL?
Antimony	7440-36-0	14	8	57	23.5	24.76	14.44	5.3	42	4.9	5	NE	NA	31	Yes	35	Yes
Arsenic	7440-38-2	14	14	100	120	203.1	143.8	31	430	2.9	60	24.71	Yes	10	Yes	290	Yes
Barium	7440-39-3	14	11	79	74	81.52	76.4	6.7	270	4.9	99	111.3	Yes	15000	No	12000	No
Beryllium	7440-41-7	14	0	0	NA	NA	NA	NA	NA	0.49	0.5	0.695	No	150	No	23	No
Cadmium	7440-43-9	14	8	57	1.45	9.373	22.48	0.67	65	0.49	0.5	3.518	Yes	39	Yes	29	Yes
Chromium[a]	7440-47-3	14	10	71	13.5	13.61	7.924	2.7	30	1.9	200	11.21	Yes	120000	No	590	No
Copper	7440-50-8	14	14	100	5750	7977	7842	880	24000	2.4	100	348.5	Yes	3100	Yes	NE	NA
Lead	7439-92-1	14	14	100	108.5	243.9	325.9	18	1200	0.97	5	59.43	Yes	400	Yes	290	Yes
Manganese	7439-96-5	14	14	100	250	292.9	166.3	120	700	1.9	39	1036	No	3300	No	NE	NA
Mercury[b]	7439-97-6	14	14	100	0.825	2.554	4.475	0.17	14	0.056	0.1	0.159	Yes	23	No	12	Yes
Nickel	7440-02-0	14	11	79	8.4	10.4	6.047	3.1	22	1.9	2	8.53	Yes	1600	No	590	No
Selenium	7782-49-2	14	4	29	52.5	49	11.8	32	59	4.9	5	7.23	Yes	390	No	290	No
Silver	7440-22-4	14	13	93	5.9	7.454	3.777	2.5	14	2.4	2.5	NE	NA	390	No	NE	NA
Thallium	7440-28-0	14	0	0	NA	NA	NA	NA	NA	4.9	500	NE	NA	5.2	No	12	No
Zinc	7440-66-6	14	14	100	210	1277	3953	55	15000	4.9	200	178.3	Yes	23000	No	NE	NA

Notes:
Shading indicates soil direct contact COPC and/or leaching to groundwater COPC. COPC determined by comparing the MDC (or the MRL for 100 % nondetected results) to the SRL and GPL.
[a] Chromium assumed to be chromium III.
[b] Mercury assumed to be mercuric chloride.
% = percent
CAS = Chemical Abstract Service
COPC= Chemical of Potential Concern
GPL = groundwater protection limit
MDC = maximum detected concentration
mg/kg = milligrams per kilogram
MRL = minimum reporting limit
NA = not available
NE = not established
SRL = Soil Remediation Limit
UCL = Upper Confidence Limit

Table 9b
Descriptive Statistics and Soil SPLP COPC Determination: Exposure Area 2

ANALYTE	CAS NUMBER	Number of Samples	Number of Detects	Detection Frequency (%)	Minimum Detected Concentration (mg/L)	Maximum Detected Concentration (mg/L)	Minimum Reporting Limit (mg/L)	Maximum Reporting Limit (mg/L)	PBC-NWQC mg/L	MDC or MRL Exceeds PBC-NWQC?
Antimony	7440-36-0	4	0	0	NA	NA	0.015	0.015	0.747	No
Arsenic	7440-38-2	8	0	0	NA	NA	0.015	0.5	0.28	Yes
Barium	7440-39-3	4	0	0	NA	NA	10	10	98	No
Beryllium	7440-41-7	4	0	0	NA	NA	0.25	0.25	1.867	No
Cadmium	7440-43-9	4	0	0	NA	NA	0.25	0.25	0.7	No
Chromium[a]	7440-47-3	4	0	0	NA	NA	0.5	0.5	2.8	No
Copper	7440-50-8	4	4	100	1.5	34	0.5	0.5	1.3	Yes
Lead	7439-92-1	4	0	0	NA	NA	0.5	0.5	0.015	Yes
Manganese	7439-96-5	4	1	25	1.1	1.1	0.5	0.5	130.7	No
Mercury[b]	7439-97-6	4	0	0	NA	NA	0.0005	0.0005	0.28	No
Nickel	7440-02-0	4	0	0	NA	NA	0.5	0.5	28	No
Selenium	7782-49-2	4	3	75	0.0057	0.012	0.005	0.005	4.667	No
Silver	7440-22-4	4	0	0	NA	NA	0.25	0.25	4.667	No
Thallium	7440-28-0	4	0	0	NA	NA	0.005	0.005	0.075	No
Zinc	7440-66-6	4	1	25	4.2	4.2	2	2	280	No

Notes:

Shading indicates soil SPLP COPC. COPC determined by comparing the MDC (or the MRL for 100 % nondetected results) to the PBC-NWQS.

[a] Chromium compared to the PBC for chromium VI.

[b] Mercury assumed to be mercuric chloride.

% = percent

CAS = Chemical Abstract Service

COPC= Chemical of Potential Concern

MDC = maximum detected concentration

mg/L = milligrams per liter

MRL = minimum reporting limit

NA = not available

PBC-NWQC = Partial Body Contact- Numerical Water Quality Criteria

RL = reporting limit

Table 10a
Descriptive Statistics and Sediment COPC Determination: Hull Canyon Wash Area

ANALYTE	CAS NUMBER	Number of Samples[a]	Number of Detects	Detection Frequency (%)	Median	Mean	Standard Deviation	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)	Minimum Reporting Limit (mg/kg)	Maximum Reporting Limit (mg/kg)	Residential Soil Remediation Level (mgkg)	MDC or MRL Exceeds Residential SRL?	Groundwater Protection Limit (mgkg)	MDC or MRL Exceeds GPL?
Antimony	7440-36-0	4	0	0	NA	NA	NA	NA	NA	4.8	5	31	No	35	No
Arsenic	7440-38-2	4	3	75	32	24.9	14.07	8.7	34	4.8	5	10	Yes	290	No
Barium	7440-39-3	4	4	100	43.5	55.25	30.19	34	100	4.8	5	15000	No	12000	No
Beryllium	7440-41-7	4	1	25	1.3	1.3	NA	1.3	1.3	0.48	0.5	150	No	23	No
Cadmium	7440-43-9	4	4	100	0.665	0.708	0.164	0.57	0.93	0.48	0.5	39	No	29	No
Chromium[b]	7440-47-3	4	4	100	10.5	18.93	18.07	8	46	1.9	2	120000	No	590	No
Copper	7440-50-8	4	4	100	870	1001	1067	64	2200	4.8	5	3100	No	NE	NA
Lead	7439-92-1	4	4	100	21.5	21.75	9.43	11	33	4.8	5	400	No	290	No
Manganese	7439-96-5	4	4	100	320	362.5	242.8	120	690	1.9	20	3300	No	NE	NA
Mercury[c]	7439-97-6	4	2	50	0.515	0.515	0.53	0.14	0.89	0.089	0.1	23	No	12	No
Nickel	7440-02-0	4	4	100	13	19.7	17.78	6.8	46	1.9	2	1600	No	590	No
Selenium	7782-49-2	4	3	75	10	9.5	2.784	6.5	12	4.8	5	390	No	290	No
Silver	7440-22-4	4	0	0	NA	NA	NA	NA	NA	2.4	2.5	390	No	NE	NA
Thallium	7440-28-0	4	0	0	NA	NA	NA	NA	NA	4.8	5	5.2	No	12	No
Zinc	7440-66-6	4	4	100	155	157	95.06	48	270	9.6	10	23000	No	NE	NA

Notes:
Shading indicates sediment direct contact COPC and/or leaching to groundwater COPC. COPC determined by comparing the MDC (or the minimum reporting limit [MRL] for 100 % nondetected results) to the SRL and GPL.
[a] Number of samples includes one duplicate result.
[b] Chromium assumed to be chromium III.
[c] Mercury assumed to be mercuric chloride.
% = percent
CAS = Chemical Abstract Service
COPC= Chemical of Potential Concern
GPL = groundwater protection limit
MDC = maximum detected concentration
mg/kg = milligrams per kilogram
MRL = minimum reporting limit
NA = not available
NE = not established
UCL = Upper Confidence Limit

Table 10b
Descriptive Statistics and Sediment SPLP COPC Determination: Hull Canyon Wash Area

ANALYTE	CAS NUMBER	Number of Samples	Number of Detects	Detection Frequency (%)	Minimum Detected Concentration (mg/L)	Maximum Detected Concentration (mg/L)	Minimum Reporting Limit (mg/L)	Maximum Reporting Limit (mg/L)	PBC-NWQC mg/L	MDC or MRL Exceeds PBC-NWQC?
Antimony	7440-36-0	5	0	0	NA	NA	0.015	0.015	0.747	No
Arsenic	7440-38-2	10	2	20	0.019	0.023	0.015	0.5	0.28	Yes
Barium	7440-39-3	5	0	0	NA	NA	10	10	98	No
Beryllium	7440-41-7	5	0	0	NA	NA	0.25	0.25	1.867	No
Cadmium	7440-43-9	5	0	0	NA	NA	0.25	0.25	0.7	No
Chromium[a]	7440-47-3	5	0	0	NA	NA	0.5	0.5	2.8	No
Copper	7440-50-8	5	3	60	0.98	3.7	0.5	0.5	1.3	Yes
Lead	7439-92-1	5	0	0	NA	NA	0.5	0.5	0.015	Yes
Manganese	7439-96-5	5	0	0	NA	NA	0.5	0.5	130.7	No
Mercury[b]	7439-97-6	5	0	0	NA	NA	0.0005	0.0005	0.28	No
Nickel	7440-02-0	5	0	0	NA	NA	0.5	0.5	28	No
Selenium	7782-49-2	5	0	0	NA	NA	0.005	0.005	4.667	No
Silver	7440-22-4	5	0	0	NA	NA	0.25	0.25	4.667	No
Thallium	7440-28-0	5	0	0	NA	NA	0.005	0.005	0.075	No
Zinc	7440-66-6	5	0	0	NA	NA	2	2	280	No

Notes:

Shading indicates sediment SPLP COPC. COPC determined by comparing the MDC (or the minimum reporting limit [MRL] for 100 % nondetected results) to the PBC-NWQS.

[a] Chromium compared to the PBC for chromium VI.

[b] Mercury assumed to be mercuric chloride.

% = percent

CAS = Chemical Abstract Service

COPC= Chemical of Potential Concern

MDC = maximum detected concentration

mg/L = milligrams per liter

MRL = minimum reporting limit

NA = not available

PBC-NWQC = Partial Body Contact- Numerical Water Quality Criteria

RL = reporting limit

Table 10c
Descriptive Statistics and Surface Water COPC Determination: Hull Canyon Wash Area

Analyte	CAS Number	Number of Samples	Number of Detections	Detection Frequency (%)	Minimum Detected Concentration (mg/L)	Maximum Detected Concentration (mg/L)	Minimum Reporting Limit (mg/L)	Maximum Reporting Limit (mg/L)	PBC-NWQS (mg/L)	MDC Exceeds PBC-NWQS?	MRL Exceeds PBC-NWQS?
Antimony	7440-36-0	12	2	16.7	0.0035	0.0035	0.003	0.003	0.747	No	No
Antimony, Dissolved	7440-36-0	10	0	0.0	NA	NA	0.003	0.03	NA	NA	NA
Arsenic	7440-38-2	12	5	41.7	0.0031	0.03	0.003	0.003	0.28	No	No
Arsenic, Dissolved	7440-38-2	10	1	10.0	0.0074	0.0074	0.003	0.03	NA	NA	NA
Barium	7440-39-3	12	11	91.7	0.012	0.13	0.01	0.01	98	No	No
Barium, Dissolved	7440-39-3	10	7	70.0	0.013	0.027	0.01	0.1	NA	NA	NA
Beryllium	7440-41-7	12	0	0.0	NA	NA	0.001	0.001	1.867	No	No
Beryllium, Dissolved	7440-41-7	10	0	0.0	NA	NA	0.001	0.01	NA	NA	NA
Cadmium	7440-43-9	12	1	8.3	0.0015	0.0015	0.001	0.001	0.7	No	No
Cadmium, Dissolved	7440-43-9	10	0	0.0	NA	NA	0.001	0.01	NA	NA	NA
Chromium	7440-47-3	12	3	25.0	0.011	0.014	0.01	0.01	2.8	No	No
Chromium, Dissolved	7440-47-3	10	0	0.0	NA	NA	0.01	0.1	NA	NA	NA
Copper	7440-50-8	12	10	83.3	0.012	1.3	0.01	0.01	1.3	No	No
Copper, Dissolved	7440-50-8	10	6	60.0	0.013	0.087	0.01	0.1	NA	NA	NA
Mercury	7439-97-6	12	2	16.7	0.00044	0.00068	0.0002	0.0002	0.28	No	No
Mercury, Dissolved	7439-97-6	10	1	10.0	0.00028	0.00028	0.0002	0.0002	NA	NA	NA
Lead	7439-92-1	12	4	33.3	0.022	0.12	0.015	0.015	0.015	**Yes**	No
Lead, Dissolved	7439-92-1	10	0	0.0	NA	NA	0.015	0.15	NA	NA	NA
Manganese	7439-96-5	12	7	58.3	0.015	0.53	0.01	0.01	130.7	No	No
Manganese, Dissolved	7439-96-5	10	2	20.0	0.018	0.026	0.01	0.1	NA	NA	NA
Nickel	7440-02-0	12	1	8.3	0.012	0.012	0.01	0.01	28	No	No
Nickel, Dissolved	7440-02-0	10	0	0.0	NA	NA	0.01	0.1	NA	NA	NA
Selenium	7782-49-2	12	5	41.7	0.0042	0.0093	0.002	0.002	4.667	No	No
Selenium, Dissolved	7782-49-2	10	5	50.0	0.002	0.011	0.002	0.02	NA	NA	NA
Silver	7440-22-4	12	0	0.0	NA	NA	0.01	0.01	4.667	No	No
Silver, Dissolved	7440-22-4	10	0	0.0	NA	NA	0.01	0.1	NA	NA	NA
Thallium	7440-28-0	12	0	0.0	NA	NA	0.001	0.001	0.075	No	No
Thallium, Dissolved	7440-28-0	10	0	0.0	NA	NA	0.001	0.01	NA	NA	NA
Zinc	7440-66-6	12	5	41.7	0.078	0.65	0.05	0.05	280	No	No
Zinc, Dissolved	7440-66-6	10	0	0.0	NA	NA	0.05	0.5	NA	NA	NA

Notes:

Shading indicates surface water COPC. COPC determined by comparing the MDC (or the minimum reporting limit [MRL] for 100 % nondetected results) of total results to the PBC-NWQS. Dissolved metal results are presented for informational purposes only; these results are not used for comparison to the PBC-NWQS.

[a] Chromium compared to PBC for chromium VI.

[b] Mercury assumed to be mercuric chloride.

% = percent

CAS = Chemical Abstract Service

COPC= Chemical of Potential Concern

MDC = maximum detected concentration

mg/L = milligrams per liter

MRL = minimum reporting limit

NA = not available or not applicable

PBC-NWQC = Partial Body Contact- Numerical Water Quality Criteria

Table 11
Summary of Exposure Assumptions for the Current/Future Adolescent Trespasser

General Assumptions	Site-specific	Reference
BW (body weight)	46 kg	Mean body weight for adolescents (USEPA 2011)
AT (averaging times):		
Carcinogenic effects	70 yrs	Life expectancy; recommended exposure factor (USEPA, 1989, 2014)
Chronic effects (noncarc.) - adolescent	10 yrs	Based on adolescent exposure 7-16 years old [professional judgement]
Surface Soil/Sediment Exposure Assumptions [1]		
EF (exposure frequency)	15 days/yr	Based on assumption of 1 visit per month for 9 months (September - May [school attendance]) of the year = 9 days/year and 2 visits per month for 3 months of the year (June- August [summer vacation]) = 6 days per year for a total of 15 days per year.
ED (exposure duration)	10 yrs	Based on adolescent exposure 7 -16 years old [professional judgement]
Dermal Contact		
EV (exposure event)	1 event/day	Recommended RME value for a resident (USEPA, 2004; Exhibit 3-5)
BSAE (body surface area exposed)	6,032 cm^2	Recommended value for a adult resident (USEPA, 2011; USEPA, 2014)
FBE (fraction of body exposed)	100%	Assumes complete contact with exposed skin
AF (soil adherence factor)	0.07 mg/cm^2	Recommended USEPA default value for an adult resident (USEPA, 2014)
FC (fraction of site soil potentially impacted)	100%	Assumes 100% of on-site areas are potentially impacted
ABS (absorption fraction from soil)	chemical-specific	Chemical-specific (USEPA, 2004)
Incidental Ingestion		
IR (ingestion rate) - adult	100 mg/day	Standard default exposure factor for adult resident (USEPA 2014)
FI (fraction ingested)	25%	Assumes 2 hr/day exposure based on potential trespasser activities at the site [i.e., 25% of soil ingested is from site - professional judgment]
Inhalation of Dust/Particulates		
ET (exposure time)	2 hr/day	Based on potential trespasser activities [professional judgment]

Notes:
[1] Exposed sediments in ephemeral water bodies located on site are assumed to be soils.
% = percent
cm^2 = centimeter squared
hr = hour
kg = kilogram
mg = milligram
RME = Reasonable Maximum Exposure
USEPA = United States Environmental Protection Agency
yr = year

Table 11
Summary of Exposure Assumptions for the Current/Future Adolescent Trespasser

Source:

USEPA 1989. Risk Assessment Guidance for Superfund Volume 1: Human Health Evaluation Manual (Part A) Interim Final. Office of Emergency and Remedial Response. EPA/540/1-89/002.

USEPA 2004. Risk Assessment Guidance for Superfund Volume 1: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. OSWER 9285.7-02EP. July

USEPA 2011. Exposure Factors Handbook: 2011 Edition. United States Environmental Protection Agency. Office of Research and Development, Washington, DC. National Center for Environmental Assessment. EPA/600/R-090/052F. September 2011

USEPA 2014. Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors, February 2014. United States Environmental Protection Agency. Office of Solid Waste and Emergency Response, Washington, DC. February.

Table 12
Exposure Point Concentrations for COPCs in Soil and Sediment

COPC	Exposure Area 1	Exposure Area 2	Hull Canyon Wash
	Surface Soil EPC[a] (mg/kg)	Surface Soil EPC[a] (mg/kg)	Sediment EPC[b] (mg/kg)
Antimony	NA	23.42	NA
Arsenic	143.2	315	34
Cadmium	NA	26.11	NA
Copper	5077	11,689	NA
Lead	NA	514.8	NA

Notes:

[a] Surface soil EPCs are 95 percent UCLs of the mean developed by ProUCL and presented in Attachment B.

[b] Because of the small sample size for sediment, the MDC for arsenic in sediment is used as the EPC.

COPC = contaminant of potential concern

EPC = exposure point concentration

MDC = maximum detected concentration

mg/kg = milligram per kilogram

NA = not applicable (Antimony, cadmium, and lead are not identified as soil COPCs in Exposure Area 1 and antimony, cadmium, copper and lead are not identified as sediment COPCs.)

UCL = upper confidence limit

Table 13
Toxicity Values for COPCs

COPC	CAS Number	Oral Cancer Slope Factor $(mg/kg/d)^{-1}$	Cancer Slope Factor $(mg/kg/d)^{-1}$ (Dermal) = Oral CSF / GIABS	Inhalation Unit Risk $(ug/m^3)^{-1}$	Oral Reference Dose (mg/kg/d)	Reference Dose (mg/kg/d) (Dermal) = Oral RfD x GIABS	Inhalation Reference Concentration (mg/m^3)	Volatile	Volatilization Factor (m^3/kg)	Mutagen	GIABS	Dermal ABS	RBA (Oral)
Antimony	7440-36-0	NA	NA	NA	4.00E-04	6.00E-05	NA	No	NA	No	0.15	NA	1
Arsenic	7440-38-2	1.50E+00	1.5E+00	4.30E-03	3.00E-04	3.0E-04	1.50E-05	No	NA	No	1	0.03	0.4
Cadmium	7440-43-9	NA	NA	1.8E-03	1.00E-03	2.5E-05	1.00E-05	No	NA	No	0.025	0.001	1
Copper	7440-50-8	NA	NA	NA	4.00E-02	4.00E-02	NA	No	NA	No	1	NA	1
Lead	7439-92-1	NA	NA	NA	NA	NA	NA	No	NA	No	NA	NA	1
Mercury[a]	7439-97-6	NA	NA	NA	3.0E-04	2.10E-05	3.0E-04	No	NA	No	0.07	NA	1

Notes:
Toxicity information obtained from April 2019 RSL Table (USEPA 2019). All toxicity values are from the Integrated Risk Information System (IRIS) except for the following:
The inhalation reference concentration for arsenic (California Environmental Protection Agency)
The inhalation reference concentration for cadmium (ATSDR)
The oral reference dose for copper (HEAST)
[a] The toxicity information for mercury is based on mercuric chloride.
ABS = Absorption Factor
ATSDR = Agency for Toxic Substance and Disease Registry
CAS = Chemical Abstract Service
COPC = Chemical of Potential Concern
GI = gastrointestinal
HEAST = Health Effects Assessment Summary Table
mg/kg/d = milligram per kilogram per day
mg/m^3 = milligram per cubic meter
m^3/kg = cubic meters per kilogram
ug/m^3 = microgram per cubic meter
NA = not applicable
RBA = Relative Bioavailability Factor
RfC = reference concentration
RfD = reference dose
RSL= Regional Screening Level
USEPA = United States Environmental Protection Agency

Table 14
Site-Specific Soil Remediation Levels for COPCs in Soil and Sediment

General Assumptions		
BW	Mean Body Weight (Kg):	46
AT	Averaging time (years):	
	Carcinogenic	70
	Noncarcinogenic	
	Days/year	365
	Years	10
ADAF	Age-dependent adjustment factor (mutagens)	3
Incidental Ingestion		
IR	Incidental Ingestion Rate (mg-soil/day):	100
FI	Fraction Ingested of Daily Total (unitless):	0.25
EF	Exposure Frequency (days/year):	15
ED	Exposure Duration (years):	10
CF	Conversion Factor (Kg-soil/mg-soil):	1.00E-06
	Intake Factor (carc, Kg-soil/Kg-BW-day)	**3.19E-09**
	Intake Factor (noncarc, Kg-soil/Kg-BW-day)	**2.23E-08**
Dermal Contact		
BSAE	Body Surface Area Exposed (cm^2):	6,032
AF	Adherence Factor (mg-soil/cm^2-event):	0.07
EV	Event Frequency (events/day)	1
EF	Exposure Frequency (days/year):	15
ED	Exposure Duration (years):	10
CF	Conversion Factor (Kg-soil/mg-soil):	1.00E-06
	Intake Factor (carc, Kg-soil-/Kg-BW-day)	**5.39E-08**
	Intake Factor (noncarc, Kg-soil/Kg-BW-day)	**3.77E-07**
Inhalation		
ET	Exposure Time (hours/day):	2
FI	Fraction Inhaled of Daily Total (unitless):	0
EF	Exposure Frequency (days/year):	15
ED	Exposure Duration (years):	10
	Intake Factor (carc, unitless)	**1.22E-04**
	Intake Factor (noncarc, unitless)	**8.56E-04**

COPC	Cancer Slope Factor $(mg/kg/day)^{-1}$	Cancer Slope Factor $(mg/kg/day)^{-1}$	Unit Risk $(ug/m^3)^{-1}$	Reference Dose (mg/kg/day)	Reference Dose (mg/kg/day)	Reference Concentration (mg/m^3)	Volatile	MUTAGENIC	ABS	Default PEF (kg/m3)	NON CANCER INTAKES			CANCER INTAKES			SRLs: Noncancer Effects (HI=1)[g]				SRLs: Cancer Effects (TRL = $1x10^{-5}$)[h]				Minimum Site-Specific SRL (mg/kg)
	(Oral)	(Dermal)	(Inhalation)	(Oral)	(Dermal)	(Inhalation)	V = Volatile N = Not Volatile	M = Mutagenic N = Nonmutagenic	(Dermal)	(kg/m^3)	Oral Soil Intake (Kg-soil/Kg-BW-day)[a]	Dermal Soil Intake (Kg-soil/Kg-BW-day)[b]	Inhalation Soil Intake (kg/m^3)[c]	Oral Soil Intake (Kg-soil/Kg-BW-day)[d]	Dermal Soil Intake (Kg-soil/Kg-BW)[e]	Inhalation Soil Intake (kg/m^3)[f]	Ingestion (mg/kg)	Dermal (mg/kg)	Inhalation (mg/kg)	Combined (mg/kg)	Ingestion (mg/kg)	Dermal (mg/kg)	Inhalation (mg/kg)	Combined (mg/kg)	
Antimony	NA	NA	NA	4.00E-04	6.00E-05	NA	N	N	NA	7.35E-10	2.23E-08	NA	6.29E-13	3.19E-09	NA	8.99E-14	1.8E+04	NA	NA	1.8E+04	NA	NA	NA	NA	**1.80E+03**
Arsenic	1.50E+00	1.50E+00	4.30E-03	3.00E-04	3.00E-04	1.50E-05	N	N	0.03	7.35E-10	8.93E-09	1.13E-08	6.29E-13	1.28E-09	1.62E-09	8.99E-14	3.4E+04	2.7E+04	2.4E+07	1.5E+04	5.2E+03	4.1E+03	2.6E+07	2.3E+03	**2.30E+03**
Cadmium	NA	NA	1.80E-03	1.00E-03	2.50E-05	1.00E-05	N	N	0.001	7.35E-10	2.23E-08	3.77E-10	6.29E-13	3.19E-09	5.39E-11	8.99E-14	4.5E+04	6.6E+04	1.6E+07	2.7E+04	NA	NA	6.2E+07	6.2E+07	**2.70E+04**
Copper	NA	NA	NA	4.00E-02	4.00E-02	NA	N	N	NA	7.35E-10	2.23E-08	NA	6.29E-13	3.19E-09	NA	8.99E-14	1.8E+06	NA	NA	1.8E+06	NA	NA	NA	NA	**1.80E+06**
Mercury	NA	NA	NA	3.00E-04	2.10E-05	3.00E-04	N	N	NA	7.35E-10	2.23E-08	NA	6.29E-13	3.19E-09	NA	8.99E-14	1.3E+04	NA	4.8E+08	1.3E+04	NA	NA	NA	NA	**1.30E+04**

Notes:
ABS = absorption factor
COPC = chemical of potential concern
HI = hazard index
IF = intake factor
kg = kilogram
kg/m^3 = kilogram per cubic meter
mg/kg = milligram per kilogram
mg/m^3 = milligrams per cubic meter
NA = not applicable
TRL = target risk level
SRL = soil remediation level

[a] IFnoncancer = (IR*FI*EF*ED*CF)/(BW*ATnoncarc*365)
[b] IFnoncancer = (BSAE*AF*ABSder*FC*EF*ED*EV*CF)/(BW*ATnoncancer*365)
[c] IF noncancer = [PEF (non-volatiles) or VF (volatiles)] * [(ET*FI*EF*ED)]/(24*ATnoncancer*365)
[d] IFcancer = (IR*FI*EF*ED*CF)/(BW*ATcarc*365) *ADAF
[e] IFcancer = (BSAE*AF*ABSder*FC*EF*ED*EV*CF)/(BW*ATcarc*365) * ADAF
[f] IFcancer = [PEF (non-volatiles) or VF (volatiles)] * [(ET*FI*EF*ED)]/(24*ATcarc*365) *ADAF
[g] The noncancer SRLequation is presented in Section 6.1.1 of the HHRA
[h] The carcinogenic SRL equation is presented in Section 6.1.2 of the HHRA.

Table 15
Comparison of Site-Specific Soil Remediation Levels to COPCs in Soil and Sediment

COPC	Site-Specific Adolescent Trespasser SRL (TRL = 1 x 10^{-4}, HQ = 1) (mg/kg)	Site-Specific Adolescent Trespasser SRL (TRL = 1 x 10^{-6}, HQ = 1) (mg/kg)	Site-Specific Adolescent Trespasser SRL (TRL = 1 x 10^{-5}, HQ = 1)[a] (mg/kg)	Exposure Area 1			Exposure Area 2			Hull Canyon Wash
				Soil MDC in Exposure Area 1 (mg/kg)	95% UCL of the Mean in Exposure Area 1 (mg/kg)	Does the Soil MDC or 95% UCL of the Mean Exceed the Site-Specific SRL?	Soil MDC in Exposure Area 2 (mg/kg)	95% UCL of the Mean in Exposure Area 2 (mg/kg)	Does the Soil MDC or 95% UCL of the Mean Exceed the Site-Specific SRL?	Sediment MDC
Antimony	18,000	18,000	**18,000**	NA	NA	No	42	23.42	No	NA
Arsenic	15,000	230	**2,300**	250	143.2	No	430	315	No	34
Cadmium	27,000	27,000	**27,000**	NA	NA	No	65	26.11	No	NA
Copper	1,800,000	1,800,000	**1,800,000**	22,000	5077	No	24,000	11,689	No	NA
Lead[b]	18,000	18,000	**18,000**	NA	NA	NA	1200	514.8	No	NA

Notes:
Shading denotes exceedance of site-specific adolescent trespasser SRL.

[a] Because the Arizona VRP allows for a target risk level of 1 x 10^{-5}, the Site-Specific Adolescent Trespasser SRL used for comparison to COPC concentrations is based on a target risk level of 1 x 10^{-5} or HQ of 1. The site-specific adolescent trespasser SRLs based on target risk levels of 1 x 10^{-4} and 1 x 10^{-6} are representative of the USEPA acceptable risk range and are for informational purposes only.

[b] Lead is evaluated separately, as presented in Section 6.3 of the HHRA. However, the Preliminary Remediation Goal developed for lead using the Adult Lead Model (ALM) and based on a 10 microgram per deciliter target blood lead level is listed here. The outputs from the ALM is presented as Attachment C of the Human Health Risk Assessment.

COPC = Chemical of Potential Concern
HHRA = Human Health Risk Assessment
HQ = hazard quotient
MDC = maximum detected concentration
mg/kg = milligram per kilogram
NA = not applicable (Antimony, cadmium, and lead are not considered soil COPCs in Exposure Area 1 and antimony, cadmium, copper and lead are not considered sediment COPCs.)
SRL = Soil Remediation Level
TRL = target risk level
UCL = upper confidence limit

Table 16
Determination of Alternative Groundwater Protection Levels

Exposure Area	Analyte	Sample ID	Soil Sample Result Exceeding GPLs [1] (mg/kg)	SPLP Result [2] (mg/L)	R value (L/kg)	Cw [3] mg/L	Alternative GPL (mg/kg)
Exposure Area 1	Copper	SC-LGO-3	22,000	12	1,833.3	1.3	698,078
Exposure Area 1	Copper	SC-T-1	1,300	2.2	590.9	1.3	225,000
Exposure Area 2	Antimony	SC-SWC-1 & SC-SWC-2	42	0.015	2800.0	0.006	4,920
Exposure Area 2	Arsenic	SC-HGO-1	410	0.015	27,333.3	0.01	80,000
Exposure Area 2	Arsenic	SC-SWC-2	300	0.015	20000.0	0.01	58,580
Exposure Area 2	Cadmium	SC-SWC-1	65	0.0098	6632.7	0.005	9,713
Exposure Area 2	Copper	SC-T-3	1,000	1.5	666.7	1.3	253,846
Exposure Area 2	Copper	SC-HGO-1	4,600	4.4	1,045.5	1.3	398,077
Exposure Area 2	Copper	SC-SWC-1 & SC-SWC-2	20,000	3.5	5,714.3	1.3	2,175,828
Exposure Area 2	Lead	SC-SWC-1 & SC-SWC-2	310	0.021	14761.9	0.05	216,000
Exposure Area 2	Mercury[4]	SC-SS-3	14	0.0005	28000.0	0.0005	4,100
Hull Canyon Wash (sediment)	Copper	SC-HCW-S-4 & SC-HCW-S-2	910	1.1	827.3	1.3	315,000

Notes:

Alternative GPLs determined per Section IV, A Screening Method to Determine Soil Concentrations Protective of Groundwater Quality. Arizona Dept. of Environmental Quality. September, 1996.

Alternative GPL = $(292.9)*R*C_w$

C = concentration

GPL = Groundwater Protection Limit

ID = identification

L/kg = liters per kilogram

MCL - Maximum Contaminant Level

mg/kg = milligrams per kilogram

mg/L = milligrams per liter

PBC-NWQS = Partial Body Contact- Numeric Water Quality Standard

$R = C_{soil} / C_{leachate}$

SPLP = Synthetic Precipitation Leachate Procedure

[1] Copper has no GPL for comparison; however, it was retained for further evaluation because SPLP results exceeded the PBC-NWQS.

[2] Where two samples exceeded the default GPL, as a conservative approach the lowest soil sample concentration was used to calculate R. If the SPLP result was reported as a nondetection, the laboratory reporting limit was used to calculate R.

[3] Cw is a health-based action level, such as MCL. The value for arsenic is based on the secondary MCL. Other values used are based on AWQS.

[4] Because no SPLP result for mercury was associated with location SC-SS-3, the SPLP results from nearby locations were evaluated to use in its place. All SPLP results for mercury in nearby locations SWC-1, SWC-2, and HGO were reported as nondetections. The reporting limit of 0.0005 mg/L was used to represent the SPLP concentration for mercury.

Table 17
Summary of Representative Receptors and Exposure Pathways

Media		Exposure Areas 1 and 2 [1]		Area Surface Water	
		Surface Soil		Surface Water	Sediment/Soil [2]
Representative Receptor	**Biota Ingestion**	**Uptake and Direct Contact [4]**	**Incidental Ingestion**	**Uptake and Direct Contact [4]**	**Uptake and Direct Contact [4]**
Aquatic Receptors [3]					
Terrestrial biota that occasionally use ephemeral water in the Wash				o	o
Terrestrial Receptors					
Terrestrial Plant Community		x [5]			x [5]
Terrestrial Invertebrate Community		x [5]			x [5]
Omnivorous/Insectivorous Wildlife (Horned Lark)	x	x	x		
Herbivorous Wildlife (Black-tailed Jackrabbit)	x	x	x		
Carnivorous Wildlife (Coyote)	x	x	x		

Notes:

[1] Exposure pathways are defined assuming the whole of the site is suitable ecological habitat.

[2] Surface water is ephemeral in the Hull Canyon wash. Ephemeral water is defined as "a surface water that has a channel that is at all times above the water table and flows only in direct response to precipitation" (AAC, 2009). Associated sediments are thus effectively considered soil.

[3] Aquatic and benthic communities are not present in the ephemeral Hull Canyon Wash.

[4] For the purposes of the ecological risk assessment, only "direct contact" with media is applicable to community level receptors. Wildlife receptors are assessed based on uptake via biota from applicable media, and incidental ingestion of soil as indicated.

[5] Evaluation of terrestrial communities is based on a comparison to generic screening levels coupled with a weight of evidence evaluation to assess potential risk.

x = Primary exposure route addressed quantitatively in the ecological risk assessment.
o = Primary exposure route addressed qualitatively in the ecological risk assessment.
Blank cells indicate that receptor is not evaluated for given exposure area/media.

Reference:

Arizona Administrative Code (AAC). 2009. Title 18, Environmental Quality. Chapter 11, Department of Environmental Quality – Water Quality Standards. January 31.

Table 18
Summary of Potential Ecological Risks for the Verde Central Mine Site

Terrestrial Receptor	Exposure Medium	Potential Risk Concerns (HQ>1)		
	Media	Exposure Area 1	Exposure Area 2	Hull Canyon Wash
Omnivorous/Insectivorous Wildlife (Horned Lark)	Surface soil and biota	Copper, selenium and zinc	Cadmium, copper, lead, mercury, selenium and zinc	--
Herbivorous Wildlife (Black-tailed Jackrabbit)	Surface soil and biota	No risk expected	No risk expected	--
Carnivorous Wildlife (Coyote)	Surface soil and biota	No risk expected	No risk expected	--
Terrestrial Plant Community	Surface soil	Arsenic, copper and selenium	Arsenic, copper, selenium and zinc	--
Soil Invertebrate Community	Surface soil	Arsenic, copper and mercury	Arsenic, copper, mercury, selenium and zinc	--
Terrestrial Biota	Surface water	--	--	Copper (two samples at two locations)
Terrestrial Biota	Sediment/Soil	--	--	Copper and Selenium (two sample locations), cadmium and nickel (one sample location)

Notes:
-- = not applicable
HQ = hazard quotient

APPENDIX A

PUBLIC INVOLVEMENT

URS

August 18, 2014

Ms. Kathleen Jarvis
Librarian
Jerome Public Library
600 Clark Street, Drawer I
Jerome, Arizona 86331

Re: Transmittal of Additional Copies of Project Documents for the Verde Central Mine Voluntary Remediation Project

Dear Ms. Jarvis:

In accordance with our conversation of July 24, 2014, please find enclosed a second set of project documents for the Verde Central Mine Voluntary Remediation Project to be made available for public review in the Jerome Public Library (the library). The project is being conducted by Freeport Minerals Corporation under the Arizona Department of Environmental Quality Voluntary Remediation Program to evaluate mining residuals at the former Verde Central Mine located adjacent to Hull Canyon Wash, south of Jerome, Arizona.

The enclosed copies include a Project Work Plan, a Sampling and Analysis Plan, a Fact Sheet, and a Frequently Asked Questions document for the project. One copy of each of these documents had previously been hand-delivered to the library on July 7 (Project Work Plan and Sampling and Analysis Plan) and July 24 (Fact Sheet and Frequently Asked Questions document). As we discussed, in the future, two copies of project documents will be submitted to the library to provide for public review.

Thank you for your assistance.

Sincerely,
URS Corporation

Janet M. Workman, P.E.
Project Manager

Enclosures: Revised Project Work Plan, Verde Central Mine Voluntary Remediation Project
Revised Sampling and Analysis Plan, Verde Central Mine Voluntary Remediation Project
Fact Sheet, Verde Central Mine Voluntary Remediation Project
Verde Central Mine Voluntary Remediation Project Frequently Asked Questions

cc: Barbara Nielsen, Freeport-McMoRan Copper & Gold (without enclosures)
Patrick Gorman, URS (without enclosures)

URS Corporation
7720 North 16th Street, Suite 100
Phoenix, AZ 85020
Tel: 602.371.1100
Fax: 602.371.1615P:\WRES\Freeport_McMoRan\23446591_Verde_Central\5_0_Technical\5_7_Community_Involvement\Jerome_Public_Library\Document_Transmittal_Aug_2014.docx

Verde Central Mine Voluntary Remediation Project

Verde Central mining and concentrating operations occurred from 1928 to 1930.

Freeport Minerals Corporation is working with the Arizona Department of Environmental Quality (ADEQ) through the agency's Voluntary Remediation Program (VRP) to evaluate mining residuals at the former Verde Central Mine located adjacent to Hull Canyon Wash, south of Jerome, Arizona. The purpose of the investigation is to determine whether remediation of the mine residuals is necessary and, if so, what remedial actions should be taken. Site characterization and risk assessment are expected to be completed in 2014.

History

After the discovery of ore at the Verde Central property in 1923, an underground mine was developed by Verde Central Mines, Inc., and a mill was constructed in 1928. Mining and milling operations ceased in 1930, and the mine building was dismantled. Waste rock and low-grade ore extracted during mining operations were deposited in Hull Canyon downhill of the main shaft.

Tailings were generated during the milling and concentrating process. A pipeline or launder appears to have been used to convey tailings from the mill to a thickener tank on the west side of Hull Canyon Wash. At one time, tailings may have been discharged to a small impoundment in this vicinity before being pumped to an off-site location.

The property on which the mine is located is now owned by Freeport Minerals Corporation. The Verde Central site was acquired in 1935 by a predecessor of Freeport.

The Project and Timeline

Waste rock and ore removed from the mine was stockpiled on mine property adjacent to Hull Canyon Wash. This project will investigate the concentration of metals within the waste rock and ore, assess whether these concentrations exceed standards intended to protect human health and the environment, and assess whether there is a risk to surface water quality as a result of stormwater runoff that comes in contact with the waste rock. If there are conditions that exceed the ADEQ approved cleanup criteria, a remediation plan will be developed and implemented.

Verde Central Mine Voluntary Remediation Project

Site Characterization and Risk Assessment

Field activities to collect and analyze samples of the mining materials and background soil at the site are tentatively scheduled to occur in July 2014. An evaluation of the potential to exceed ADEQ standards will follow the field sampling activities. A report will be generated and submitted to ADEQ for review.

Remedial Activities

Should the results of field sampling indicate that the mining materials remaining at the site may exceed ADEQ standards, a remedial action may be warranted. The type and scope of remedial activities will be developed based on the results of the site characterization. A summary of remedial activities to be performed will be provided in a future fact sheet.

Regulatory Oversight

This project is being conducted with the oversight of ADEQ. The VRP allows interested parties to work cooperatively with ADEQ in the assessment and cleanup of contaminated properties.

Impacts to the Community and Surrounding Area

The field activities conducted under the Site Characterization phase of this project will not impact the community or the surrounding area. During the field work, Freeport will take appropriate safety measures near the roadway. Field sampling activities are expected to require about one week for completion and are not anticipated to generate dust or result in additional traffic within the community.

More Information

The company will provide copies of all reports, correspondence with the ADEQ, and other public information at the Jerome Library as the project progresses. News media and other interested parties may contact James Telle – Manager, External Communications, Freeport Minerals Corporation, 333 North Central Avenue, Phoenix, Arizona 85004; by email at james_telle@fmi.com; or at 602-366-7963.

Verde Central Mine Voluntary Remediation Project
Frequently Asked Questions (FAQ)

Where is the project located?
The Verde Central Mine is located approximately 0.7 mile southwest of the Town of Jerome. The project area includes a mine rock stockpile, various mining material residuals, and foundations of the former mine and mill support facilities.

What is the purpose of the project?
Freeport Minerals Corporation (Freeport) is coordinating with the Arizona Department of Environmental Quality (ADEQ) through its Voluntary Remediation Program (VRP) to evaluate mining residuals at the former Verde Central Mine located adjacent to Hull Canyon Wash, south of Jerome, Arizona. The purpose of the investigation is to determine whether remediation of the mine residues is necessary and, if so, the appropriate remedial method. Site characterization and risk assessment will be completed in 2014.

Why is Freeport undertaking this project?
Freeport will be working cooperatively with ADEQ to identify and evaluate mining residues and to determine if any action should be taken to protect human health and the environment, specifically surface water quality. The company is systematically addressing these types of sites across Arizona with ADEQ.

Will the mine be reopening?
Freeport has no plans to reopen the mine. Mining activities ceased in 1930. The Verde Central site was acquired in 1935 by a predecessor of Freeport.

What previous work was done at the Verde Central Mine?
Multiple mine shafts and adits at the project area were closed between May 2008 and January 2009 with polyurethane foam plugs (some with bat gates and/or vents) and covered by natural materials. The closed shafts and adits are routinely inspected by Freeport.

What is the Voluntary Remediation Program?
The following description excerpted from ADEQ's Voluntary Remediation Program brochure describes the program:

> "The Voluntary Remediation Program (VRP) allows interested parties to work cooperatively with ADEQ to clean up contaminated properties and return them to beneficial use. The main goals of the VRP are:
>
> 1. To allow interested parties to conduct remediation of properties and return them to productive use.
> 2. To work cooperatively with interested parties to achieve their remediation goals in a cost effective manner.
> 3. To allow interested parties to proactively reduce risk to public health and the environment.
> 4. To inform the community of the activities being performed at the site.
> 5. To facilitate the selection of regulatory tools such as risk assessments, and institutional controls and engineering controls available to the interested party to reach site closure.

After a site or portion of a site has been accepted into the VRP, a work plan may be submitted for review and approval. Once approved, the applicant can proceed with investigation and/or remediation according to the work plan. Work plan modifications should be submitted to VRP.

Interested parties can submit pertinent documents for review after remedial activities are complete; however, the VRP encourages interested parties to work cooperatively throughout the process. Once the remedial goals have been met, and community involvement requirements completed, the applicant submits a request for determination of no further action.

The department reviews and, if appropriate, grants the determination of no further action for the site or portion of the site."

What is the scope of the project?
The project will consist of several stages including field sampling and analysis for site characterization, risk assessment, evaluation and selection of restoration options (if warranted), and implementation of the selected restoration option (if warranted). Site characterization, consisting of field sampling activities, is expected to be conducted in summer 2014. Laboratory analysis of the data generated during site characterization is expected to be completed within two to three months and a Site Characterization Report submitted to the ADEQ VRP in fall 2014. Site restoration activities will be developed in the future, if needed.

Is the Town of Jerome paying for any part of this project?
No. Freeport will be paying all costs associated with this project.

Will there be any interruption to water and/or sewer services as a result of this project?
The project has been developed so that no interruption to water and/or sewer services will result from the project. A water supply main serving the Town of Jerome runs through the project area. The exact location is not currently defined. Field activities associated with the planned site characterization will not affect the water main. Should planned sampling activities be determined to be located near the water line, the sampling location will be altered to prevent any potential damage to the water line.

Will this mean that there will be a lot of construction traffic through town?
Site characterization is not anticipated to result in additional traffic through Jerome or along Highway 89A. Should restoration or remediation activities be warranted, a traffic plan will be developed and coordinated with stakeholders to limit disruption to businesses and residents.

How will dust be controlled during the project?
Site characterization activities are not expected to generate dust, and dust control measures will not be required for this phase of the project. Should remediation activities be warranted at a later stage in the project, a dust control plan will be developed in accordance with standard construction practice and presented to ADEQ for approval prior to implementation of the remediation activities.

What are the company's plans for the site after the cleanup?
Freeport has no plans at this time to sell, develop, or mine the property upon completion of the project.

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Page 1 of 1

Freeport Minerals Corporation is working with the Arizona Department of Environmental Quality (ADEQ) through the agency's Voluntary Remediation Program (VRP) to evaluate mining residuals at the former Verde Central Mine located adjacent to Hull Canyon Wash, south of Jerome, Arizona.

Freeport Minerals Corporation will host a public meeting in Lawrence Memorial Hall (Spook Hall) located on Hull Avenue in Jerome, Arizona from 4:00 to 6:00 pm in the afternoon of July 7, 2014 to provide the public an opportunity to review the plan to conduct an investigation to determine whether remediation of the mining residuals is necessary.

For more information, you may contact:

James Telle - Manager, External Communications, Freeport Minerals Corporation by email at james_telle@fmi.com; or at 602-366-7963

Joey Pace - Project Manager, ADEQ Remedial Projects Section, Voluntary Remediation Program by email at Pace.Joey@azdeq.gov; or at 602-771-4818

2TVI Publish: 6/25, 7/4, 2014

APPENDIX B

FIELD NOTES

Verde Central Mine 7/22/14

1100 Leah Wills + Adam Kneeland onsite at FCX Jerome office. Meet with Duff Sorells. Get site specific H+S cards
1115 LW, AK, + Duff head to overlook of Site
1145 LW + AK MOB to Cottonwood for supplies
1330 LW+AK onsite at Verde Central Mine
Task: Take 10 Background soil samples
Weather: 96°F, partly cloudy
1345 Set up sampling
1428 Sampled Background B-3, Moved location due to thick brush. SC-B-3
1525 Sampled SC-WR-1
1535 Sampled B-2, SC-B-2
* relocated due to thick brush
1624 Sampled SC-B-9
1652 Sampled SC-B-8
1723 Sampled SC-B-4
1730 Secure access gate. LW + AK offsite. Notify Janet Workman + Duff
1835 Collect EB-1, equipment blank, by pouring DI water over rock hammer

FCX - Verde Central Mine 7/23/14

0940 Leah Wills + Adam Kneeling onsite
0945 Conduct H&S meeting
Task: Take site characterization soil samples
Weather: 90°F, Clear, sunny
0950 Begin sample setup
1105 Sampled SC-B-5
1109 Sampled SC-B-11, field dup of B-5
1121 Sampled SC-HCW-S-1, stream sediment
1134 Sampled SC-B-6
1252 Sampled SC-HCW-S-2
1303 Sampled SC-WR-2
1322 Sampled SC-WR-3
1329 Sampled SC-T-1
1335 Sampled SC-WR-4
1343 Sampled SC-HCW-S-3
1346 Sampled ~~WR~~ LW SC-WR-5 ~~5~~
1405 Sampled SC-WR-6
1418 Sampled SC-T-2
1424 Sampled SC-T-3
1510 Sampled SC-B-1
1530 LW + ACK offsite. Notify Janet
~~1615~~ Workman + Duff
1645 Collect EB-2

FCX-Verde Central Mine 7/24/14

0820 Leah Wills + Adam Kneeling onsite
0830 Conduct H+S Meeting
Task: Site characterization Soil sampling
Weather: Cloudy, 80°F
0852 Sampled SC-WR-10
0905 Sampled SC-WR-9
0915 Sampled SC-WR-8
0926 Sampled SC-WR-~~8~~ LW 7
0930 Sampled SC-WR-11, field dup of WR-7
0946 " SC-LGO-8
0947 " SC-LGO-11, field dup of LGO-8
1003 " SC-LGO-7
1017 " SC-LGO-6
1034 " SC-LGO-3
1050 " SC-LGO-5
1250 " SC-B-10
1311 " SC-B-7
1338 " SC-LGO-4
1342 " SC-LGO-2
1346 " SC-LGO-1
1401 " SC-LGO-9
1408 " SC-LGO-10
1425 Sampled EB-3, poured DI H2O over hammer + trowel into sample container
1455 LW + ACK offsite

FCX-Verde Central Mine 7/25/14

0800 Leah Wills + Adam Kneeling onsite
0810 Conduct H+S meeting
Task: Site characterization Soil sampling
Weather: 75°F, clear sunny
0820 Sampled SC-HCW-S-4 + SC-HCW-S-5, S-5 is a field dup of S-4
0837 Sampled SC-HGO-1
0856 Sampled SC-SWC-1 for SWC, VOC, + paste pH. Attempted to hand auger but could not get down due to wood + metal rope debris. Estimated thickness of SWC ~ 2.5-3ft
0905 Sampled SC-SWC-2 for same analytes as LW SWC-1, in both samples Soil was brown-dk brown-black + contained coated lumber, stained soil, + had an organic odor
0930 Sampled EB-4 by pouring DI water over the rock hammer + trowel and collecting it in the sample container
1030 LW + AK offsite. Notify Duff + J. Workman

8/7/14

1010 Adam Kneeling (ACK) and Dean Walkowiak (DW) onsite @ FCX Jerome office for site specific training for DW.
Activities include setting up low-tech gravity stream water samplers @ four locations along Hull Canyon Wash @ Verde Central

1035 Meet Robert Miller - Conduct training for DW, mob to site

1050 ACK and DW onsite; conduct health & safety meeting.
Decon and set up samplers.
decon by washing w/ alconox & distilled water and rinsing w/ distilled water

1120 Complete set up of samplers: each sampler consists of a 5-ft section of 2" PVC pipe w/ end cap w/ teflon tape and duct taped on 1/4" screen @ top - duct tape on end will be anchored w/ a rock @ the bottom and 2 Texas spikes across gradient w/ nylon rope.
~~Collect~~ Collect EB-5 by pouring distilled water into completed

8/7/14

(HCW-1)

1120 cont. sampler, then pouring sediment into sampler container (250 ml) w/ HNO_3 for total metals analysis

1150 Set up HCW-1 sampler photo

1215 Set up HCW-3 sampler photo

1240 Set up HCW-2 sampler w/ photo

1310 Set up HCW-4 sampler - photo

1315 clean up + depart site

1325 Call Duff and Janet Wakman
Decide to collect EB-5 for VOCs and PAHs and collect additional samples from the suspected waste concentrate

1400 Retrieve HCW-4 sampler for additional EB samples

1405 Collect EB-5 from HCW-4 sampler for VOCs and PAHs analysis

1410 Collect additional ~~EB~~ Acq samples from SWC-1 and SWC-2; reinstall sampler

1440 ACK + DW off site

Note: EB-5 sample was collected @ 1405
Metals sample was recollected @ 1405

9/16/14 FCX Verde Central H_2O Sampler
Double check
1230 M. Hearn + A. kneeling on Site. Gate lock Not in DAISY chain. Will Hike to Sample Collectors.
H+S Meeting.
Task: Maintain + Empty Sample-Collect in Stream Bed.
Review Sample locations. HCW 1A, 3 Contain Water. HCW-2 Dry
1405 Collect HCW-3-W 500ml Nitric only
1425 Collect HCW-4-W " " And 1L Amber
1430 Collect HCW-1-W 500ml Nitric + 500ml
1440 Collect Ponded Sample Near HCW-3 for below-tailings pH. Pack up
1515 Pond Sample held for possible Analysis Contact lab, disregard pond Sample Contact J. Workman to Update.
1530 URS off Site

9/16/14

Task: pH readings for water samples
Equip: Hanna HI 991300 #21849
Cal 9/16/14 @ 1740
pH 7 => 6.85
4 => 3.98

HCW-1-W	pH = 7.30
HCW-2-W	pH = 6.99
HCW-3-W	pH = 7.87
HCW-4-W	pH = 6.98

10/2/11 FCX Verde Central GW Sample

1145 M. Hearn + A. kneeling on Site.
Sitewalk + H+S Discussion.
Task: Sample 4x GW Collectors
Weather: Clear, Warm
Equip: ~~Horiba~~ (MH) Hanna HI991300

1215 Collect HCW-3-W 500ml Unpreserved, 500 ml Nitric

1232 Collect HCW-4-W 500ml Unpreserved, 500 ml Nitric

1245 Collect HCW-1-W, only enough Water in Sampler for pH reading

1300 Cal. Hanna => pH 7.01 / pH 4.01
1413 uS/cm Cal. Solution

1310 HCW-1-W => pH = 7.32
HCW-3-W => pH = 7.36
HCW-4-W => pH = 7.33

1320 P/U, URS off Site.

10/2/14 FCX Verde Central GW Sample

1145 M. Hearn + A. kneeling on Site.
Sitewalk + H&S Discussion.
Task: Sample 4x GW Collectors
Weather: Clear, Warm
Equip: ~~Horiba~~ Hanna HI991300

1215 Collect HCW-3-W 500ml
Unpreserved, 500 ml Nitric

1232 Collect HCW-4-W 500ml
Unpreserved, 500 ml Nitric

1245 Collect HCW-1-W, only enough
Water in Sampler for pH reading

1300 Cal. Hanna => pH 7.01 / pH 4.01
1413 uS/cm Cal. Solution

1310 HCW-1-W => pH = 7.32
HCW-3-W => pH = 7.36
HCW-4-W => pH = 7.33

1320 P/u, URS off Site.

FCX VERDE CENTRAL GW SAMPLE 12.4.14

1455 DEAN WALKOWIAK ON SITE
TASK: SAMPLE 4X GW COLLECTORS
WEATHER: CLOUDY 49°F - NOT RAINING
VEGITATION WET. FLOW @ RD.
EQUIP HANNA PH METER
HI 991300
TERRA TECH #108 RENTAL

1510 SAMPLE HCW-1-W
PH 8.36 / 51.2°F

1530 SAMPLE HCW-4-W
PH 6.83 / 50.4°F
CREEK BED FLOW STOPPED @
±100' DOWN STREAM FROM
HCW-4
CREEK BED FLOWING @ ±450'
DOWN STREAM, NO FLOW @ ±500'
DOWN STREAM

1550 HCW-3-W NO FLOW
MAY NOT BE ENOUGH FOR SAMPLE

1600 HCW-2W NO FLOW
NOT ENOUGH FOR SAMPLES

1630 PICK UP URS OFFSITE

5-20-15

FGX Verde Central H_2O Sample

0715 Dean Wachowiak Dai Sites

WEATHER: Partly Cloudy 56°F

TASK: Sample 4 GW Collectors

Plus 1 Duplicate

EQUIPMENT: Peristaltic Pump

Terratech Rental

Hanna pH meter 21849 Calibrated 5-19-15

0815 Sample SC-HCW-2-UNFILT-20150520

0830 Sample SC-HCW-2-FILTER-20150520

pH = 8.59 Reset Collector

0910 Sample - SC-HCW-3-UNFILT-20150520

Not enough water for filter sample

pH = 7.88 Reset Collector

1005 Sample SC-HCW-4-UNFILT-20150520

1015 Sample SC-HCW-4-FILTER-20150520

pH = 8.11

1030 Sample SC-HCW-5-UNFILT-20150520

(* dup of HCW4 unfilt)

1040 Sample SC-HCW-5-FILTER-20150520

(* dup of HCW4 filter) Reset Collector

1105 Sample SC-HCW-1-UNFILT-20150520

1115 Sample SC-HCW-1-FILTER-20150520

pH = 8.33 Reset Collector

1216 Pick up, COC, Lock gate offsite

APPENDIX C

ANALYTICAL DATA

TestAmerica

THE LEADER IN ENVIRONMENTAL TESTING

ANALYTICAL REPORT

TestAmerica Laboratories, Inc.
TestAmerica Phoenix
4625 East Cotton Ctr Blvd
Suite 189
Phoenix, AZ 85040
Tel: (602)437-3340

TestAmerica Job ID: 550-105830-1
Client Project/Site: 60580510
Revision: 2

For:
AECOM Technical Services Inc.
7720 North 16th Street
Suite 100
Phoenix, Arizona 85020

Attn: Frances Ackerman

Authorized for release by:
10/31/2018 9:50:03 AM

Carlene McCutcheon, Project Manager II
(602)659-7612
carlene.mccutcheon@testamericainc.com

LINKS

Review your project results through TotalAccess

Have a Question? Ask The Expert

Visit us at: www.testamericainc.com

This report has been electronically signed and authorized by the signatory. Electronic signature is intended to be the legally binding equivalent of a traditionally handwritten signature.

Results relate only to the items tested and the sample(s) as received by the laboratory.

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Qualifiers

Metals

Qualifier	Qualifier Description
M2	Matrix spike recovery was low, the associated blank spike recovery was acceptable.
D1	Sample required dilution due to matrix.
M3	The spike recovery value is unusable since the analyte concentration in the sample is disproportionate to the spike level. The associated blank spike was acceptable.
R13	MS/MSD RPD exceeded the method acceptance limit. Matrix spike recovery was outside acceptance criteria. Batch precision and accuracy were demonstrated.
E8	Analyte reported to MDL per project specification. Target analyte was not detected in the sample.
D2	Sample required dilution due to high concentration of analyte.
M3	The spike recovery value is unusable since the analyte concentration in the sample is disproportionate to the spike level. The associated blank spike was acceptable.
M2	Matrix spike recovery was low, the associated blank spike recovery was acceptable.
R13	MS/MSD RPD exceeded the method acceptance limit. Matrix spike recovery was outside acceptance criteria. Batch precision and accuracy were demonstrated.
R4	MS/MSD RPD exceeded the method control limit. Recovery met acceptance criteria.
E8	Analyte reported to MDL per project specification. Target analyte was not detected in the sample.
E4	Concentration estimated. Analyte was detected below laboratory minimum reporting level (MRL) but above MDL.

General Chemistry

Qualifier	Qualifier Description
R8	Sample RPD exceeded the method acceptance limit.

Glossary

Abbreviation	These commonly used abbreviations may or may not be present in this report.
¤	Listed under the "D" column to designate that the result is reported on a dry weight basis
%R	Percent Recovery
CFL	Contains Free Liquid
CNF	Contains No Free Liquid
DER	Duplicate Error Ratio (normalized absolute difference)
Dil Fac	Dilution Factor
DL	Detection Limit (DoD/DOE)
DL, RA, RE, IN	Indicates a Dilution, Re-analysis, Re-extraction, or additional Initial metals/anion analysis of the sample
DLC	Decision Level Concentration (Radiochemistry)
EDL	Estimated Detection Limit (Dioxin)
LOD	Limit of Detection (DoD/DOE)
LOQ	Limit of Quantitation (DoD/DOE)
MDA	Minimum Detectable Activity (Radiochemistry)
MDC	Minimum Detectable Concentration (Radiochemistry)
MDL	Method Detection Limit
ML	Minimum Level (Dioxin)
NC	Not Calculated
ND	Not Detected at the reporting limit (or MDL or EDL if shown)
PQL	Practical Quantitation Limit
QC	Quality Control
RER	Relative Error Ratio (Radiochemistry)
RL	Reporting Limit or Requested Limit (Radiochemistry)
RPD	Relative Percent Difference, a measure of the relative difference between two points
TEF	Toxicity Equivalent Factor (Dioxin)
TEQ	Toxicity Equivalent Quotient (Dioxin)

Case Narrative

Client: AECOM Technical Services Inc.
Project/Site: 60580510

TestAmerica Job ID: 550-105830-1

Job ID: 550-105830-1

Laboratory: TestAmerica Phoenix

Narrative

Job Narrative
550-105830-1

Comments
No additional comments.

Receipt
The samples were received on 7/12/2018 10:30 AM; the samples arrived in good condition, properly preserved and, where required, on ice. The temperatures of the 2 coolers at receipt time were 1.3º C and 1.4º C.

Metals
Method(s) 6010C: The low level continuing calibration verification (CCVL) associated with batch 550-152062 recovered above the upper control limit for Beryllium. The samples associated with this CCV were non-detects for the affected analytes; therefore, the data have been reported.

No additional analytical or quality issues were noted, other than those described above or in the Definitions/Glossary page.

General Chemistry
Method(s) Moisture: The sample duplicate (DU) precision for analytical batch 550-151719 was outside control limits. Sample non-homogeneity was suspected. As such, these data have been reported and qualified with R8 flags.

REVISION (9/5/18): Please note that this report has been revised to add additional methods as requested by the Client.

No additional analytical or quality issues were noted, other than those described above or in the Definitions/Glossary page.

Job ID: 550-105830-2

Laboratory: TestAmerica Phoenix

Narrative

Job Narrative
550-105830-2

Comments
No additional comments.

Receipt
The samples were received on 7/12/2018 10:30 AM; the samples arrived in good condition, properly preserved and, where required, on ice. The temperatures of the 2 coolers at receipt time were 1.3º C and 1.4º C.

Metals
Method(s) 6010C: The low level continuing calibration verification (CCVL) associated with batch 550-152062 recovered above the upper control limit for Beryllium. The samples associated with this CCV were non-detects for the affected analytes; therefore, the data have been reported.

No additional analytical or quality issues were noted, other than those described above or in the Definitions/Glossary page.

REVISION (10/31/18): Please note that this report has been revised to include additional SPLP analytes.

Job ID: 550-105830-3

Laboratory: TestAmerica Phoenix

Job ID: 550-105830-3 (Continued)

Laboratory: TestAmerica Phoenix (Continued)

Narrative

Job Narrative
550-105830-3

Comments
No additional comments.

Receipt
The samples were received on 7/12/2018 10:30 AM; the samples arrived in good condition, properly preserved and, where required, on ice. The temperatures of the 2 coolers at receipt time were 1.3º C and 1.4º C.

Metals
No analytical or quality issues were noted, other than those described in the Definitions/Glossary page.

Job ID: 550-105830-4

Laboratory: TestAmerica Phoenix

Narrative

Job Narrative
550-105830-4

Comments
No additional comments.

Receipt
The samples were received on 7/12/2018 10:30 AM; the samples arrived in good condition, properly preserved and, where required, on ice. The temperatures of the 2 coolers at receipt time were 1.3º C and 1.4º C.

Metals
No analytical or quality issues were noted, other than those described in the Definitions/Glossary page.

Sample Summary

Client: AECOM Technical Services Inc.
Project/Site: 60580510

TestAmerica Job ID: 550-105830-1

Lab Sample ID	Client Sample ID	Matrix	Collected	Received
550-105830-1	SC-SS-3	Solid	07/11/18 10:15	07/12/18 10:30
550-105830-2	SC-SWC-3-MS	Solid	07/11/18 11:45	07/12/18 10:30
550-105830-3	SC-SWC-3	Solid	07/11/18 11:45	07/12/18 10:30
550-105830-4	SC-T4	Solid	07/11/18 12:50	07/12/18 10:30
550-105830-5	SC-SS-1	Solid	07/11/18 09:50	07/12/18 10:30
550-105830-6	SC-SS-2	Solid	07/11/18 10:30	07/12/18 10:30
550-105830-7	SC-SS-7	Solid	07/11/18 11:20	07/12/18 10:30
550-105830-8	SC-SS-4	Solid	07/11/18 10:55	07/12/18 10:30
550-105830-9	SC-T5	Solid	07/11/18 12:10	07/12/18 10:30
550-105830-10	SC-SS-5	Solid	07/11/18 11:30	07/12/18 10:30
550-105830-11	SC-SS-6	Solid	07/11/18 11:00	07/12/18 10:30
550-105830-12	SC-TS-D	Solid	07/11/18 12:10	07/12/18 10:30

Detection Summary

Client: AECOM Technical Services Inc.
Project/Site: 60580510

TestAmerica Job ID: 550-105830-1

Client Sample ID: SC-SS-3 — Lab Sample ID: 550-105830-1

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Antimony	6.8	M2	4.9		mg/Kg	1		6010C	Total/NA
Arsenic	330	D1 M3	59		mg/Kg	20		6010C	Total/NA
Barium	140	D1 M2 R13	99		mg/Kg	20		6010C	Total/NA
Cadmium	1.5		0.49		mg/Kg	1		6010C	Total/NA
Chromium	14		2.0		mg/Kg	1		6010C	Total/NA
Copper	10000	M3	2.5		mg/Kg	1		6010C	Total/NA
Lead	240		0.99		mg/Kg	1		6010C	Total/NA
Manganese	140		2.0		mg/Kg	1		6010C	Total/NA
Nickel	6.9		2.0		mg/Kg	1		6010C	Total/NA
Silver	14		2.5		mg/Kg	1		6010C	Total/NA
Zinc	280		4.9		mg/Kg	1		6010C	Total/NA
Copper	1.2		0.50		mg/L	1		6010C	SPLP West
Selenium	58	D1	0.49		mg/Kg	10		6020B	Total/NA
Mercury	14		0.057		mg/Kg	1		7471B	Total/NA

Client Sample ID: SC-SWC-3-MS — Lab Sample ID: 550-105830-2

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Antimony	9.5		4.9		mg/Kg	1		6010C	Total/NA
Arsenic	68		2.9		mg/Kg	1		6010C	Total/NA
Barium	99		4.9		mg/Kg	1		6010C	Total/NA
Cadmium	1.4		0.49		mg/Kg	1		6010C	Total/NA
Chromium	11		2.0		mg/Kg	1		6010C	Total/NA
Copper	5500		2.5		mg/Kg	1		6010C	Total/NA
Lead	210		0.98		mg/Kg	1		6010C	Total/NA
Manganese	190		2.0		mg/Kg	1		6010C	Total/NA
Nickel	9.0		2.0		mg/Kg	1		6010C	Total/NA
Silver	2.6		2.5		mg/Kg	1		6010C	Total/NA
Zinc	400		4.9		mg/Kg	1		6010C	Total/NA
Selenium	31	D1	0.50		mg/Kg	10		6020B	Total/NA
Mercury	1.1		0.057		mg/Kg	1		7471B	Total/NA

Client Sample ID: SC-SWC-3 — Lab Sample ID: 550-105830-3

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Antimony	23		5.0		mg/Kg	1		6010C	Total/NA
Arsenic	86		3.0		mg/Kg	1		6010C	Total/NA
Barium	120		5.0		mg/Kg	1		6010C	Total/NA
Cadmium	1.2		0.50		mg/Kg	1		6010C	Total/NA
Chromium	16		2.0		mg/Kg	1		6010C	Total/NA
Copper	6500		2.5		mg/Kg	1		6010C	Total/NA
Lead	240		0.99		mg/Kg	1		6010C	Total/NA
Manganese	210		2.0		mg/Kg	1		6010C	Total/NA
Nickel	12		2.0		mg/Kg	1		6010C	Total/NA
Silver	3.6		2.5		mg/Kg	1		6010C	Total/NA
Zinc	370		5.0		mg/Kg	1		6010C	Total/NA
Selenium	17	D1	0.50		mg/Kg	10		6020B	Total/NA
Mercury	1.1		0.058		mg/Kg	1		7471B	Total/NA

Client Sample ID: SC-T4 — Lab Sample ID: 550-105830-4

This Detection Summary does not include radiochemical test results.

Detection Summary

Client: AECOM Technical Services Inc.
Project/Site: 60580510

TestAmerica Job ID: 550-105830-1

Client Sample ID: SC-T4 (Continued) — Lab Sample ID: 550-105830-4

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Arsenic	130		3.0		mg/Kg	1		6010C	Total/NA
Barium	21		4.9		mg/Kg	1		6010C	Total/NA
Chromium	5.3		2.0		mg/Kg	1		6010C	Total/NA
Copper	880		2.5		mg/Kg	1		6010C	Total/NA
Lead	34		0.99		mg/Kg	1		6010C	Total/NA
Manganese	120		2.0		mg/Kg	1		6010C	Total/NA
Nickel	3.1		2.0		mg/Kg	1		6010C	Total/NA
Silver	5.9		2.5		mg/Kg	1		6010C	Total/NA
Zinc	65		4.9		mg/Kg	1		6010C	Total/NA
Selenium	27	D1	0.50		mg/Kg	10		6020B	Total/NA
Mercury	1.2		0.058		mg/Kg	1		7471B	Total/NA

Client Sample ID: SC-SS-1 — Lab Sample ID: 550-105830-5

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Arsenic	110		2.9		mg/Kg	1		6010C	Total/NA
Barium	58		4.9		mg/Kg	1		6010C	Total/NA
Cadmium	0.91		0.49		mg/Kg	1		6010C	Total/NA
Chromium	8.7		1.9		mg/Kg	1		6010C	Total/NA
Copper	6000		2.4		mg/Kg	1		6010C	Total/NA
Lead	42		0.97		mg/Kg	1		6010C	Total/NA
Manganese	610		1.9		mg/Kg	1		6010C	Total/NA
Nickel	8.8		1.9		mg/Kg	1		6010C	Total/NA
Silver	4.2		2.4		mg/Kg	1		6010C	Total/NA
Zinc	260		4.9		mg/Kg	1		6010C	Total/NA
Selenium	19	D1	0.50		mg/Kg	10		6020B	Total/NA
Mercury	0.46		0.058		mg/Kg	1		7471B	Total/NA

Client Sample ID: SC-SS-2 — Lab Sample ID: 550-105830-6

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Arsenic	31		3.0		mg/Kg	1		6010C	Total/NA
Barium	93		5.0		mg/Kg	1		6010C	Total/NA
Chromium	13		2.0		mg/Kg	1		6010C	Total/NA
Copper	1200		2.5		mg/Kg	1		6010C	Total/NA
Lead	32		1.0		mg/Kg	1		6010C	Total/NA
Manganese	250		2.0		mg/Kg	1		6010C	Total/NA
Nickel	7.4		2.0		mg/Kg	1		6010C	Total/NA
Zinc	55		5.0		mg/Kg	1		6010C	Total/NA
Selenium	8.3	D1	0.49		mg/Kg	10		6020B	Total/NA
Mercury	0.17		0.056		mg/Kg	1		7471B	Total/NA

Client Sample ID: SC-SS-7 — Lab Sample ID: 550-105830-7

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Antimony	36		4.9		mg/Kg	1		6010C	Total/NA
Arsenic	88	D1	5.9		mg/Kg	2		6010C	Total/NA
Barium	74	D1	9.9		mg/Kg	2		6010C	Total/NA
Cadmium	1.3		0.49		mg/Kg	1		6010C	Total/NA
Chromium	21		2.0		mg/Kg	1		6010C	Total/NA

This Detection Summary does not include radiochemical test results.

Detection Summary

Client: AECOM Technical Services Inc.
Project/Site: 60580510

TestAmerica Job ID: 550-105830-1

Client Sample ID: SC-SS-7 (Continued) — Lab Sample ID: 550-105830-7

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Copper	8700		2.5		mg/Kg	1		6010C	Total/NA
Lead	450		0.99		mg/Kg	1		6010C	Total/NA
Manganese	250		2.0		mg/Kg	1		6010C	Total/NA
Nickel	12		2.0		mg/Kg	1		6010C	Total/NA
Silver	5.3		2.5		mg/Kg	1		6010C	Total/NA
Zinc	390		4.9		mg/Kg	1		6010C	Total/NA
Selenium	12	D1	0.50		mg/Kg	10		6020B	Total/NA
Mercury	0.31		0.057		mg/Kg	1		7471B	Total/NA

Client Sample ID: SC-SS-4 — Lab Sample ID: 550-105830-8

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Antimony	24		5.0		mg/Kg	1		6010C	Total/NA
Arsenic	430	D1	60		mg/Kg	20		6010C	Total/NA
Cadmium	0.67		0.50		mg/Kg	1		6010C	Total/NA
Chromium	30		2.0		mg/Kg	1		6010C	Total/NA
Copper	5500		2.5		mg/Kg	1		6010C	Total/NA
Lead	160		0.99		mg/Kg	1		6010C	Total/NA
Manganese	240		2.0		mg/Kg	1		6010C	Total/NA
Nickel	21		2.0		mg/Kg	1		6010C	Total/NA
Silver	9.9		2.5		mg/Kg	1		6010C	Total/NA
Zinc	83		5.0		mg/Kg	1		6010C	Total/NA
Selenium	51	D1	0.49		mg/Kg	10		6020B	Total/NA
Mercury	0.55		0.059		mg/Kg	1		7471B	Total/NA

Client Sample ID: SC-T5 — Lab Sample ID: 550-105830-9

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Arsenic	59		3.0		mg/Kg	1		6010C	Total/NA
Barium	76		4.9		mg/Kg	1		6010C	Total/NA
Chromium	16		2.0		mg/Kg	1		6010C	Total/NA
Copper	1000		2.5		mg/Kg	1		6010C	Total/NA
Lead	54		0.99		mg/Kg	1		6010C	Total/NA
Manganese	180		2.0		mg/Kg	1		6010C	Total/NA
Nickel	8.0		2.0		mg/Kg	1		6010C	Total/NA
Zinc	72		4.9		mg/Kg	1		6010C	Total/NA
Selenium	12	D1	0.50		mg/Kg	10		6020B	Total/NA
Mercury	0.37		0.060		mg/Kg	1		7471B	Total/NA

Client Sample ID: SC-SS-5 — Lab Sample ID: 550-105830-10

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Antimony	19		4.9		mg/Kg	1		6010C	Total/NA
Arsenic	250	D1	59		mg/Kg	20		6010C	Total/NA
Barium	270	D1	98		mg/Kg	20		6010C	Total/NA
Cadmium	2.0		0.49		mg/Kg	1		6010C	Total/NA
Chromium	9.4		2.0		mg/Kg	1		6010C	Total/NA
Copper	20000	D2	4.9		mg/Kg	2		6010C	Total/NA
Lead	570		0.98		mg/Kg	1		6010C	Total/NA
Manganese	250		2.0		mg/Kg	1		6010C	Total/NA

This Detection Summary does not include radiochemical test results.

Detection Summary

Client: AECOM Technical Services Inc.
Project/Site: 60580510

TestAmerica Job ID: 550-105830-1

Client Sample ID: SC-SS-5 (Continued) — Lab Sample ID: 550-105830-10

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Nickel	6.9		2.0		mg/Kg	1		6010C	Total/NA
Silver	11		2.4		mg/Kg	1		6010C	Total/NA
Zinc	430		4.9		mg/Kg	1		6010C	Total/NA
Manganese	0.53		0.50		mg/L	1		6010C	SPLP West
Selenium	45	D1	0.49		mg/Kg	10		6020B	Total/NA
Mercury	12		0.058		mg/Kg	1		7471B	Total/NA

Client Sample ID: SC-SS-6 — Lab Sample ID: 550-105830-11

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Arsenic	400	D1	60		mg/Kg	20		6010C	Total/NA
Copper	2000		2.5		mg/Kg	1		6010C	Total/NA
Lead	21		1.0		mg/Kg	1		6010C	Total/NA
Manganese	360		2.0		mg/Kg	1		6010C	Total/NA
Silver	3.7		2.5		mg/Kg	1		6010C	Total/NA
Zinc	160		5.0		mg/Kg	1		6010C	Total/NA
Selenium	33	D1	0.50		mg/Kg	10		6020B	Total/NA
Mercury	0.42		0.060		mg/Kg	1		7471B	Total/NA

Client Sample ID: SC-TS-D — Lab Sample ID: 550-105830-12

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Arsenic	68	D1	6.0		mg/Kg	2		6010C	Total/NA
Barium	74	D1	9.9		mg/Kg	2		6010C	Total/NA
Chromium	16		2.0		mg/Kg	1		6010C	Total/NA
Copper	1300		2.5		mg/Kg	1		6010C	Total/NA
Lead	57		0.99		mg/Kg	1		6010C	Total/NA
Manganese	230		2.0		mg/Kg	1		6010C	Total/NA
Nickel	8.4		2.0		mg/Kg	1		6010C	Total/NA
Silver	2.5		2.5		mg/Kg	1		6010C	Total/NA
Zinc	83		5.0		mg/Kg	1		6010C	Total/NA
Selenium	13	D1	0.49		mg/Kg	10		6020B	Total/NA
Mercury	0.35		0.058		mg/Kg	1		7471B	Total/NA

This Detection Summary does not include radiochemical test results.

Client Sample Results

Client: AECOM Technical Services Inc.
Project/Site: 60580510

TestAmerica Job ID: 550-105830-1

Client Sample ID: SC-SS-3

Date Collected: 07/11/18 10:15
Date Received: 07/12/18 10:30

Lab Sample ID: 550-105830-1

Matrix: Solid

Method: 6010C - Metals (ICP)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Antimony	6.8	M2	4.9		mg/Kg		07/17/18 17:44	07/18/18 12:33	1
Arsenic	330	D1 M3	59		mg/Kg		07/17/18 17:44	07/19/18 14:54	20
Barium	140	D1 M2 R13	99		mg/Kg		07/17/18 17:44	07/19/18 14:54	20
Beryllium	ND		0.49		mg/Kg		07/17/18 17:44	07/18/18 12:33	1
Cadmium	1.5		0.49		mg/Kg		07/17/18 17:44	07/18/18 12:33	1
Chromium	14		2.0		mg/Kg		07/17/18 17:44	07/18/18 12:33	1
Copper	10000	M3	2.5		mg/Kg		07/17/18 17:44	07/20/18 07:55	1
Lead	240		0.99		mg/Kg		07/17/18 17:44	07/18/18 12:33	1
Manganese	140		2.0		mg/Kg		07/17/18 17:44	07/18/18 12:33	1
Nickel	6.9		2.0		mg/Kg		07/17/18 17:44	07/18/18 12:33	1
Selenium	ND	M2	4.9		mg/Kg		07/17/18 17:44	07/18/18 12:33	1
Silver	14		2.5		mg/Kg		07/17/18 17:44	07/18/18 12:33	1
Thallium	ND	M2	4.9		mg/Kg		07/17/18 17:44	07/18/18 12:33	1
Zinc	280		4.9		mg/Kg		07/17/18 17:44	07/18/18 12:33	1

Method: 6010C - Metals (ICP) - SPLP West

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Aluminum	ND		4.0		mg/L		08/08/18 14:30	08/08/18 20:43	1
Beryllium	ND	E8	0.25	0.0025	mg/L		08/08/18 14:30	08/08/18 20:43	1
Antimony	ND		0.50		mg/L		08/08/18 14:30	08/08/18 20:43	1
Arsenic	ND		0.50		mg/L		08/08/18 14:30	08/08/18 20:43	1
Barium	ND		10		mg/L		08/08/18 14:30	08/08/18 20:43	1
Cadmium	ND		0.25		mg/L		08/08/18 14:30	08/08/18 20:43	1
Chromium	ND		0.50		mg/L		08/08/18 14:30	08/08/18 20:43	1
Cobalt	ND		0.20		mg/L		08/08/18 14:30	08/08/18 20:43	1
Copper	1.2		0.50		mg/L		08/08/18 14:30	08/08/18 20:43	1
Lead	ND		0.50		mg/L		08/08/18 14:30	08/08/18 20:43	1
Manganese	ND		0.50		mg/L		08/08/18 14:30	08/08/18 20:43	1
Nickel	ND		0.50		mg/L		08/08/18 14:30	08/08/18 20:43	1
Selenium	ND		0.25		mg/L		08/08/18 14:30	08/08/18 20:43	1
Silver	ND		0.25		mg/L		08/08/18 14:30	08/08/18 20:43	1
Thallium	ND		0.50		mg/L		08/08/18 14:30	08/08/18 20:43	1
Zinc	ND		2.0		mg/L		08/08/18 14:30	08/08/18 20:43	1

Method: 6020B - Metals (ICP/MS)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Selenium	58	D1	0.49		mg/Kg		08/21/18 05:37	08/22/18 14:29	10

Method: 7470A - Mercury (CVAA) - SPLP West

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	ND		0.00050		mg/L		08/08/18 13:04	08/08/18 15:44	1

Method: 7471B - Mercury (CVAA)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	14		0.057		mg/Kg		07/16/18 10:12	07/16/18 14:53	1

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Percent Moisture	2.1		0.1		%			07/13/18 09:44	1
Percent Solids	97.9		0.1		%			07/13/18 09:44	1

Client Sample Results

Client: AECOM Technical Services Inc.
Project/Site: 60580510

TestAmerica Job ID: 550-105830-1

Client Sample ID: SC-SWC-3-MS

Lab Sample ID: 550-105830-2
Date Collected: 07/11/18 11:45
Matrix: Solid
Date Received: 07/12/18 10:30

Method: 6010C - Metals (ICP)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Antimony	9.5		4.9		mg/Kg		07/17/18 17:44	07/18/18 12:38	1
Arsenic	68		2.9		mg/Kg		07/17/18 17:44	07/18/18 12:38	1
Barium	99		4.9		mg/Kg		07/17/18 17:44	07/18/18 12:38	1
Beryllium	ND		0.49		mg/Kg		07/17/18 17:44	07/18/18 12:38	1
Cadmium	1.4		0.49		mg/Kg		07/17/18 17:44	07/18/18 12:38	1
Chromium	11		2.0		mg/Kg		07/17/18 17:44	07/18/18 12:38	1
Copper	5500		2.5		mg/Kg		07/17/18 17:44	07/20/18 08:00	1
Lead	210		0.98		mg/Kg		07/17/18 17:44	07/18/18 12:38	1
Manganese	190		2.0		mg/Kg		07/17/18 17:44	07/18/18 12:38	1
Nickel	9.0		2.0		mg/Kg		07/17/18 17:44	07/18/18 12:38	1
Selenium	ND		4.9		mg/Kg		07/17/18 17:44	07/18/18 12:38	1
Silver	2.6		2.5		mg/Kg		07/17/18 17:44	07/18/18 12:38	1
Thallium	ND		4.9		mg/Kg		07/17/18 17:44	07/18/18 12:38	1
Zinc	400		4.9		mg/Kg		07/17/18 17:44	07/18/18 12:38	1

Method: 6020B - Metals (ICP/MS)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Selenium	31	D1	0.50		mg/Kg		08/21/18 05:37	08/22/18 14:38	10

Method: 7471B - Mercury (CVAA)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	1.1		0.057		mg/Kg		07/16/18 10:12	07/16/18 14:55	1

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Percent Moisture	2.8		0.1		%			07/13/18 09:44	1
Percent Solids	97.2		0.1		%			07/13/18 09:44	1

Client Sample ID: SC-SWC-3

Lab Sample ID: 550-105830-3
Date Collected: 07/11/18 11:45
Matrix: Solid
Date Received: 07/12/18 10:30

Method: 6010C - Metals (ICP)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Antimony	23		5.0		mg/Kg		07/17/18 17:44	07/18/18 12:43	1
Arsenic	86		3.0		mg/Kg		07/17/18 17:44	07/18/18 12:43	1
Barium	120		5.0		mg/Kg		07/17/18 17:44	07/18/18 12:43	1
Beryllium	ND		0.50		mg/Kg		07/17/18 17:44	07/18/18 12:43	1
Cadmium	1.2		0.50		mg/Kg		07/17/18 17:44	07/18/18 12:43	1
Chromium	16		2.0		mg/Kg		07/17/18 17:44	07/18/18 12:43	1
Copper	6500		2.5		mg/Kg		07/17/18 17:44	07/20/18 08:05	1
Lead	240		0.99		mg/Kg		07/17/18 17:44	07/18/18 12:43	1
Manganese	210		2.0		mg/Kg		07/17/18 17:44	07/18/18 12:43	1
Nickel	12		2.0		mg/Kg		07/17/18 17:44	07/18/18 12:43	1
Selenium	ND		5.0		mg/Kg		07/17/18 17:44	07/18/18 12:43	1
Silver	3.6		2.5		mg/Kg		07/17/18 17:44	07/18/18 12:43	1
Thallium	ND		5.0		mg/Kg		07/17/18 17:44	07/18/18 12:43	1
Zinc	370		5.0		mg/Kg		07/17/18 17:44	07/18/18 12:43	1

Client Sample Results

Client: AECOM Technical Services Inc.
Project/Site: 60580510

TestAmerica Job ID: 550-105830-1

Client Sample ID: SC-SWC-3

Lab Sample ID: 550-105830-3
Date Collected: 07/11/18 11:45
Matrix: Solid
Date Received: 07/12/18 10:30

Method: 6020B - Metals (ICP/MS)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Selenium	17	D1	0.50		mg/Kg		08/21/18 05:37	08/22/18 14:40	10

Method: 7471B - Mercury (CVAA)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	1.1		0.058		mg/Kg		07/16/18 10:12	07/16/18 14:56	1

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Percent Moisture	2.9		0.1		%			07/13/18 09:44	1
Percent Solids	97.1		0.1		%			07/13/18 09:44	1

Client Sample ID: SC-T4

Lab Sample ID: 550-105830-4
Date Collected: 07/11/18 12:50
Matrix: Solid
Date Received: 07/12/18 10:30

Method: 6010C - Metals (ICP)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Antimony	ND		4.9		mg/Kg		07/17/18 17:44	07/18/18 12:48	1
Arsenic	130		3.0		mg/Kg		07/17/18 17:44	07/18/18 12:48	1
Barium	21		4.9		mg/Kg		07/17/18 17:44	07/18/18 12:48	1
Beryllium	ND		0.49		mg/Kg		07/17/18 17:44	07/18/18 12:48	1
Cadmium	ND		0.49		mg/Kg		07/17/18 17:44	07/18/18 12:48	1
Chromium	5.3		2.0		mg/Kg		07/17/18 17:44	07/18/18 12:48	1
Copper	880		2.5		mg/Kg		07/17/18 17:44	07/20/18 08:10	1
Lead	34		0.99		mg/Kg		07/17/18 17:44	07/18/18 12:48	1
Manganese	120		2.0		mg/Kg		07/17/18 17:44	07/18/18 12:48	1
Nickel	3.1		2.0		mg/Kg		07/17/18 17:44	07/18/18 12:48	1
Selenium	ND		4.9		mg/Kg		07/17/18 17:44	07/18/18 12:48	1
Silver	5.9		2.5		mg/Kg		07/17/18 17:44	07/18/18 12:48	1
Thallium	ND		4.9		mg/Kg		07/17/18 17:44	07/18/18 12:48	1
Zinc	65		4.9		mg/Kg		07/17/18 17:44	07/18/18 12:48	1

Method: 6020B - Metals (ICP/MS)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Selenium	27	D1	0.50		mg/Kg		08/21/18 05:37	08/22/18 14:43	10

Method: 7471B - Mercury (CVAA)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	1.2		0.058		mg/Kg		07/16/18 10:12	07/16/18 14:57	1

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Percent Moisture	3.1		0.1		%			07/13/18 09:44	1
Percent Solids	96.9		0.1		%			07/13/18 09:44	1

Client Sample Results

Client: AECOM Technical Services Inc.
Project/Site: 60580510

TestAmerica Job ID: 550-105830-1

Client Sample ID: SC-SS-1

Lab Sample ID: 550-105830-5
Date Collected: 07/11/18 09:50
Matrix: Solid
Date Received: 07/12/18 10:30

Method: 6010C - Metals (ICP)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Antimony	ND		4.9		mg/Kg		07/17/18 17:44	07/18/18 12:54	1
Arsenic	**110**		2.9		mg/Kg		07/17/18 17:44	07/18/18 12:54	1
Barium	**58**		4.9		mg/Kg		07/17/18 17:44	07/18/18 12:54	1
Beryllium	ND		0.49		mg/Kg		07/17/18 17:44	07/18/18 12:54	1
Cadmium	**0.91**		0.49		mg/Kg		07/17/18 17:44	07/18/18 12:54	1
Chromium	**8.7**		1.9		mg/Kg		07/17/18 17:44	07/18/18 12:54	1
Copper	**6000**		2.4		mg/Kg		07/17/18 17:44	07/20/18 08:16	1
Lead	**42**		0.97		mg/Kg		07/17/18 17:44	07/18/18 12:54	1
Manganese	**610**		1.9		mg/Kg		07/17/18 17:44	07/18/18 12:54	1
Nickel	**8.8**		1.9		mg/Kg		07/17/18 17:44	07/18/18 12:54	1
Selenium	ND		4.9		mg/Kg		07/17/18 17:44	07/18/18 12:54	1
Silver	**4.2**		2.4		mg/Kg		07/17/18 17:44	07/18/18 12:54	1
Thallium	ND		4.9		mg/Kg		07/17/18 17:44	07/18/18 12:54	1
Zinc	**260**		4.9		mg/Kg		07/17/18 17:44	07/18/18 12:54	1

Method: 6020B - Metals (ICP/MS)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Selenium	**19**	**D1**	0.50		mg/Kg		08/21/18 05:37	08/22/18 14:45	10

Method: 7471B - Mercury (CVAA)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	**0.46**		0.058		mg/Kg		07/16/18 10:12	07/16/18 14:58	1

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Percent Moisture	**5.8**		0.1		%			07/13/18 09:44	1
Percent Solids	**94.2**		0.1		%			07/13/18 09:44	1

Client Sample ID: SC-SS-2

Lab Sample ID: 550-105830-6
Date Collected: 07/11/18 10:30
Matrix: Solid
Date Received: 07/12/18 10:30

Method: 6010C - Metals (ICP)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Antimony	ND		5.0		mg/Kg		07/17/18 17:44	07/18/18 12:59	1
Arsenic	**31**		3.0		mg/Kg		07/17/18 17:44	07/18/18 12:59	1
Barium	**93**		5.0		mg/Kg		07/17/18 17:44	07/18/18 12:59	1
Beryllium	ND		0.50		mg/Kg		07/17/18 17:44	07/18/18 12:59	1
Cadmium	ND		0.50		mg/Kg		07/17/18 17:44	07/18/18 12:59	1
Chromium	**13**		2.0		mg/Kg		07/17/18 17:44	07/18/18 12:59	1
Copper	**1200**		2.5		mg/Kg		07/17/18 17:44	07/20/18 08:27	1
Lead	**32**		1.0		mg/Kg		07/17/18 17:44	07/18/18 12:59	1
Manganese	**250**		2.0		mg/Kg		07/17/18 17:44	07/18/18 12:59	1
Nickel	**7.4**		2.0		mg/Kg		07/17/18 17:44	07/18/18 12:59	1
Selenium	ND		5.0		mg/Kg		07/17/18 17:44	07/18/18 12:59	1
Silver	ND		2.5		mg/Kg		07/17/18 17:44	07/18/18 12:59	1
Thallium	ND		5.0		mg/Kg		07/17/18 17:44	07/18/18 12:59	1
Zinc	**55**		5.0		mg/Kg		07/17/18 17:44	07/18/18 12:59	1

Client Sample Results

Client: AECOM Technical Services Inc.
Project/Site: 60580510

TestAmerica Job ID: 550-105830-1

Client Sample ID: SC-SS-2

Lab Sample ID: 550-105830-6
Date Collected: 07/11/18 10:30
Matrix: Solid
Date Received: 07/12/18 10:30

Method: 6020B - Metals (ICP/MS)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Selenium	8.3	D1	0.49		mg/Kg		08/21/18 05:37	08/22/18 14:47	10

Method: 7471B - Mercury (CVAA)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	0.17		0.056		mg/Kg		07/16/18 10:12	07/16/18 15:02	1

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Percent Moisture	10.2		0.1		%			07/13/18 09:44	1
Percent Solids	89.8		0.1		%			07/13/18 09:44	1

Client Sample ID: SC-SS-7

Lab Sample ID: 550-105830-7
Date Collected: 07/11/18 11:20
Matrix: Solid
Date Received: 07/12/18 10:30

Method: 6010C - Metals (ICP)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Antimony	36		4.9		mg/Kg		07/17/18 17:44	07/18/18 13:04	1
Arsenic	88	D1	5.9		mg/Kg		07/17/18 17:44	07/19/18 16:30	2
Barium	74	D1	9.9		mg/Kg		07/17/18 17:44	07/19/18 16:30	2
Beryllium	ND		0.49		mg/Kg		07/17/18 17:44	07/18/18 13:04	1
Cadmium	1.3		0.49		mg/Kg		07/17/18 17:44	07/18/18 13:04	1
Chromium	21		2.0		mg/Kg		07/17/18 17:44	07/18/18 13:04	1
Copper	8700		2.5		mg/Kg		07/17/18 17:44	07/20/18 08:32	1
Lead	450		0.99		mg/Kg		07/17/18 17:44	07/18/18 13:04	1
Manganese	250		2.0		mg/Kg		07/17/18 17:44	07/18/18 13:04	1
Nickel	12		2.0		mg/Kg		07/17/18 17:44	07/18/18 13:04	1
Selenium	ND		4.9		mg/Kg		07/17/18 17:44	07/18/18 13:04	1
Silver	5.3		2.5		mg/Kg		07/17/18 17:44	07/18/18 13:04	1
Thallium	ND		4.9		mg/Kg		07/17/18 17:44	07/18/18 13:04	1
Zinc	390		4.9		mg/Kg		07/17/18 17:44	07/18/18 13:04	1

Method: 6010C - Metals (ICP) - SPLP West

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Aluminum	ND		4.0		mg/L		08/08/18 14:30	08/08/18 20:45	1
Beryllium	ND	E8	0.25	0.0025	mg/L		08/08/18 14:30	08/08/18 20:45	1
Antimony	ND		0.50		mg/L		08/08/18 14:30	08/08/18 20:45	1
Arsenic	ND		0.50		mg/L		08/08/18 14:30	08/08/18 20:45	1
Barium	ND		10		mg/L		08/08/18 14:30	08/08/18 20:45	1
Cadmium	ND		0.25		mg/L		08/08/18 14:30	08/08/18 20:45	1
Chromium	ND		0.50		mg/L		08/08/18 14:30	08/08/18 20:45	1
Cobalt	ND		0.20		mg/L		08/08/18 14:30	08/08/18 20:45	1
Copper	ND		0.50		mg/L		08/08/18 14:30	08/08/18 20:45	1
Lead	ND		0.50		mg/L		08/08/18 14:30	08/08/18 20:45	1
Manganese	ND		0.50		mg/L		08/08/18 14:30	08/08/18 20:45	1
Nickel	ND		0.50		mg/L		08/08/18 14:30	08/08/18 20:45	1
Selenium	ND		0.25		mg/L		08/08/18 14:30	08/08/18 20:45	1
Silver	ND		0.25		mg/L		08/08/18 14:30	08/08/18 20:45	1
Thallium	ND		0.50		mg/L		08/08/18 14:30	08/08/18 20:45	1
Zinc	ND		2.0		mg/L		08/08/18 14:30	08/08/18 20:45	1

Client Sample Results

Client: AECOM Technical Services Inc.
Project/Site: 60580510

TestAmerica Job ID: 550-105830-1

Client Sample ID: SC-SS-7

Lab Sample ID: 550-105830-7
Date Collected: 07/11/18 11:20
Matrix: Solid
Date Received: 07/12/18 10:30

Method: 6020B - Metals (ICP/MS)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Selenium	12	D1	0.50		mg/Kg		08/21/18 05:37	08/22/18 14:54	10

Method: 7470A - Mercury (CVAA) - SPLP West

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	ND		0.00050		mg/L		08/08/18 13:04	08/08/18 15:45	1

Method: 7471B - Mercury (CVAA)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	0.31		0.057		mg/Kg		07/16/18 10:12	07/16/18 15:03	1

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Percent Moisture	4.3		0.1		%			07/13/18 09:44	1
Percent Solids	95.7		0.1		%			07/13/18 09:44	1

Client Sample ID: SC-SS-4

Lab Sample ID: 550-105830-8
Date Collected: 07/11/18 10:55
Matrix: Solid
Date Received: 07/12/18 10:30

Method: 6010C - Metals (ICP)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Antimony	24		5.0		mg/Kg		07/17/18 17:44	07/18/18 13:15	1
Arsenic	430	D1	60		mg/Kg		07/17/18 17:44	07/19/18 16:49	20
Barium	ND	D1	99		mg/Kg		07/17/18 17:44	07/19/18 16:49	20
Beryllium	ND		0.50		mg/Kg		07/17/18 17:44	07/18/18 13:15	1
Cadmium	0.67		0.50		mg/Kg		07/17/18 17:44	07/18/18 13:15	1
Chromium	30		2.0		mg/Kg		07/17/18 17:44	07/18/18 13:15	1
Copper	5500		2.5		mg/Kg		07/17/18 17:44	07/20/18 08:37	1
Lead	160		0.99		mg/Kg		07/17/18 17:44	07/18/18 13:15	1
Manganese	240		2.0		mg/Kg		07/17/18 17:44	07/18/18 13:15	1
Nickel	21		2.0		mg/Kg		07/17/18 17:44	07/18/18 13:15	1
Selenium	ND		5.0		mg/Kg		07/17/18 17:44	07/18/18 13:15	1
Silver	9.9		2.5		mg/Kg		07/17/18 17:44	07/18/18 13:15	1
Thallium	ND		5.0		mg/Kg		07/17/18 17:44	07/18/18 13:15	1
Zinc	83		5.0		mg/Kg		07/17/18 17:44	07/18/18 13:15	1

Method: 6020B - Metals (ICP/MS)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Selenium	51	D1	0.49		mg/Kg		08/21/18 05:37	08/22/18 14:56	10

Method: 7471B - Mercury (CVAA)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	0.55		0.059		mg/Kg		07/16/18 10:12	07/16/18 15:04	1

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Percent Moisture	4.3		0.1		%			07/13/18 09:44	1
Percent Solids	95.7		0.1		%			07/13/18 09:44	1

Client Sample Results

Client: AECOM Technical Services Inc.
Project/Site: 60580510

TestAmerica Job ID: 550-105830-1

Client Sample ID: SC-T5

Lab Sample ID: 550-105830-9
Date Collected: 07/11/18 12:10
Matrix: Solid
Date Received: 07/12/18 10:30

Method: 6010C - Metals (ICP)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Antimony	ND		4.9		mg/Kg		07/17/18 17:44	07/18/18 13:21	1
Arsenic	59		3.0		mg/Kg		07/17/18 17:44	07/18/18 13:21	1
Barium	76		4.9		mg/Kg		07/17/18 17:44	07/18/18 13:21	1
Beryllium	ND		0.49		mg/Kg		07/17/18 17:44	07/18/18 13:21	1
Cadmium	ND		0.49		mg/Kg		07/17/18 17:44	07/18/18 13:21	1
Chromium	16		2.0		mg/Kg		07/17/18 17:44	07/18/18 13:21	1
Copper	1000		2.5		mg/Kg		07/17/18 17:44	07/20/18 08:43	1
Lead	54		0.99		mg/Kg		07/17/18 17:44	07/18/18 13:21	1
Manganese	180		2.0		mg/Kg		07/17/18 17:44	07/18/18 13:21	1
Nickel	8.0		2.0		mg/Kg		07/17/18 17:44	07/18/18 13:21	1
Selenium	ND		4.9		mg/Kg		07/17/18 17:44	07/18/18 13:21	1
Silver	ND		2.5		mg/Kg		07/17/18 17:44	07/18/18 13:21	1
Thallium	ND		4.9		mg/Kg		07/17/18 17:44	07/18/18 13:21	1
Zinc	72		4.9		mg/Kg		07/17/18 17:44	07/18/18 13:21	1

Method: 6020B - Metals (ICP/MS)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Selenium	12	D1	0.50		mg/Kg		08/21/18 05:37	08/22/18 14:59	10

Method: 7471B - Mercury (CVAA)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	0.37		0.060		mg/Kg		07/16/18 10:12	07/16/18 15:05	1

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Percent Moisture	4.9		0.1		%			07/13/18 09:44	1
Percent Solids	95.1		0.1		%			07/13/18 09:44	1

Client Sample ID: SC-SS-5

Lab Sample ID: 550-105830-10
Date Collected: 07/11/18 11:30
Matrix: Solid
Date Received: 07/12/18 10:30

Method: 6010C - Metals (ICP)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Antimony	19		4.9		mg/Kg		07/17/18 17:44	07/18/18 13:26	1
Arsenic	250	D1	59		mg/Kg		07/17/18 17:44	07/19/18 17:16	20
Barium	270	D1	98		mg/Kg		07/17/18 17:44	07/19/18 17:16	20
Beryllium	ND		0.49		mg/Kg		07/17/18 17:44	07/18/18 13:26	1
Cadmium	2.0		0.49		mg/Kg		07/17/18 17:44	07/18/18 13:26	1
Chromium	9.4		2.0		mg/Kg		07/17/18 17:44	07/18/18 13:26	1
Copper	20000	D2	4.9		mg/Kg		07/17/18 17:44	07/20/18 08:48	2
Lead	570		0.98		mg/Kg		07/17/18 17:44	07/18/18 13:26	1
Manganese	250		2.0		mg/Kg		07/17/18 17:44	07/18/18 13:26	1
Nickel	6.9		2.0		mg/Kg		07/17/18 17:44	07/18/18 13:26	1
Selenium	ND		4.9		mg/Kg		07/17/18 17:44	07/18/18 13:26	1
Silver	11		2.4		mg/Kg		07/17/18 17:44	07/18/18 13:26	1
Thallium	ND		4.9		mg/Kg		07/17/18 17:44	07/18/18 13:26	1
Zinc	430		4.9		mg/Kg		07/17/18 17:44	07/18/18 13:26	1

Client Sample Results

Client: AECOM Technical Services Inc.
Project/Site: 60580510

TestAmerica Job ID: 550-105830-1

Client Sample ID: SC-SS-5

Lab Sample ID: 550-105830-10
Date Collected: 07/11/18 11:30
Matrix: Solid
Date Received: 07/12/18 10:30

Method: 6010C - Metals (ICP) - SPLP West

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Aluminum	ND		4.0		mg/L		08/08/18 14:30	08/08/18 20:48	1
Beryllium	ND	E8	0.25	0.0025	mg/L		08/08/18 14:30	08/08/18 20:48	1
Antimony	ND		0.50		mg/L		08/08/18 14:30	08/08/18 20:48	1
Arsenic	ND		0.50		mg/L		08/08/18 14:30	08/08/18 20:48	1
Barium	ND		10		mg/L		08/08/18 14:30	08/08/18 20:48	1
Cadmium	ND		0.25		mg/L		08/08/18 14:30	08/08/18 20:48	1
Chromium	ND		0.50		mg/L		08/08/18 14:30	08/08/18 20:48	1
Cobalt	ND		0.20		mg/L		08/08/18 14:30	08/08/18 20:48	1
Copper	ND		0.50		mg/L		08/08/18 14:30	08/08/18 20:48	1
Lead	ND		0.50		mg/L		08/08/18 14:30	08/08/18 20:48	1
Manganese	**0.53**		0.50		mg/L		08/08/18 14:30	08/08/18 20:48	1
Nickel	ND		0.50		mg/L		08/08/18 14:30	08/08/18 20:48	1
Selenium	ND		0.25		mg/L		08/08/18 14:30	08/08/18 20:48	1
Silver	ND		0.25		mg/L		08/08/18 14:30	08/08/18 20:48	1
Thallium	ND		0.50		mg/L		08/08/18 14:30	08/08/18 20:48	1
Zinc	ND		2.0		mg/L		08/08/18 14:30	08/08/18 20:48	1

Method: 6020B - Metals (ICP/MS)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Selenium	**45**	**D1**	0.49		mg/Kg		08/21/18 05:37	08/22/18 15:01	10

Method: 7470A - Mercury (CVAA) - SPLP West

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	ND		0.00050		mg/L		08/08/18 13:04	08/08/18 15:47	1

Method: 7471B - Mercury (CVAA)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	**12**		0.058		mg/Kg		07/16/18 10:12	07/16/18 15:07	1

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Percent Moisture	**5.0**	**R8**	0.1		%			07/13/18 09:44	1
Percent Solids	**95.0**		0.1		%			07/13/18 09:44	1

Client Sample ID: SC-SS-6

Lab Sample ID: 550-105830-11
Date Collected: 07/11/18 11:00
Matrix: Solid
Date Received: 07/12/18 10:30

Method: 6010C - Metals (ICP)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Antimony	ND		5.0		mg/Kg		07/17/18 17:44	07/18/18 13:31	1
Arsenic	**400**	**D1**	60		mg/Kg		07/17/18 17:44	07/19/18 17:24	20
Barium	ND		5.0		mg/Kg		07/17/18 17:44	07/18/18 13:31	1
Beryllium	ND		0.50		mg/Kg		07/17/18 17:44	07/18/18 13:31	1
Cadmium	ND		0.50		mg/Kg		07/17/18 17:44	07/18/18 13:31	1
Chromium	ND		2.0		mg/Kg		07/17/18 17:44	07/18/18 13:31	1
Copper	**2000**		2.5		mg/Kg		07/17/18 17:44	07/20/18 08:53	1
Lead	**21**		1.0		mg/Kg		07/17/18 17:44	07/18/18 13:31	1
Manganese	**360**		2.0		mg/Kg		07/17/18 17:44	07/18/18 13:31	1
Nickel	ND		2.0		mg/Kg		07/17/18 17:44	07/18/18 13:31	1
Selenium	ND		5.0		mg/Kg		07/17/18 17:44	07/18/18 13:31	1

Client Sample ID: SC-SS-6

Lab Sample ID: 550-105830-11
Date Collected: 07/11/18 11:00
Matrix: Solid
Date Received: 07/12/18 10:30

Method: 6010C - Metals (ICP) (Continued)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Silver	3.7		2.5		mg/Kg		07/17/18 17:44	07/18/18 13:31	1
Thallium	ND		5.0		mg/Kg		07/17/18 17:44	07/18/18 13:31	1
Zinc	160		5.0		mg/Kg		07/17/18 17:44	07/18/18 13:31	1

Method: 6020B - Metals (ICP/MS)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Selenium	33	D1	0.50		mg/Kg		08/21/18 05:37	08/22/18 15:03	10

Method: 7471B - Mercury (CVAA)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	0.42		0.060		mg/Kg		07/16/18 10:12	07/16/18 15:08	1

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Percent Moisture	1.7		0.1		%			07/13/18 09:44	1
Percent Moisture	1.7		0.1		%			07/13/18 09:44	1
Percent Solids	98.3		0.1		%			07/13/18 09:44	1
Percent Solids	98.3		0.1		%			07/13/18 09:44	1

Client Sample ID: SC-TS-D

Lab Sample ID: 550-105830-12
Date Collected: 07/11/18 12:10
Matrix: Solid
Date Received: 07/12/18 10:30

Method: 6010C - Metals (ICP)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Antimony	ND		5.0		mg/Kg		07/17/18 17:44	07/18/18 13:37	1
Arsenic	68	D1	6.0		mg/Kg		07/17/18 17:44	07/19/18 17:50	2
Barium	74	D1	9.9		mg/Kg		07/17/18 17:44	07/19/18 17:50	2
Beryllium	ND		0.50		mg/Kg		07/17/18 17:44	07/18/18 13:37	1
Cadmium	ND		0.50		mg/Kg		07/17/18 17:44	07/18/18 13:37	1
Chromium	16		2.0		mg/Kg		07/17/18 17:44	07/18/18 13:37	1
Copper	1300		2.5		mg/Kg		07/17/18 17:44	07/20/18 08:59	1
Lead	57		0.99		mg/Kg		07/17/18 17:44	07/18/18 13:37	1
Manganese	230		2.0		mg/Kg		07/17/18 17:44	07/18/18 13:37	1
Nickel	8.4		2.0		mg/Kg		07/17/18 17:44	07/18/18 13:37	1
Selenium	ND		5.0		mg/Kg		07/17/18 17:44	07/18/18 13:37	1
Silver	2.5		2.5		mg/Kg		07/17/18 17:44	07/18/18 13:37	1
Thallium	ND		5.0		mg/Kg		07/17/18 17:44	07/18/18 13:37	1
Zinc	83		5.0		mg/Kg		07/17/18 17:44	07/18/18 13:37	1

Method: 6020B - Metals (ICP/MS)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Selenium	13	D1	0.49		mg/Kg		08/21/18 05:37	08/22/18 15:06	10

Method: 7471B - Mercury (CVAA)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	0.35		0.058		mg/Kg		07/16/18 10:12	07/16/18 15:10	1

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Percent Moisture	5.1		0.1		%			07/13/18 09:44	1

Client Sample Results

Client: AECOM Technical Services Inc.
Project/Site: 60580510

TestAmerica Job ID: 550-105830-1

Client Sample ID: SC-TS-D

Date Collected: 07/11/18 12:10
Date Received: 07/12/18 10:30

Lab Sample ID: 550-105830-12

Matrix: Solid

General Chemistry (Continued)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Percent Solids	94.9		0.1		%			07/13/18 09:44	1

Method: 6010C - Metals (ICP)

Lab Sample ID: MB 550-151886/1-A
Matrix: Solid
Analysis Batch: 152062

Client Sample ID: Method Blank
Prep Type: Total/NA
Prep Batch: 151886

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Antimony	ND		4.9		mg/Kg		07/17/18 17:44	07/18/18 12:12	1
Arsenic	ND		2.9		mg/Kg		07/17/18 17:44	07/18/18 12:12	1
Barium	ND		4.9		mg/Kg		07/17/18 17:44	07/18/18 12:12	1
Beryllium	ND		0.49		mg/Kg		07/17/18 17:44	07/18/18 12:12	1
Cadmium	ND		0.49		mg/Kg		07/17/18 17:44	07/18/18 12:12	1
Chromium	ND		2.0		mg/Kg		07/17/18 17:44	07/18/18 12:12	1
Lead	ND		0.98		mg/Kg		07/17/18 17:44	07/18/18 12:12	1
Manganese	ND		2.0		mg/Kg		07/17/18 17:44	07/18/18 12:12	1
Nickel	ND		2.0		mg/Kg		07/17/18 17:44	07/18/18 12:12	1
Selenium	ND		4.9		mg/Kg		07/17/18 17:44	07/18/18 12:12	1
Silver	ND		2.5		mg/Kg		07/17/18 17:44	07/18/18 12:12	1
Thallium	ND		4.9		mg/Kg		07/17/18 17:44	07/18/18 12:12	1
Zinc	ND		4.9		mg/Kg		07/17/18 17:44	07/18/18 12:12	1

Lab Sample ID: MB 550-151886/1-A
Matrix: Solid
Analysis Batch: 152157

Client Sample ID: Method Blank
Prep Type: Total/NA
Prep Batch: 151886

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	ND		2.9		mg/Kg		07/17/18 17:44	07/19/18 14:09	1
Barium	ND		4.9		mg/Kg		07/17/18 17:44	07/19/18 14:09	1

Lab Sample ID: MB 550-151886/1-A
Matrix: Solid
Analysis Batch: 152212

Client Sample ID: Method Blank
Prep Type: Total/NA
Prep Batch: 151886

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Copper	ND		2.5		mg/Kg		07/17/18 17:44	07/20/18 07:31	1

Lab Sample ID: LCS 550-151886/2-A
Matrix: Solid
Analysis Batch: 152062

Client Sample ID: Lab Control Sample
Prep Type: Total/NA
Prep Batch: 151886

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Antimony	49.7	45.6		mg/Kg		92	80 - 111
Arsenic	49.7	45.0		mg/Kg		91	77 - 105
Barium	49.7	49.1		mg/Kg		99	84 - 111
Beryllium	49.7	47.4		mg/Kg		95	87 - 113
Cadmium	49.7	46.5		mg/Kg		93	82 - 104
Chromium	49.7	49.1		mg/Kg		99	85 - 112
Lead	49.7	47.3		mg/Kg		95	83 - 108
Manganese	49.7	49.6		mg/Kg		100	85 - 112
Nickel	49.7	48.3		mg/Kg		97	83 - 112
Selenium	49.7	44.5		mg/Kg		90	77 - 107
Silver	3.73	3.54		mg/Kg		95	87 - 111
Thallium	49.7	49.0		mg/Kg		99	87 - 113
Zinc	49.7	44.6		mg/Kg		90	83 - 113

Method: 6010C - Metals (ICP) (Continued)

Lab Sample ID: LCS 550-151886/2-A — **Client Sample ID: Lab Control Sample**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 152157 — **Prep Batch: 151886**

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Arsenic	49.7	46.0		mg/Kg		93	77 - 105
Barium	49.7	47.2		mg/Kg		95	84 - 111

Lab Sample ID: LCS 550-151886/2-A — **Client Sample ID: Lab Control Sample**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 152212 — **Prep Batch: 151886**

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Copper	49.7	48.1		mg/Kg		97	85 - 114

Lab Sample ID: LCSD 550-151886/3-A — **Client Sample ID: Lab Control Sample Dup**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 152062 — **Prep Batch: 151886**

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Antimony	49.2	46.4		mg/Kg		94	80 - 111	2	20
Arsenic	49.2	45.6		mg/Kg		93	77 - 105	1	20
Barium	49.2	48.8		mg/Kg		99	84 - 111	1	20
Beryllium	49.2	47.6		mg/Kg		97	87 - 113	0	20
Cadmium	49.2	46.1		mg/Kg		94	82 - 104	1	20
Chromium	49.2	48.8		mg/Kg		99	85 - 112	1	20
Lead	49.2	48.0		mg/Kg		98	83 - 108	1	20
Manganese	49.2	49.0		mg/Kg		100	85 - 112	1	20
Nickel	49.2	48.8		mg/Kg		99	83 - 112	1	20
Selenium	49.2	45.0		mg/Kg		92	77 - 107	1	20
Silver	3.69	3.56		mg/Kg		97	87 - 111	1	20
Thallium	49.2	49.2		mg/Kg		100	87 - 113	0	20
Zinc	49.2	45.6		mg/Kg		93	83 - 113	2	20

Lab Sample ID: LCSD 550-151886/3-A — **Client Sample ID: Lab Control Sample Dup**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 152157 — **Prep Batch: 151886**

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Arsenic	49.2	45.5		mg/Kg		92	77 - 105	1	20
Barium	49.2	47.7		mg/Kg		97	84 - 111	1	20

Lab Sample ID: LCSD 550-151886/3-A — **Client Sample ID: Lab Control Sample Dup**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 152212 — **Prep Batch: 151886**

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Copper	49.2	48.3		mg/Kg		98	85 - 114	0	20

Method: 6010C - Metals (ICP) (Continued)

Lab Sample ID: 550-105830-1 MS — **Client Sample ID: SC-SS-3**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 152062 — **Prep Batch: 151886**

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits
Antimony	6.8	M2	49.9	33.7	M2	mg/Kg		54	75 - 125
Beryllium	ND		49.9	49.4		mg/Kg		99	75 - 125
Cadmium	1.5		49.9	51.2		mg/Kg		100	75 - 125
Chromium	14		49.9	68.5		mg/Kg		110	75 - 125
Lead	240		49.9	293	M3	mg/Kg		96	75 - 125
Manganese	140		49.9	186		mg/Kg		91	75 - 125
Nickel	6.9		49.9	58.0		mg/Kg		102	75 - 125
Selenium	ND	M2	49.9	ND	M2	mg/Kg		5	75 - 125
Silver	14		3.74	18.6		mg/Kg		119	75 - 125
Thallium	ND	M2	49.9	33.7	M2	mg/Kg		67	75 - 125
Zinc	280		49.9	328	M3	mg/Kg		93	75 - 125

Lab Sample ID: 550-105830-1 MS — **Client Sample ID: SC-SS-3**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 152157 — **Prep Batch: 151886**

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits
Arsenic	330	D1 M3	49.9	397	M3	mg/Kg		132	75 - 125
Barium	140	R13 D1 M2	49.9	190		mg/Kg		104	75 - 125

Lab Sample ID: 550-105830-1 MS — **Client Sample ID: SC-SS-3**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 152212 — **Prep Batch: 151886**

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits
Copper	10000	M3	49.9	10600	M3	mg/Kg		1218	75 - 125

Lab Sample ID: 550-105830-1 MSD — **Client Sample ID: SC-SS-3**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 152062 — **Prep Batch: 151886**

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Antimony	6.8	M2	48.6	37.7	M2	mg/Kg		64	75 - 125	11	20
Beryllium	ND		48.6	47.1		mg/Kg		97	75 - 125	5	20
Cadmium	1.5		48.6	49.9		mg/Kg		100	75 - 125	3	20
Chromium	14		48.6	65.7		mg/Kg		107	75 - 125	4	20
Lead	240		48.6	290	M3	mg/Kg		93	75 - 125	1	20
Manganese	140		48.6	192		mg/Kg		105	75 - 125	3	20
Nickel	6.9		48.6	56.2		mg/Kg		101	75 - 125	3	20
Selenium	ND	M2	48.6	ND	M2	mg/Kg		0	75 - 125	NC	20
Silver	14		3.65	17.6		mg/Kg		93	75 - 125	6	20
Thallium	ND	M2	48.6	33.6	M2	mg/Kg		69	75 - 125	0	20
Zinc	280		48.6	342	M3	mg/Kg		124	75 - 125	4	20

Method: 6010C - Metals (ICP) (Continued)

Lab Sample ID: 550-105830-1 MSD — **Client Sample ID: SC-SS-3**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 152157 — **Prep Batch: 151886**

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Arsenic	330	D1 M3	48.6	361	M3	mg/Kg		61	75 - 125	9	20
Barium	140	R13 D1 M2	48.6	152	M2 R13	mg/Kg		28	75 - 125	22	20

Lab Sample ID: 550-105830-1 MSD — **Client Sample ID: SC-SS-3**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 152212 — **Prep Batch: 151886**

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Copper	10000	M3	48.6	9940	M3	mg/Kg		-95	75 - 125	6	20

Lab Sample ID: MB 550-153538/1-A — **Client Sample ID: Method Blank**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 153594 — **Prep Batch: 153538**

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Aluminum	ND		4.0		mg/L		08/08/18 14:30	08/08/18 20:23	1
Beryllium	ND	E8	0.25	0.0025	mg/L		08/08/18 14:30	08/08/18 20:23	1
Antimony	ND		0.50		mg/L		08/08/18 14:30	08/08/18 20:23	1
Arsenic	ND		0.50		mg/L		08/08/18 14:30	08/08/18 20:23	1
Barium	ND		10		mg/L		08/08/18 14:30	08/08/18 20:23	1
Cadmium	ND		0.25		mg/L		08/08/18 14:30	08/08/18 20:23	1
Chromium	ND		0.50		mg/L		08/08/18 14:30	08/08/18 20:23	1
Cobalt	ND		0.20		mg/L		08/08/18 14:30	08/08/18 20:23	1
Copper	ND		0.50		mg/L		08/08/18 14:30	08/08/18 20:23	1
Lead	ND		0.50		mg/L		08/08/18 14:30	08/08/18 20:23	1
Manganese	ND		0.50		mg/L		08/08/18 14:30	08/08/18 20:23	1
Nickel	ND		0.50		mg/L		08/08/18 14:30	08/08/18 20:23	1
Selenium	ND		0.25		mg/L		08/08/18 14:30	08/08/18 20:23	1
Silver	ND		0.25		mg/L		08/08/18 14:30	08/08/18 20:23	1
Thallium	ND		0.50		mg/L		08/08/18 14:30	08/08/18 20:23	1
Zinc	ND		2.0		mg/L		08/08/18 14:30	08/08/18 20:23	1

Lab Sample ID: LCS 550-153538/2-A — **Client Sample ID: Lab Control Sample**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 153594 — **Prep Batch: 153538**

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Aluminum	10.0	9.13		mg/L		91	89 - 109
Beryllium	5.00	4.91		mg/L		98	93 - 112
Antimony	5.00	4.83		mg/L		97	91 - 111
Arsenic	5.00	4.92		mg/L		98	89 - 111
Barium	5.00	4.90	E4	mg/L		98	87 - 114
Cadmium	5.00	4.80		mg/L		96	90 - 110
Chromium	5.00	4.86		mg/L		97	86 - 112
Copper	5.00	4.63		mg/L		93	86 - 110
Lead	5.00	4.98		mg/L		100	89 - 115
Manganese	5.00	4.85		mg/L		97	87 - 112
Nickel	5.00	4.89		mg/L		98	91 - 114

Method: 6010C - Metals (ICP) (Continued)

Lab Sample ID: LCS 550-153538/2-A
Matrix: Solid
Analysis Batch: 153594

Client Sample ID: Lab Control Sample
Prep Type: Total/NA
Prep Batch: 153538

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Selenium	5.00	5.16		mg/L		103	92 - 120
Silver	0.375	0.354		mg/L		94	87 - 110
Thallium	5.00	5.06		mg/L		101	94 - 117
Zinc	5.00	4.96		mg/L		99	94 - 115

Lab Sample ID: LCSD 550-153538/3-A
Matrix: Solid
Analysis Batch: 153594

Client Sample ID: Lab Control Sample Dup
Prep Type: Total/NA
Prep Batch: 153538

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Aluminum	10.0	9.29		mg/L		93	89 - 109	2	20
Beryllium	5.00	4.97		mg/L		99	93 - 112	1	20
Antimony	5.00	4.96		mg/L		99	91 - 111	3	20
Arsenic	5.00	5.02		mg/L		100	89 - 111	2	20
Barium	5.00	5.04	E4	mg/L		101	87 - 114	3	20
Cadmium	5.00	4.92		mg/L		98	90 - 110	2	20
Chromium	5.00	4.99		mg/L		100	86 - 112	3	20
Copper	5.00	4.74		mg/L		95	86 - 110	2	20
Lead	5.00	5.12		mg/L		102	89 - 115	3	20
Manganese	5.00	4.97		mg/L		99	87 - 112	2	20
Nickel	5.00	5.01		mg/L		100	91 - 114	2	20
Selenium	5.00	5.32		mg/L		106	92 - 120	3	20
Silver	0.375	0.360		mg/L		96	87 - 110	2	20
Thallium	5.00	5.19		mg/L		104	94 - 117	3	20
Zinc	5.00	5.08		mg/L		102	94 - 115	2	20

Lab Sample ID: MB 550-154893/1-A
Matrix: Solid
Analysis Batch: 154968

Client Sample ID: Method Blank
Prep Type: Total/NA
Prep Batch: 154893

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Antimony	ND		5.0		mg/Kg		08/24/18 04:58	08/24/18 14:12	1
Arsenic	ND		3.0		mg/Kg		08/24/18 04:58	08/24/18 14:12	1
Barium	ND		5.0		mg/Kg		08/24/18 04:58	08/24/18 14:12	1
Cadmium	ND		0.50		mg/Kg		08/24/18 04:58	08/24/18 14:12	1
Chromium	ND		2.0		mg/Kg		08/24/18 04:58	08/24/18 14:12	1
Copper	ND		2.5		mg/Kg		08/24/18 04:58	08/24/18 14:12	1
Lead	ND		1.0		mg/Kg		08/24/18 04:58	08/24/18 14:12	1
Manganese	ND		2.0		mg/Kg		08/24/18 04:58	08/24/18 14:12	1
Nickel	ND		2.0		mg/Kg		08/24/18 04:58	08/24/18 14:12	1
Selenium	ND		5.0		mg/Kg		08/24/18 04:58	08/24/18 14:12	1
Silver	ND		2.5		mg/Kg		08/24/18 04:58	08/24/18 14:12	1
Thallium	ND		5.0		mg/Kg		08/24/18 04:58	08/24/18 14:12	1
Zinc	ND		5.0		mg/Kg		08/24/18 04:58	08/24/18 14:12	1

Method: 6010C - Metals (ICP) (Continued)

Lab Sample ID: LCS 550-154893/2-A — **Client Sample ID: Lab Control Sample**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 154968 — **Prep Batch: 154893**

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Antimony	49.3	47.1		mg/Kg		96	80 - 111
Arsenic	49.3	45.8		mg/Kg		93	77 - 105
Barium	49.3	48.7		mg/Kg		99	84 - 111
Cadmium	49.3	46.3		mg/Kg		94	82 - 104
Chromium	49.3	49.2		mg/Kg		100	85 - 112
Copper	49.3	50.3		mg/Kg		102	85 - 114
Lead	49.3	47.7		mg/Kg		97	83 - 108
Manganese	49.3	49.7		mg/Kg		101	85 - 112
Nickel	49.3	47.9		mg/Kg		97	83 - 112
Selenium	49.3	46.1		mg/Kg		94	77 - 107
Silver	3.70	3.59		mg/Kg		97	87 - 111
Thallium	49.3	48.9		mg/Kg		99	87 - 113
Zinc	49.3	45.7		mg/Kg		93	83 - 113

Lab Sample ID: LCSD 550-154893/3-A — **Client Sample ID: Lab Control Sample Dup**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 154968 — **Prep Batch: 154893**

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Antimony	49.7	47.9		mg/Kg		96	80 - 111	2	20
Arsenic	49.7	46.2		mg/Kg		93	77 - 105	1	20
Barium	49.7	49.1		mg/Kg		99	84 - 111	1	20
Cadmium	49.7	46.6		mg/Kg		94	82 - 104	1	20
Chromium	49.7	49.4		mg/Kg		99	85 - 112	0	20
Copper	49.7	50.6		mg/Kg		102	85 - 114	1	20
Lead	49.7	48.3		mg/Kg		97	83 - 108	1	20
Manganese	49.7	49.5		mg/Kg		100	85 - 112	0	20
Nickel	49.7	48.2		mg/Kg		97	83 - 112	1	20
Selenium	49.7	46.9		mg/Kg		94	77 - 107	2	20
Silver	3.73	3.61		mg/Kg		97	87 - 111	1	20
Thallium	49.7	49.2		mg/Kg		99	87 - 113	1	20
Zinc	49.7	45.8		mg/Kg		92	83 - 113	0	20

Lab Sample ID: 550-105830-11 MS — **Client Sample ID: SC-SS-6**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 154968 — **Prep Batch: 154893**

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits
Antimony	ND	M2	49.5	21.1	M2	mg/Kg		43	75 - 125
Cadmium	ND		49.5	48.3		mg/Kg		97	75 - 125
Chromium	2.1		49.5	49.5		mg/Kg		96	75 - 125
Copper	1700	M3 R4	49.5	1400	M3	mg/Kg		-555	75 - 125
Lead	24		49.5	65.4		mg/Kg		84	75 - 125
Manganese	450	M3	49.5	445	M3	mg/Kg		-7	75 - 125
Nickel	ND		49.5	45.7		mg/Kg		89	75 - 125
Selenium	ND	M2 R4	49.5	ND	M2	mg/Kg		1	75 - 125
Thallium	ND		49.5	41.0		mg/Kg		83	75 - 125
Zinc	160	M2	49.5	182	M2	mg/Kg		38	75 - 125

Method: 6010C - Metals (ICP) (Continued)

Lab Sample ID: 550-105830-11 MSD — **Client Sample ID: SC-SS-6**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 154968 — **Prep Batch: 154893**

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Antimony	ND	M2	49.1	18.1	M2	mg/Kg		37	75 - 125	15	20
Cadmium	ND		49.1	48.4		mg/Kg		98	75 - 125	0	20
Chromium	2.1		49.1	50.1		mg/Kg		98	75 - 125	1	20
Copper	1700	M3 R4	49.1	2860	M3 R4	mg/Kg		2412	75 - 125	68	20
Lead	24		49.1	70.3		mg/Kg		94	75 - 125	7	20
Manganese	450	M3	49.1	418	M3	mg/Kg		-61	75 - 125	6	20
Nickel	ND		49.1	46.3		mg/Kg		90	75 - 125	1	20
Selenium	ND	M2 R4	49.1	6.46	M2 R4	mg/Kg		13	75 - 125	165	20
Thallium	ND		49.1	40.4		mg/Kg		82	75 - 125	2	20
Zinc	160	M2	49.1	188	M2	mg/Kg		51	75 - 125	3	20

Lab Sample ID: LB2 550-153515/1-C — **Client Sample ID: Method Blank**
Matrix: Solid — **Prep Type: SPLP West**
Analysis Batch: 153594 — **Prep Batch: 153538**

Analyte	LB2 Result	LB2 Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Aluminum	ND		4.0		mg/L		08/08/18 14:30	08/08/18 20:40	1
Beryllium	ND	E8	0.25	0.0025	mg/L		08/08/18 14:30	08/08/18 20:40	1
Antimony	ND		0.50		mg/L		08/08/18 14:30	08/08/18 20:40	1
Arsenic	ND		0.50		mg/L		08/08/18 14:30	08/08/18 20:40	1
Barium	ND		10		mg/L		08/08/18 14:30	08/08/18 20:40	1
Cadmium	ND		0.25		mg/L		08/08/18 14:30	08/08/18 20:40	1
Chromium	ND		0.50		mg/L		08/08/18 14:30	08/08/18 20:40	1
Cobalt	ND		0.20		mg/L		08/08/18 14:30	08/08/18 20:40	1
Copper	ND		0.50		mg/L		08/08/18 14:30	08/08/18 20:40	1
Lead	ND		0.50		mg/L		08/08/18 14:30	08/08/18 20:40	1
Manganese	ND		0.50		mg/L		08/08/18 14:30	08/08/18 20:40	1
Nickel	ND		0.50		mg/L		08/08/18 14:30	08/08/18 20:40	1
Selenium	ND		0.25		mg/L		08/08/18 14:30	08/08/18 20:40	1
Silver	ND		0.25		mg/L		08/08/18 14:30	08/08/18 20:40	1
Thallium	ND		0.50		mg/L		08/08/18 14:30	08/08/18 20:40	1
Zinc	ND		2.0		mg/L		08/08/18 14:30	08/08/18 20:40	1

Lab Sample ID: 550-105830-1 MS — **Client Sample ID: SC-SS-3**
Matrix: Solid — **Prep Type: SPLP West**
Analysis Batch: 153594 — **Prep Batch: 153538**

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits
Aluminum	ND		10.0	9.20		mg/L		92	75 - 125
Beryllium	ND	E8	5.00	4.93		mg/L		99	75 - 125
Antimony	ND		5.00	4.88		mg/L		98	75 - 125
Arsenic	ND		5.00	4.99		mg/L		100	75 - 125
Barium	ND		5.00	ND		mg/L		99	75 - 125
Cadmium	ND		5.00	4.89		mg/L		98	75 - 125
Chromium	ND		5.00	4.94		mg/L		99	75 - 125
Copper	1.2		5.00	5.81		mg/L		92	75 - 125
Lead	ND		5.00	5.05		mg/L		101	75 - 125
Manganese	ND		5.00	4.97		mg/L		99	75 - 125

Method: 6010C - Metals (ICP) (Continued)

Lab Sample ID: 550-105830-1 MS — **Client Sample ID: SC-SS-3**
Matrix: Solid — **Prep Type: SPLP West**
Analysis Batch: 153594 — **Prep Batch: 153538**

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits
Nickel	ND		5.00	4.97		mg/L		99	75 - 125
Selenium	ND		5.00	5.22		mg/L		104	75 - 125
Silver	ND		0.375	0.360		mg/L		96	75 - 125
Thallium	ND		5.00	5.12		mg/L		102	75 - 125
Zinc	ND		5.00	5.11		mg/L		101	75 - 125

Lab Sample ID: 550-105830-1 MSD — **Client Sample ID: SC-SS-3**
Matrix: Solid — **Prep Type: SPLP West**
Analysis Batch: 153594 — **Prep Batch: 153538**

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Aluminum	ND		10.0	9.33		mg/L		93	75 - 125	1	20
Beryllium	ND	E8	5.00	4.94		mg/L		99	75 - 125	0	20
Antimony	ND		5.00	4.85		mg/L		97	75 - 125	1	20
Arsenic	ND		5.00	4.98		mg/L		100	75 - 125	0	20
Barium	ND		5.00	ND		mg/L		98	75 - 125	1	20
Cadmium	ND		5.00	4.82		mg/L		96	75 - 125	1	20
Chromium	ND		5.00	4.87		mg/L		97	75 - 125	1	20
Copper	1.2		5.00	5.73		mg/L		90	75 - 125	1	20
Lead	ND		5.00	5.01		mg/L		100	75 - 125	1	20
Manganese	ND		5.00	4.90		mg/L		97	75 - 125	2	20
Nickel	ND		5.00	4.90		mg/L		98	75 - 125	1	20
Selenium	ND		5.00	5.21		mg/L		104	75 - 125	0	20
Silver	ND		0.375	0.353		mg/L		94	75 - 125	2	20
Thallium	ND		5.00	5.05		mg/L		100	75 - 125	1	20
Zinc	ND		5.00	5.05		mg/L		100	75 - 125	1	20

Method: 6020B - Metals (ICP/MS)

Lab Sample ID: MB 550-154553/1-A — **Client Sample ID: Method Blank**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 154730 — **Prep Batch: 154553**

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Selenium	ND		0.050		mg/Kg		08/21/18 05:37	08/22/18 14:22	1

Lab Sample ID: LCS 550-154553/2-A — **Client Sample ID: Lab Control Sample**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 154730 — **Prep Batch: 154553**

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Selenium	9.91	10.1		mg/Kg		102	80 - 120

Lab Sample ID: LCSD 550-154553/3-A — **Client Sample ID: Lab Control Sample Dup**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 154730 — **Prep Batch: 154553**

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Selenium	9.87	10.1		mg/Kg		102	80 - 120	0	20

Lab Sample ID: 550-105830-1 MS — **Client Sample ID: SC-SS-3**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 154730 — **Prep Batch: 154553**

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits
Selenium	58	D1	9.94	66.0	M3	mg/Kg		75	75 - 125

Lab Sample ID: 550-105830-1 MSD — **Client Sample ID: SC-SS-3**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 154730 — **Prep Batch: 154553**

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Selenium	58	D1	9.94	66.2	M3	mg/Kg		78	75 - 125	0	20

Method: 7470A - Mercury (CVAA)

Lab Sample ID: MB 550-153532/1-A — **Client Sample ID: Method Blank**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 153554 — **Prep Batch: 153532**

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	ND		0.00050		mg/L		08/08/18 13:04	08/08/18 15:33	1

Lab Sample ID: LCS 550-153532/2-A — **Client Sample ID: Lab Control Sample**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 153554 — **Prep Batch: 153532**

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Mercury	0.0100	0.00930		mg/L		93	80 - 120

Lab Sample ID: LCSD 550-153532/3-A — **Client Sample ID: Lab Control Sample Dup**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 153554 — **Prep Batch: 153532**

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Mercury	0.0100	0.00955		mg/L		95	80 - 120	3	20

Lab Sample ID: LB2 550-153515/1-B — **Client Sample ID: Method Blank**
Matrix: Solid — **Prep Type: SPLP West**
Analysis Batch: 153554 — **Prep Batch: 153532**

Analyte	LB2 Result	LB2 Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	ND		0.00050		mg/L		08/08/18 13:04	08/08/18 15:42	1

Lab Sample ID: 550-105830-1 MS — **Client Sample ID: SC-SS-3**
Matrix: Solid — **Prep Type: SPLP West**
Analysis Batch: 153554 — **Prep Batch: 153532**

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits
Mercury	ND		0.0100	0.00951		mg/L		95	75 - 125

Lab Sample ID: 550-105830-1 MSD — **Client Sample ID: SC-SS-3**
Matrix: Solid — **Prep Type: SPLP West**
Analysis Batch: 153554 — **Prep Batch: 153532**

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Mercury	ND		0.0100	0.00949		mg/L		95	75 - 125	0	20

Method: 7471B - Mercury (CVAA)

Lab Sample ID: MB 550-151827/13-A — **Client Sample ID: Method Blank**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 151868 — **Prep Batch: 151827**

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Mercury	ND		0.056		mg/Kg		07/16/18 10:12	07/16/18 14:39	1

Lab Sample ID: LCS 550-151827/14-A — **Client Sample ID: Lab Control Sample**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 151868 — **Prep Batch: 151827**

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Mercury	0.944	1.01		mg/Kg		107	80 - 120

Lab Sample ID: LCSD 550-151827/15-A — **Client Sample ID: Lab Control Sample Dup**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 151868 — **Prep Batch: 151827**

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Mercury	0.994	1.06		mg/Kg		107	80 - 120	5	20

Lab Sample ID: 550-105931-A-3-A MS — **Client Sample ID: Matrix Spike**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 151868 — **Prep Batch: 151827**

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits
Mercury	ND		0.960	0.961		mg/Kg		100	80 - 120

Lab Sample ID: 550-105931-A-3-B MSD — **Client Sample ID: Matrix Spike Duplicate**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 151868 — **Prep Batch: 151827**

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Mercury	ND		0.991	1.01		mg/Kg		102	80 - 120	5	20

Method: 2540G - SM 2540G

Lab Sample ID: MB 550-151719/1 — **Client Sample ID: Method Blank**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 151719

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Percent Moisture	0.007		0.1		%			07/13/18 09:44	1
Percent Solids	100		0.1		%			07/13/18 09:44	1

Lab Sample ID: 550-105830-10 DU — **Client Sample ID: SC-SS-5**
Matrix: Solid — **Prep Type: Total/NA**
Analysis Batch: 151719

Analyte	Sample Result	Sample Qualifier	DU Result	DU Qualifier	Unit	D	RPD	RPD Limit
Percent Moisture	5.0	R8	4.3	R8	%		13	10
Percent Solids	95.0		95.7		%		0.6	10

QC Association Summary

Client: AECOM Technical Services Inc.
Project/Site: 60580510

TestAmerica Job ID: 550-105830-1

Metals

Prep Batch: 151827

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
550-105830-1	SC-SS-3	Total/NA	Solid	7471B	
550-105830-2	SC-SWC-3-MS	Total/NA	Solid	7471B	
550-105830-3	SC-SWC-3	Total/NA	Solid	7471B	
550-105830-4	SC-T4	Total/NA	Solid	7471B	
550-105830-5	SC-SS-1	Total/NA	Solid	7471B	
550-105830-6	SC-SS-2	Total/NA	Solid	7471B	
550-105830-7	SC-SS-7	Total/NA	Solid	7471B	
550-105830-8	SC-SS-4	Total/NA	Solid	7471B	
550-105830-9	SC-T5	Total/NA	Solid	7471B	
550-105830-10	SC-SS-5	Total/NA	Solid	7471B	
550-105830-11	SC-SS-6	Total/NA	Solid	7471B	
550-105830-12	SC-TS-D	Total/NA	Solid	7471B	
MB 550-151827/13-A	Method Blank	Total/NA	Solid	7471B	
LCS 550-151827/14-A	Lab Control Sample	Total/NA	Solid	7471B	
LCSD 550-151827/15-A	Lab Control Sample Dup	Total/NA	Solid	7471B	
550-105931-A-3-A MS	Matrix Spike	Total/NA	Solid	7471B	
550-105931-A-3-B MSD	Matrix Spike Duplicate	Total/NA	Solid	7471B	

Analysis Batch: 151868

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
550-105830-1	SC-SS-3	Total/NA	Solid	7471B	151827
550-105830-2	SC-SWC-3-MS	Total/NA	Solid	7471B	151827
550-105830-3	SC-SWC-3	Total/NA	Solid	7471B	151827
550-105830-4	SC-T4	Total/NA	Solid	7471B	151827
550-105830-5	SC-SS-1	Total/NA	Solid	7471B	151827
550-105830-6	SC-SS-2	Total/NA	Solid	7471B	151827
550-105830-7	SC-SS-7	Total/NA	Solid	7471B	151827
550-105830-8	SC-SS-4	Total/NA	Solid	7471B	151827
550-105830-9	SC-T5	Total/NA	Solid	7471B	151827
550-105830-10	SC-SS-5	Total/NA	Solid	7471B	151827
550-105830-11	SC-SS-6	Total/NA	Solid	7471B	151827
550-105830-12	SC-TS-D	Total/NA	Solid	7471B	151827
MB 550-151827/13-A	Method Blank	Total/NA	Solid	7471B	151827
LCS 550-151827/14-A	Lab Control Sample	Total/NA	Solid	7471B	151827
LCSD 550-151827/15-A	Lab Control Sample Dup	Total/NA	Solid	7471B	151827
550-105931-A-3-A MS	Matrix Spike	Total/NA	Solid	7471B	151827
550-105931-A-3-B MSD	Matrix Spike Duplicate	Total/NA	Solid	7471B	151827

Prep Batch: 151886

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
550-105830-1	SC-SS-3	Total/NA	Solid	3050B	
550-105830-2	SC-SWC-3-MS	Total/NA	Solid	3050B	
550-105830-3	SC-SWC-3	Total/NA	Solid	3050B	
550-105830-4	SC-T4	Total/NA	Solid	3050B	
550-105830-5	SC-SS-1	Total/NA	Solid	3050B	
550-105830-6	SC-SS-2	Total/NA	Solid	3050B	
550-105830-7	SC-SS-7	Total/NA	Solid	3050B	
550-105830-8	SC-SS-4	Total/NA	Solid	3050B	
550-105830-9	SC-T5	Total/NA	Solid	3050B	
550-105830-10	SC-SS-5	Total/NA	Solid	3050B	
550-105830-11	SC-SS-6	Total/NA	Solid	3050B	

Metals (Continued)

Prep Batch: 151886 (Continued)

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
550-105830-12	SC-TS-D	Total/NA	Solid	3050B	
MB 550-151886/1-A	Method Blank	Total/NA	Solid	3050B	
LCS 550-151886/2-A	Lab Control Sample	Total/NA	Solid	3050B	
LCSD 550-151886/3-A	Lab Control Sample Dup	Total/NA	Solid	3050B	
550-105830-1 MS	SC-SS-3	Total/NA	Solid	3050B	
550-105830-1 MSD	SC-SS-3	Total/NA	Solid	3050B	

Analysis Batch: 152062

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
550-105830-1	SC-SS-3	Total/NA	Solid	6010C	151886
550-105830-2	SC-SWC-3-MS	Total/NA	Solid	6010C	151886
550-105830-3	SC-SWC-3	Total/NA	Solid	6010C	151886
550-105830-4	SC-T4	Total/NA	Solid	6010C	151886
550-105830-5	SC-SS-1	Total/NA	Solid	6010C	151886
550-105830-6	SC-SS-2	Total/NA	Solid	6010C	151886
550-105830-7	SC-SS-7	Total/NA	Solid	6010C	151886
550-105830-8	SC-SS-4	Total/NA	Solid	6010C	151886
550-105830-9	SC-T5	Total/NA	Solid	6010C	151886
550-105830-10	SC-SS-5	Total/NA	Solid	6010C	151886
550-105830-11	SC-SS-6	Total/NA	Solid	6010C	151886
550-105830-12	SC-TS-D	Total/NA	Solid	6010C	151886
MB 550-151886/1-A	Method Blank	Total/NA	Solid	6010C	151886
LCS 550-151886/2-A	Lab Control Sample	Total/NA	Solid	6010C	151886
LCSD 550-151886/3-A	Lab Control Sample Dup	Total/NA	Solid	6010C	151886
550-105830-1 MS	SC-SS-3	Total/NA	Solid	6010C	151886
550-105830-1 MSD	SC-SS-3	Total/NA	Solid	6010C	151886

Analysis Batch: 152157

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
550-105830-1	SC-SS-3	Total/NA	Solid	6010C	151886
550-105830-7	SC-SS-7	Total/NA	Solid	6010C	151886
550-105830-8	SC-SS-4	Total/NA	Solid	6010C	151886
550-105830-10	SC-SS-5	Total/NA	Solid	6010C	151886
550-105830-11	SC-SS-6	Total/NA	Solid	6010C	151886
550-105830-12	SC-TS-D	Total/NA	Solid	6010C	151886
MB 550-151886/1-A	Method Blank	Total/NA	Solid	6010C	151886
LCS 550-151886/2-A	Lab Control Sample	Total/NA	Solid	6010C	151886
LCSD 550-151886/3-A	Lab Control Sample Dup	Total/NA	Solid	6010C	151886
550-105830-1 MS	SC-SS-3	Total/NA	Solid	6010C	151886
550-105830-1 MSD	SC-SS-3	Total/NA	Solid	6010C	151886

Analysis Batch: 152212

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
550-105830-1	SC-SS-3	Total/NA	Solid	6010C	151886
550-105830-2	SC-SWC-3-MS	Total/NA	Solid	6010C	151886
550-105830-3	SC-SWC-3	Total/NA	Solid	6010C	151886
550-105830-4	SC-T4	Total/NA	Solid	6010C	151886
550-105830-5	SC-SS-1	Total/NA	Solid	6010C	151886
550-105830-6	SC-SS-2	Total/NA	Solid	6010C	151886
550-105830-7	SC-SS-7	Total/NA	Solid	6010C	151886
550-105830-8	SC-SS-4	Total/NA	Solid	6010C	151886

Metals (Continued)

Analysis Batch: 152212 (Continued)

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
550-105830-9	SC-T5	Total/NA	Solid	6010C	151886
550-105830-10	SC-SS-5	Total/NA	Solid	6010C	151886
550-105830-11	SC-SS-6	Total/NA	Solid	6010C	151886
550-105830-12	SC-TS-D	Total/NA	Solid	6010C	151886
MB 550-151886/1-A	Method Blank	Total/NA	Solid	6010C	151886
LCS 550-151886/2-A	Lab Control Sample	Total/NA	Solid	6010C	151886
LCSD 550-151886/3-A	Lab Control Sample Dup	Total/NA	Solid	6010C	151886
550-105830-1 MS	SC-SS-3	Total/NA	Solid	6010C	151886
550-105830-1 MSD	SC-SS-3	Total/NA	Solid	6010C	151886

Leach Batch: 153515

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
550-105830-1	SC-SS-3	SPLP West	Solid	1312	
550-105830-7	SC-SS-7	SPLP West	Solid	1312	
550-105830-10	SC-SS-5	SPLP West	Solid	1312	
LB2 550-153515/1-B	Method Blank	SPLP West	Solid	1312	
LB2 550-153515/1-C	Method Blank	SPLP West	Solid	1312	
550-105830-1 MS	SC-SS-3	SPLP West	Solid	1312	
550-105830-1 MSD	SC-SS-3	SPLP West	Solid	1312	

Prep Batch: 153532

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
550-105830-1	SC-SS-3	SPLP West	Solid	7470A	153515
550-105830-7	SC-SS-7	SPLP West	Solid	7470A	153515
550-105830-10	SC-SS-5	SPLP West	Solid	7470A	153515
LB2 550-153515/1-B	Method Blank	SPLP West	Solid	7470A	153515
MB 550-153532/1-A	Method Blank	Total/NA	Solid	7470A	
LCS 550-153532/2-A	Lab Control Sample	Total/NA	Solid	7470A	
LCSD 550-153532/3-A	Lab Control Sample Dup	Total/NA	Solid	7470A	
550-105830-1 MS	SC-SS-3	SPLP West	Solid	7470A	153515
550-105830-1 MSD	SC-SS-3	SPLP West	Solid	7470A	153515

Prep Batch: 153538

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
550-105830-1	SC-SS-3	SPLP West	Solid	3010A	153515
550-105830-7	SC-SS-7	SPLP West	Solid	3010A	153515
550-105830-10	SC-SS-5	SPLP West	Solid	3010A	153515
LB2 550-153515/1-C	Method Blank	SPLP West	Solid	3010A	153515
MB 550-153538/1-A	Method Blank	Total/NA	Solid	3010A	
LCS 550-153538/2-A	Lab Control Sample	Total/NA	Solid	3010A	
LCSD 550-153538/3-A	Lab Control Sample Dup	Total/NA	Solid	3010A	
550-105830-1 MS	SC-SS-3	SPLP West	Solid	3010A	153515
550-105830-1 MSD	SC-SS-3	SPLP West	Solid	3010A	153515

Analysis Batch: 153554

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
550-105830-1	SC-SS-3	SPLP West	Solid	7470A	153532
550-105830-7	SC-SS-7	SPLP West	Solid	7470A	153532
550-105830-10	SC-SS-5	SPLP West	Solid	7470A	153532
LB2 550-153515/1-B	Method Blank	SPLP West	Solid	7470A	153532
MB 550-153532/1-A	Method Blank	Total/NA	Solid	7470A	153532

Metals (Continued)

Analysis Batch: 153554 (Continued)

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
LCS 550-153532/2-A	Lab Control Sample	Total/NA	Solid	7470A	153532
LCSD 550-153532/3-A	Lab Control Sample Dup	Total/NA	Solid	7470A	153532
550-105830-1 MS	SC-SS-3	SPLP West	Solid	7470A	153532
550-105830-1 MSD	SC-SS-3	SPLP West	Solid	7470A	153532

Analysis Batch: 153594

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
550-105830-1	SC-SS-3	SPLP West	Solid	6010C	153538
550-105830-7	SC-SS-7	SPLP West	Solid	6010C	153538
550-105830-10	SC-SS-5	SPLP West	Solid	6010C	153538
LB2 550-153515/1-C	Method Blank	SPLP West	Solid	6010C	153538
MB 550-153538/1-A	Method Blank	Total/NA	Solid	6010C	153538
LCS 550-153538/2-A	Lab Control Sample	Total/NA	Solid	6010C	153538
LCSD 550-153538/3-A	Lab Control Sample Dup	Total/NA	Solid	6010C	153538
550-105830-1 MS	SC-SS-3	SPLP West	Solid	6010C	153538
550-105830-1 MSD	SC-SS-3	SPLP West	Solid	6010C	153538

Prep Batch: 154553

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
550-105830-1	SC-SS-3	Total/NA	Solid	3050B	
550-105830-2	SC-SWC-3-MS	Total/NA	Solid	3050B	
550-105830-3	SC-SWC-3	Total/NA	Solid	3050B	
550-105830-4	SC-T4	Total/NA	Solid	3050B	
550-105830-5	SC-SS-1	Total/NA	Solid	3050B	
550-105830-6	SC-SS-2	Total/NA	Solid	3050B	
550-105830-7	SC-SS-7	Total/NA	Solid	3050B	
550-105830-8	SC-SS-4	Total/NA	Solid	3050B	
550-105830-9	SC-T5	Total/NA	Solid	3050B	
550-105830-10	SC-SS-5	Total/NA	Solid	3050B	
550-105830-11	SC-SS-6	Total/NA	Solid	3050B	
550-105830-12	SC-TS-D	Total/NA	Solid	3050B	
MB 550-154553/1-A	Method Blank	Total/NA	Solid	3050B	
LCS 550-154553/2-A	Lab Control Sample	Total/NA	Solid	3050B	
LCSD 550-154553/3-A	Lab Control Sample Dup	Total/NA	Solid	3050B	
550-105830-1 MS	SC-SS-3	Total/NA	Solid	3050B	
550-105830-1 MSD	SC-SS-3	Total/NA	Solid	3050B	

Analysis Batch: 154730

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
550-105830-1	SC-SS-3	Total/NA	Solid	6020B	154553
550-105830-2	SC-SWC-3-MS	Total/NA	Solid	6020B	154553
550-105830-3	SC-SWC-3	Total/NA	Solid	6020B	154553
550-105830-4	SC-T4	Total/NA	Solid	6020B	154553
550-105830-5	SC-SS-1	Total/NA	Solid	6020B	154553
550-105830-6	SC-SS-2	Total/NA	Solid	6020B	154553
550-105830-7	SC-SS-7	Total/NA	Solid	6020B	154553
550-105830-8	SC-SS-4	Total/NA	Solid	6020B	154553
550-105830-9	SC-T5	Total/NA	Solid	6020B	154553
550-105830-10	SC-SS-5	Total/NA	Solid	6020B	154553
550-105830-11	SC-SS-6	Total/NA	Solid	6020B	154553
550-105830-12	SC-TS-D	Total/NA	Solid	6020B	154553

Metals (Continued)

Analysis Batch: 154730 (Continued)

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
MB 550-154553/1-A	Method Blank	Total/NA	Solid	6020B	154553
LCS 550-154553/2-A	Lab Control Sample	Total/NA	Solid	6020B	154553
LCSD 550-154553/3-A	Lab Control Sample Dup	Total/NA	Solid	6020B	154553
550-105830-1 MS	SC-SS-3	Total/NA	Solid	6020B	154553
550-105830-1 MSD	SC-SS-3	Total/NA	Solid	6020B	154553

Prep Batch: 154893

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
MB 550-154893/1-A	Method Blank	Total/NA	Solid	3050B	
LCS 550-154893/2-A	Lab Control Sample	Total/NA	Solid	3050B	
LCSD 550-154893/3-A	Lab Control Sample Dup	Total/NA	Solid	3050B	
550-105830-11 MS	SC-SS-6	Total/NA	Solid	3050B	
550-105830-11 MSD	SC-SS-6	Total/NA	Solid	3050B	

Analysis Batch: 154968

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
MB 550-154893/1-A	Method Blank	Total/NA	Solid	6010C	154893
LCS 550-154893/2-A	Lab Control Sample	Total/NA	Solid	6010C	154893
LCSD 550-154893/3-A	Lab Control Sample Dup	Total/NA	Solid	6010C	154893
550-105830-11 MS	SC-SS-6	Total/NA	Solid	6010C	154893
550-105830-11 MSD	SC-SS-6	Total/NA	Solid	6010C	154893

General Chemistry

Analysis Batch: 151719

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
550-105830-1	SC-SS-3	Total/NA	Solid	2540G	
550-105830-2	SC-SWC-3-MS	Total/NA	Solid	2540G	
550-105830-3	SC-SWC-3	Total/NA	Solid	2540G	
550-105830-4	SC-T4	Total/NA	Solid	2540G	
550-105830-5	SC-SS-1	Total/NA	Solid	2540G	
550-105830-6	SC-SS-2	Total/NA	Solid	2540G	
550-105830-7	SC-SS-7	Total/NA	Solid	2540G	
550-105830-8	SC-SS-4	Total/NA	Solid	2540G	
550-105830-9	SC-T5	Total/NA	Solid	2540G	
550-105830-10	SC-SS-5	Total/NA	Solid	2540G	
550-105830-11	SC-SS-6	Total/NA	Solid	2540G	
550-105830-12	SC-TS-D	Total/NA	Solid	2540G	
MB 550-151719/1	Method Blank	Total/NA	Solid	2540G	
550-105830-10 DU	SC-SS-5	Total/NA	Solid	2540G	

Lab Chronicle

Client: AECOM Technical Services Inc.
Project/Site: 60580510

TestAmerica Job ID: 550-105830-1

Client Sample ID: SC-SS-3

Lab Sample ID: 550-105830-1
Date Collected: 07/11/18 10:15
Matrix: Solid
Date Received: 07/12/18 10:30

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
SPLP West	Leach	1312			153515	08/07/18 18:05	EXZ	TAL PHX
SPLP West	Prep	3010A			153538	08/08/18 14:30	EXZ	TAL PHX
SPLP West	Analysis	6010C		1	153594	08/08/18 20:43	ARE	TAL PHX
Total/NA	Prep	3050B			151886	07/17/18 17:44	EXZ	TAL PHX
Total/NA	Analysis	6010C		1	152062	07/18/18 12:33	ARE	TAL PHX
Total/NA	Prep	3050B			151886	07/17/18 17:44	EXZ	TAL PHX
Total/NA	Analysis	6010C		20	152157	07/19/18 14:54	ARE	TAL PHX
Total/NA	Prep	3050B			151886	07/17/18 17:44	EXZ	TAL PHX
Total/NA	Analysis	6010C		1	152212	07/20/18 07:55	ARE	TAL PHX
Total/NA	Prep	3050B			154553	08/21/18 05:37	SGO	TAL PHX
Total/NA	Analysis	6020B		10	154730	08/22/18 14:29	TEK	TAL PHX
SPLP West	Leach	1312			153515	08/07/18 18:05	EXZ	TAL PHX
SPLP West	Prep	7470A			153532	08/08/18 13:04	JTG	TAL PHX
SPLP West	Analysis	7470A		1	153554	08/08/18 15:44	JTG	TAL PHX
Total/NA	Prep	7471B			151827	07/16/18 10:12	JTG	TAL PHX
Total/NA	Analysis	7471B		1	151868	07/16/18 14:53	JTG	TAL PHX
Total/NA	Analysis	2540G		1	151719		YET	TAL PHX
					(Start)	07/13/18 09:44		
					(End)	07/16/18 09:50		

Client Sample ID: SC-SWC-3-MS

Lab Sample ID: 550-105830-2
Date Collected: 07/11/18 11:45
Matrix: Solid
Date Received: 07/12/18 10:30

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Prep	3050B			151886	07/17/18 17:44	EXZ	TAL PHX
Total/NA	Analysis	6010C		1	152062	07/18/18 12:38	ARE	TAL PHX
Total/NA	Prep	3050B			151886	07/17/18 17:44	EXZ	TAL PHX
Total/NA	Analysis	6010C		1	152212	07/20/18 08:00	ARE	TAL PHX
Total/NA	Prep	3050B			154553	08/21/18 05:37	SGO	TAL PHX
Total/NA	Analysis	6020B		10	154730	08/22/18 14:38	TEK	TAL PHX
Total/NA	Prep	7471B			151827	07/16/18 10:12	JTG	TAL PHX
Total/NA	Analysis	7471B		1	151868	07/16/18 14:55	JTG	TAL PHX
Total/NA	Analysis	2540G		1	151719		YET	TAL PHX
					(Start)	07/13/18 09:44		
					(End)	07/16/18 09:50		

Client Sample ID: SC-SWC-3

Lab Sample ID: 550-105830-3
Date Collected: 07/11/18 11:45
Matrix: Solid
Date Received: 07/12/18 10:30

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Prep	3050B			151886	07/17/18 17:44	EXZ	TAL PHX
Total/NA	Analysis	6010C		1	152062	07/18/18 12:43	ARE	TAL PHX

Lab Chronicle

Client: AECOM Technical Services Inc.
Project/Site: 60580510

TestAmerica Job ID: 550-105830-1

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Prep	3050B			151886	07/17/18 17:44	EXZ	TAL PHX
Total/NA	Analysis	6010C		1	152212	07/20/18 08:05	ARE	TAL PHX
Total/NA	Prep	3050B			154553	08/21/18 05:37	SGO	TAL PHX
Total/NA	Analysis	6020B		10	154730	08/22/18 14:40	TEK	TAL PHX
Total/NA	Prep	7471B			151827	07/16/18 10:12	JTG	TAL PHX
Total/NA	Analysis	7471B		1	151868	07/16/18 14:56	JTG	TAL PHX
Total/NA	Analysis	2540G		1	151719		YET	TAL PHX
					(Start)	07/13/18 09:44		
					(End)	07/16/18 09:50		

Client Sample ID: SC-T4

Lab Sample ID: 550-105830-4

Date Collected: 07/11/18 12:50

Matrix: Solid

Date Received: 07/12/18 10:30

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Prep	3050B			151886	07/17/18 17:44	EXZ	TAL PHX
Total/NA	Analysis	6010C		1	152062	07/18/18 12:48	ARE	TAL PHX
Total/NA	Prep	3050B			151886	07/17/18 17:44	EXZ	TAL PHX
Total/NA	Analysis	6010C		1	152212	07/20/18 08:10	ARE	TAL PHX
Total/NA	Prep	3050B			154553	08/21/18 05:37	SGO	TAL PHX
Total/NA	Analysis	6020B		10	154730	08/22/18 14:43	TEK	TAL PHX
Total/NA	Prep	7471B			151827	07/16/18 10:12	JTG	TAL PHX
Total/NA	Analysis	7471B		1	151868	07/16/18 14:57	JTG	TAL PHX
Total/NA	Analysis	2540G		1	151719		YET	TAL PHX
					(Start)	07/13/18 09:44		
					(End)	07/16/18 09:50		

Client Sample ID: SC-SS-1

Lab Sample ID: 550-105830-5

Date Collected: 07/11/18 09:50

Matrix: Solid

Date Received: 07/12/18 10:30

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Prep	3050B			151886	07/17/18 17:44	EXZ	TAL PHX
Total/NA	Analysis	6010C		1	152062	07/18/18 12:54	ARE	TAL PHX
Total/NA	Prep	3050B			151886	07/17/18 17:44	EXZ	TAL PHX
Total/NA	Analysis	6010C		1	152212	07/20/18 08:16	ARE	TAL PHX
Total/NA	Prep	3050B			154553	08/21/18 05:37	SGO	TAL PHX
Total/NA	Analysis	6020B		10	154730	08/22/18 14:45	TEK	TAL PHX
Total/NA	Prep	7471B			151827	07/16/18 10:12	JTG	TAL PHX
Total/NA	Analysis	7471B		1	151868	07/16/18 14:58	JTG	TAL PHX
Total/NA	Analysis	2540G		1	151719		YET	TAL PHX
					(Start)	07/13/18 09:44		
					(End)	07/16/18 09:50		

Lab Chronicle

Client: AECOM Technical Services Inc.
Project/Site: 60580510

TestAmerica Job ID: 550-105830-1

Client Sample ID: SC-SS-2

Lab Sample ID: 550-105830-6
Date Collected: 07/11/18 10:30
Matrix: Solid
Date Received: 07/12/18 10:30

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Prep	3050B			151886	07/17/18 17:44	EXZ	TAL PHX
Total/NA	Analysis	6010C		1	152062	07/18/18 12:59	ARE	TAL PHX
Total/NA	Prep	3050B			151886	07/17/18 17:44	EXZ	TAL PHX
Total/NA	Analysis	6010C		1	152212	07/20/18 08:27	ARE	TAL PHX
Total/NA	Prep	3050B			154553	08/21/18 05:37	SGO	TAL PHX
Total/NA	Analysis	6020B		10	154730	08/22/18 14:47	TEK	TAL PHX
Total/NA	Prep	7471B			151827	07/16/18 10:12	JTG	TAL PHX
Total/NA	Analysis	7471B		1	151868	07/16/18 15:02	JTG	TAL PHX
Total/NA	Analysis	2540G		1	151719		YET	TAL PHX
					(Start)	07/13/18 09:44		
					(End)	07/16/18 09:50		

Client Sample ID: SC-SS-7

Lab Sample ID: 550-105830-7
Date Collected: 07/11/18 11:20
Matrix: Solid
Date Received: 07/12/18 10:30

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
SPLP West	Leach	1312			153515	08/07/18 18:05	EXZ	TAL PHX
SPLP West	Prep	3010A			153538	08/08/18 14:30	EXZ	TAL PHX
SPLP West	Analysis	6010C		1	153594	08/08/18 20:45	ARE	TAL PHX
Total/NA	Prep	3050B			151886	07/17/18 17:44	EXZ	TAL PHX
Total/NA	Analysis	6010C		1	152062	07/18/18 13:04	ARE	TAL PHX
Total/NA	Prep	3050B			151886	07/17/18 17:44	EXZ	TAL PHX
Total/NA	Analysis	6010C		2	152157	07/19/18 16:30	ARE	TAL PHX
Total/NA	Prep	3050B			151886	07/17/18 17:44	EXZ	TAL PHX
Total/NA	Analysis	6010C		1	152212	07/20/18 08:32	ARE	TAL PHX
Total/NA	Prep	3050B			154553	08/21/18 05:37	SGO	TAL PHX
Total/NA	Analysis	6020B		10	154730	08/22/18 14:54	TEK	TAL PHX
SPLP West	Leach	1312			153515	08/07/18 18:05	EXZ	TAL PHX
SPLP West	Prep	7470A			153532	08/08/18 13:04	JTG	TAL PHX
SPLP West	Analysis	7470A		1	153554	08/08/18 15:45	JTG	TAL PHX
Total/NA	Prep	7471B			151827	07/16/18 10:12	JTG	TAL PHX
Total/NA	Analysis	7471B		1	151868	07/16/18 15:03	JTG	TAL PHX
Total/NA	Analysis	2540G		1	151719		YET	TAL PHX
					(Start)	07/13/18 09:44		
					(End)	07/16/18 09:50		

Client Sample ID: SC-SS-4

Lab Sample ID: 550-105830-8
Date Collected: 07/11/18 10:55
Matrix: Solid
Date Received: 07/12/18 10:30

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Prep	3050B			151886	07/17/18 17:44	EXZ	TAL PHX
Total/NA	Analysis	6010C		1	152062	07/18/18 13:15	ARE	TAL PHX

Lab Chronicle

Client: AECOM Technical Services Inc.
Project/Site: 60580510

TestAmerica Job ID: 550-105830-1

Client Sample ID: SC-SS-4

Lab Sample ID: 550-105830-8
Date Collected: 07/11/18 10:55
Matrix: Solid
Date Received: 07/12/18 10:30

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Prep	3050B			151886	07/17/18 17:44	EXZ	TAL PHX
Total/NA	Analysis	6010C		20	152157	07/19/18 16:49	ARE	TAL PHX
Total/NA	Prep	3050B			151886	07/17/18 17:44	EXZ	TAL PHX
Total/NA	Analysis	6010C		1	152212	07/20/18 08:37	ARE	TAL PHX
Total/NA	Prep	3050B			154553	08/21/18 05:37	SGO	TAL PHX
Total/NA	Analysis	6020B		10	154730	08/22/18 14:56	TEK	TAL PHX
Total/NA	Prep	7471B			151827	07/16/18 10:12	JTG	TAL PHX
Total/NA	Analysis	7471B		1	151868	07/16/18 15:04	JTG	TAL PHX
Total/NA	Analysis	2540G		1	151719		YET	TAL PHX
					(Start)	07/13/18 09:44		
					(End)	07/16/18 09:50		

Client Sample ID: SC-T5

Lab Sample ID: 550-105830-9
Date Collected: 07/11/18 12:10
Matrix: Solid
Date Received: 07/12/18 10:30

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Prep	3050B			151886	07/17/18 17:44	EXZ	TAL PHX
Total/NA	Analysis	6010C		1	152062	07/18/18 13:21	ARE	TAL PHX
Total/NA	Prep	3050B			151886	07/17/18 17:44	EXZ	TAL PHX
Total/NA	Analysis	6010C		1	152212	07/20/18 08:43	ARE	TAL PHX
Total/NA	Prep	3050B			154553	08/21/18 05:37	SGO	TAL PHX
Total/NA	Analysis	6020B		10	154730	08/22/18 14:59	TEK	TAL PHX
Total/NA	Prep	7471B			151827	07/16/18 10:12	JTG	TAL PHX
Total/NA	Analysis	7471B		1	151868	07/16/18 15:05	JTG	TAL PHX
Total/NA	Analysis	2540G		1	151719		YET	TAL PHX
					(Start)	07/13/18 09:44		
					(End)	07/16/18 09:50		

Client Sample ID: SC-SS-5

Lab Sample ID: 550-105830-10
Date Collected: 07/11/18 11:30
Matrix: Solid
Date Received: 07/12/18 10:30

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
SPLP West	Leach	1312			153515	08/07/18 18:05	EXZ	TAL PHX
SPLP West	Prep	3010A			153538	08/08/18 14:30	EXZ	TAL PHX
SPLP West	Analysis	6010C		1	153594	08/08/18 20:48	ARE	TAL PHX
Total/NA	Prep	3050B			151886	07/17/18 17:44	EXZ	TAL PHX
Total/NA	Analysis	6010C		1	152062	07/18/18 13:26	ARE	TAL PHX
Total/NA	Prep	3050B			151886	07/17/18 17:44	EXZ	TAL PHX
Total/NA	Analysis	6010C		20	152157	07/19/18 17:16	ARE	TAL PHX
Total/NA	Prep	3050B			151886	07/17/18 17:44	EXZ	TAL PHX
Total/NA	Analysis	6010C		2	152212	07/20/18 08:48	ARE	TAL PHX
Total/NA	Prep	3050B			154553	08/21/18 05:37	SGO	TAL PHX

Lab Chronicle

Client: AECOM Technical Services Inc.
Project/Site: 60580510

TestAmerica Job ID: 550-105830-1

Client Sample ID: SC-SS-5

Lab Sample ID: 550-105830-10
Date Collected: 07/11/18 11:30
Matrix: Solid
Date Received: 07/12/18 10:30

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Analysis	6020B		10	154730	08/22/18 15:01	TEK	TAL PHX
SPLP West	Leach	1312			153515	08/07/18 18:05	EXZ	TAL PHX
SPLP West	Prep	7470A			153532	08/08/18 13:04	JTG	TAL PHX
SPLP West	Analysis	7470A		1	153554	08/08/18 15:47	JTG	TAL PHX
Total/NA	Prep	7471B			151827	07/16/18 10:12	JTG	TAL PHX
Total/NA	Analysis	7471B		1	151868	07/16/18 15:07	JTG	TAL PHX
Total/NA	Analysis	2540G		1	151719		YET	TAL PHX
					(Start)	07/13/18 09:44		
					(End)	07/16/18 09:50		

Client Sample ID: SC-SS-6

Lab Sample ID: 550-105830-11
Date Collected: 07/11/18 11:00
Matrix: Solid
Date Received: 07/12/18 10:30

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Prep	3050B			151886	07/17/18 17:44	EXZ	TAL PHX
Total/NA	Analysis	6010C		1	152062	07/18/18 13:31	ARE	TAL PHX
Total/NA	Prep	3050B			151886	07/17/18 17:44	EXZ	TAL PHX
Total/NA	Analysis	6010C		20	152157	07/19/18 17:24	ARE	TAL PHX
Total/NA	Prep	3050B			151886	07/17/18 17:44	EXZ	TAL PHX
Total/NA	Analysis	6010C		1	152212	07/20/18 08:53	ARE	TAL PHX
Total/NA	Prep	3050B			154553	08/21/18 05:37	SGO	TAL PHX
Total/NA	Analysis	6020B		10	154730	08/22/18 15:03	TEK	TAL PHX
Total/NA	Prep	7471B			151827	07/16/18 10:12	JTG	TAL PHX
Total/NA	Analysis	7471B		1	151868	07/16/18 15:08	JTG	TAL PHX
Total/NA	Analysis	2540G		1	151719		YET	TAL PHX
					(Start)	07/13/18 09:44		
					(End)	07/16/18 09:50		

Client Sample ID: SC-TS-D

Lab Sample ID: 550-105830-12
Date Collected: 07/11/18 12:10
Matrix: Solid
Date Received: 07/12/18 10:30

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Prep	3050B			151886	07/17/18 17:44	EXZ	TAL PHX
Total/NA	Analysis	6010C		1	152062	07/18/18 13:37	ARE	TAL PHX
Total/NA	Prep	3050B			151886	07/17/18 17:44	EXZ	TAL PHX
Total/NA	Analysis	6010C		2	152157	07/19/18 17:50	ARE	TAL PHX
Total/NA	Prep	3050B			151886	07/17/18 17:44	EXZ	TAL PHX
Total/NA	Analysis	6010C		1	152212	07/20/18 08:59	ARE	TAL PHX
Total/NA	Prep	3050B			154553	08/21/18 05:37	SGO	TAL PHX
Total/NA	Analysis	6020B		10	154730	08/22/18 15:06	TEK	TAL PHX
Total/NA	Prep	7471B			151827	07/16/18 10:12	JTG	TAL PHX
Total/NA	Analysis	7471B		1	151868	07/16/18 15:10	JTG	TAL PHX

Lab Chronicle

Client: AECOM Technical Services Inc.
Project/Site: 60580510

TestAmerica Job ID: 550-105830-1

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Analysis	2540G		1	151719		YET	TAL PHX
					(Start)	07/13/18 09:44		
					(End)	07/16/18 09:50		

Laboratory References:

TAL PHX = TestAmerica Phoenix, 4625 East Cotton Ctr Blvd, Suite 189, Phoenix, AZ 85040, TEL (602)437-3340

Accreditation/Certification Summary

Client: AECOM Technical Services Inc.
Project/Site: 60580510

TestAmerica Job ID: 550-105830-1

Laboratory: TestAmerica Phoenix

Unless otherwise noted, all analytes for this laboratory were covered under each accreditation/certification below.

Authority	Program	EPA Region	Identification Number	Expiration Date
Arizona	State Program	9	AZ0728	06-09-19

The following analytes are included in this report, but the laboratory is not certified by the governing authority. This list may include analytes for which the agency does not offer certification.

Analysis Method	Prep Method	Matrix	Analyte

Method Summary

Client: AECOM Technical Services Inc.
Project/Site: 60580510

TestAmerica Job ID: 550-105830-1

Method	Method Description	Protocol	Laboratory
6010C	Metals (ICP)	SW846	TAL PHX
6020B	Metals (ICP/MS)	SW846	TAL PHX
7470A	Mercury (CVAA)	SW846	TAL PHX
7471B	Mercury (CVAA)	SW846	TAL PHX
2540G	SM 2540G	SM22	TAL PHX
1312	SPLP Extraction	SW846	TAL PHX
3010A	Preparation, Total Metals	SW846	TAL PHX
3050B	Preparation, Metals	SW846	TAL PHX
7470A	Preparation, Mercury	SW846	TAL PHX
7471B	Preparation, Mercury	SW846	TAL PHX

Protocol References:

SM22 = Standard Methods For The Examination Of Water And Wastewater, 22nd Edition

SW846 = "Test Methods For Evaluating Solid Waste, Physical/Chemical Methods", Third Edition, November 1986 And Its Updates.

Laboratory References:

TAL PHX = TestAmerica Phoenix, 4625 East Cotton Ctr Blvd, Suite 189, Phoenix, AZ 85040, TEL (602)437-3340

TestAmerica

THE LEADER IN ENVIRONMENTAL TESTING

TAL-0013-550 (0116)

CHAIN OF CUSTODY FORM

[ ] Phoenix - 4625 E. Cotton Center Blvd., Suite 189, Phoenix, AZ 85040 (602) 437-3340

105830

Page 1 of 1

Client Name/Address: AECOM 7720 N 16th Street Suite 100 Phoenix, AZ 85020

Project/PO Number: 60580510

Project Manager: Frances Ackerman

Phone Number: 480-431-1580

Sampler: Vann Lucas Turner

Email Address: frances.ackerman@AECOM.com

Analysis Required

	Sample Description	Sample Matrix	Container Type	# of Cont.	Sampling Date	Sampling Time	Preservatives	Priority Pollutant 13 Metals plus Ba + Mn	SPLP Priority Pollutant 13 Metals + Ba + Mn								Special Instructions
-1	SC-SS-3	S	16oz	2	7/11/18	10:15	—	✓	✓								
-2	SC-SWC-3-MS	S	16oz	1	7/11/18	11:45	—	✓	✓								
-3	SC-SWC-3	S	16oz	1	7/11/18	11:45	—	✓	✓								
-4	SC-T4	S	16oz	2	7/11/18	12:50	—	✓	✓								
-5	~~SC-SS~~ SC-SS-1	S	16oz	2	7/11/18	9:50	—	✓	✓								
-6	~~SC-SS-2~~ SC-SS-2	S	16oz	2	7/11/18	10:30	—	✓	✓								
-7	SC-SS-7	S	16oz	2	7/11/18	11:20	-	✓	✓								
-8	SC-SS-4	S	16oz	2	7/11/18	10:55	-	✓	✓								
-9	SC-T5	S	16oz	2	7/11/18	12:10	-	✓	✓								
-10	SC-SS-5	S	16oz	2	7/11/18	11:30	-	✓	✓								
-11	SC-SS-6	S	16oz	2	7/11/18	11:00	-	✓	✓								
-12	SC-TS-1	S	16oz	2	7/11/18	12:10	-	✓	✓								

550-105830 Chain of Custody

Relinquished By:	Date/Time:	Received By:	Date/Time:
Vann Lucas Turner	7/11/18 5:15pm	AECOM Office holding	7/11/18 5:15pm
AECOM Office Holding	7/12/18 9:40am	Vann Lucas Turner	7/12/18 9:40am
Vann Lucas Turner	7/12/18 10:30am	Received in Lab By: TABHV	7-12-18 1030

Turnaround Time: (Check)
same day ____ 72 hours ____
24 hours ____ 5 days ____
48 hours ____ normal ✓

Sample Integrity: (Check)
intact ____ on ice X

1.3°C 1.4°C

Note: By relinquishing samples to TestAmerica, client agrees to pay for the services requested on this chain of custody form and any additional analyses performed on this project. Payment for services is due within 30 days from the date of invoice. Sample(s) will be disposed of after 30 days.

Login Sample Receipt Checklist

Client: AECOM Technical Services Inc.

Job Number: 550-105830-1

Login Number: 105830
List Number: 1
Creator: Maycock, Lisa

List Source: TestAmerica Phoenix

Question	Answer	Comment
Radioactivity wasn't checked or is </= background as measured by a survey meter.	True	
The cooler's custody seal, if present, is intact.	True	
Sample custody seals, if present, are intact.	True	
The cooler or samples do not appear to have been compromised or tampered with.	True	
Samples were received on ice.	True	
Cooler Temperature is acceptable.	True	
Cooler Temperature is recorded.	True	
COC is present.	True	
COC is filled out in ink and legible.	True	
COC is filled out with all pertinent information.	True	
Is the Field Sampler's name present on COC?	True	
There are no discrepancies between the containers received and the COC.	True	
Samples are received within Holding Time (excluding tests with immediate HTs)	True	
Sample containers have legible labels.	True	
Containers are not broken or leaking.	True	
Sample collection date/times are provided.	True	
Appropriate sample containers are used.	True	
Sample bottles are completely filled.	True	
Sample Preservation Verified.	True	
There is sufficient vol. for all requested analyses, incl. any requested MS/MSDs	True	
Containers requiring zero headspace have no headspace or bubble is <6mm (1/4").	True	
Multiphasic samples are not present.	True	
Samples do not require splitting or compositing.	True	
Residual Chlorine Checked.	False	Check done at department level as required.

APPENDIX D

PROUCL OUTPUT FILES

	A	B	C	D	E	F	G	H	I	J	K	L	M
1				General Statistics on Uncensored Data									
2			Date/Time of Computation	ProUCL 5.111/15/2019 10:45:29 AM									
3			User Selected Options										
4			From File	ProUCL_Input BKG_b.xls									
5			Full Precision	OFF									
6													
7	From File: ProUCL_Input BKG_b.xls												
8													
9						General Statistics for Censored Data Set (with NDs) using Kaplan Meier Method							
10													
11		Variable	NumObs	# Missing	Num Ds	NumNDs	% NDs	Min ND	Max ND	KM Mean	KM Var	KM SD	KM CV
12		Antimony	10	0	0	10	100.00%	4.9	5	N/A	N/A	N/A	N/A
13		Arsenic	10	0	10	0	0.00%	N/A	N/A	19.6	77.6	8.809	0.449
14		Barium	10	0	10	0	0.00%	N/A	N/A	88.1	1597	39.96	0.454
15		Beryllium	10	0	6	4	40.00%	0.48	0.49	0.613	0.0167	0.129	0.211
16		Cadmium	10	0	8	2	20.00%	0.49	0.49	2.331	3.67	1.916	0.822
17		Chromium	10	0	10	0	0.00%	N/A	N/A	9.36	10.16	3.188	0.341
18		Copper	10	0	10	0	0.00%	N/A	N/A	232.1	40301	200.8	0.865
19		Lead	10	0	9	1	10.00%	4.9	4.9	39.75	1024	32.01	0.805
20		Manganese	10	0	10	0	0.00%	N/A	N/A	618.8	517134	719.1	1.162
21		Mercury	10	0	4	6	60.00%	0.088	0.1	0.12	0.00334	0.0578	0.483
22		Nickel	10	0	9	1	10.00%	2	2	7.01	4.733	2.176	0.31
23		Selenium	10	0	6	4	40.00%	4.8	4.9	6.26	2.348	1.532	0.245
24		Silver	10	0	0	10	100.00%	2.4	2.5	N/A	N/A	N/A	N/A
25		Thallium	10	0	0	10	100.00%	4.8	480	N/A	N/A	N/A	N/A
26		Zinc	10	0	10	0	0.00%	N/A	N/A	135.2	5517	74.28	0.549
27													
28						General Statistics for Raw Data Sets using Detected Data Only							
29													
30		Variable	NumObs	# Missing	Minimum	Maximum	Mean	Median	Var	SD	MAD/0.675	Skewness	CV
31		Antimony	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
32		Arsenic	10	0	5	33	19.6	20	77.6	8.809	9.637	0.0148	0.449
33		Barium	10	0	33	160	88.1	89	1597	39.96	38.55	0.309	0.454
34		Beryllium	6	0	0.56	0.84	0.702	0.7	0.0099	0.0995	0.0964	-0.0367	0.142
35		Cadmium	8	0	0.86	5.9	2.791	2.2	4.033	2.008	1.979	0.556	0.719
36		Chromium	10	0	2.4	14	9.36	9.9	10.16	3.188	1.557	-1.065	0.341
37		Copper	10	0	25	590	232.1	170	40301	200.8	178.7	0.802	0.865
38		Lead	9	0	5.3	85	43.62	42	1112	33.34	49.96	0.254	0.764
39		Manganese	10	0	88	2500	618.8	330	517134	719.1	298	2.334	1.162
40		Mercury	4	0	0.11	0.28	0.168	0.14	0.00609	0.078	0.0371	1.579	0.466
41		Nickel	9	0	4.9	8.8	7.567	8.4	2.43	1.559	0.445	-1.2	0.206
42		Selenium	6	0	5.2	9.3	7.233	7.3	1.855	1.362	0.964	0.0248	0.188
43		Silver	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
44		Thallium	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
45		Zinc	10	0	47	290	135.2	125	5517	74.28	65.97	1.018	0.549
46													

	A	B	C	D	E	F	G	H	I	J	K	L	M
47	Percentiles using all Detects (Ds) and Non-Detects (NDs)												
48													
49	Variable		NumObs	# Missing	10%ile	20%ile	25%ile(Q1)	50%ile(Q2)	75%ile(Q3)	80%ile	90%ile	95%ile	99%ile
50		Antimony	10	0	4.9	4.9	4.9	4.9	4.975	5	5	5	5
51		Arsenic	10	0	11.3	12.8	13.25	20	24.5	26.2	31.2	32.1	32.82
52		Barium	10	0	38.4	54.2	61.75	89	107.5	114	133	146.5	157.3
53		Beryllium	10	0	0.489	0.49	0.49	0.6	0.715	0.738	0.777	0.809	0.834
54		Cadmium	10	0	0.49	0.786	0.863	1.5	3.825	4.44	5.09	5.495	5.819
55		Chromium	10	0	5.73	8.34	9.025	9.9	10.75	11.2	12.2	13.1	13.82
56		Copper	10	0	28.6	69	83.75	170	352.5	406	518	554	582.8
57		Lead	10	0	5.26	7.7	10.23	31	74.75	83	83.2	84.1	84.82
58		Manganese	10	0	161.8	170	185	330	750	798	1069	1785	2357
59		Mercury	10	0	0.0889	0.0914	0.0925	0.0985	0.118	0.128	0.172	0.226	0.269
60		Nickel	10	0	4.61	5.06	5.55	8.35	8.55	8.62	8.71	8.755	8.791
61		Selenium	10	0	4.89	4.9	4.9	5.85	7.3	7.4	7.95	8.625	9.165
62		Silver	10	0	2.4	2.4	2.4	2.4	2.5	2.5	2.5	2.5	2.5
63		Thallium	10	0	4.89	4.9	4.9	4.9	4.9	4.92	52.5	266.2	437.3
64		Zinc	10	0	62.3	69.6	80.75	125	155	172	227	258.5	283.7

	A	B	C	D	E	F	G	H	I	J	K	L
1	**UCL Statistics for Data Sets with Non-Detects**											
2												
3	User Selected Options											
4	Date/Time of Computation			ProUCL 5.110/10/2019 9:56:04 AM								
5	From File			ProUCL_Input BKG_b.xls								
6	Full Precision			OFF								
7	Confidence Coefficient			95%								
8	Number of Bootstrap Operations			2000								
9												
10	**Antimony**											
11												
12	**General Statistics**											
13	Total Number of Observations					10	Number of Distinct Observations					2
14	Number of Detects					0	Number of Non-Detects					10
15	Number of Distinct Detects					0	Number of Distinct Non-Detects					2
16												
17	**Warning: All observations are Non-Detects (NDs), therefore all statistics and estimates should also be NDs!**											
18	**Specifically, sample mean, UCLs, UPLs, and other statistics are also NDs lying below the largest detection limit!**											
19	**The Project Team may decide to use alternative site specific values to estimate environmental parameters (e.g., EPC, BTV).**											
20												
21	**The data set for variable Antimony was not processed!**											
22												
23												
24												
25	**Arsenic**											
26												
27	**General Statistics**											
28	Total Number of Observations					10	Number of Distinct Observations					10
29							Number of Missing Observations					0
30	Minimum					5	Mean					19.6
31	Maximum					33	Median					20
32	SD					8.809	Std. Error of Mean					2.786
33	Coefficient of Variation					0.449	Skewness					0.0148
34												
35	**Normal GOF Test**											
36	Shapiro Wilk Test Statistic					0.973	**Shapiro Wilk GOF Test**					
37	5% Shapiro Wilk Critical Value					0.842	Data appear Normal at 5% Significance Level					
38	Lilliefors Test Statistic					0.138	**Lilliefors GOF Test**					
39	5% Lilliefors Critical Value					0.262	Data appear Normal at 5% Significance Level					
40	**Data appear Normal at 5% Significance Level**											
41												
42	**Assuming Normal Distribution**											
43	**95% Normal UCL**						**95% UCLs (Adjusted for Skewness)**					
44	95% Student's-t UCL					24.71	95% Adjusted-CLT UCL (Chen-1995)					24.2
45							95% Modified-t UCL (Johnson-1978)					24.71
46												
47	**Gamma GOF Test**											
48	A-D Test Statistic					0.256	**Anderson-Darling Gamma GOF Test**					
49	5% A-D Critical Value					0.729	Detected data appear Gamma Distributed at 5% Significance Level					
50	K-S Test Statistic					0.138	**Kolmogorov-Smirnov Gamma GOF Test**					
51	5% K-S Critical Value					0.268	Detected data appear Gamma Distributed at 5% Significance Level					
52	**Detected data appear Gamma Distributed at 5% Significance Level**											

	A	B	C	D	E	F	G	H	I	J	K	L
53												
54						**Gamma Statistics**						
55					k hat (MLE)	4.386					k star (bias corrected MLE)	3.137
56					Theta hat (MLE)	4.469					Theta star (bias corrected MLE)	6.248
57					nu hat (MLE)	87.72					nu star (bias corrected)	62.74
58					MLE Mean (bias corrected)	19.6					MLE Sd (bias corrected)	11.07
59											Approximate Chi Square Value (0.05)	45.52
60					Adjusted Level of Significance	0.0267					Adjusted Chi Square Value	42.98
61												
62						**Assuming Gamma Distribution**						
63					95% Approximate Gamma UCL (use when n>=50))	27.02					95% Adjusted Gamma UCL (use when n<50)	28.61
64												
65						**Lognormal GOF Test**						
66					Shapiro Wilk Test Statistic	0.908					**Shapiro Wilk Lognormal GOF Test**	
67					5% Shapiro Wilk Critical Value	0.842					Data appear Lognormal at 5% Significance Level	
68					Lilliefors Test Statistic	0.162					**Lilliefors Lognormal GOF Test**	
69					5% Lilliefors Critical Value	0.262					Data appear Lognormal at 5% Significance Level	
70						**Data appear Lognormal at 5% Significance Level**						
71												
72						**Lognormal Statistics**						
73					Minimum of Logged Data	1.609					Mean of logged Data	2.857
74					Maximum of Logged Data	3.497					SD of logged Data	0.56
75												
76						**Assuming Lognormal Distribution**						
77					95% H-UCL	31.32					90% Chebyshev (MVUE) UCL	30.88
78					95% Chebyshev (MVUE) UCL	35.8					97.5% Chebyshev (MVUE) UCL	42.63
79					99% Chebyshev (MVUE) UCL	56.04						
80												
81						**Nonparametric Distribution Free UCL Statistics**						
82						**Data appear to follow a Discernible Distribution at 5% Significance Level**						
83												
84						**Nonparametric Distribution Free UCLs**						
85					95% CLT UCL	24.18					95% Jackknife UCL	24.71
86					95% Standard Bootstrap UCL	24					95% Bootstrap-t UCL	24.73
87					95% Hall's Bootstrap UCL	24.38					95% Percentile Bootstrap UCL	23.9
88					95% BCA Bootstrap UCL	24						
89					90% Chebyshev(Mean, Sd) UCL	27.96					95% Chebyshev(Mean, Sd) UCL	31.74
90					97.5% Chebyshev(Mean, Sd) UCL	37					99% Chebyshev(Mean, Sd) UCL	47.32
91												
92						**Suggested UCL to Use**						
93					95% Student's-t UCL	24.71						
94												
95						Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.						
96						Recommendations are based upon data size, data distribution, and skewness.						
97						These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).						
98						However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.						
99												
100												

	A	B	C	D	E	F	G	H	I	J	K	L
101	**Barium**											
102												
103						**General Statistics**						
104					Total Number of Observations	10				Number of Distinct Observations		9
105										Number of Missing Observations		0
106					Minimum	33				Mean		88.1
107					Maximum	160				Median		89
108					SD	39.96				Std. Error of Mean		12.64
109					Coefficient of Variation	0.454				Skewness		0.309
110												
111						**Normal GOF Test**						
112					Shapiro Wilk Test Statistic	0.971				**Shapiro Wilk GOF Test**		
113					5% Shapiro Wilk Critical Value	0.842				Data appear Normal at 5% Significance Level		
114					Lilliefors Test Statistic	0.117				**Lilliefors GOF Test**		
115					5% Lilliefors Critical Value	0.262				Data appear Normal at 5% Significance Level		
116						**Data appear Normal at 5% Significance Level**						
117												
118						**Assuming Normal Distribution**						
119					**95% Normal UCL**					**95% UCLs (Adjusted for Skewness)**		
120					95% Student's-t UCL	111.3				95% Adjusted-CLT UCL (Chen-1995)		110.2
121										95% Modified-t UCL (Johnson-1978)		111.5
122												
123						**Gamma GOF Test**						
124					A-D Test Statistic	0.211				**Anderson-Darling Gamma GOF Test**		
125					5% A-D Critical Value	0.729				Detected data appear Gamma Distributed at 5% Significance Level		
126					K-S Test Statistic	0.168				**Kolmogorov-Smirnov Gamma GOF Test**		
127					5% K-S Critical Value	0.267				Detected data appear Gamma Distributed at 5% Significance Level		
128						**Detected data appear Gamma Distributed at 5% Significance Level**						
129												
130						**Gamma Statistics**						
131					k hat (MLE)	4.862				k star (bias corrected MLE)		3.47
132					Theta hat (MLE)	18.12				Theta star (bias corrected MLE)		25.39
133					nu hat (MLE)	97.24				nu star (bias corrected)		69.4
134					MLE Mean (bias corrected)	88.1				MLE Sd (bias corrected)		47.29
135										Approximate Chi Square Value (0.05)		51.22
136					Adjusted Level of Significance	0.0267				Adjusted Chi Square Value		48.52
137												
138						**Assuming Gamma Distribution**						
139					95% Approximate Gamma UCL (use when n>=50))	119.4				95% Adjusted Gamma UCL (use when n<50)		126
140												
141						**Lognormal GOF Test**						
142					Shapiro Wilk Test Statistic	0.95				**Shapiro Wilk Lognormal GOF Test**		
143					5% Shapiro Wilk Critical Value	0.842				Data appear Lognormal at 5% Significance Level		
144					Lilliefors Test Statistic	0.177				**Lilliefors Lognormal GOF Test**		
145					5% Lilliefors Critical Value	0.262				Data appear Lognormal at 5% Significance Level		
146						**Data appear Lognormal at 5% Significance Level**						
147												
148						**Lognormal Statistics**						
149					Minimum of Logged Data	3.497				Mean of logged Data		4.372
150					Maximum of Logged Data	5.075				SD of logged Data		0.509
151												

	A	B	C	D	E	F	G	H	I	J	K	L
152	**Assuming Lognormal Distribution**											
153					95% H-UCL	131.6				90% Chebyshev (MVUE) UCL		132.6
154					95% Chebyshev (MVUE) UCL	152.4				97.5% Chebyshev (MVUE) UCL		179.8
155					99% Chebyshev (MVUE) UCL	233.8						
156												
157	**Nonparametric Distribution Free UCL Statistics**											
158	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
159												
160	**Nonparametric Distribution Free UCLs**											
161					95% CLT UCL	108.9				95% Jackknife UCL		111.3
162					95% Standard Bootstrap UCL	107.3				95% Bootstrap-t UCL		111.4
163					95% Hall's Bootstrap UCL	114.3				95% Percentile Bootstrap UCL		107.7
164					95% BCA Bootstrap UCL	109.3						
165					90% Chebyshev(Mean, Sd) UCL	126				95% Chebyshev(Mean, Sd) UCL		143.2
166					97.5% Chebyshev(Mean, Sd) UCL	167				99% Chebyshev(Mean, Sd) UCL		213.8
167												
168	**Suggested UCL to Use**											
169					95% Student's-t UCL	111.3						
170												
171	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
172	Recommendations are based upon data size, data distribution, and skewness.											
173	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
174	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
175												
176	**Beryllium**											
177												
178	**General Statistics**											
179					Total Number of Observations	10				Number of Distinct Observations		8
180					Number of Detects	6				Number of Non-Detects		4
181					Number of Distinct Detects	6				Number of Distinct Non-Detects		2
182					Minimum Detect	0.56				Minimum Non-Detect		0.48
183					Maximum Detect	0.84				Maximum Non-Detect		0.49
184					Variance Detects	0.0099				Percent Non-Detects		40%
185					Mean Detects	0.702				SD Detects		0.0995
186					Median Detects	0.7				CV Detects		0.142
187					Skewness Detects	-0.0367				Kurtosis Detects		-0.483
188					Mean of Logged Detects	-0.363				SD of Logged Detects		0.144
189												
190	**Normal GOF Test on Detects Only**											
191					Shapiro Wilk Test Statistic	0.994				**Shapiro Wilk GOF Test**		
192					5% Shapiro Wilk Critical Value	0.788				Detected Data appear Normal at 5% Significance Level		
193					Lilliefors Test Statistic	0.125				**Lilliefors GOF Test**		
194					5% Lilliefors Critical Value	0.325				Detected Data appear Normal at 5% Significance Level		
195	**Detected Data appear Normal at 5% Significance Level**											
196												
197	**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**											
198					KM Mean	0.613				KM Standard Error of Mean		0.0448
199					KM SD	0.129				95% KM (BCA) UCL		0.683
200					95% KM (t) UCL	0.695				95% KM (Percentile Bootstrap) UCL		0.683
201					95% KM (z) UCL	0.687				95% KM Bootstrap t UCL		0.678
202					90% KM Chebyshev UCL	0.747				95% KM Chebyshev UCL		0.808
203					97.5% KM Chebyshev UCL	0.893				99% KM Chebyshev UCL		1.059

	A	B	C	D	E	F	G	H	I	J	K	L
204												
205	**Gamma GOF Tests on Detected Observations Only**											
206					A-D Test Statistic	0.154	**Anderson-Darling GOF Test**					
207					5% A-D Critical Value	0.697	Detected data appear Gamma Distributed at 5% Significance Level					
208					K-S Test Statistic	0.136	**Kolmogorov-Smirnov GOF**					
209					5% K-S Critical Value	0.332	Detected data appear Gamma Distributed at 5% Significance Level					
210	**Detected data appear Gamma Distributed at 5% Significance Level**											
211												
212	**Gamma Statistics on Detected Data Only**											
213					k hat (MLE)	58.72	k star (bias corrected MLE)					29.47
214					Theta hat (MLE)	0.0119	Theta star (bias corrected MLE)					0.0238
215					nu hat (MLE)	704.7	nu star (bias corrected)					353.7
216					Mean (detects)	0.702						
217												
218	**Gamma ROS Statistics using Imputed Non-Detects**											
219	GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs											
220	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)											
221	For such situations, GROS method may yield incorrect values of UCLs and BTVs											
222	This is especially true when the sample size is small.											
223	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates											
224					Minimum	0.375	Mean					0.598
225					Maximum	0.84	Median					0.6
226					SD	0.156	CV					0.261
227					k hat (MLE)	15.83	k star (bias corrected MLE)					11.15
228					Theta hat (MLE)	0.0378	Theta star (bias corrected MLE)					0.0536
229					nu hat (MLE)	316.6	nu star (bias corrected)					222.9
230					Adjusted Level of Significance (β)	0.0267						
231					Approximate Chi Square Value (222.92, α)	189.4	Adjusted Chi Square Value (222.92, β)					184
232					95% Gamma Approximate UCL (use when n>=50)	0.704	95% Gamma Adjusted UCL (use when n<50)					0.724
233												
234	**Estimates of Gamma Parameters using KM Estimates**											
235					Mean (KM)	0.613	SD (KM)					0.129
236					Variance (KM)	0.0167	SE of Mean (KM)					0.0448
237					k hat (KM)	22.45	k star (KM)					15.78
238					nu hat (KM)	448.9	nu star (KM)					315.6
239					theta hat (KM)	0.0273	theta star (KM)					0.0388
240					80% gamma percentile (KM)	0.738	90% gamma percentile (KM)					0.817
241					95% gamma percentile (KM)	0.887	99% gamma percentile (KM)					1.028
242												
243	**Gamma Kaplan-Meier (KM) Statistics**											
244					Approximate Chi Square Value (315.58, α)	275.4	Adjusted Chi Square Value (315.58, β)					268.9
245					95% Gamma Approximate KM-UCL (use when n>=50)	0.702	95% Gamma Adjusted KM-UCL (use when n<50)					0.719
246												
247	**Lognormal GOF Test on Detected Observations Only**											
248					Shapiro Wilk Test Statistic	0.989	**Shapiro Wilk GOF Test**					
249					5% Shapiro Wilk Critical Value	0.788	Detected Data appear Lognormal at 5% Significance Level					
250					Lilliefors Test Statistic	0.131	**Lilliefors GOF Test**					
251					5% Lilliefors Critical Value	0.325	Detected Data appear Lognormal at 5% Significance Level					
252	**Detected Data appear Lognormal at 5% Significance Level**											
253												

	A	B	C	D	E	F	G	H	I	J	K	L
254	**Lognormal ROS Statistics Using Imputed Non-Detects**											
255					Mean in Original Scale	0.608					Mean in Log Scale	-0.522
256					SD in Original Scale	0.143					SD in Log Scale	0.237
257				95% t UCL (assumes normality of ROS data)		0.691					95% Percentile Bootstrap UCL	0.678
258					95% BCA Bootstrap UCL	0.682					95% Bootstrap t UCL	0.695
259					95% H-UCL (Log ROS)	0.71						
260												
261	**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**											
262					KM Mean (logged)	-0.511					KM Geo Mean	0.6
263					KM SD (logged)	0.208					95% Critical H Value (KM-Log)	1.888
264					KM Standard Error of Mean (logged)	0.0722					95% H-UCL (KM -Log)	0.699
265					KM SD (logged)	0.208					95% Critical H Value (KM-Log)	1.888
266					KM Standard Error of Mean (logged)	0.0722						
267												
268	**DL/2 Statistics**											
269				**DL/2 Normal**						**DL/2 Log-Transformed**		
270					Mean in Original Scale	0.519					Mean in Log Scale	-0.782
271					SD in Original Scale	0.248					SD in Log Scale	0.552
272					95% t UCL (Assumes normality)	0.662					95% H-Stat UCL	0.813
273	**DL/2 is not a recommended method, provided for comparisons and historical reasons**											
274												
275	**Nonparametric Distribution Free UCL Statistics**											
276	**Detected Data appear Normal Distributed at 5% Significance Level**											
277												
278	**Suggested UCL to Use**											
279					95% KM (t) UCL	0.695						
280												
281	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
282	Recommendations are based upon data size, data distribution, and skewness.											
283	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
284	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
285												
286	**Cadmium**											
287												
288	**General Statistics**											
289					Total Number of Observations	10					Number of Distinct Observations	9
290					Number of Detects	8					Number of Non-Detects	2
291					Number of Distinct Detects	8					Number of Distinct Non-Detects	1
292					Minimum Detect	0.86					Minimum Non-Detect	0.49
293					Maximum Detect	5.9					Maximum Non-Detect	0.49
294					Variance Detects	4.033					Percent Non-Detects	20%
295					Mean Detects	2.791					SD Detects	2.008
296					Median Detects	2.2					CV Detects	0.719
297					Skewness Detects	0.556					Kurtosis Detects	-1.513
298					Mean of Logged Detects	0.765					SD of Logged Detects	0.799
299												
300	**Normal GOF Test on Detects Only**											
301					Shapiro Wilk Test Statistic	0.87					**Shapiro Wilk GOF Test**	
302					5% Shapiro Wilk Critical Value	0.818					Detected Data appear Normal at 5% Significance Level	
303					Lilliefors Test Statistic	0.202					**Lilliefors GOF Test**	
304					5% Lilliefors Critical Value	0.283					Detected Data appear Normal at 5% Significance Level	
305	**Detected Data appear Normal at 5% Significance Level**											

	A	B	C	D	E	F	G	H	I	J	K	L
306												
307	**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**											
308					KM Mean	2.331			KM Standard Error of Mean			0.648
309					KM SD	1.916			95% KM (BCA) UCL			3.332
310					95% KM (t) UCL	3.518			95% KM (Percentile Bootstrap) UCL			3.324
311					95% KM (z) UCL	3.396			95% KM Bootstrap t UCL			4.012
312					90% KM Chebyshev UCL	4.274			95% KM Chebyshev UCL			5.154
313					97.5% KM Chebyshev UCL	6.376			99% KM Chebyshev UCL			8.775
314												
315	**Gamma GOF Tests on Detected Observations Only**											
316					A-D Test Statistic	0.455	**Anderson-Darling GOF Test**					
317					5% A-D Critical Value	0.724	Detected data appear Gamma Distributed at 5% Significance Level					
318					K-S Test Statistic	0.219	**Kolmogorov-Smirnov GOF**					
319					5% K-S Critical Value	0.297	Detected data appear Gamma Distributed at 5% Significance Level					
320	**Detected data appear Gamma Distributed at 5% Significance Level**											
321												
322	**Gamma Statistics on Detected Data Only**											
323					k hat (MLE)	2.065			k star (bias corrected MLE)			1.374
324					Theta hat (MLE)	1.352			Theta star (bias corrected MLE)			2.032
325					nu hat (MLE)	33.04			nu star (bias corrected)			21.98
326					Mean (detects)	2.791						
327												
328	**Gamma ROS Statistics using Imputed Non-Detects**											
329	GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs											
330	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)											
331	For such situations, GROS method may yield incorrect values of UCLs and BTVs											
332	This is especially true when the sample size is small.											
333	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates											
334					Minimum	0.01			Mean			2.235
335					Maximum	5.9			Median			1.5
336					SD	2.124			CV			0.95
337					k hat (MLE)	0.561			k star (bias corrected MLE)			0.459
338					Theta hat (MLE)	3.986			Theta star (bias corrected MLE)			4.867
339					nu hat (MLE)	11.21			nu star (bias corrected)			9.183
340					Adjusted Level of Significance (β)	0.0267						
341					Approximate Chi Square Value (9.18, α)	3.438			Adjusted Chi Square Value (9.18, β)			2.855
342					95% Gamma Approximate UCL (use when n>=50)	5.97			95% Gamma Adjusted UCL (use when n<50)			7.189
343												
344	**Estimates of Gamma Parameters using KM Estimates**											
345					Mean (KM)	2.331			SD (KM)			1.916
346					Variance (KM)	3.67			SE of Mean (KM)			0.648
347					k hat (KM)	1.48			k star (KM)			1.103
348					nu hat (KM)	29.61			nu star (KM)			22.06
349					theta hat (KM)	1.574			theta star (KM)			2.113
350					80% gamma percentile (KM)	3.72			90% gamma percentile (KM)			5.239
351					95% gamma percentile (KM)	6.746			99% gamma percentile (KM)			10.22
352												
353	**Gamma Kaplan-Meier (KM) Statistics**											
354					Approximate Chi Square Value (22.06, α)	12.38			Adjusted Chi Square Value (22.06, β)			11.14
355					95% Gamma Approximate KM-UCL (use when n>=50)	4.153			95% Gamma Adjusted KM-UCL (use when n<50)			4.615
356												

	A	B	C	D	E	F	G	H	I	J	K	L
357	**Lognormal GOF Test on Detected Observations Only**											
358					Shapiro Wilk Test Statistic	0.879	**Shapiro Wilk GOF Test**					
359					5% Shapiro Wilk Critical Value	0.818	Detected Data appear Lognormal at 5% Significance Level					
360					Lilliefors Test Statistic	0.206	**Lilliefors GOF Test**					
361					5% Lilliefors Critical Value	0.283	Detected Data appear Lognormal at 5% Significance Level					
362	**Detected Data appear Lognormal at 5% Significance Level**											
363												
364	**Lognormal ROS Statistics Using Imputed Non-Detects**											
365					Mean in Original Scale	2.297				Mean in Log Scale		0.377
366					SD in Original Scale	2.056				SD in Log Scale		1.085
367					95% t UCL (assumes normality of ROS data)	3.488				95% Percentile Bootstrap UCL		3.374
368					95% BCA Bootstrap UCL	3.51				95% Bootstrap t UCL		3.883
369					95% H-UCL (Log ROS)	8.611						
370												
371	**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**											
372					KM Mean (logged)	0.469				KM Geo Mean		1.599
373					KM SD (logged)	0.893				95% Critical H Value (KM-Log)		2.888
374					KM Standard Error of Mean (logged)	0.302				95% H-UCL (KM -Log)		5.626
375					KM SD (logged)	0.893				95% Critical H Value (KM-Log)		2.888
376					KM Standard Error of Mean (logged)	0.302						
377												
378	**DL/2 Statistics**											
379	**DL/2 Normal**						**DL/2 Log-Transformed**					
380					Mean in Original Scale	2.282				Mean in Log Scale		0.331
381					SD in Original Scale	2.071				SD in Log Scale		1.156
382					95% t UCL (Assumes normality)	3.483				95% H-Stat UCL		10.18
383	**DL/2 is not a recommended method, provided for comparisons and historical reasons**											
384												
385	**Nonparametric Distribution Free UCL Statistics**											
386	**Detected Data appear Normal Distributed at 5% Significance Level**											
387												
388	**Suggested UCL to Use**											
389					95% KM (t) UCL	3.518						
390												
391	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
392	Recommendations are based upon data size, data distribution, and skewness.											
393	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
394	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
395												
396												
397	**Chromium**											
398												
399	**General Statistics**											
400					Total Number of Observations	10				Number of Distinct Observations		9
401										Number of Missing Observations		0
402					Minimum	2.4				Mean		9.36
403					Maximum	14				Median		9.9
404					SD	3.188				Std. Error of Mean		1.008
405					Coefficient of Variation	0.341				Skewness		-1.065
406												

	A	B	C	D	E	F	G	H	I	J	K	L
407	**Normal GOF Test**											
408					Shapiro Wilk Test Statistic	0.911	**Shapiro Wilk GOF Test**					
409					5% Shapiro Wilk Critical Value	0.842	Data appear Normal at 5% Significance Level					
410					Lilliefors Test Statistic	0.243	**Lilliefors GOF Test**					
411					5% Lilliefors Critical Value	0.262	Data appear Normal at 5% Significance Level					
412	**Data appear Normal at 5% Significance Level**											
413												
414	**Assuming Normal Distribution**											
415	**95% Normal UCL**						**95% UCLs (Adjusted for Skewness)**					
416					95% Student's-t UCL	11.21			95% Adjusted-CLT UCL (Chen-1995)			10.66
417									95% Modified-t UCL (Johnson-1978)			11.15
418												
419	**Gamma GOF Test**											
420					A-D Test Statistic	0.893	**Anderson-Darling Gamma GOF Test**					
421					5% A-D Critical Value	0.728	Data Not Gamma Distributed at 5% Significance Level					
422					K-S Test Statistic	0.305	**Kolmogorov-Smirnov Gamma GOF Test**					
423					5% K-S Critical Value	0.267	Data Not Gamma Distributed at 5% Significance Level					
424	**Data Not Gamma Distributed at 5% Significance Level**											
425												
426	**Gamma Statistics**											
427					k hat (MLE)	6.082			k star (bias corrected MLE)			4.324
428					Theta hat (MLE)	1.539			Theta star (bias corrected MLE)			2.165
429					nu hat (MLE)	121.6			nu star (bias corrected)			86.49
430					MLE Mean (bias corrected)	9.36			MLE Sd (bias corrected)			4.501
431									Approximate Chi Square Value (0.05)			66.05
432					Adjusted Level of Significance	0.0267			Adjusted Chi Square Value			62.95
433												
434	**Assuming Gamma Distribution**											
435					95% Approximate Gamma UCL (use when n>=50))	12.26			95% Adjusted Gamma UCL (use when n<50)			12.86
436												
437	**Lognormal GOF Test**											
438					Shapiro Wilk Test Statistic	0.745	**Shapiro Wilk Lognormal GOF Test**					
439					5% Shapiro Wilk Critical Value	0.842	Data Not Lognormal at 5% Significance Level					
440					Lilliefors Test Statistic	0.327	**Lilliefors Lognormal GOF Test**					
441					5% Lilliefors Critical Value	0.262	Data Not Lognormal at 5% Significance Level					
442	**Data Not Lognormal at 5% Significance Level**											
443												
444	**Lognormal Statistics**											
445					Minimum of Logged Data	0.875			Mean of logged Data			2.152
446					Maximum of Logged Data	2.639			SD of logged Data			0.498
447												
448	**Assuming Lognormal Distribution**											
449					95% H-UCL	14.06			90% Chebyshev (MVUE) UCL			14.22
450					95% Chebyshev (MVUE) UCL	16.31			97.5% Chebyshev (MVUE) UCL			19.21
451					99% Chebyshev (MVUE) UCL	24.91						
452												
453	**Nonparametric Distribution Free UCL Statistics**											
454	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
455												

	A	B	C	D	E	F	G	H	I	J	K	L
456	**Nonparametric Distribution Free UCLs**											
457					95% CLT UCL	11.02				95% Jackknife UCL		11.21
458					95% Standard Bootstrap UCL	10.97				95% Bootstrap-t UCL		10.86
459					95% Hall's Bootstrap UCL	10.78				95% Percentile Bootstrap UCL		10.75
460					95% BCA Bootstrap UCL	10.8						
461					90% Chebyshev(Mean, Sd) UCL	12.38				95% Chebyshev(Mean, Sd) UCL		13.75
462					97.5% Chebyshev(Mean, Sd) UCL	15.66				99% Chebyshev(Mean, Sd) UCL		19.39
463												
464	**Suggested UCL to Use**											
465					95% Student's-t UCL	11.21						
466												
467	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
468	Recommendations are based upon data size, data distribution, and skewness.											
469	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
470	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
471												
472	**Note: For highly negatively-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be**											
473	**reliable. Chen's and Johnson's methods provide adjustments for positvely skewed data sets.**											
474												
475												
476	**Copper**											
477												
478	**General Statistics**											
479					Total Number of Observations	10				Number of Distinct Observations		10
480										Number of Missing Observations		0
481					Minimum	25				Mean		232.1
482					Maximum	590				Median		170
483					SD	200.8				Std. Error of Mean		63.48
484					Coefficient of Variation	0.865				Skewness		0.802
485												
486	**Normal GOF Test**											
487					Shapiro Wilk Test Statistic	0.895				**Shapiro Wilk GOF Test**		
488					5% Shapiro Wilk Critical Value	0.842				Data appear Normal at 5% Significance Level		
489					Lilliefors Test Statistic	0.183				**Lilliefors GOF Test**		
490					5% Lilliefors Critical Value	0.262				Data appear Normal at 5% Significance Level		
491	**Data appear Normal at 5% Significance Level**											
492												
493	**Assuming Normal Distribution**											
494	**95% Normal UCL**									**95% UCLs (Adjusted for Skewness)**		
495					95% Student's-t UCL	348.5				95% Adjusted-CLT UCL (Chen-1995)		353.7
496										95% Modified-t UCL (Johnson-1978)		351.2
497												
498	**Gamma GOF Test**											
499					A-D Test Statistic	0.209				**Anderson-Darling Gamma GOF Test**		
500					5% A-D Critical Value	0.744				Detected data appear Gamma Distributed at 5% Significance Level		
501					K-S Test Statistic	0.12				**Kolmogorov-Smirnov Gamma GOF Test**		
502					5% K-S Critical Value	0.272				Detected data appear Gamma Distributed at 5% Significance Level		
503	**Detected data appear Gamma Distributed at 5% Significance Level**											
504												

	A	B	C	D	E	F	G	H	I	J	K	L
505	**Gamma Statistics**											
506					k hat (MLE)	1.246				k star (bias corrected MLE)		0.939
507					Theta hat (MLE)	186.2				Theta star (bias corrected MLE)		247.1
508					nu hat (MLE)	24.93				nu star (bias corrected)		18.78
509					MLE Mean (bias corrected)	232.1				MLE Sd (bias corrected)		239.5
510										Approximate Chi Square Value (0.05)		9.959
511					Adjusted Level of Significance	0.0267				Adjusted Chi Square Value		8.863
512												
513	**Assuming Gamma Distribution**											
514				95% Approximate Gamma UCL (use when n>=50))		437.7				95% Adjusted Gamma UCL (use when n<50)		491.9
515												
516	**Lognormal GOF Test**											
517					Shapiro Wilk Test Statistic	0.935	**Shapiro Wilk Lognormal GOF Test**					
518					5% Shapiro Wilk Critical Value	0.842	Data appear Lognormal at 5% Significance Level					
519					Lilliefors Test Statistic	0.128	**Lilliefors Lognormal GOF Test**					
520					5% Lilliefors Critical Value	0.262	Data appear Lognormal at 5% Significance Level					
521	**Data appear Lognormal at 5% Significance Level**											
522												
523	**Lognormal Statistics**											
524					Minimum of Logged Data	3.219				Mean of logged Data		4.995
525					Maximum of Logged Data	6.38				SD of logged Data		1.113
526												
527	**Assuming Lognormal Distribution**											
528					95% H-UCL	945.8				90% Chebyshev (MVUE) UCL		530.7
529					95% Chebyshev (MVUE) UCL	657.2				97.5% Chebyshev (MVUE) UCL		832.8
530					99% Chebyshev (MVUE) UCL	1178						
531												
532	**Nonparametric Distribution Free UCL Statistics**											
533	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
534												
535	**Nonparametric Distribution Free UCLs**											
536					95% CLT UCL	336.5				95% Jackknife UCL		348.5
537					95% Standard Bootstrap UCL	330.2				95% Bootstrap-t UCL		386.6
538					95% Hall's Bootstrap UCL	365.2				95% Percentile Bootstrap UCL		332.5
539					95% BCA Bootstrap UCL	341.2						
540					90% Chebyshev(Mean, Sd) UCL	422.5				95% Chebyshev(Mean, Sd) UCL		508.8
541					97.5% Chebyshev(Mean, Sd) UCL	628.6				99% Chebyshev(Mean, Sd) UCL		863.7
542												
543	**Suggested UCL to Use**											
544					95% Student's-t UCL	348.5						
545												
546	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
547	Recommendations are based upon data size, data distribution, and skewness.											
548	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
549	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
550												

	A	B	C	D	E	F	G	H	I	J	K	L
551	Lead											
552												
553						General Statistics						
554					Total Number of Observations	10				Number of Distinct Observations		9
555					Number of Detects	9				Number of Non-Detects		1
556					Number of Distinct Detects	8				Number of Distinct Non-Detects		1
557					Minimum Detect	5.3				Minimum Non-Detect		4.9
558					Maximum Detect	85				Maximum Non-Detect		4.9
559					Variance Detects	1112				Percent Non-Detects		10%
560					Mean Detects	43.62				SD Detects		33.34
561					Median Detects	42				CV Detects		0.764
562					Skewness Detects	0.254				Kurtosis Detects		-1.895
563					Mean of Logged Detects	3.387				SD of Logged Detects		1.045
564												
565						Normal GOF Test on Detects Only						
566					Shapiro Wilk Test Statistic	0.856				Shapiro Wilk GOF Test		
567					5% Shapiro Wilk Critical Value	0.829				Detected Data appear Normal at 5% Significance Level		
568					Lilliefors Test Statistic	0.215				Lilliefors GOF Test		
569					5% Lilliefors Critical Value	0.274				Detected Data appear Normal at 5% Significance Level		
570						Detected Data appear Normal at 5% Significance Level						
571												
572						Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs						
573					KM Mean	39.75				KM Standard Error of Mean		10.73
574					KM SD	32.01				95% KM (BCA) UCL		54.42
575					95% KM (t) UCL	59.43				95% KM (Percentile Bootstrap) UCL		57.09
576					95% KM (z) UCL	57.41				95% KM Bootstrap t UCL		62.14
577					90% KM Chebyshev UCL	71.95				95% KM Chebyshev UCL		86.54
578					97.5% KM Chebyshev UCL	106.8				99% KM Chebyshev UCL		146.6
579												
580						Gamma GOF Tests on Detected Observations Only						
581					A-D Test Statistic	0.435				Anderson-Darling GOF Test		
582					5% A-D Critical Value	0.736				Detected data appear Gamma Distributed at 5% Significance Level		
583					K-S Test Statistic	0.204				Kolmogorov-Smirnov GOF		
584					5% K-S Critical Value	0.284				Detected data appear Gamma Distributed at 5% Significance Level		
585						Detected data appear Gamma Distributed at 5% Significance Level						
586												
587						Gamma Statistics on Detected Data Only						
588					k hat (MLE)	1.43				k star (bias corrected MLE)		1.028
589					Theta hat (MLE)	30.5				Theta star (bias corrected MLE)		42.45
590					nu hat (MLE)	25.75				nu star (bias corrected)		18.5
591					Mean (detects)	43.62						
592												
593						Gamma ROS Statistics using Imputed Non-Detects						
594						GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs						
595						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)						
596						For such situations, GROS method may yield incorrect values of UCLs and BTVs						
597						This is especially true when the sample size is small.						
598						For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates						
599					Minimum	0.01				Mean		39.26
600					Maximum	85				Median		31
601					SD	34.33				CV		0.874
602					k hat (MLE)	0.574				k star (bias corrected MLE)		0.469

	A	B	C	D	E	F	G	H	I	J	K	L
603					Theta hat (MLE)	68.34					Theta star (bias corrected MLE)	83.75
604					nu hat (MLE)	11.49					nu star (bias corrected)	9.376
605					Adjusted Level of Significance (β)	0.0267						
606					Approximate Chi Square Value (9.38, α)	3.556					Adjusted Chi Square Value (9.38, β)	2.96
607					95% Gamma Approximate UCL (use when n>=50)	103.5					95% Gamma Adjusted UCL (use when n<50)	124.3
608												
609					**Estimates of Gamma Parameters using KM Estimates**							
610					Mean (KM)	39.75					SD (KM)	32.01
611					Variance (KM)	1024					SE of Mean (KM)	10.73
612					k hat (KM)	1.543					k star (KM)	1.146
613					nu hat (KM)	30.85					nu star (KM)	22.93
614					theta hat (KM)	25.77					theta star (KM)	34.67
615					80% gamma percentile (KM)	63.21					90% gamma percentile (KM)	88.49
616					95% gamma percentile (KM)	113.5					99% gamma percentile (KM)	171
617												
618					**Gamma Kaplan-Meier (KM) Statistics**							
619					Approximate Chi Square Value (22.93, α)	13.04					Adjusted Chi Square Value (22.93, β)	11.76
620					95% Gamma Approximate KM-UCL (use when n>=50)	69.91					95% Gamma Adjusted KM-UCL (use when n<50)	77.5
621												
622					**Lognormal GOF Test on Detected Observations Only**							
623					Shapiro Wilk Test Statistic	0.892			**Shapiro Wilk GOF Test**			
624					5% Shapiro Wilk Critical Value	0.829			Detected Data appear Lognormal at 5% Significance Level			
625					Lilliefors Test Statistic	0.187			**Lilliefors GOF Test**			
626					5% Lilliefors Critical Value	0.274			Detected Data appear Lognormal at 5% Significance Level			
627					**Detected Data appear Lognormal at 5% Significance Level**							
628												
629					**Lognormal ROS Statistics Using Imputed Non-Detects**							
630					Mean in Original Scale	39.51					Mean in Log Scale	3.138
631					SD in Original Scale	34.03					SD in Log Scale	1.262
632					95% t UCL (assumes normality of ROS data)	59.23					95% Percentile Bootstrap UCL	56.49
633					95% BCA Bootstrap UCL	56.53					95% Bootstrap t UCL	61.54
634					95% H-UCL (Log ROS)	238.6						
635												
636					**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**							
637					KM Mean (logged)	3.207					KM Geo Mean	24.71
638					KM SD (logged)	1.079					95% Critical H Value (KM-Log)	3.268
639					KM Standard Error of Mean (logged)	0.362					95% H-UCL (KM -Log)	143.4
640					KM SD (logged)	1.079					95% Critical H Value (KM-Log)	3.268
641					KM Standard Error of Mean (logged)	0.362						
642												
643					**DL/2 Statistics**							
644					**DL/2 Normal**				**DL/2 Log-Transformed**			
645					Mean in Original Scale	39.51					Mean in Log Scale	3.138
646					SD in Original Scale	34.03					SD in Log Scale	1.262
647					95% t UCL (Assumes normality)	59.23					95% H-Stat UCL	238.7
648					**DL/2 is not a recommended method, provided for comparisons and historical reasons**							
649												
650					**Nonparametric Distribution Free UCL Statistics**							
651					**Detected Data appear Normal Distributed at 5% Significance Level**							
652												
653					**Suggested UCL to Use**							
654					95% KM (t) UCL	59.43						

	A	B	C	D	E	F	G	H	I	J	K	L
655												
656	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
657	Recommendations are based upon data size, data distribution, and skewness.											
658	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
659	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
660												
661												
662	**Manganese**											
663												
664	**General Statistics**											
665	Total Number of Observations					10	Number of Distinct Observations					8
666							Number of Missing Observations					0
667	Minimum					88	Mean					618.8
668	Maximum					2500	Median					330
669	SD					719.1	Std. Error of Mean					227.4
670	Coefficient of Variation					1.162	Skewness					2.334
671												
672	**Normal GOF Test**											
673	Shapiro Wilk Test Statistic					0.706	**Shapiro Wilk GOF Test**					
674	5% Shapiro Wilk Critical Value					0.842	Data Not Normal at 5% Significance Level					
675	Lilliefors Test Statistic					0.256	**Lilliefors GOF Test**					
676	5% Lilliefors Critical Value					0.262	Data appear Normal at 5% Significance Level					
677	**Data appear Approximate Normal at 5% Significance Level**											
678												
679	**Assuming Normal Distribution**											
680	**95% Normal UCL**						**95% UCLs (Adjusted for Skewness)**					
681	95% Student's-t UCL					1036	95% Adjusted-CLT UCL (Chen-1995)					1172
682							95% Modified-t UCL (Johnson-1978)					1064
683												
684	**Gamma GOF Test**											
685	A-D Test Statistic					0.424	**Anderson-Darling Gamma GOF Test**					
686	5% A-D Critical Value					0.744	Detected data appear Gamma Distributed at 5% Significance Level					
687	K-S Test Statistic					0.221	**Kolmogorov-Smirnov Gamma GOF Test**					
688	5% K-S Critical Value					0.273	Detected data appear Gamma Distributed at 5% Significance Level					
689	**Detected data appear Gamma Distributed at 5% Significance Level**											
690												
691	**Gamma Statistics**											
692	k hat (MLE)					1.21	k star (bias corrected MLE)					0.913
693	Theta hat (MLE)					511.5	Theta star (bias corrected MLE)					677.4
694	nu hat (MLE)					24.19	nu star (bias corrected)					18.27
695	MLE Mean (bias corrected)					618.8	MLE Sd (bias corrected)					647.5
696							Approximate Chi Square Value (0.05)					9.585
697	Adjusted Level of Significance					0.0267	Adjusted Chi Square Value					8.513
698												
699	**Assuming Gamma Distribution**											
700	95% Approximate Gamma UCL (use when n>=50))					1179	95% Adjusted Gamma UCL (use when n<50)					1328
701												
702	**Lognormal GOF Test**											
703	Shapiro Wilk Test Statistic					0.966	**Shapiro Wilk Lognormal GOF Test**					
704	5% Shapiro Wilk Critical Value					0.842	Data appear Lognormal at 5% Significance Level					
705	Lilliefors Test Statistic					0.165	**Lilliefors Lognormal GOF Test**					
706	5% Lilliefors Critical Value					0.262	Data appear Lognormal at 5% Significance Level					

	A	B	C	D	E	F	G	H	I	J	K	L
707	Data appear Lognormal at 5% Significance Level											
708												
709	Lognormal Statistics											
710					Minimum of Logged Data	4.477				Mean of logged Data		5.961
711					Maximum of Logged Data	7.824				SD of logged Data		0.994
712												
713	Assuming Lognormal Distribution											
714					95% H-UCL	1769				90% Chebyshev (MVUE) UCL		1183
715					95% Chebyshev (MVUE) UCL	1449				97.5% Chebyshev (MVUE) UCL		1819
716					99% Chebyshev (MVUE) UCL	2545						
717												
718	Nonparametric Distribution Free UCL Statistics											
719	Data appear to follow a Discernible Distribution at 5% Significance Level											
720												
721	Nonparametric Distribution Free UCLs											
722					95% CLT UCL	992.8				95% Jackknife UCL		1036
723					95% Standard Bootstrap UCL	970.6				95% Bootstrap-t UCL		1563
724					95% Hall's Bootstrap UCL	2354				95% Percentile Bootstrap UCL		994.6
725					95% BCA Bootstrap UCL	1213						
726					90% Chebyshev(Mean, Sd) UCL	1301				95% Chebyshev(Mean, Sd) UCL		1610
727					97.5% Chebyshev(Mean, Sd) UCL	2039				99% Chebyshev(Mean, Sd) UCL		2881
728												
729	Suggested UCL to Use											
730					95% Student's-t UCL	1036						
731												
732	When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test											
733	When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL											
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	Mercury											
741												
742	General Statistics											
743					Total Number of Observations	10				Number of Distinct Observations		10
744					Number of Detects	4				Number of Non-Detects		6
745					Number of Distinct Detects	4				Number of Distinct Non-Detects		6
746					Minimum Detect	0.11				Minimum Non-Detect		0.088
747					Maximum Detect	0.28				Maximum Non-Detect		0.1
748					Variance Detects	0.00609				Percent Non-Detects		60%
749					Mean Detects	0.168				SD Detects		0.078
750					Median Detects	0.14				CV Detects		0.466
751					Skewness Detects	1.579				Kurtosis Detects		2.328
752					Mean of Logged Detects	-1.858				SD of Logged Detects		0.422
753												
754	Normal GOF Test on Detects Only											
755					Shapiro Wilk Test Statistic	0.835				Shapiro Wilk GOF Test		
756					5% Shapiro Wilk Critical Value	0.748				Detected Data appear Normal at 5% Significance Level		
757					Lilliefors Test Statistic	0.288				Lilliefors GOF Test		
758					5% Lilliefors Critical Value	0.375				Detected Data appear Normal at 5% Significance Level		

	A	B	C	D	E	F	G	H	I	J	K	L
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	0.12			KM Standard Error of Mean			0.0211
763					KM SD	0.0578			95% KM (BCA) UCL			N/A
764					95% KM (t) UCL	0.159			95% KM (Percentile Bootstrap) UCL			N/A
765					95% KM (z) UCL	0.155			95% KM Bootstrap t UCL			N/A
766					90% KM Chebyshev UCL	0.183			95% KM Chebyshev UCL			0.212
767					97.5% KM Chebyshev UCL	0.252			99% KM Chebyshev UCL			0.33
768												
769	**Gamma GOF Tests on Detected Observations Only**											
770					A-D Test Statistic	0.409	**Anderson-Darling GOF Test**					
771					5% A-D Critical Value	0.658	Detected data appear Gamma Distributed at 5% Significance Level					
772					K-S Test Statistic	0.263	**Kolmogorov-Smirnov GOF**					
773					5% K-S Critical Value	0.395	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)	7.156			k star (bias corrected MLE)			1.956
778					Theta hat (MLE)	0.0234			Theta star (bias corrected MLE)			0.0857
779					nu hat (MLE)	57.24			nu star (bias corrected)			15.64
780					Mean (detects)	0.168						
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	0.01			Mean			0.073
789					Maximum	0.28			Median			0.01
790					SD	0.093			CV			1.274
791					k hat (MLE)	0.682			k star (bias corrected MLE)			0.544
792					Theta hat (MLE)	0.107			Theta star (bias corrected MLE)			0.134
793					nu hat (MLE)	13.64			nu star (bias corrected)			10.88
794					Adjusted Level of Significance (β)	0.0267						
795					Approximate Chi Square Value (10.88, α)	4.501			Adjusted Chi Square Value (10.88, β)			3.814
796					95% Gamma Approximate UCL (use when n>=50)	0.177			95% Gamma Adjusted UCL (use when n<50)			N/A
797												
798	**Estimates of Gamma Parameters using KM Estimates**											
799					Mean (KM)	0.12			SD (KM)			0.0578
800					Variance (KM)	0.00334			SE of Mean (KM)			0.0211
801					k hat (KM)	4.291			k star (KM)			3.071
802					nu hat (KM)	85.83			nu star (KM)			61.41
803					theta hat (KM)	0.0279			theta star (KM)			0.039
804					80% gamma percentile (KM)	0.17			90% gamma percentile (KM)			0.211
805					95% gamma percentile (KM)	0.25			99% gamma percentile (KM)			0.333
806												
807	**Gamma Kaplan-Meier (KM) Statistics**											
808					Approximate Chi Square Value (61.41, α)	44.39			Adjusted Chi Square Value (61.41, β)			41.88
809					95% Gamma Approximate KM-UCL (use when n>=50)	0.166			95% Gamma Adjusted KM-UCL (use when n<50)			0.176
810												

	A	B	C	D	E	F	G	H	I	J	K	L
811	**Lognormal GOF Test on Detected Observations Only**											
812					Shapiro Wilk Test Statistic	0.893	**Shapiro Wilk GOF Test**					
813					5% Shapiro Wilk Critical Value	0.748	Detected Data appear Lognormal at 5% Significance Level					
814					Lilliefors Test Statistic	0.233	**Lilliefors GOF Test**					
815					5% Lilliefors Critical Value	0.375	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					-2.729
820					SD in Original Scale	0.0813	SD in Log Scale					0.788
821					95% t UCL (assumes normality of ROS data)	0.136	95% Percentile Bootstrap UCL					0.133
822					95% BCA Bootstrap UCL	0.145	95% Bootstrap t UCL					0.171
823					95% H-UCL (Log ROS)	0.18						
824												
825	**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**											
826					KM Mean (logged)	-2.202	KM Geo Mean					0.111
827					KM SD (logged)	0.363	95% Critical H Value (KM-Log)					2.046
828					KM Standard Error of Mean (logged)	0.133	95% H-UCL (KM -Log)					0.151
829					KM SD (logged)	0.363	95% Critical H Value (KM-Log)					2.046
830					KM Standard Error of Mean (logged)	0.133						
831												
832	**DL/2 Statistics**											
833		**DL/2 Normal**					**DL/2 Log-Transformed**					
834					Mean in Original Scale	0.095	Mean in Log Scale					-2.583
835					SD in Original Scale	0.077	SD in Log Scale					0.67
836					95% t UCL (Assumes normality)	0.14	95% H-Stat UCL					0.165
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	0.159						
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	**Nickel**											
851												
852	**General Statistics**											
853					Total Number of Observations	10	Number of Distinct Observations					9
854					Number of Detects	9	Number of Non-Detects					1
855					Number of Distinct Detects	8	Number of Distinct Non-Detects					1
856					Minimum Detect	4.9	Minimum Non-Detect					2
857					Maximum Detect	8.8	Maximum Non-Detect					2
858					Variance Detects	2.43	Percent Non-Detects					10%
859					Mean Detects	7.567	SD Detects					1.559
860					Median Detects	8.4	CV Detects					0.206
861					Skewness Detects	-1.2	Kurtosis Detects					-0.301
862					Mean of Logged Detects	2.001	SD of Logged Detects					0.234

	A	B	C	D	E	F	G	H	I	J	K	L
863												
864	**Normal GOF Test on Detects Only**											
865					Shapiro Wilk Test Statistic	0.747	**Shapiro Wilk GOF Test**					
866					5% Shapiro Wilk Critical Value	0.829	Detected Data Not Normal at 5% Significance Level					
867					Lilliefors Test Statistic	0.348	**Lilliefors GOF Test**					
868					5% Lilliefors Critical Value	0.274	Detected Data Not Normal at 5% Significance Level					
869	**Detected Data Not Normal at 5% Significance Level**											
870												
871	**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**											
872					KM Mean	7.01	KM Standard Error of Mean					0.73
873					KM SD	2.176	95% KM (BCA) UCL					8.06
874					95% KM (t) UCL	8.348	95% KM (Percentile Bootstrap) UCL					8.07
875					95% KM (z) UCL	8.21	95% KM Bootstrap t UCL					8.052
876					90% KM Chebyshev UCL	9.199	95% KM Chebyshev UCL					10.19
877					97.5% KM Chebyshev UCL	11.57	99% KM Chebyshev UCL					14.27
878												
879	**Gamma GOF Tests on Detected Observations Only**											
880					A-D Test Statistic	1.215	**Anderson-Darling GOF Test**					
881					5% A-D Critical Value	0.721	Detected Data Not Gamma Distributed at 5% Significance Level					
882					K-S Test Statistic	0.364	**Kolmogorov-Smirnov GOF**					
883					5% K-S Critical Value	0.279	Detected Data Not Gamma Distributed at 5% Significance Level					
884	**Detected Data Not Gamma Distributed at 5% Significance Level**											
885												
886	**Gamma Statistics on Detected Data Only**											
887					k hat (MLE)	22.53	k star (bias corrected MLE)					15.09
888					Theta hat (MLE)	0.336	Theta star (bias corrected MLE)					0.501
889					nu hat (MLE)	405.5	nu star (bias corrected)					271.7
890					Mean (detects)	7.567						
891												
892	**Gamma ROS Statistics using Imputed Non-Detects**											
893	GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs											
894	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)											
895	For such situations, GROS method may yield incorrect values of UCLs and BTVs											
896	This is especially true when the sample size is small.											
897	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates											
898					Minimum	4.685	Mean					7.279
899					Maximum	8.8	Median					8.35
900					SD	1.729	CV					0.238
901					k hat (MLE)	17.27	k star (bias corrected MLE)					12.16
902					Theta hat (MLE)	0.421	Theta star (bias corrected MLE)					0.599
903					nu hat (MLE)	345.4	nu star (bias corrected)					243.1
904					Adjusted Level of Significance (β)	0.0267						
905					Approximate Chi Square Value (243.10, α)	208	Adjusted Chi Square Value (243.10, β)					202.4
906					95% Gamma Approximate UCL (use when n>=50)	8.507	95% Gamma Adjusted UCL (use when n<50)					8.744
907												
908	**Estimates of Gamma Parameters using KM Estimates**											
909					Mean (KM)	7.01	SD (KM)					2.176
910					Variance (KM)	4.733	SE of Mean (KM)					0.73
911					k hat (KM)	10.38	k star (KM)					7.335
912					nu hat (KM)	207.7	nu star (KM)					146.7
913					theta hat (KM)	0.675	theta star (KM)					0.956
914					80% gamma percentile (KM)	9.045	90% gamma percentile (KM)					10.46

	A	B	C	D	E	F	G	H	I	J	K	L
915					95% gamma percentile (KM)	11.74					99% gamma percentile (KM)	14.39
916												
917					Gamma Kaplan-Meier (KM) Statistics							
918					Approximate Chi Square Value (146.69, α)	119.7					Adjusted Chi Square Value (146.69, β)	115.5
919					95% Gamma Approximate KM-UCL (use when n>=50)	8.591					95% Gamma Adjusted KM-UCL (use when n<50)	8.906
920												
921					Lognormal GOF Test on Detected Observations Only							
922					Shapiro Wilk Test Statistic	0.724			Shapiro Wilk GOF Test			
923					5% Shapiro Wilk Critical Value	0.829			Detected Data Not Lognormal at 5% Significance Level			
924					Lilliefors Test Statistic	0.355			Lilliefors GOF Test			
925					5% Lilliefors Critical Value	0.274			Detected Data Not Lognormal at 5% Significance Level			
926					Detected Data Not Lognormal at 5% Significance Level							
927												
928					Lognormal ROS Statistics Using Imputed Non-Detects							
929					Mean in Original Scale	7.263					Mean in Log Scale	1.952
930					SD in Original Scale	1.755					SD in Log Scale	0.269
931					95% t UCL (assumes normality of ROS data)	8.281					95% Percentile Bootstrap UCL	8.12
932					95% BCA Bootstrap UCL	8.013					95% Bootstrap t UCL	8.162
933					95% H-UCL (Log ROS)	8.701						
934												
935					Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution							
936					KM Mean (logged)	1.871					KM Geo Mean	6.492
937					KM SD (logged)	0.445					95% Critical H Value (KM-Log)	2.145
938					KM Standard Error of Mean (logged)	0.149					95% H-UCL (KM -Log)	9.85
939					KM SD (logged)	0.445					95% Critical H Value (KM-Log)	2.145
940					KM Standard Error of Mean (logged)	0.149						
941												
942					DL/2 Statistics							
943					DL/2 Normal				DL/2 Log-Transformed			
944					Mean in Original Scale	6.91					Mean in Log Scale	1.801
945					SD in Original Scale	2.544					SD in Log Scale	0.67
946					95% t UCL (Assumes normality)	8.385					95% H-Stat UCL	13.2
947					DL/2 is not a recommended method, provided for comparisons and historical reasons							
948												
949					Nonparametric Distribution Free UCL Statistics							
950					Data do not follow a Discernible Distribution at 5% Significance Level							
951												
952					Suggested UCL to Use							
953					95% KM (t) UCL	8.348					KM H-UCL	9.85
954					95% KM (BCA) UCL	8.06						
955												
956					Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.							
957					Recommendations are based upon data size, data distribution, and skewness.							
958					These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).							
959					However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.							
960												

	A	B	C	D	E	F	G	H	I	J	K	L
961	**Selenium**											
962												
963						**General Statistics**						
964					Total Number of Observations	10			Number of Distinct Observations			7
965					Number of Detects	6			Number of Non-Detects			4
966					Number of Distinct Detects	5			Number of Distinct Non-Detects			2
967					Minimum Detect	5.2			Minimum Non-Detect			4.8
968					Maximum Detect	9.3			Maximum Non-Detect			4.9
969					Variance Detects	1.855			Percent Non-Detects			40%
970					Mean Detects	7.233			SD Detects			1.362
971					Median Detects	7.3			CV Detects			0.188
972					Skewness Detects	0.0248			Kurtosis Detects			1.021
973					Mean of Logged Detects	1.963			SD of Logged Detects			0.194
974												
975						**Normal GOF Test on Detects Only**						
976					Shapiro Wilk Test Statistic	0.971			**Shapiro Wilk GOF Test**			
977					5% Shapiro Wilk Critical Value	0.788			Detected Data appear Normal at 5% Significance Level			
978					Lilliefors Test Statistic	0.186			**Lilliefors GOF Test**			
979					5% Lilliefors Critical Value	0.325			Detected Data appear Normal at 5% Significance Level			
980						**Detected Data appear Normal at 5% Significance Level**						
981												
982						**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**						
983					KM Mean	6.26			KM Standard Error of Mean			0.531
984					KM SD	1.532			95% KM (BCA) UCL			7.05
985					95% KM (t) UCL	7.233			95% KM (Percentile Bootstrap) UCL			7.07
986					95% KM (z) UCL	7.133			95% KM Bootstrap t UCL			7.082
987					90% KM Chebyshev UCL	7.853			95% KM Chebyshev UCL			8.574
988					97.5% KM Chebyshev UCL	9.575			99% KM Chebyshev UCL			11.54
989												
990						**Gamma GOF Tests on Detected Observations Only**						
991					A-D Test Statistic	0.255			**Anderson-Darling GOF Test**			
992					5% A-D Critical Value	0.697			Detected data appear Gamma Distributed at 5% Significance Level			
993					K-S Test Statistic	0.211			**Kolmogorov-Smirnov GOF**			
994					5% K-S Critical Value	0.332			Detected data appear Gamma Distributed at 5% Significance Level			
995						**Detected data appear Gamma Distributed at 5% Significance Level**						
996												
997						**Gamma Statistics on Detected Data Only**						
998					k hat (MLE)	32.83			k star (bias corrected MLE)			16.52
999					Theta hat (MLE)	0.22			Theta star (bias corrected MLE)			0.438
1000					nu hat (MLE)	393.9			nu star (bias corrected)			198.3
1001					Mean (detects)	7.233						
1002												
1003						**Gamma ROS Statistics using Imputed Non-Detects**						
1004						GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs						
1005						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)						
1006						For such situations, GROS method may yield incorrect values of UCLs and BTVs						
1007						This is especially true when the sample size is small.						
1008						For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates						
1009					Minimum	2.997			Mean			5.879
1010					Maximum	9.3			Median			5.85
1011					SD	2.056			CV			0.35
1012					k hat (MLE)	8.653			k star (bias corrected MLE)			6.124

	A	B	C	D	E	F	G	H	I	J	K	L
1013					Theta hat (MLE)	0.679					Theta star (bias corrected MLE)	0.96
1014					nu hat (MLE)	173.1					nu star (bias corrected)	122.5
1015					Adjusted Level of Significance (β)	0.0267						
1016					Approximate Chi Square Value (122.47, α)	97.91					Adjusted Chi Square Value (122.47, β)	94.1
1017					95% Gamma Approximate UCL (use when n>=50)	7.354					95% Gamma Adjusted UCL (use when n<50)	7.652
1018												
1019					**Estimates of Gamma Parameters using KM Estimates**							
1020					Mean (KM)	6.26					SD (KM)	1.532
1021					Variance (KM)	2.348					SE of Mean (KM)	0.531
1022					k hat (KM)	16.69					k star (KM)	11.75
1023					nu hat (KM)	333.7					nu star (KM)	235
1024					theta hat (KM)	0.375					theta star (KM)	0.533
1025					80% gamma percentile (KM)	7.723					90% gamma percentile (KM)	8.685
1026					95% gamma percentile (KM)	9.535					99% gamma percentile (KM)	11.27
1027												
1028					**Gamma Kaplan-Meier (KM) Statistics**							
1029					Approximate Chi Square Value (234.95, α)	200.5					Adjusted Chi Square Value (234.95, β)	194.9
1030					95% Gamma Approximate KM-UCL (use when n>=50)	7.337					95% Gamma Adjusted KM-UCL (use when n<50)	7.545
1031												
1032					**Lognormal GOF Test on Detected Observations Only**							
1033					Shapiro Wilk Test Statistic	0.961			**Shapiro Wilk GOF Test**			
1034					5% Shapiro Wilk Critical Value	0.788			Detected Data appear Lognormal at 5% Significance Level			
1035					Lilliefors Test Statistic	0.217			**Lilliefors GOF Test**			
1036					5% Lilliefors Critical Value	0.325			Detected Data appear Lognormal at 5% Significance Level			
1037					**Detected Data appear Lognormal at 5% Significance Level**							
1038												
1039					**Lognormal ROS Statistics Using Imputed Non-Detects**							
1040					Mean in Original Scale	6.048					Mean in Log Scale	1.757
1041					SD in Original Scale	1.856					SD in Log Scale	0.31
1042					95% t UCL (assumes normality of ROS data)	7.124					95% Percentile Bootstrap UCL	7.037
1043					95% BCA Bootstrap UCL	7.059					95% Bootstrap t UCL	7.238
1044					95% H-UCL (Log ROS)	7.465						
1045												
1046					**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**							
1047					KM Mean (logged)	1.805					KM Geo Mean	6.083
1048					KM SD (logged)	0.237					95% Critical H Value (KM-Log)	1.915
1049					KM Standard Error of Mean (logged)	0.0821					95% H-UCL (KM -Log)	7.278
1050					KM SD (logged)	0.237					95% Critical H Value (KM-Log)	1.915
1051					KM Standard Error of Mean (logged)	0.0821						
1052												
1053					**DL/2 Statistics**							
1054					**DL/2 Normal**				**DL/2 Log-Transformed**			
1055					Mean in Original Scale	5.315					Mean in Log Scale	1.534
1056					SD in Original Scale	2.677					SD in Log Scale	0.572
1057					95% t UCL (Assumes normality)	6.867					95% H-Stat UCL	8.516
1058					**DL/2 is not a recommended method, provided for comparisons and historical reasons**							
1059												
1060					**Nonparametric Distribution Free UCL Statistics**							
1061					**Detected Data appear Normal Distributed at 5% Significance Level**							
1062												
1063					**Suggested UCL to Use**							
1064					95% KM (t) UCL	7.233						

	A	B	C	D	E	F	G	H	I	J	K	L
1065												
1066	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
1067	Recommendations are based upon data size, data distribution, and skewness.											
1068	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
1069	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
1070												
1071	**Silver**											
1072												
1073	**General Statistics**											
1074					Total Number of Observations	10			Number of Distinct Observations			2
1075					Number of Detects	0			Number of Non-Detects			10
1076					Number of Distinct Detects	0			Number of Distinct Non-Detects			2
1077												
1078	**Warning: All observations are Non-Detects (NDs), therefore all statistics and estimates should also be NDs!**											
1079	**Specifically, sample mean, UCLs, UPLs, and other statistics are also NDs lying below the largest detection limit!**											
1080	**The Project Team may decide to use alternative site specific values to estimate environmental parameters (e.g., EPC, BTV).**											
1081												
1082	**The data set for variable Silver was not processed!**											
1083												
1084												
1085	**Thallium**											
1086												
1087	**General Statistics**											
1088					Total Number of Observations	10			Number of Distinct Observations			4
1089					Number of Detects	0			Number of Non-Detects			10
1090					Number of Distinct Detects	0			Number of Distinct Non-Detects			4
1091												
1092	**Warning: All observations are Non-Detects (NDs), therefore all statistics and estimates should also be NDs!**											
1093	**Specifically, sample mean, UCLs, UPLs, and other statistics are also NDs lying below the largest detection limit!**											
1094	**The Project Team may decide to use alternative site specific values to estimate environmental parameters (e.g., EPC, BTV).**											
1095												
1096	**The data set for variable Thallium was not processed!**											
1097												
1098												
1099												
1100	**Zinc**											
1101												
1102	**General Statistics**											
1103					Total Number of Observations	10			Number of Distinct Observations			10
1104									Number of Missing Observations			0
1105					Minimum	47			Mean			135.2
1106					Maximum	290			Median			125
1107					SD	74.28			Std. Error of Mean			23.49
1108					Coefficient of Variation	0.549			Skewness			1.018
1109												
1110	**Normal GOF Test**											
1111					Shapiro Wilk Test Statistic	0.922			**Shapiro Wilk GOF Test**			
1112					5% Shapiro Wilk Critical Value	0.842			Data appear Normal at 5% Significance Level			
1113					Lilliefors Test Statistic	0.174			**Lilliefors GOF Test**			
1114					5% Lilliefors Critical Value	0.262			Data appear Normal at 5% Significance Level			
1115	**Data appear Normal at 5% Significance Level**											
1116												

	A	B	C	D	E	F	G	H	I	J	K	L
1117	**Assuming Normal Distribution**											
1118	**95% Normal UCL**						**95% UCLs (Adjusted for Skewness)**					
1119					95% Student's-t UCL	178.3				95% Adjusted-CLT UCL (Chen-1995)		181.9
1120										95% Modified-t UCL (Johnson-1978)		179.5
1121												
1122	**Gamma GOF Test**											
1123					A-D Test Statistic	0.194	**Anderson-Darling Gamma GOF Test**					
1124					5% A-D Critical Value	0.73	Detected data appear Gamma Distributed at 5% Significance Level					
1125					K-S Test Statistic	0.132	**Kolmogorov-Smirnov Gamma GOF Test**					
1126					5% K-S Critical Value	0.268	Detected data appear Gamma Distributed at 5% Significance Level					
1127	**Detected data appear Gamma Distributed at 5% Significance Level**											
1128												
1129	**Gamma Statistics**											
1130					k hat (MLE)	3.835				k star (bias corrected MLE)		2.751
1131					Theta hat (MLE)	35.25				Theta star (bias corrected MLE)		49.14
1132					nu hat (MLE)	76.7				nu star (bias corrected)		55.03
1133					MLE Mean (bias corrected)	135.2				MLE Sd (bias corrected)		81.51
1134										Approximate Chi Square Value (0.05)		38.98
1135					Adjusted Level of Significance	0.0267				Adjusted Chi Square Value		36.64
1136												
1137	**Assuming Gamma Distribution**											
1138					95% Approximate Gamma UCL (use when n>=50))	190.9				95% Adjusted Gamma UCL (use when n<50)		203
1139												
1140	**Lognormal GOF Test**											
1141					Shapiro Wilk Test Statistic	0.977	**Shapiro Wilk Lognormal GOF Test**					
1142					5% Shapiro Wilk Critical Value	0.842	Data appear Lognormal at 5% Significance Level					
1143					Lilliefors Test Statistic	0.15	**Lilliefors Lognormal GOF Test**					
1144					5% Lilliefors Critical Value	0.262	Data appear Lognormal at 5% Significance Level					
1145	**Data appear Lognormal at 5% Significance Level**											
1146												
1147	**Lognormal Statistics**											
1148					Minimum of Logged Data	3.85				Mean of logged Data		4.771
1149					Maximum of Logged Data	5.67				SD of logged Data		0.559
1150												
1151	**Assuming Lognormal Distribution**											
1152					95% H-UCL	212				90% Chebyshev (MVUE) UCL		209.1
1153					95% Chebyshev (MVUE) UCL	242.3				97.5% Chebyshev (MVUE) UCL		288.5
1154					99% Chebyshev (MVUE) UCL	379.3						
1155												
1156	**Nonparametric Distribution Free UCL Statistics**											
1157	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
1158												
1159	**Nonparametric Distribution Free UCLs**											
1160					95% CLT UCL	173.8				95% Jackknife UCL		178.3
1161					95% Standard Bootstrap UCL	172				95% Bootstrap-t UCL		198.1
1162					95% Hall's Bootstrap UCL	232.3				95% Percentile Bootstrap UCL		175.1
1163					95% BCA Bootstrap UCL	178.1						
1164					90% Chebyshev(Mean, Sd) UCL	205.7				95% Chebyshev(Mean, Sd) UCL		237.6
1165					97.5% Chebyshev(Mean, Sd) UCL	281.9				99% Chebyshev(Mean, Sd) UCL		368.9
1166												
1167	**Suggested UCL to Use**											
1168					95% Student's-t UCL	178.3						

	A	B	C	D	E	F	G	H	I	J	K	L
1169												
1170	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
1171	Recommendations are based upon data size, data distribution, and skewness.											
1172	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
1173	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
1174												

Table D-1
Descriptive Statistics for all Data and Specific Source Types in Exposure Area 1 and Exposure Area 2

				Summary Statistics											
Exposure Area	Analyte	Unit	Source Type	No. of Samples	Detection Rate	No. of Detects	Mean	Std Dev	KM Mean	KM Std Dev	Min Detected	Max Detected	Min DL of NDs	Max DL of NDs	Parametric Distributed?
EA1	**Antimony**	**mg/kg**	**All**	**22**	**18%**	**4**	**5.16**	**0.62**	**5.07**	**0.64**	**5.3**	**7.2**	**4.8**	**5**	**Normal**
EA1	Antimony	mg/kg	Low grade ore	10	40%	4	5.47	0.84	5.45	0.808	5.3	7.2	4.9	5	
EA1	Antimony	mg/kg	Tailings	2	0%	0	-	-	-	-	-	-	4.9	5	
EA1	Antimony	mg/kg	Waste Rock	10	0%	0	-	-	-	-	-	-	4.8	5	
EA1	**Arsenic**	**mg/kg**	**All**	**22**	**100%**	**22**	**115**	**77**	**-**	**-**	**19**	**250**	**-**	**-**	**Normal**
EA1	Arsenic	mg/kg	Low grade ore	10	100%	10	165	72	-	-	36	250	-	-	
EA1	Arsenic	mg/kg	Tailings	2	100%	2	150	42	-	-	120	180	-	-	
EA1	Arsenic	mg/kg	Waste Rock	10	100%	10	58.3	41.3	-	-	19	120	-	-	
EA1	**Barium**	**mg/kg**	**All**	**22**	**100%**	**22**	**27.6**	**15.6**	**-**	**-**	**6.7**	**64**	**-**	**-**	**Normal**
EA1	Barium	mg/kg	Low grade ore	10	100%	10	32.0	16.8	-	-	13	64	-	-	
EA1	Barium	mg/kg	Tailings	2	100%	2	9.9	4.5	-	-	6.7	13	-	-	
EA1	Barium	mg/kg	Waste Rock	10	100%	10	26.8	13.9	-	-	7.6	50	-	-	
EA1	**Cadmium**	**mg/kg**	**All**	**22**	**41%**	**9**	**1.04**	**1.36**	**1.03**	**1.33**	**0.75**	**6.8**	**0.48**	**0.5**	**Gamma**
EA1	Cadmium	mg/kg	Low grade ore	10	10%	1	0.522	0.094	0.511	0.093	0.79	0.79	0.48	0.5	
EA1	Cadmium	mg/kg	Tailings	2	0%	0	-	-	-	-	-	-	0.48	0.5	
EA1	Cadmium	mg/kg	Waste Rock	10	80%	8	1.66	1.87			0.75	6.8	0.49	0.5	
EA1	**Chromium**	**mg/kg**	**All**	**22**	**32%**	**7**	**3.31**	**2.90**	**3.26**	**2.85**	**2**	**14**	**1.9**	**2**	**Normal**
EA1	Chromium	mg/kg	Low grade ore	10	30%	3	3.96	3.89	3.91	3.719	5.5	14	1.9	2	
EA1	Chromium	mg/kg	Tailings	2	50%	1	2.25	0.354	2.25	0.250	2.5	2.5	2	2	
EA1	Chromium	mg/kg	Waste Rock	10	30%	3	2.87	1.86			2.0	6.5	1.9	2	
EA1	**Copper**	**mg/kg**	**All**	**22**	**100%**	**22**	**3,260**	**4,520**	**-**	**-**	**240**	**22,000**	**-**	**-**	**Gamma**
EA1	Copper	mg/kg	Low grade ore	10	100%	10	5,078	6,191	-	-	480	22,000	-	-	
EA1	Copper	mg/kg	Tailings	2	100%	2	990	438	-	-	680	1,300	-	-	
EA1	Copper	mg/kg	Waste Rock	10	100%	10	1,897	1,564	-	-	240	5,000	-	-	
EA1	**Lead**	**mg/kg**	**All**	**22**	**100%**	**22**	**36.2**	**31.2**	**-**	**-**	**5.7**	**140**	**-**	**-**	**Gamma**
EA1	Lead	mg/kg	Low grade ore	10	100%	10	58.8	31.9	-	-	22	140	-	-	
EA1	Lead	mg/kg	Tailings	2	100%	2	16.5	2.1	-	-	15	18	-	-	
EA1	Lead	mg/kg	Waste Rock	10	100%	10	17.4	14.4	-	-	5.7	56	-	-	
EA1	**Manganese**	**mg/kg**	**All**	**22**	**100%**	**22**	**623.6**	**519.3**	**-**	**-**	**150**	**2,400**	**-**	**-**	**Gamma**
EA1	Manganese	mg/kg	Low grade ore	10	100%	10	407	235	-	-	230	1000	-	-	
EA1	Manganese	mg/kg	Tailings	2	100%	2	185	49	-	-	150	220	-	-	
EA1	Manganese	mg/kg	Waste Rock	10	100%	10	928	613	-	-	250	2,400	-	-	
EA1	**Mercury**	**mg/kg**	**All**	**22**	**100%**	**22**	**0.942**	**0.793**	**-**	**-**	**0.14**	**2.7**	**-**	**-**	**Gamma**
EA1	Mercury	mg/kg	Low grade ore	10	100%	10	0.972	0.869	-	-	0.14	2.7	-	-	
EA1	Mercury	mg/kg	Tailings	2	100%	2	0.360	0.141	-	-	0.26	0.46	-	-	
EA1	Mercury	mg/kg	Waste Rock	10	100%	10	1.03	0.79	-	-	0.14	2.2	-	-	
EA1	**Nickel**	**mg/kg**	**All**	**22**	**41%**	**9**	**3.11**	**2.74**	**3.07**	**2.69**	**2.1**	**14**	**1.9**	**2**	**Gamma**
EA1	Nickel	mg/kg	Low grade ore	10	50%	5	3.63	3.75	3.6	3.569	2.1	14	1.9	2	
EA1	Nickel	mg/kg	Tailings	2	0%	0	-	-	-	-	-	-	1.9	2	
EA1	Nickel	mg/kg	Waste Rock	10	40%	4	2.82	1.65			2.3	7.2	1.9	2	
EA1	**Selenium**	**mg/kg**	**All**	**22**	**100%**	**22**	30.47	20.63	-	-	**5.4**	**77**	**-**	**-**	**Gamma**
EA1	Selenium	mg/kg	Low grade ore	10	100%	10	47.60	18.60	-	-	16	77	-	-	
EA1	Selenium	mg/kg	Tailings	2	100%	2	25.50	6.36	-	-	21	30	-	-	
EA1	Selenium	mg/kg	Waste Rock	10	100%	10	14.34	4.68	-	-	5.4	20	-	-	

Table D-1
Descriptive Statistics for all Data and Specific Source Types in Exposure Area 1 and Exposure Area 2

				Summary Statistics											
Exposure Area	Analyte	Unit	Source Type	No. of Samples	Detection Rate	No. of Detects	Mean	Std Dev	KM Mean	KM Std Dev	Min Detected	Max Detected	Min DL of NDs	Max DL of NDs	Parametric Distributed?
EA1	**Silver**	**mg/kg**	**All**	**22**	**59%**	**13**	**5.95**	**5.10**	**5.93**	**5.00**	**3**	**20**	**2.4**	**2.5**	**Normal**
EA1	Silver	mg/kg	Low grade ore	10	90%	9	9.52	5.82	9.52	5.52	3.4	20	2.4	2.4	
EA1	Silver	mg/kg	Tailings	2	100%	2	4.80	0.14	-	-	4.7	4.9	-	-	
EA1	Silver	mg/kg	Waste Rock	10	20%	2	2.62	0.36			3	3.5	2.4	2.5	
EA1	**Zinc**	**mg/kg**	**All**	**22**	**100%**	**22**	304.68	356.85	-	-	**57**	**1,800**	**-**	**-**	**Lognormal**
EA1	Zinc	mg/kg	Low grade ore	10	100%	10	207.60	91.24	-	-	86	350	-	-	
EA1	Zinc	mg/kg	Tailings	2	100%	2	83.50	37.48	-	-	57	110	-	-	
EA1	Zinc	mg/kg	Waste Rock	10	100%	10	446.00	495.09	-	-	120	1,800	-	-	
EA2	**Antimony**	**mg/kg**	**All**	**14**	**57%**	**8**	16.27	14.69			**5.3**	**42**	**4.9**	**5**	**Normal**
EA2	Antimony	mg/kg	High grade ore	1	100%	1	5.30	-			5.3	5.3	-	-	
EA2	Antimony	mg/kg	Soil	7	57%	4	14.39	12.28			6.8	36	4.9	5	
EA2	Antimony	mg/kg	Tailings	3	0%	0	-	-			-	-	4.9	5	
EA2	Antimony	mg/kg	Waste concentrate	3	100%	3	35.67	10.97			23	42	-	-	
EA2	**Arsenic**	**mg/kg**	**All**	**14**	**100%**	**14**	203.07	143.82			**31**	**430**	**-**	**-**	**Gamma**
EA2	Arsenic	mg/kg	High grade ore	1	100%	1	410.0	-			410	410	-	-	
EA2	Arsenic	mg/kg	Soil	7	100%	7	234.14	159.87			31	430	-	-	
EA2	Arsenic	mg/kg	Tailings	3	100%	3	99.33	31.01			68	130	-	-	
EA2	Arsenic	mg/kg	Waste concentrate	3	100%	3	165.33	117.24			86	300	-	-	
EA2	**Barium**	**mg/kg**	**All**	**14**	**79%**	**11**	71.83	72.90			**6.7**	**270**	**4.9**	**99**	**Normal**
EA2	Barium	mg/kg	High grade ore	1	100%	1	6.70	-			6.7	6.7	-	-	
EA2	Barium	mg/kg	Soil	7	71%	5	105.57	83.46			58	270	5	99	
EA2	Barium	mg/kg	Tailings	3	67%	2	33.97	37.28			21	76	4.9	4.9	
EA2	Barium	mg/kg	Waste concentrate	3	100%	3	52.67	58.73			12	120	-	-	
EA2	**Cadmium**	**mg/kg**	**All**	**14**	**57%**	**8**	5.57	17.12			**0.67**	**65**	**0.49**	**0.5**	**Non-parametric**
EA2	Cadmium	mg/kg	High grade ore	1	0%	0	-	-			-	-	0.5	0.5	
EA2	Cadmium	mg/kg	Soil	7	71%	5	1.05	0.57			0.67	2	0.5	0.5	
EA2	Cadmium	mg/kg	Tailings	3	0%	0	-	-			-	-	0.49	0.49	
EA2	Cadmium	mg/kg	Waste concentrate	3	100%	3	22.87	36.49			1.4	65	-	-	
EA2	**Chromium**	**mg/kg**	**All**	**14**	**71%**	**10**	24.44	51.19			**2.7**	**30**	**2**	**200**	**Normal**
EA2	Chromium	mg/kg	High grade ore	1	0%	0	-	-			-	-	200	200	
EA2	Chromium	mg/kg	Soil	7	86%	6	14.0	9.1			8.7	30	2	2	
EA2	Chromium	mg/kg	Tailings	3	67%	2	7.77	7.32			5.3	16	2	2	
EA2	Chromium	mg/kg	Waste concentrate	3	67%	2	6.90	7.89			2.7	16	2	2	
EA2	**Copper**	**mg/kg**	**All**	**14**	**100%**	**14**	**7,977**	**7,842**			**880**	**24,000**	**-**	**-**	**Normal**
EA2	Copper	mg/kg	High grade ore	1	100%	1	4,600	-			4,600	4,600	-	-	
EA2	Copper	mg/kg	Soil	7	100%	7	7,629	6,325			1,200	20,000	-	-	
EA2	Copper	mg/kg	Tailings	3	100%	3	1,060	216			880	1,300	-	-	
EA2	Copper	mg/kg	Waste concentrate	3	100%	3	16,833	9,170			6,500	24,000	-	-	
EA2	**Lead**	**mg/kg**	**All**	**14**	**100%**	**14**	**244**	**326**			**18**	**1,200**	**-**	**-**	**Gamma**
EA2	Lead	mg/kg	High grade ore	1	100%	1	41.0	-			41	41	-	-	
EA2	Lead	mg/kg	Soil	7	100%	7	216	218			21	570	-	-	
EA2	Lead	mg/kg	Tailings	3	100%	3	36.3	19.6			18	57	-	-	
EA2	Lead	mg/kg	Waste concentrate	3	100%	3	583	535			240	1,200	-	-	

Table D-1
Descriptive Statistics for all Data and Specific Source Types in Exposure Area 1 and Exposure Area 2

				Summary Statistics											
Exposure Area	Analyte	Unit	Source Type	No. of Samples	Detection Rate	No. of Detects	Mean	Std Dev	KM Mean	KM Std Dev	Min Detected	Max Detected	Min DL of NDs	Max DL of NDs	Parametric Distributed?
EA2	**Manganese**	**mg/kg**	**All**	**14**	**100%**	**14**	**293**	**166**			**120**	**700**	**-**	**-**	**Lognormal**
EA2	Manganese	mg/kg	High grade ore	1	100%	1	260	-			260	260	-	-	
EA2	Manganese	mg/kg	Soil	7	100%	7	300	151			140	610	-	-	
EA2	Manganese	mg/kg	Tailings	3	100%	3	173	55			120	230	-	-	
EA2	Manganese	mg/kg	Waste concentrate	3	100%	3	407	259			210	700	-	-	
EA2	**Mercury**	**mg/kg**	**All**	**14**	**100%**	**14**	**2.55**	**4.48**			**0.17**	**14**	**-**	**-**	**Lognormal**
EA2	Mercury	mg/kg	High grade ore	1	100%	1	2.00	-			2	2	-	-	
EA2	Mercury	mg/kg	Soil	7	100%	7	3.99	6.19			0.17	14	-	-	
EA2	Mercury	mg/kg	Tailings	3	100%	3	0.650	0.476			0.37	1.2	-	-	
EA2	Mercury	mg/kg	Waste concentrate	3	100%	3	1.30	0.20			1.1	1.5	-	-	
EA2	**Nickel**	**mg/kg**	**All**	**14**	**79%**	**11**	8.60	6.40			**3.1**	**22**	**2**	**2**	**Normal**
EA2	Nickel	mg/kg	High grade ore	1	0%	0	-	-			-	-	2	2	
EA2	Nickel	mg/kg	Soil	7	86%	6	9.29	5.96			6.9	21	2	2	
EA2	Nickel	mg/kg	Tailings	3	67%	2	4.50	3.42			3.1	8.4	2	2	
EA2	Nickel	mg/kg	Waste concentrate	3	100%	3	13.3	8.1			5.9	22	-	-	
EA2	**Selenium**	**mg/kg**	**All**	**14**	**100%**	**14**	**35.2**	**17.9**			**8.3**	**59**	**-**	**-**	**Normal**
EA2	Selenium	mg/kg	High grade ore	1	100%	1	51.0	-			51	51	-	-	
EA2	Selenium	mg/kg	Soil	7	100%	7	32.3	19.7			8.3	58	-	-	
EA2	Selenium	mg/kg	Tailings	3	100%	3	24.0	9.8			13	32	-	-	
EA2	Selenium	mg/kg	Waste concentrate	3	100%	3	48.0	14.9			31	59	-	-	
EA2	**Silver**	**mg/kg**	**All**	**14**	**93%**	**13**	7.10	3.86			**2.5**	**14**	**2.5**	**2.5**	**Normal**
EA2	Silver	mg/kg	High grade ore	1	100%	1	11.0	-			11	11	-	-	
EA2	Silver	mg/kg	Soil	7	86%	6	7.23	4.38			3.7	14	2.5	2.5	
EA2	Silver	mg/kg	Tailings	3	100%	3	4.40	1.73			2.5	5.9	-	-	
EA2	Silver	mg/kg	Waste concentrate	3	100%	3	8.20	4.01			3.6	11	-	-	
EA2	**Zinc**	**mg/kg**	**All**	**14**	**100%**	**14**	**1,277**	**3,953**			**55**	**15,000**	**-**	**-**	**Non-parametric**
EA2	Zinc	mg/kg	High grade ore	1	100%	1	140	-			140	140	-	-	
EA2	Zinc	mg/kg	Soil	7	100%	7	237	145			55	430	-	-	
EA2	Zinc	mg/kg	Tailings	3	100%	3	68.0	3.6			65	72	-	-	
EA2	Zinc	mg/kg	Waste concentrate	3	100%	3	5,293	8,406			400	15,000	-	-	

Notes:

Mean and standard deviation calculated assuming all concentrations are detected for those metals with detection frequency less than 100%. Mean and standard deviation not calculated where detection frequency is zero (0%).

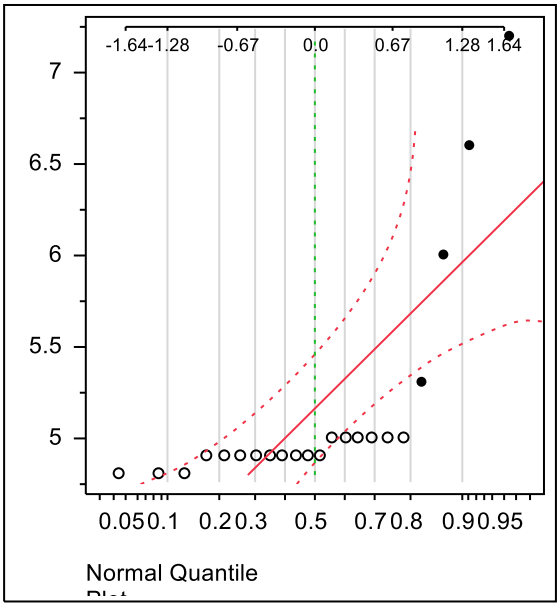
Additional summary statistics showing Kaplan-Meier (KM) mean and standard deviation presented for reference. KM statistics and other statistical parameters are presented in ProUCL output.

Bold text intended to aid presentation only.

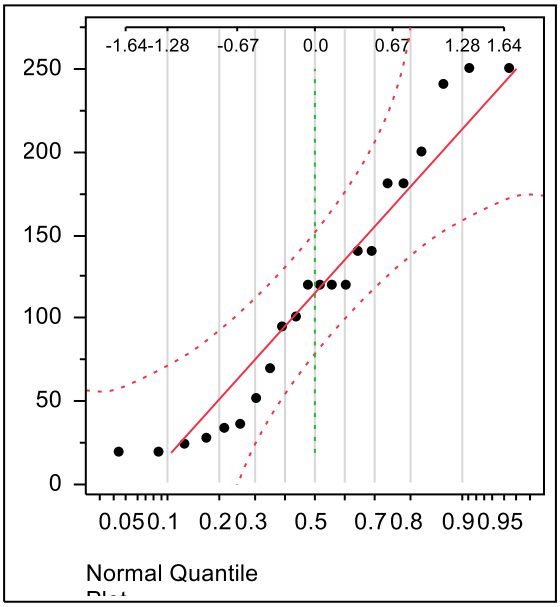
Normal Quantile Plots for Exposure Area 1 and Exposure Area 2

Exposure Area 1

Distributions Exposure Area=EA1, Analyte=Antimony, Unit=mg/kg, Parametric Distributed?=Normal
Conc or Transformed Conc (mg/kg)

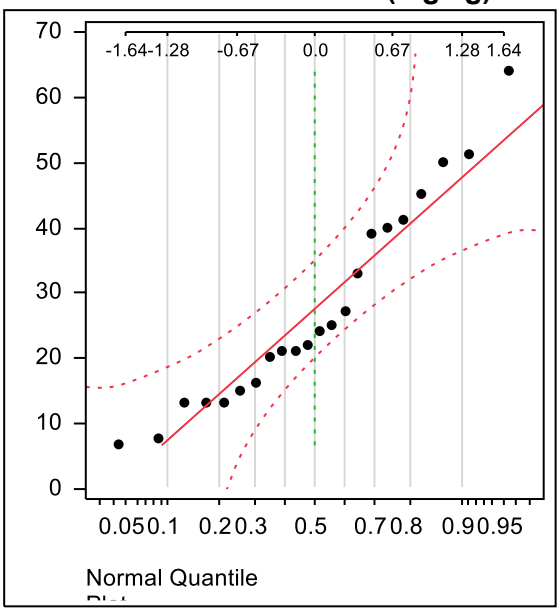


Distributions Exposure Area=EA1, Analyte=Arsenic, Unit=mg/kg, Parametric Distributed?=Normal
Conc or Transformed Conc (mg/kg)

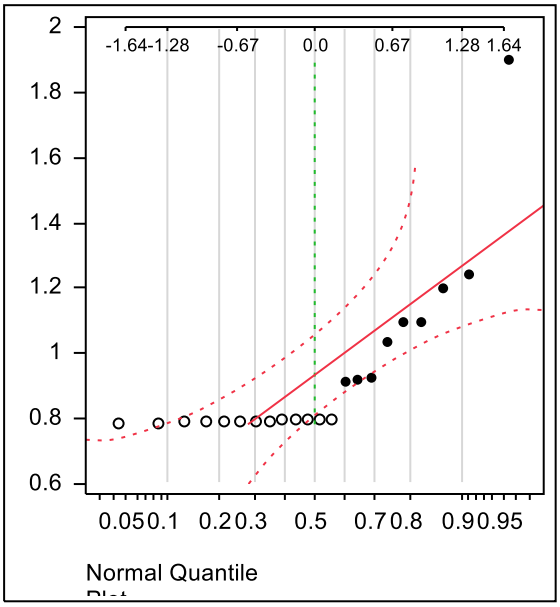


Normal Quantile Plots for Exposure Area 1 and Exposure Area 2

Distributions Exposure Area=EA1, Analyte=Barium, Units=mg/kg, Parametric Distributed?=Normal
Conc or Transformed Conc (mg/kg)

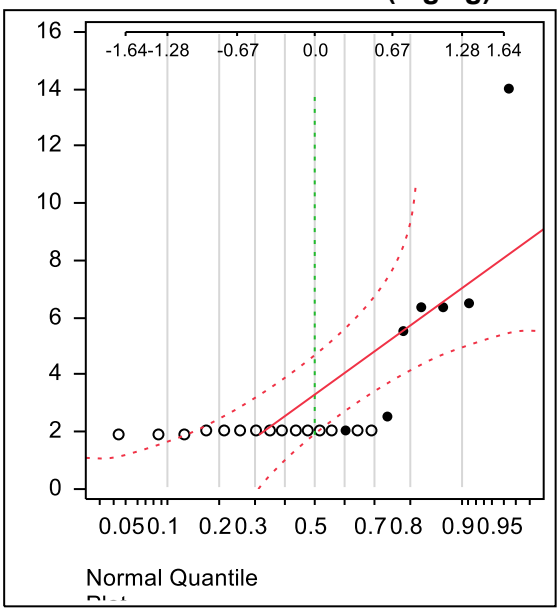


Distributions Exposure Area=EA1, Analyte=Cadmium, Unit=mg/kg, Parametric Distributed?=Gamma
Conc or Transformed Conc (mg/kg)

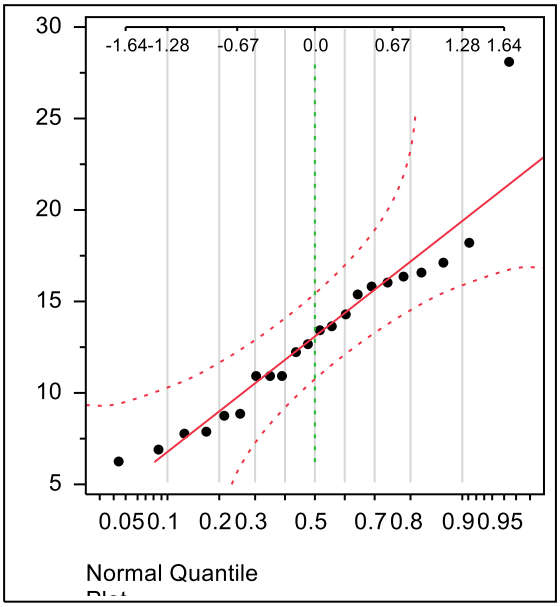


Normal Quantile Plots for Exposure Area 1 and Exposure Area 2

Distributions Exposure Area=EA1, Analyte=Chromium, Units=mg/kg, Parametric Distributed?=Normal
Conc or Transformed Conc (mg/kg)

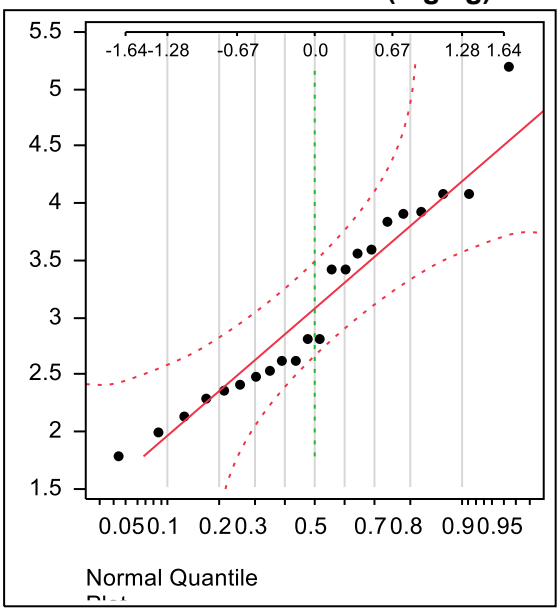


Distributions Exposure Area=EA1, Analyte=Copper, Unit=mg/kg, Parametric Distributed?=Gamma
Conc or Transformed Conc (mg/kg)

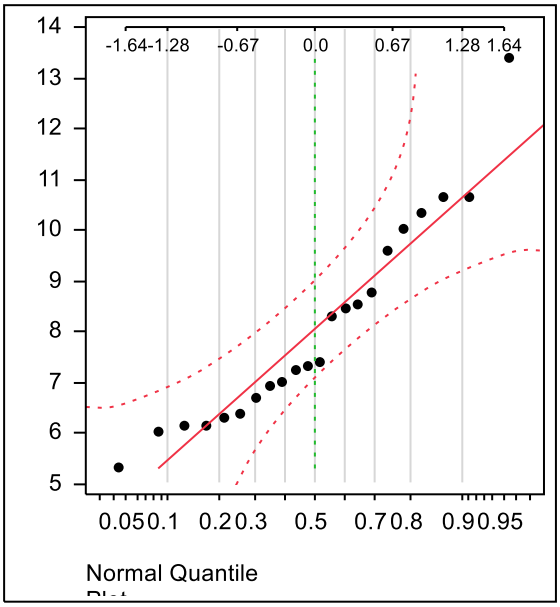


Normal Quantile Plots for Exposure Area 1 and Exposure Area 2

Distributions Exposure Area=EA1, Analyte=Lead, Unit=mg/kg, Parametric Distributed?=Gamma
Conc or Transformed Conc (mg/kg)

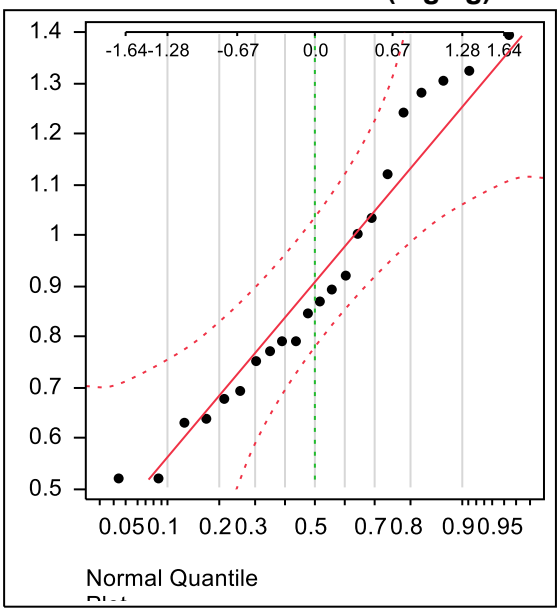


Distributions Exposure Area=EA1, Analyte=Manganese, Unit=mg/kg, Parametric Distributed?=Gamma
Conc or Transformed Conc (mg/kg)

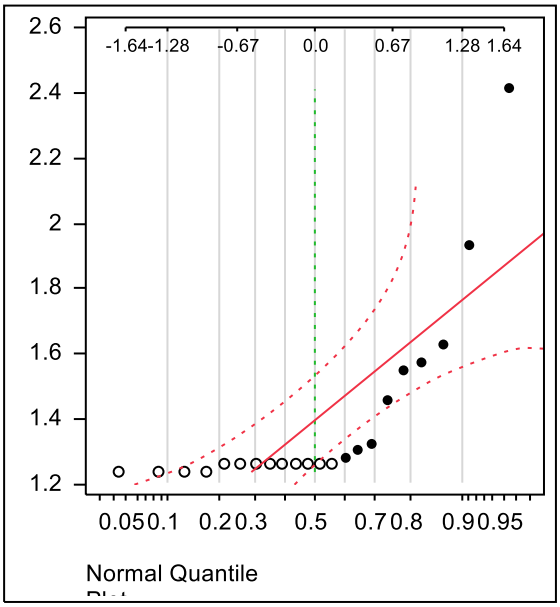


Normal Quantile Plots for Exposure Area 1 and Exposure Area 2

Distributions Exposure Area=EA1, Analyte=Mercury, Unit=mg/kg, Parametric Distributed?=Gamma
Conc or Transformed Conc (mg/kg)

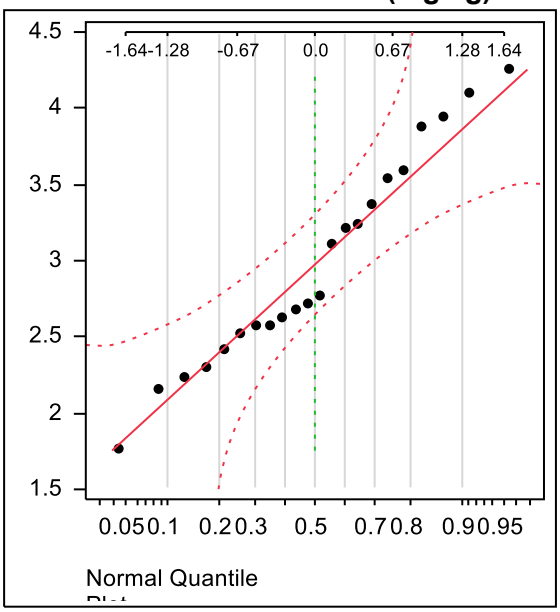


Distributions Exposure Area=EA1, Analyte=Nickel, Unit=mg/kg, Parametric Distributed?=Gamma
Conc or Transformed Conc (mg/kg)

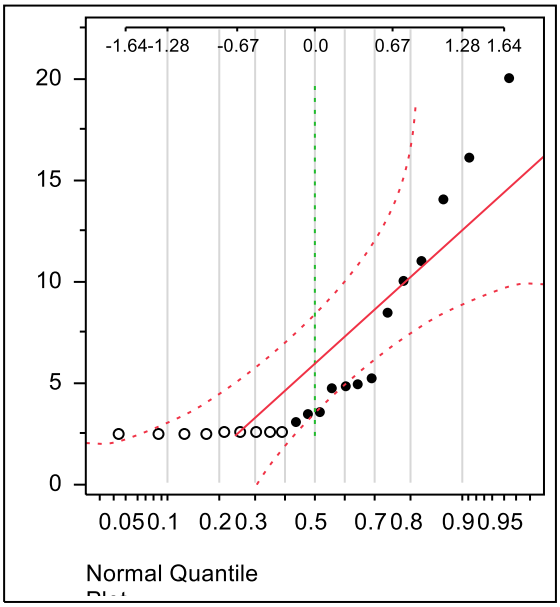


Normal Quantile Plots for Exposure Area 1 and Exposure Area 2

Distributions Exposure Area=EA1, Analyte=Selenium, Unit=mg/kg, Parametric Distributed?=Gamma
Conc or Transformed Conc (mg/kg)

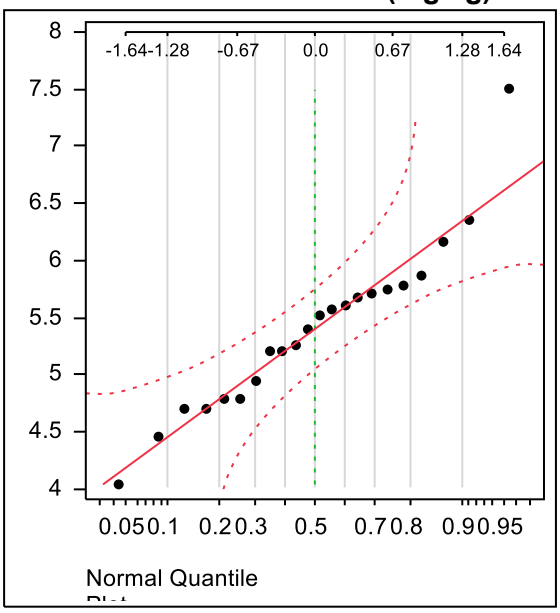


Distributions Exposure Area=EA1, Analyte=Silver, Unit=mg/kg, Parametric Distributed?=Normal
Conc or Transformed Conc (mg/kg)



Normal Quantile Plots for Exposure Area 1 and Exposure Area 2

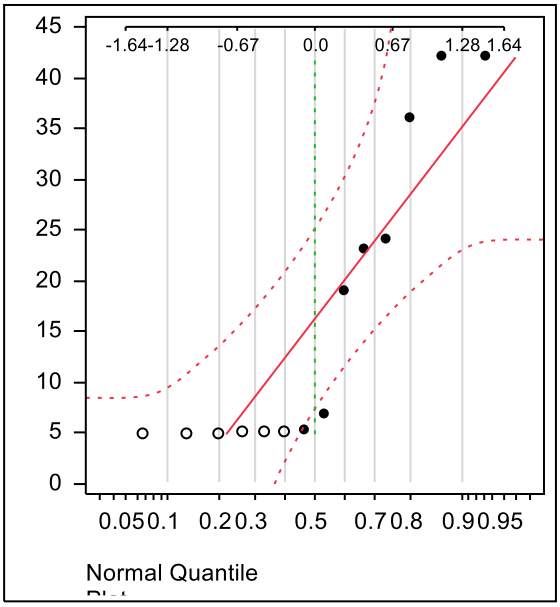
Distributions Exposure Area=EA1, Analyte=Zinc, Unit=mg/kg, Parametric Distributed?=Lognormal
Conc or Transformed Conc (mg/kg)



Normal Quantile Plots for Exposure Area 1 and Exposure Area 2

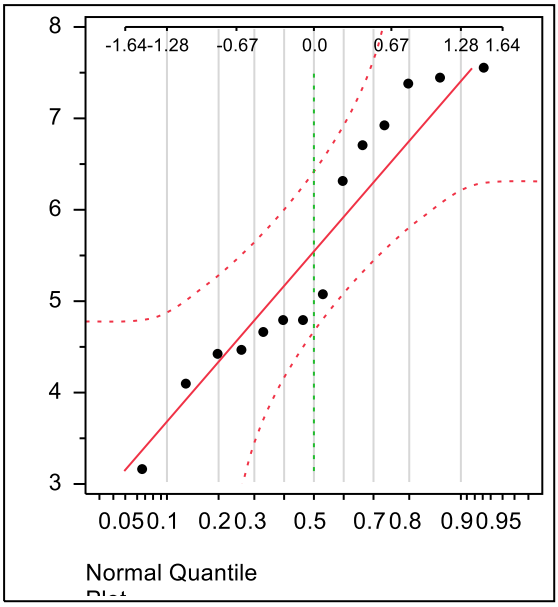
Exposure Area 2

Distributions Exposure Area=EA2, Analyte=Antimony, Unit=mg/kg, Parametric Distributed?=Normal
Conc or Transformed Conc (mg/kg)



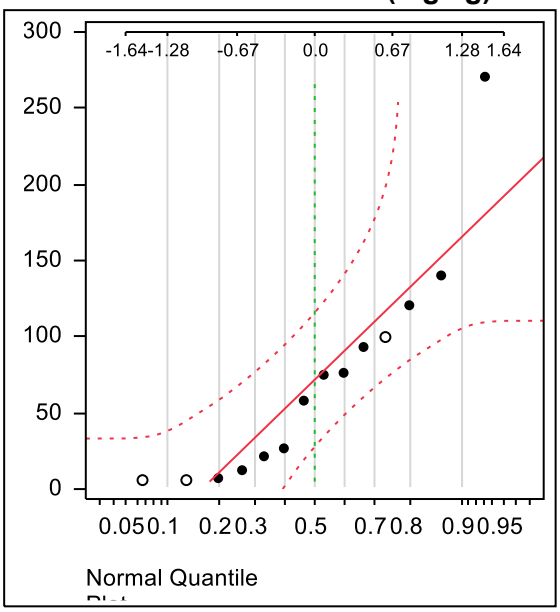
Distributions Exposure Area=EA2, Analyte=Arsenic, Unit=mg/kg, Parametric Distributed?=Gamma

Conc or Transformed Conc (mg/kg)

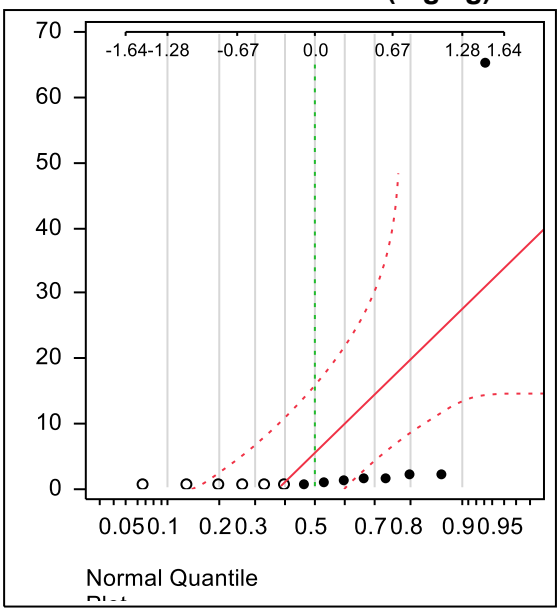


Normal Quantile Plots for Exposure Area 1 and Exposure Area 2

Distributions Exposure Area=EA2, Analyte=Barium, Units=mg/kg, Parametric Distributed?=Normal
Conc or Transformed Conc (mg/kg)

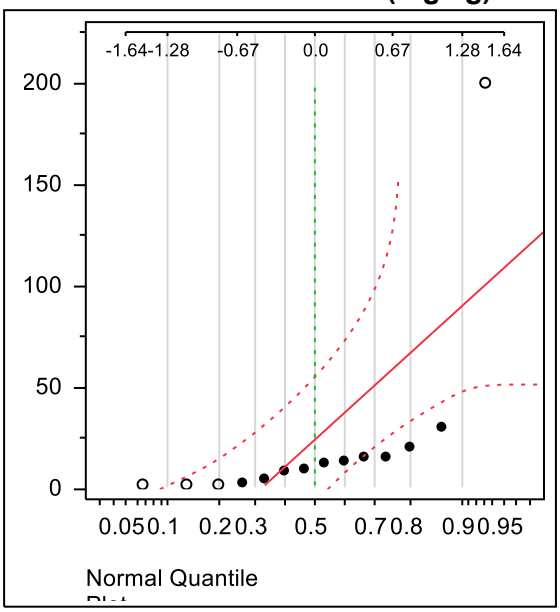


Distributions Exposure Area=EA2, Analyte=Cadmium, Unit=mg/kg, Parametric Distributed?=Non-parametric
Conc or Transformed Conc (mg/kg)

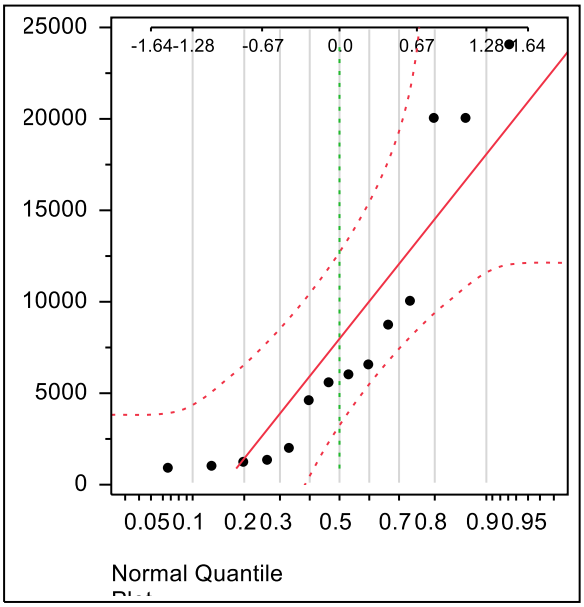


Normal Quantile Plots for Exposure Area 1 and Exposure Area 2

Distributions Exposure Area=EA2, Analyte=Chromium, Unit=mg/kg, Parametric Distributed?=Normal
Conc or Transformed Conc (mg/kg)

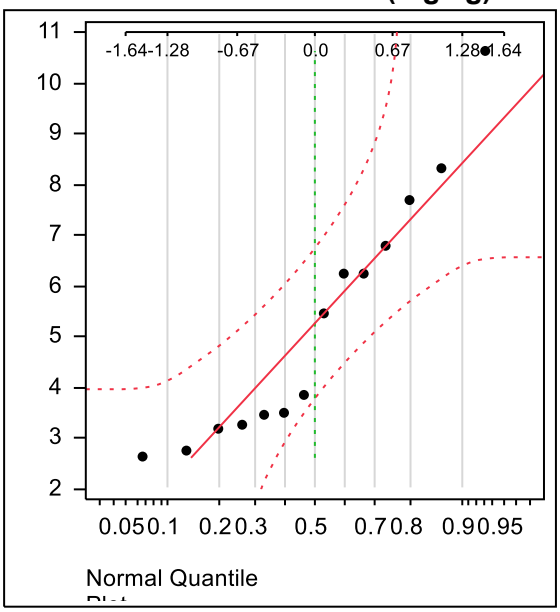


Distributions Exposure Area=EA2, Analyte=Copper, Unit=mg/kg, Parametric Distributed?=Normal
Conc or Transformed Conc (mg/kg)

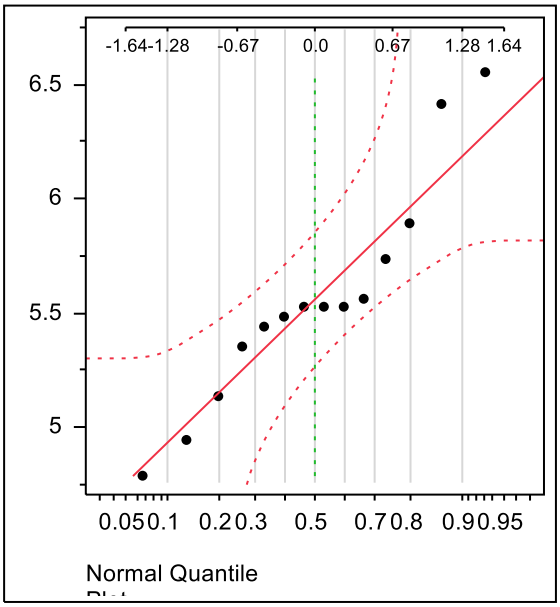


Normal Quantile Plots for Exposure Area 1 and Exposure Area 2

Distributions Exposure Area=EA2, Analyte=Lead, Unit=mg/kg, Parametric Distributed?=Gamma
Conc or Transformed Conc (mg/kg)

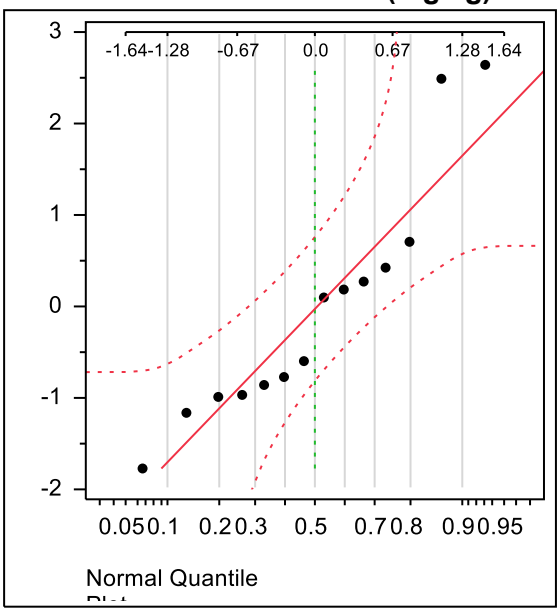


Distributions Exposure Area=EA2, Analyte=Manganese, Unit=mg/kg, Parametric Distributed?=Lognormal
Conc or Transformed Conc (mg/kg)

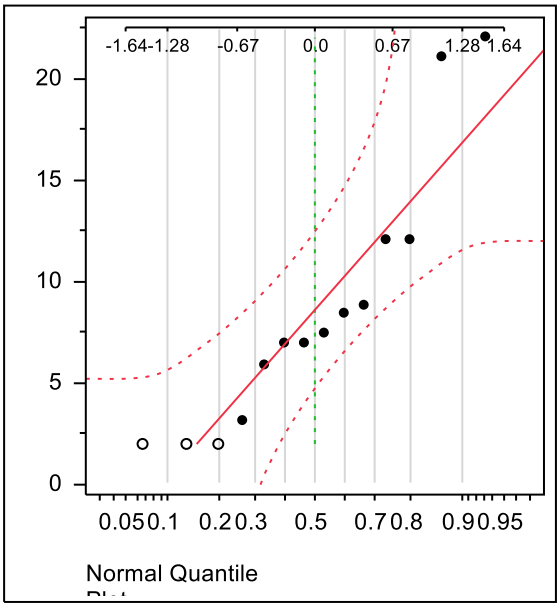


Normal Quantile Plots for Exposure Area 1 and Exposure Area 2

Distributions Exposure Area=EA2, Analyte=Mercury, Unit=mg/kg, Parametric Distributed?=Lognormal
Conc or Transformed Conc (mg/kg)

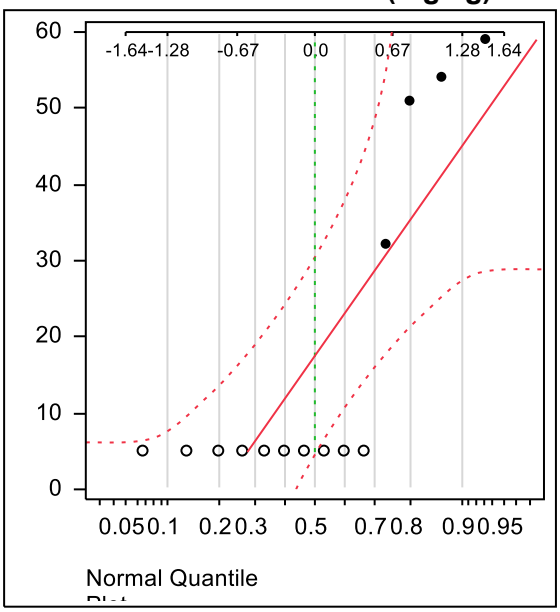


Distributions Exposure Area=EA2, Analyte=Nickel, Unit=mg/kg, Parametric Distributed?=Normal
Conc or Transformed Conc (mg/kg)

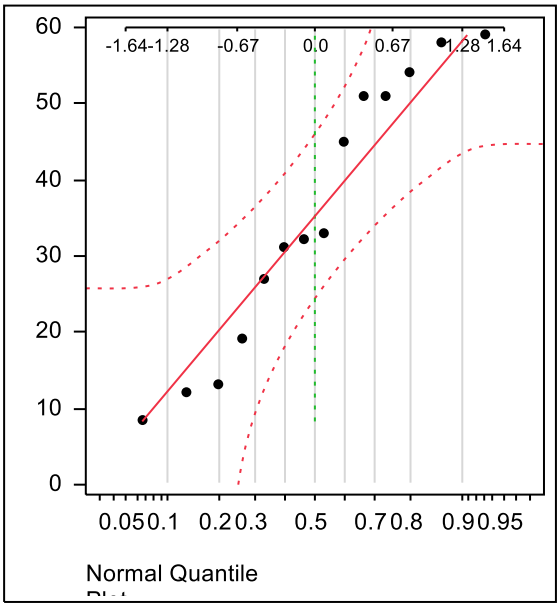


Normal Quantile Plots for Exposure Area 1 and Exposure Area 2

Distributions Exposure Area=EA2, Analyte=Selenium, Unit=mg/kg, Parametric Distributed?=Normal
Conc or Transformed Conc (mg/kg)

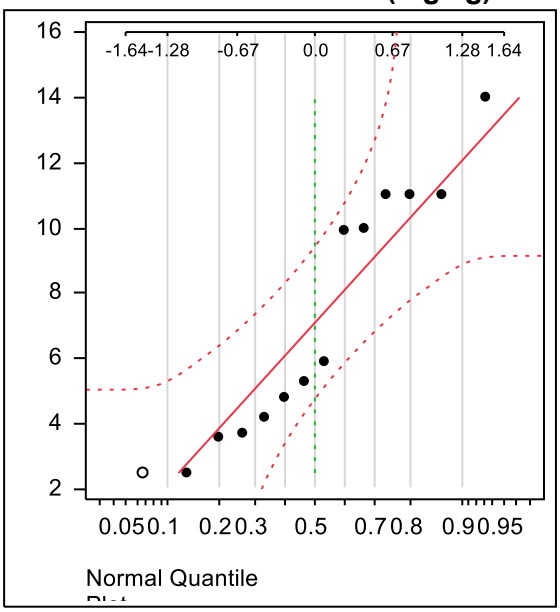


Distributions Exposure Area=EA2, Analyte=Selenium0823, Unit=mg/kg, Parametric Distributed?=Normal
Conc or Transformed Conc (mg/kg)

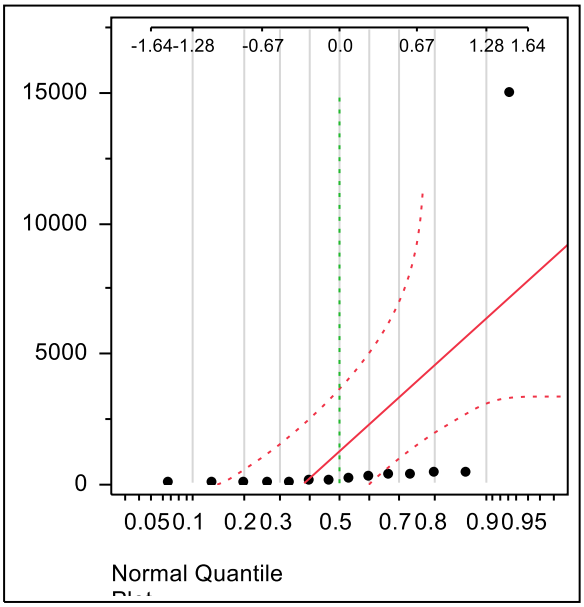


Normal Quantile Plots for Exposure Area 1 and Exposure Area 2

Distributions Exposure Area=EA2, Analyte=Silver, Unit=mg/kg, Parametric Distributed?=Normal
Conc or Transformed Conc (mg/kg)



Distributions Exposure Area=EA2, Analyte=Zinc, Unit=mg/kg, Parametric Distributed?=Non-parametric
Conc or Transformed Conc (mg/kg)



Notes:
The scale on the top of the Q-Q plot is the standard normal z-score corresponding the percentile (theoretic quantiles) presented on the bottom scale along the x-axis.

The vertical axis is the untransformed concentration. For gamma distribution, the displayed concentration is the cubed root of untransformed result ($[conc]^{1/3}$). For log normal distribution, the displayed concentration is the natural logarithm of the concentration (Ln[conc]).

	A	B	C	D	E	F	G	H	I	J	K	L	M
1				General Statistics on Uncensored Data: Exposure Area 1									
2			Date/Time of Computation	ProUCL 5.110/17/2019 3:03:46 PM									
3			User Selected Options										
4			From File	ProUCL Input 3_EA1_rev083019.xls									
5			Full Precision	OFF									
6													
7	From File: ProUCL Input 3_EA1_rev083019.xls												
8													
9	General Statistics for Censored Data Set (with NDs) using Kaplan Meier Method												
10													
11	Variable		NumObs	# Missing	Num Ds	NumNDs	% NDs	Min ND	Max ND	KM Mean	KM Var	KM SD	KM CV
12	Antimony		22	0	4	18	81.82%	4.8	5	5.068	0.414	0.643	0.127
13	Arsenic		22	0	22	0	0.00%	N/A	N/A	115.1	5868	76.61	0.665
14	Barium		22	0	22	0	0.00%	N/A	N/A	27.6	244.5	15.64	0.566
15	Cadmium		22	0	9	13	59.09%	0.48	0.5	1.03	1.763	1.328	1.29
16	Chromium		22	0	7	15	68.18%	1.9	2	3.255	8.148	2.854	0.877
17	Copper		22	0	22	0	0.00%	N/A	N/A	3260	20431643	4520	1.386
18	Lead		22	0	22	0	0.00%	N/A	N/A	36.15	973.9	31.21	0.863
19	Manganese		22	0	22	0	0.00%	N/A	N/A	623.6	269719	519.3	0.833
20	Mercury		22	0	22	0	0.00%	N/A	N/A	0.942	0.629	0.793	0.842
21	Nickel		22	0	9	13	59.09%	1.9	2	3.068	7.237	2.69	0.877
22	Selenium		22	0	22	0	0.00%	N/A	N/A	30.47	425.6	20.63	0.677
23	Silver		22	0	13	9	40.91%	2.4	2.5	5.932	25.01	5.001	0.843
24	Zinc		22	0	22	0	0.00%	N/A	N/A	304.7	127341	356.8	1.171
25													
26	General Statistics for Raw Data Sets using Detected Data Only												
27													
28	Variable		NumObs	# Missing	Minimum	Maximum	Mean	Median	Var	SD	MAD/0.675	Skewness	CV
29	Antimony		4	0	5.3	7.2	6.275	6.3	0.663	0.814	0.89	-0.151	0.13
30	Arsenic		22	0	19	250	115.1	120	5868	76.61	95.63	0.398	0.665
31	Barium		22	0	6.7	64	27.6	23	244.5	15.64	14.83	0.714	0.566
32	Cadmium		9	0	0.75	6.8	1.823	1.3	3.649	1.91	0.756	2.746	1.048
33	Chromium		7	0	2	14	6.157	6.3	15.46	3.932	1.186	1.387	0.639
34	Copper		22	0	240	22000	3260	2200	20431643	4520	2409	3.658	1.386
35	Lead		22	0	5.7	140	36.15	22	973.9	31.21	22.54	1.858	0.863
36	Manganese		22	0	150	2400	623.6	395	269719	519.3	259.5	2.113	0.833
37	Mercury		22	0	0.14	2.7	0.942	0.625	0.629	0.793	0.549	1.025	0.842
38	Nickel		9	0	2.1	14	4.756	3.7	14.48	3.805	2.076	2.182	0.8
39	Selenium		22	0	5.4	77	30.47	20.5	425.6	20.63	14.83	0.943	0.677
40	Silver		13	0	3	20	8.377	5.2	30.03	5.48	3.262	0.987	0.654
41	Zinc		22	0	57	1800	304.7	235	127341	356.8	133.4	3.807	1.171

	A	B	C	D	E	F	G	H	I	J	K	L	M
42													
43	Percentiles using all Detects (Ds) and Non-Detects (NDs)												
44													
45	Variable		NumObs	# Missing	10%ile	20%ile	25%ile(Q1)	50%ile(Q2)	75%ile(Q3)	80%ile	90%ile	95%ile	99%ile
46		Antimony	22	0	4.81	4.9	4.9	4.9	5	5	5.93	6.57	7.074
47		Arsenic	22	0	24.3	34.4	39.75	120	170	180	236	249.5	250
48		Barium	22	0	13	13.4	15.25	23	39.75	40.8	49.5	50.95	61.27
49		Cadmium	22	0	0.49	0.49	0.49	0.5	1.023	1.26	1.66	1.89	5.771
50		Chromium	22	0	1.91	2	2	2	2.375	4.9	6.3	6.49	12.43
51		Copper	22	0	462	656	835	2200	4050	4260	4950	5950	18640
52		Lead	22	0	9.93	13.2	14.25	22	53.5	58.4	67.2	68	124.9
53		Manganese	22	0	230	252	270	395	827.5	976	1190	1200	2148
54		Mercury	22	0	0.251	0.314	0.353	0.625	1.325	1.8	2.19	2.295	2.616
55		Nickel	22	0	1.9	2	2	2	2.9	3.58	4.26	7.055	12.57
56		Selenium	22	0	11.1	14.4	16.25	20.5	42.5	45.6	60.7	68.6	75.32
57		Silver	22	0	2.4	2.5	2.5	3.45	7.6	9.68	13.7	15.9	19.16
58		Zinc	22	0	110	120	125	235	307.5	318	458	565	1542

	A	B	C	D	E	F	G	H	I	J	K	L
1	**UCL Statistics for Data Sets with Non-Detects: Exposure Area 1**											
2												
3	User Selected Options											
4	Date/Time of Computation			ProUCL 5.110/17/2019 3:06:06 PM								
5	From File			ProUCL Input 3_EA1_rev083019.xls								
6	Full Precision			OFF								
7	Confidence Coefficient			95%								
8	Number of Bootstrap Operations			2000								
9												
10	**Antimony**											
11												
12	**General Statistics**											
13	Total Number of Observations					22	Number of Distinct Observations					7
14	Number of Detects					4	Number of Non-Detects					18
15	Number of Distinct Detects					4	Number of Distinct Non-Detects					3
16	Minimum Detect					5.3	Minimum Non-Detect					4.8
17	Maximum Detect					7.2	Maximum Non-Detect					5
18	Variance Detects					0.663	Percent Non-Detects					81.82%
19	Mean Detects					6.275	SD Detects					0.814
20	Median Detects					6.3	CV Detects					0.13
21	Skewness Detects					-0.151	Kurtosis Detects					-0.949
22	Mean of Logged Detects					1.83	SD of Logged Detects					0.131
23												
24	**Normal GOF Test on Detects Only**											
25	Shapiro Wilk Test Statistic					0.995	**Shapiro Wilk GOF Test**					
26	5% Shapiro Wilk Critical Value					0.748	Detected Data appear Normal at 5% Significance Level					
27	Lilliefors Test Statistic					0.155	**Lilliefors GOF Test**					
28	5% Lilliefors Critical Value					0.375	Detected Data appear Normal at 5% Significance Level					
29	**Detected Data appear Normal at 5% Significance Level**											
30												
31	**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**											
32	KM Mean					5.068	KM Standard Error of Mean					0.158
33	KM SD					0.643	95% KM (BCA) UCL					N/A
34	95% KM (t) UCL					5.341	95% KM (Percentile Bootstrap) UCL					N/A
35	95% KM (z) UCL					5.329	95% KM Bootstrap t UCL					N/A
36	90% KM Chebyshev UCL					5.543	95% KM Chebyshev UCL					5.759
37	97.5% KM Chebyshev UCL					6.057	99% KM Chebyshev UCL					6.644
38												
39	**Gamma GOF Tests on Detected Observations Only**											
40	A-D Test Statistic					0.203	**Anderson-Darling GOF Test**					
41	5% A-D Critical Value					0.656	Detected data appear Gamma Distributed at 5% Significance Level					
42	K-S Test Statistic					0.187	**Kolmogorov-Smirnov GOF**					
43	5% K-S Critical Value					0.394	Detected data appear Gamma Distributed at 5% Significance Level					
44	**Detected data appear Gamma Distributed at 5% Significance Level**											
45												
46	**Gamma Statistics on Detected Data Only**											
47	k hat (MLE)					78.06	k star (bias corrected MLE)					19.68
48	Theta hat (MLE)					0.0804	Theta star (bias corrected MLE)					0.319
49	nu hat (MLE)					624.5	nu star (bias corrected)					157.4
50	Mean (detects)					6.275						
51												

	A	B	C	D	E	F	G	H	I	J	K	L
52	**Gamma ROS Statistics using Imputed Non-Detects**											
53	GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs											
54	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)											
55	For such situations, GROS method may yield incorrect values of UCLs and BTVs											
56	This is especially true when the sample size is small.											
57	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates											
58					Minimum	0.01				Mean		3.097
59					Maximum	7.2				Median		2.859
60					SD	1.962				CV		0.633
61					k hat (MLE)	1.367				k star (bias corrected MLE)		1.211
62					Theta hat (MLE)	2.265				Theta star (bias corrected MLE)		2.558
63					nu hat (MLE)	60.15				nu star (bias corrected)		53.28
64					Adjusted Level of Significance (β)	0.0386						
65					Approximate Chi Square Value (53.28, α)	37.51				Adjusted Chi Square Value (53.28, β)		36.52
66					95% Gamma Approximate UCL (use when n>=50)	4.399				95% Gamma Adjusted UCL (use when n<50)		N/A
67												
68	**Estimates of Gamma Parameters using KM Estimates**											
69					Mean (KM)	5.068				SD (KM)		0.643
70					Variance (KM)	0.414				SE of Mean (KM)		0.158
71					k hat (KM)	62.05				k star (KM)		53.62
72					nu hat (KM)	2730				nu star (KM)		2359
73					theta hat (KM)	0.0817				theta star (KM)		0.0945
74					80% gamma percentile (KM)	5.64				90% gamma percentile (KM)		5.973
75					95% gamma percentile (KM)	6.258				99% gamma percentile (KM)		6.816
76												
77	**Gamma Kaplan-Meier (KM) Statistics**											
78					Approximate Chi Square Value (N/A, α)	2247				Adjusted Chi Square Value (N/A, β)		2239
79					95% Gamma Approximate KM-UCL (use when n>=50)	5.32				95% Gamma Adjusted KM-UCL (use when n<50)		5.34
80												
81	**Lognormal GOF Test on Detected Observations Only**											
82					Shapiro Wilk Test Statistic	0.99				**Shapiro Wilk GOF Test**		
83					5% Shapiro Wilk Critical Value	0.748				Detected Data appear Lognormal at 5% Significance Level		
84					Lilliefors Test Statistic	0.168				**Lilliefors GOF Test**		
85					5% Lilliefors Critical Value	0.375				Detected Data appear Lognormal at 5% Significance Level		
86	**Detected Data appear Lognormal at 5% Significance Level**											
87												
88	**Lognormal ROS Statistics Using Imputed Non-Detects**											
89					Mean in Original Scale	3.831				Mean in Log Scale		1.285
90					SD in Original Scale	1.4				SD in Log Scale		0.344
91					95% t UCL (assumes normality of ROS data)	4.345				95% Percentile Bootstrap UCL		4.319
92					95% BCA Bootstrap UCL	4.402				95% Bootstrap t UCL		4.481
93					95% H-UCL (Log ROS)	4.413						
94												
95	**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**											
96					KM Mean (logged)	1.616				KM Geo Mean		5.034
97					KM SD (logged)	0.112				95% Critical H Value (KM-Log)		1.73
98					KM Standard Error of Mean (logged)	0.0276				95% H-UCL (KM -Log)		5.284
99					KM SD (logged)	0.112				95% Critical H Value (KM-Log)		1.73
100					KM Standard Error of Mean (logged)	0.0276						
101												

	A	B	C	D	E	F	G	H	I	J	K	L
102	**DL/2 Statistics**											
103	**DL/2 Normal**						**DL/2 Log-Transformed**					
104					Mean in Original Scale	3.152				Mean in Log Scale		1.069
105					SD in Original Scale	1.538				SD in Log Scale		0.371
106					95% t UCL (Assumes normality)	3.717				95% H-Stat UCL		3.634
107	**DL/2 is not a recommended method, provided for comparisons and historical reasons**											
108												
109	**Nonparametric Distribution Free UCL Statistics**											
110	**Detected Data appear Normal Distributed at 5% Significance Level**											
111												
112	**Suggested UCL to Use**											
113					95% KM (t) UCL	5.341						
114												
115	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
116	Recommendations are based upon data size, data distribution, and skewness.											
117	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
118	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
119												
120												
121	**Arsenic**											
122												
123	**General Statistics**											
124					Total Number of Observations	22				Number of Distinct Observations		15
125										Number of Missing Observations		0
126					Minimum	19				Mean		115.1
127					Maximum	250				Median		120
128					SD	76.61				Std. Error of Mean		16.33
129					Coefficient of Variation	0.665				Skewness		0.398
130												
131	**Normal GOF Test**											
132					Shapiro Wilk Test Statistic	0.92	**Shapiro Wilk GOF Test**					
133					5% Shapiro Wilk Critical Value	0.911	Data appear Normal at 5% Significance Level					
134					Lilliefors Test Statistic	0.122	**Lilliefors GOF Test**					
135					5% Lilliefors Critical Value	0.184	Data appear Normal at 5% Significance Level					
136	**Data appear Normal at 5% Significance Level**											
137												
138	**Assuming Normal Distribution**											
139	**95% Normal UCL**						**95% UCLs (Adjusted for Skewness)**					
140					95% Student's-t UCL	143.2				95% Adjusted-CLT UCL (Chen-1995)		143.5
141										95% Modified-t UCL (Johnson-1978)		143.5
142												
143	**Gamma GOF Test**											
144					A-D Test Statistic	0.587	**Anderson-Darling Gamma GOF Test**					
145					5% A-D Critical Value	0.757	Detected data appear Gamma Distributed at 5% Significance Level					
146					K-S Test Statistic	0.164	**Kolmogorov-Smirnov Gamma GOF Test**					
147					5% K-S Critical Value	0.188	Detected data appear Gamma Distributed at 5% Significance Level					
148	**Detected data appear Gamma Distributed at 5% Significance Level**											
149												

	A	B	C	D	E	F	G	H	I	J	K	L
150						Gamma Statistics						
151					k hat (MLE)	1.872					k star (bias corrected MLE)	1.647
152					Theta hat (MLE)	61.51					Theta star (bias corrected MLE)	69.91
153					nu hat (MLE)	82.36					nu star (bias corrected)	72.46
154					MLE Mean (bias corrected)	115.1					MLE Sd (bias corrected)	89.72
155											Approximate Chi Square Value (0.05)	53.86
156					Adjusted Level of Significance	0.0386					Adjusted Chi Square Value	52.67
157												
158						Assuming Gamma Distribution						
159					95% Approximate Gamma UCL (use when n>=50))	154.9					95% Adjusted Gamma UCL (use when n<50)	158.4
160												
161						Lognormal GOF Test						
162					Shapiro Wilk Test Statistic	0.9					Shapiro Wilk Lognormal GOF Test	
163					5% Shapiro Wilk Critical Value	0.911					Data Not Lognormal at 5% Significance Level	
164					Lilliefors Test Statistic	0.195					Lilliefors Lognormal GOF Test	
165					5% Lilliefors Critical Value	0.184					Data Not Lognormal at 5% Significance Level	
166						Data Not Lognormal at 5% Significance Level						
167												
168						Lognormal Statistics						
169					Minimum of Logged Data	2.944					Mean of logged Data	4.456
170					Maximum of Logged Data	5.521					SD of logged Data	0.861
171												
172						Assuming Lognormal Distribution						
173					95% H-UCL	195.7					90% Chebyshev (MVUE) UCL	195.9
174					95% Chebyshev (MVUE) UCL	229.4					97.5% Chebyshev (MVUE) UCL	275.8
175					99% Chebyshev (MVUE) UCL	367.1						
176												
177						Nonparametric Distribution Free UCL Statistics						
178						Data appear to follow a Discernible Distribution at 5% Significance Level						
179												
180						Nonparametric Distribution Free UCLs						
181					95% CLT UCL	142					95% Jackknife UCL	143.2
182					95% Standard Bootstrap UCL	141.7					95% Bootstrap-t UCL	145.7
183					95% Hall's Bootstrap UCL	144					95% Percentile Bootstrap UCL	141
184					95% BCA Bootstrap UCL	142.4						
185					90% Chebyshev(Mean, Sd) UCL	164.1					95% Chebyshev(Mean, Sd) UCL	186.3
186					97.5% Chebyshev(Mean, Sd) UCL	217.1					99% Chebyshev(Mean, Sd) UCL	277.6
187												
188						Suggested UCL to Use						
189					95% Student's-t UCL	143.2						
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												

	A	B	C	D	E	F	G	H	I	J	K	L
197	**Barium**											
198												
199						**General Statistics**						
200					Total Number of Observations	22				Number of Distinct Observations		19
201										Number of Missing Observations		0
202					Minimum	6.7				Mean		27.6
203					Maximum	64				Median		23
204					SD	15.64				Std. Error of Mean		3.334
205					Coefficient of Variation	0.566				Skewness		0.714
206												
207						**Normal GOF Test**						
208					Shapiro Wilk Test Statistic	0.933				**Shapiro Wilk GOF Test**		
209					5% Shapiro Wilk Critical Value	0.911				Data appear Normal at 5% Significance Level		
210					Lilliefors Test Statistic	0.157				**Lilliefors GOF Test**		
211					5% Lilliefors Critical Value	0.184				Data appear Normal at 5% Significance Level		
212						**Data appear Normal at 5% Significance Level**						
213												
214						**Assuming Normal Distribution**						
215					**95% Normal UCL**					**95% UCLs (Adjusted for Skewness)**		
216					95% Student's-t UCL	33.34				95% Adjusted-CLT UCL (Chen-1995)		33.63
217										95% Modified-t UCL (Johnson-1978)		33.43
218												
219						**Gamma GOF Test**						
220					A-D Test Statistic	0.267				**Anderson-Darling Gamma GOF Test**		
221					5% A-D Critical Value	0.749				Detected data appear Gamma Distributed at 5% Significance Level		
222					K-S Test Statistic	0.117				**Kolmogorov-Smirnov Gamma GOF Test**		
223					5% K-S Critical Value	0.187				Detected data appear Gamma Distributed at 5% Significance Level		
224						**Detected data appear Gamma Distributed at 5% Significance Level**						
225												
226						**Gamma Statistics**						
227					k hat (MLE)	3.171				k star (bias corrected MLE)		2.769
228					Theta hat (MLE)	8.705				Theta star (bias corrected MLE)		9.969
229					nu hat (MLE)	139.5				nu star (bias corrected)		121.8
230					MLE Mean (bias corrected)	27.6				MLE Sd (bias corrected)		16.59
231										Approximate Chi Square Value (0.05)		97.35
232					Adjusted Level of Significance	0.0386				Adjusted Chi Square Value		95.71
233												
234						**Assuming Gamma Distribution**						
235					95% Approximate Gamma UCL (use when n>=50))	34.55				95% Adjusted Gamma UCL (use when n<50)		35.14
236												
237						**Lognormal GOF Test**						
238					Shapiro Wilk Test Statistic	0.966				**Shapiro Wilk Lognormal GOF Test**		
239					5% Shapiro Wilk Critical Value	0.911				Data appear Lognormal at 5% Significance Level		
240					Lilliefors Test Statistic	0.116				**Lilliefors Lognormal GOF Test**		
241					5% Lilliefors Critical Value	0.184				Data appear Lognormal at 5% Significance Level		
242						**Data appear Lognormal at 5% Significance Level**						
243												
244						**Lognormal Statistics**						
245					Minimum of Logged Data	1.902				Mean of logged Data		3.152
246					Maximum of Logged Data	4.159				SD of logged Data		0.613
247												

	A	B	C	D	E	F	G	H	I	J	K	L
248	**Assuming Lognormal Distribution**											
249					95% H-UCL	37.41				90% Chebyshev (MVUE) UCL		39.51
250					95% Chebyshev (MVUE) UCL	44.75				97.5% Chebyshev (MVUE) UCL		52.02
251					99% Chebyshev (MVUE) UCL	66.3						
252												
253	**Nonparametric Distribution Free UCL Statistics**											
254	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
255												
256	**Nonparametric Distribution Free UCLs**											
257					95% CLT UCL	33.09				95% Jackknife UCL		33.34
258					95% Standard Bootstrap UCL	32.84				95% Bootstrap-t UCL		33.76
259					95% Hall's Bootstrap UCL	33.64				95% Percentile Bootstrap UCL		32.77
260					95% BCA Bootstrap UCL	33.32						
261					90% Chebyshev(Mean, Sd) UCL	37.61				95% Chebyshev(Mean, Sd) UCL		42.14
262					97.5% Chebyshev(Mean, Sd) UCL	48.43				99% Chebyshev(Mean, Sd) UCL		60.78
263												
264	**Suggested UCL to Use**											
265					95% Student's-t UCL	33.34						
266												
267	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
268	Recommendations are based upon data size, data distribution, and skewness.											
269	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
270	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
271												
272	**Cadmium**											
273												
274	**General Statistics**											
275					Total Number of Observations	22				Number of Distinct Observations		11
276					Number of Detects	9				Number of Non-Detects		13
277					Number of Distinct Detects	8				Number of Distinct Non-Detects		3
278					Minimum Detect	0.75				Minimum Non-Detect		0.48
279					Maximum Detect	6.8				Maximum Non-Detect		0.5
280					Variance Detects	3.649				Percent Non-Detects		59.09%
281					Mean Detects	1.823				SD Detects		1.91
282					Median Detects	1.3				CV Detects		1.048
283					Skewness Detects	2.746				Kurtosis Detects		7.854
284					Mean of Logged Detects	0.325				SD of Logged Detects		0.687
285												
286	**Normal GOF Test on Detects Only**											
287					Shapiro Wilk Test Statistic	0.584				**Shapiro Wilk GOF Test**		
288					5% Shapiro Wilk Critical Value	0.829				Detected Data Not Normal at 5% Significance Level		
289					Lilliefors Test Statistic	0.373				**Lilliefors GOF Test**		
290					5% Lilliefors Critical Value	0.274				Detected Data Not Normal at 5% Significance Level		
291	**Detected Data Not Normal at 5% Significance Level**											
292												
293	**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**											
294					KM Mean	1.03				KM Standard Error of Mean		0.3
295					KM SD	1.328				95% KM (BCA) UCL		1.577
296					95% KM (t) UCL	1.546				95% KM (Percentile Bootstrap) UCL		1.568
297					95% KM (z) UCL	1.523				95% KM Bootstrap t UCL		2.496
298					90% KM Chebyshev UCL	1.93				95% KM Chebyshev UCL		2.338
299					97.5% KM Chebyshev UCL	2.905				99% KM Chebyshev UCL		4.017

	A	B	C	D	E	F	G	H	I	J	K	L
300												
301						Gamma GOF Tests on Detected Observations Only						
302						A-D Test Statistic	0.98	Anderson-Darling GOF Test				
303						5% A-D Critical Value	0.73	Detected Data Not Gamma Distributed at 5% Significance Level				
304						K-S Test Statistic	0.272	Kolmogorov-Smirnov GOF				
305						5% K-S Critical Value	0.283	Detected data appear Gamma Distributed at 5% Significance Level				
306						Detected data follow Appr. Gamma Distribution at 5% Significance Level						
307												
308						Gamma Statistics on Detected Data Only						
309						k hat (MLE)	1.964	k star (bias corrected MLE)				1.383
310						Theta hat (MLE)	0.928	Theta star (bias corrected MLE)				1.318
311						nu hat (MLE)	35.35	nu star (bias corrected)				24.9
312						Mean (detects)	1.823					
313												
314						Gamma ROS Statistics using Imputed Non-Detects						
315						GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs						
316						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)						
317						For such situations, GROS method may yield incorrect values of UCLs and BTVs						
318						This is especially true when the sample size is small.						
319						For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates						
320						Minimum	0.01	Mean				0.752
321						Maximum	6.8	Median				0.01
322						SD	1.491	CV				1.983
323						k hat (MLE)	0.299	k star (bias corrected MLE)				0.289
324						Theta hat (MLE)	2.51	Theta star (bias corrected MLE)				2.602
325						nu hat (MLE)	13.18	nu star (bias corrected)				12.71
326						Adjusted Level of Significance (β)	0.0386					
327						Approximate Chi Square Value (12.71, α)	5.701	Adjusted Chi Square Value (12.71, β)				5.353
328						95% Gamma Approximate UCL (use when n>=50)	1.677	95% Gamma Adjusted UCL (use when n<50)				1.786
329												
330						Estimates of Gamma Parameters using KM Estimates						
331						Mean (KM)	1.03	SD (KM)				1.328
332						Variance (KM)	1.763	SE of Mean (KM)				0.3
333						k hat (KM)	0.601	k star (KM)				0.55
334						nu hat (KM)	26.45	nu star (KM)				24.18
335						theta hat (KM)	1.712	theta star (KM)				1.873
336						80% gamma percentile (KM)	1.696	90% gamma percentile (KM)				2.73
337						95% gamma percentile (KM)	3.824	99% gamma percentile (KM)				6.489
338												
339						Gamma Kaplan-Meier (KM) Statistics						
340						Approximate Chi Square Value (24.18, α)	13.99	Adjusted Chi Square Value (24.18, β)				13.41
341						95% Gamma Approximate KM-UCL (use when n>=50)	1.78	95% Gamma Adjusted KM-UCL (use when n<50)				1.857
342												
343						Lognormal GOF Test on Detected Observations Only						
344						Shapiro Wilk Test Statistic	0.82	Shapiro Wilk GOF Test				
345						5% Shapiro Wilk Critical Value	0.829	Detected Data Not Lognormal at 5% Significance Level				
346						Lilliefors Test Statistic	0.211	Lilliefors GOF Test				
347						5% Lilliefors Critical Value	0.274	Detected Data appear Lognormal at 5% Significance Level				
348						Detected Data appear Approximate Lognormal at 5% Significance Level						
349												

	A	B	C	D	E	F	G	H	I	J	K	L
350	**Lognormal ROS Statistics Using Imputed Non-Detects**											
351					Mean in Original Scale	0.865					Mean in Log Scale	-0.913
352					SD in Original Scale	1.436					SD in Log Scale	1.234
353				95% t UCL (assumes normality of ROS data)		1.392					95% Percentile Bootstrap UCL	1.417
354					95% BCA Bootstrap UCL	1.751					95% Bootstrap t UCL	2.163
355					95% H-UCL (Log ROS)	1.888						
356												
357	**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**											
358					KM Mean (logged)	-0.301					KM Geo Mean	0.74
359					KM SD (logged)	0.665					95% Critical H Value (KM-Log)	2.164
360					KM Standard Error of Mean (logged)	0.15					95% H-UCL (KM -Log)	1.264
361					KM SD (logged)	0.665					95% Critical H Value (KM-Log)	2.164
362					KM Standard Error of Mean (logged)	0.15						
363												
364	**DL/2 Statistics**											
365				**DL/2 Normal**						**DL/2 Log-Transformed**		
366					Mean in Original Scale	0.891					Mean in Log Scale	-0.695
367					SD in Original Scale	1.421					SD in Log Scale	0.967
368					95% t UCL (Assumes normality)	1.413					95% H-Stat UCL	1.36
369	**DL/2 is not a recommended method, provided for comparisons and historical reasons**											
370												
371	**Nonparametric Distribution Free UCL Statistics**											
372	**Detected Data appear Approximate Gamma Distributed at 5% Significance Level**											
373												
374	**Suggested UCL to Use**											
375					95% KM Adjusted Gamma UCL	1.857					95% GROS Adjusted Gamma UCL	1.786
376												
377	When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test											
378	When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL											
379												
380	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
381	Recommendations are based upon data size, data distribution, and skewness.											
382	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
383	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
384												
385	**Chromium**											
386												
387	**General Statistics**											
388					Total Number of Observations	22					Number of Distinct Observations	7
389					Number of Detects	7					Number of Non-Detects	15
390					Number of Distinct Detects	6					Number of Distinct Non-Detects	2
391					Minimum Detect	2					Minimum Non-Detect	1.9
392					Maximum Detect	14					Maximum Non-Detect	2
393					Variance Detects	15.46					Percent Non-Detects	68.18%
394					Mean Detects	6.157					SD Detects	3.932
395					Median Detects	6.3					CV Detects	0.639
396					Skewness Detects	1.387					Kurtosis Detects	2.921
397					Mean of Logged Detects	1.644					SD of Logged Detects	0.653
398												

	A	B	C	D	E	F	G	H	I	J	K	L
399	**Normal GOF Test on Detects Only**											
400					Shapiro Wilk Test Statistic	0.836	**Shapiro Wilk GOF Test**					
401					5% Shapiro Wilk Critical Value	0.803	Detected Data appear Normal at 5% Significance Level					
402					Lilliefors Test Statistic	0.322	**Lilliefors GOF Test**					
403					5% Lilliefors Critical Value	0.304	Detected Data Not Normal at 5% Significance Level					
404	**Detected Data appear Approximate Normal at 5% Significance Level**											
405												
406	**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**											
407					KM Mean	3.255	KM Standard Error of Mean					0.657
408					KM SD	2.854	95% KM (BCA) UCL					4.532
409					95% KM (t) UCL	4.386	95% KM (Percentile Bootstrap) UCL					4.364
410					95% KM (z) UCL	4.336	95% KM Bootstrap t UCL					4.876
411					90% KM Chebyshev UCL	5.227	95% KM Chebyshev UCL					6.12
412					97.5% KM Chebyshev UCL	7.36	99% KM Chebyshev UCL					9.795
413												
414	**Gamma GOF Tests on Detected Observations Only**											
415					A-D Test Statistic	0.466	**Anderson-Darling GOF Test**					
416					5% A-D Critical Value	0.712	Detected data appear Gamma Distributed at 5% Significance Level					
417					K-S Test Statistic	0.244	**Kolmogorov-Smirnov GOF**					
418					5% K-S Critical Value	0.314	Detected data appear Gamma Distributed at 5% Significance Level					
419	**Detected data appear Gamma Distributed at 5% Significance Level**											
420												
421	**Gamma Statistics on Detected Data Only**											
422					k hat (MLE)	3.032	k star (bias corrected MLE)					1.828
423					Theta hat (MLE)	2.031	Theta star (bias corrected MLE)					3.369
424					nu hat (MLE)	42.45	nu star (bias corrected)					25.59
425					Mean (detects)	6.157						
426												
427	**Gamma ROS Statistics using Imputed Non-Detects**											
428	GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs											
429	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)											
430	For such situations, GROS method may yield incorrect values of UCLs and BTVs											
431	This is especially true when the sample size is small.											
432	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates											
433					Minimum	0.01	Mean					1.979
434					Maximum	14	Median					0.01
435					SD	3.599	CV					1.819
436					k hat (MLE)	0.229	k star (bias corrected MLE)					0.228
437					Theta hat (MLE)	8.64	Theta star (bias corrected MLE)					8.676
438					nu hat (MLE)	10.08	nu star (bias corrected)					10.04
439					Adjusted Level of Significance (β)	0.0386						
440					Approximate Chi Square Value (10.04, α)	3.965	Adjusted Chi Square Value (10.04, β)					3.684
441					95% Gamma Approximate UCL (use when n>=50)	5.01	95% Gamma Adjusted UCL (use when n<50)					5.393
442												
443	**Estimates of Gamma Parameters using KM Estimates**											
444					Mean (KM)	3.255	SD (KM)					2.854
445					Variance (KM)	8.148	SE of Mean (KM)					0.657
446					k hat (KM)	1.3	k star (KM)					1.153
447					nu hat (KM)	57.2	nu star (KM)					50.73
448					theta hat (KM)	2.504	theta star (KM)					2.823
449					80% gamma percentile (KM)	5.173	90% gamma percentile (KM)					7.235
450					95% gamma percentile (KM)	9.275	99% gamma percentile (KM)					13.96

	A	B	C	D	E	F	G	H	I	J	K	L
451												
452						Gamma Kaplan-Meier (KM) Statistics						
453					Approximate Chi Square Value (50.73, α)	35.38			Adjusted Chi Square Value (50.73, β)			34.42
454					95% Gamma Approximate KM-UCL (use when n>=50)	4.667			95% Gamma Adjusted KM-UCL (use when n<50)			4.797
455												
456						Lognormal GOF Test on Detected Observations Only						
457					Shapiro Wilk Test Statistic	0.905			Shapiro Wilk GOF Test			
458					5% Shapiro Wilk Critical Value	0.803			Detected Data appear Lognormal at 5% Significance Level			
459					Lilliefors Test Statistic	0.252			Lilliefors GOF Test			
460					5% Lilliefors Critical Value	0.304			Detected Data appear Lognormal at 5% Significance Level			
461						Detected Data appear Lognormal at 5% Significance Level						
462												
463						Lognormal ROS Statistics Using Imputed Non-Detects						
464					Mean in Original Scale	2.447			Mean in Log Scale			0.109
465					SD in Original Scale	3.364			SD in Log Scale			1.313
466					95% t UCL (assumes normality of ROS data)	3.681			95% Percentile Bootstrap UCL			3.722
467					95% BCA Bootstrap UCL	4.091			95% Bootstrap t UCL			4.331
468					95% H-UCL (Log ROS)	6.318						
469												
470						Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution						
471					KM Mean (logged)	0.961			KM Geo Mean			2.613
472					KM SD (logged)	0.578			95% Critical H Value (KM-Log)			2.072
473					KM Standard Error of Mean (logged)	0.133			95% H-UCL (KM -Log)			4.011
474					KM SD (logged)	0.578			95% Critical H Value (KM-Log)			2.072
475					KM Standard Error of Mean (logged)	0.133						
476												
477						DL/2 Statistics						
478					DL/2 Normal				DL/2 Log-Transformed			
479					Mean in Original Scale	2.634			Mean in Log Scale			0.516
480					SD in Original Scale	3.238			SD in Log Scale			0.862
481					95% t UCL (Assumes normality)	3.822			95% H-Stat UCL			3.817
482						DL/2 is not a recommended method, provided for comparisons and historical reasons						
483												
484						Nonparametric Distribution Free UCL Statistics						
485						Detected Data appear Approximate Normal Distributed at 5% Significance Level						
486												
487						Suggested UCL to Use						
488					95% KM (t) UCL	4.386						
489												
490						When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test						
491						When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL						
492												
493						Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.						
494						Recommendations are based upon data size, data distribution, and skewness.						
495						These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).						
496						However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.						
497												
498												

	A	B	C	D	E	F	G	H	I	J	K	L
499	Copper											
500												
501						General Statistics						
502					Total Number of Observations	22				Number of Distinct Observations		20
503										Number of Missing Observations		0
504					Minimum	240				Mean		3260
505					Maximum	22000				Median		2200
506					SD	4520				Std. Error of Mean		963.7
507					Coefficient of Variation	1.386				Skewness		3.658
508												
509						Normal GOF Test						
510					Shapiro Wilk Test Statistic	0.565				Shapiro Wilk GOF Test		
511					5% Shapiro Wilk Critical Value	0.911				Data Not Normal at 5% Significance Level		
512					Lilliefors Test Statistic	0.259				Lilliefors GOF Test		
513					5% Lilliefors Critical Value	0.184				Data Not Normal at 5% Significance Level		
514						Data Not Normal at 5% Significance Level						
515												
516						Assuming Normal Distribution						
517					95% Normal UCL					95% UCLs (Adjusted for Skewness)		
518					95% Student's-t UCL	4919				95% Adjusted-CLT UCL (Chen-1995)		5649
519										95% Modified-t UCL (Johnson-1978)		5044
520												
521						Gamma GOF Test						
522					A-D Test Statistic	0.48				Anderson-Darling Gamma GOF Test		
523					5% A-D Critical Value	0.77				Detected data appear Gamma Distributed at 5% Significance Level		
524					K-S Test Statistic	0.125				Kolmogorov-Smirnov Gamma GOF Test		
525					5% K-S Critical Value	0.191				Detected data appear Gamma Distributed at 5% Significance Level		
526						Detected data appear Gamma Distributed at 5% Significance Level						
527												
528						Gamma Statistics						
529					k hat (MLE)	1.017				k star (bias corrected MLE)		0.909
530					Theta hat (MLE)	3206				Theta star (bias corrected MLE)		3588
531					nu hat (MLE)	44.75				nu star (bias corrected)		39.98
532					MLE Mean (bias corrected)	3260				MLE Sd (bias corrected)		3421
533										Approximate Chi Square Value (0.05)		26.49
534					Adjusted Level of Significance	0.0386				Adjusted Chi Square Value		25.67
535												
536						Assuming Gamma Distribution						
537					95% Approximate Gamma UCL (use when n>=50)	4920				95% Adjusted Gamma UCL (use when n<50)		5077
538												
539						Lognormal GOF Test						
540					Shapiro Wilk Test Statistic	0.966				Shapiro Wilk Lognormal GOF Test		
541					5% Shapiro Wilk Critical Value	0.911				Data appear Lognormal at 5% Significance Level		
542					Lilliefors Test Statistic	0.102				Lilliefors Lognormal GOF Test		
543					5% Lilliefors Critical Value	0.184				Data appear Lognormal at 5% Significance Level		
544						Data appear Lognormal at 5% Significance Level						
545												
546						Lognormal Statistics						
547					Minimum of Logged Data	5.481				Mean of logged Data		7.523
548					Maximum of Logged Data	9.999				SD of logged Data		1.102
549												

	A	B	C	D	E	F	G	H	I	J	K	L
550	**Assuming Lognormal Distribution**											
551					95% H-UCL	6536				90% Chebyshev (MVUE) UCL		5886
552					95% Chebyshev (MVUE) UCL	7077				97.5% Chebyshev (MVUE) UCL		8730
553					99% Chebyshev (MVUE) UCL	11976						
554												
555	**Nonparametric Distribution Free UCL Statistics**											
556	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
557												
558	**Nonparametric Distribution Free UCLs**											
559					95% CLT UCL	4846				95% Jackknife UCL		4919
560					95% Standard Bootstrap UCL	4775				95% Bootstrap-t UCL		6883
561					95% Hall's Bootstrap UCL	11160				95% Percentile Bootstrap UCL		4947
562					95% BCA Bootstrap UCL	6208						
563					90% Chebyshev(Mean, Sd) UCL	6152				95% Chebyshev(Mean, Sd) UCL		7461
564					97.5% Chebyshev(Mean, Sd) UCL	9279				99% Chebyshev(Mean, Sd) UCL		12849
565												
566	**Suggested UCL to Use**											
567					95% Adjusted Gamma UCL	5077						
568												
569	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
570	Recommendations are based upon data size, data distribution, and skewness.											
571	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
572	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
573												
574												
575	**Lead**											
576												
577	**General Statistics**											
578					Total Number of Observations	22				Number of Distinct Observations		18
579										Number of Missing Observations		0
580					Minimum	5.7				Mean		36.15
581					Maximum	140				Median		22
582					SD	31.21				Std. Error of Mean		6.653
583					Coefficient of Variation	0.863				Skewness		1.858
584												
585	**Normal GOF Test**											
586					Shapiro Wilk Test Statistic	0.805				**Shapiro Wilk GOF Test**		
587					5% Shapiro Wilk Critical Value	0.911				Data Not Normal at 5% Significance Level		
588					Lilliefors Test Statistic	0.22				**Lilliefors GOF Test**		
589					5% Lilliefors Critical Value	0.184				Data Not Normal at 5% Significance Level		
590	**Data Not Normal at 5% Significance Level**											
591												
592	**Assuming Normal Distribution**											
593					**95% Normal UCL**					**95% UCLs (Adjusted for Skewness)**		
594					95% Student's-t UCL	47.6				95% Adjusted-CLT UCL (Chen-1995)		49.91
595										95% Modified-t UCL (Johnson-1978)		48.04
596												
597	**Gamma GOF Test**											
598					A-D Test Statistic	0.55				**Anderson-Darling Gamma GOF Test**		
599					5% A-D Critical Value	0.758				Detected data appear Gamma Distributed at 5% Significance Level		
600					K-S Test Statistic	0.174				**Kolmogorov-Smirnov Gamma GOF Test**		
601					5% K-S Critical Value	0.188				Detected data appear Gamma Distributed at 5% Significance Level		

	A	B	C	D	E	F	G	H	I	J	K	L
602	Detected data appear Gamma Distributed at 5% Significance Level											
603												
604	Gamma Statistics											
605					k hat (MLE)	1.691			k star (bias corrected MLE)			1.491
606					Theta hat (MLE)	21.38			Theta star (bias corrected MLE)			24.25
607					nu hat (MLE)	74.41			nu star (bias corrected)			65.6
608					MLE Mean (bias corrected)	36.15			MLE Sd (bias corrected)			29.61
609									Approximate Chi Square Value (0.05)			47.96
610					Adjusted Level of Significance	0.0386			Adjusted Chi Square Value			46.83
611												
612	Assuming Gamma Distribution											
613					95% Approximate Gamma UCL (use when n>=50)	49.44			95% Adjusted Gamma UCL (use when n<50)			50.63
614												
615	Lognormal GOF Test											
616					Shapiro Wilk Test Statistic	0.963			Shapiro Wilk Lognormal GOF Test			
617					5% Shapiro Wilk Critical Value	0.911			Data appear Lognormal at 5% Significance Level			
618					Lilliefors Test Statistic	0.149			Lilliefors Lognormal GOF Test			
619					5% Lilliefors Critical Value	0.184			Data appear Lognormal at 5% Significance Level			
620	Data appear Lognormal at 5% Significance Level											
621												
622	Lognormal Statistics											
623					Minimum of Logged Data	1.74			Mean of logged Data			3.264
624					Maximum of Logged Data	4.942			SD of logged Data			0.836
625												
626	Assuming Lognormal Distribution											
627					95% H-UCL	57.06			90% Chebyshev (MVUE) UCL			57.58
628					95% Chebyshev (MVUE) UCL	67.21			97.5% Chebyshev (MVUE) UCL			80.58
629					99% Chebyshev (MVUE) UCL	106.8						
630												
631	Nonparametric Distribution Free UCL Statistics											
632	Data appear to follow a Discernible Distribution at 5% Significance Level											
633												
634	Nonparametric Distribution Free UCLs											
635					95% CLT UCL	47.09			95% Jackknife UCL			47.6
636					95% Standard Bootstrap UCL	47			95% Bootstrap-t UCL			52.24
637					95% Hall's Bootstrap UCL	57.15			95% Percentile Bootstrap UCL			47.55
638					95% BCA Bootstrap UCL	49.47						
639					90% Chebyshev(Mean, Sd) UCL	56.11			95% Chebyshev(Mean, Sd) UCL			65.15
640					97.5% Chebyshev(Mean, Sd) UCL	77.7			99% Chebyshev(Mean, Sd) UCL			102.3
641												
642	Suggested UCL to Use											
643					95% Adjusted Gamma UCL	50.63						
644												
645	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
646	Recommendations are based upon data size, data distribution, and skewness.											
647	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
648	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
649												
650												

	A	B	C	D	E	F	G	H	I	J	K	L
651	**Manganese**											
652												
653						**General Statistics**						
654					Total Number of Observations	22				Number of Distinct Observations		20
655										Number of Missing Observations		0
656					Minimum	150				Mean		623.6
657					Maximum	2400				Median		395
658					SD	519.3				Std. Error of Mean		110.7
659					Coefficient of Variation	0.833				Skewness		2.113
660												
661						**Normal GOF Test**						
662					Shapiro Wilk Test Statistic	0.771				**Shapiro Wilk GOF Test**		
663					5% Shapiro Wilk Critical Value	0.911				Data Not Normal at 5% Significance Level		
664					Lilliefors Test Statistic	0.212				**Lilliefors GOF Test**		
665					5% Lilliefors Critical Value	0.184				Data Not Normal at 5% Significance Level		
666						**Data Not Normal at 5% Significance Level**						
667												
668						**Assuming Normal Distribution**						
669					**95% Normal UCL**					**95% UCLs (Adjusted for Skewness)**		
670					95% Student's-t UCL	814.2				95% Adjusted-CLT UCL (Chen-1995)		859.1
671										95% Modified-t UCL (Johnson-1978)		822.5
672												
673						**Gamma GOF Test**						
674					A-D Test Statistic	0.636				**Anderson-Darling Gamma GOF Test**		
675					5% A-D Critical Value	0.755				Detected data appear Gamma Distributed at 5% Significance Level		
676					K-S Test Statistic	0.186				**Kolmogorov-Smirnov Gamma GOF Test**		
677					5% K-S Critical Value	0.188				Detected data appear Gamma Distributed at 5% Significance Level		
678						**Detected data appear Gamma Distributed at 5% Significance Level**						
679												
680						**Gamma Statistics**						
681					k hat (MLE)	2.096				k star (bias corrected MLE)		1.841
682					Theta hat (MLE)	297.5				Theta star (bias corrected MLE)		338.8
683					nu hat (MLE)	92.23				nu star (bias corrected)		80.98
684					MLE Mean (bias corrected)	623.6				MLE Sd (bias corrected)		459.7
685										Approximate Chi Square Value (0.05)		61.25
686					Adjusted Level of Significance	0.0386				Adjusted Chi Square Value		59.97
687												
688						**Assuming Gamma Distribution**						
689					95% Approximate Gamma UCL (use when n>=50)	824.6				95% Adjusted Gamma UCL (use when n<50)		842.2
690												
691						**Lognormal GOF Test**						
692					Shapiro Wilk Test Statistic	0.959				**Shapiro Wilk Lognormal GOF Test**		
693					5% Shapiro Wilk Critical Value	0.911				Data appear Lognormal at 5% Significance Level		
694					Lilliefors Test Statistic	0.149				**Lilliefors Lognormal GOF Test**		
695					5% Lilliefors Critical Value	0.184				Data appear Lognormal at 5% Significance Level		
696						**Data appear Lognormal at 5% Significance Level**						
697												
698						**Lognormal Statistics**						
699					Minimum of Logged Data	5.011				Mean of logged Data		6.178
700					Maximum of Logged Data	7.783				SD of logged Data		0.71
701												

	A	B	C	D	E	F	G	H	I	J	K	L
702	**Assuming Lognormal Distribution**											
703					95% H-UCL	874			90% Chebyshev (MVUE) UCL			909.6
704					95% Chebyshev (MVUE) UCL	1044			97.5% Chebyshev (MVUE) UCL			1232
705					99% Chebyshev (MVUE) UCL	1600						
706												
707	**Nonparametric Distribution Free UCL Statistics**											
708	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
709												
710	**Nonparametric Distribution Free UCLs**											
711					95% CLT UCL	805.8			95% Jackknife UCL			814.2
712					95% Standard Bootstrap UCL	807			95% Bootstrap-t UCL			902.4
713					95% Hall's Bootstrap UCL	1007			95% Percentile Bootstrap UCL			823.6
714					95% BCA Bootstrap UCL	866.8						
715					90% Chebyshev(Mean, Sd) UCL	955.8			95% Chebyshev(Mean, Sd) UCL			1106
716					97.5% Chebyshev(Mean, Sd) UCL	1315			99% Chebyshev(Mean, Sd) UCL			1725
717												
718	**Suggested UCL to Use**											
719					95% Adjusted Gamma UCL	842.2						
720												
721	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
722	Recommendations are based upon data size, data distribution, and skewness.											
723	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
724	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
725												
726												
727	**Mercury**											
728												
729	**General Statistics**											
730					Total Number of Observations	22			Number of Distinct Observations			20
731									Number of Missing Observations			0
732					Minimum	0.14			Mean			0.942
733					Maximum	2.7			Median			0.625
734					SD	0.793			Std. Error of Mean			0.169
735					Coefficient of Variation	0.842			Skewness			1.025
736												
737	**Normal GOF Test**											
738					Shapiro Wilk Test Statistic	0.843			**Shapiro Wilk GOF Test**			
739					5% Shapiro Wilk Critical Value	0.911			Data Not Normal at 5% Significance Level			
740					Lilliefors Test Statistic	0.217			**Lilliefors GOF Test**			
741					5% Lilliefors Critical Value	0.184			Data Not Normal at 5% Significance Level			
742	**Data Not Normal at 5% Significance Level**											
743												
744	**Assuming Normal Distribution**											
745					**95% Normal UCL**				**95% UCLs (Adjusted for Skewness)**			
746					95% Student's-t UCL	1.233			95% Adjusted-CLT UCL (Chen-1995)			1.26
747									95% Modified-t UCL (Johnson-1978)			1.239
748												
749	**Gamma GOF Test**											
750					A-D Test Statistic	0.492			**Anderson-Darling Gamma GOF Test**			
751					5% A-D Critical Value	0.758			Detected data appear Gamma Distributed at 5% Significance Level			
752					K-S Test Statistic	0.13			**Kolmogorov-Smirnov Gamma GOF Test**			
753					5% K-S Critical Value	0.188			Detected data appear Gamma Distributed at 5% Significance Level			

	A	B	C	D	E	F	G	H	I	J	K	L
754	**Detected data appear Gamma Distributed at 5% Significance Level**											
755												
756	**Gamma Statistics**											
757					k hat (MLE)	1.554			k star (bias corrected MLE)			1.372
758					Theta hat (MLE)	0.606			Theta star (bias corrected MLE)			0.687
759					nu hat (MLE)	68.38			nu star (bias corrected)			60.39
760					MLE Mean (bias corrected)	0.942			MLE Sd (bias corrected)			0.804
761									Approximate Chi Square Value (0.05)			43.52
762					Adjusted Level of Significance	0.0386			Adjusted Chi Square Value			42.45
763												
764	**Assuming Gamma Distribution**											
765				95% Approximate Gamma UCL (use when n>=50)		1.308			95% Adjusted Gamma UCL (use when n<50)			1.34
766												
767	**Lognormal GOF Test**											
768					Shapiro Wilk Test Statistic	0.958			**Shapiro Wilk Lognormal GOF Test**			
769					5% Shapiro Wilk Critical Value	0.911			Data appear Lognormal at 5% Significance Level			
770					Lilliefors Test Statistic	0.109			**Lilliefors Lognormal GOF Test**			
771					5% Lilliefors Critical Value	0.184			Data appear Lognormal at 5% Significance Level			
772	**Data appear Lognormal at 5% Significance Level**											
773												
774	**Lognormal Statistics**											
775					Minimum of Logged Data	-1.966			Mean of logged Data			-0.414
776					Maximum of Logged Data	0.993			SD of logged Data			0.891
777												
778	**Assuming Lognormal Distribution**											
779					95% H-UCL	1.578			90% Chebyshev (MVUE) UCL			1.564
780					95% Chebyshev (MVUE) UCL	1.838			97.5% Chebyshev (MVUE) UCL			2.218
781					99% Chebyshev (MVUE) UCL	2.965						
782												
783	**Nonparametric Distribution Free UCL Statistics**											
784	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
785												
786	**Nonparametric Distribution Free UCLs**											
787					95% CLT UCL	1.22			95% Jackknife UCL			1.233
788					95% Standard Bootstrap UCL	1.213			95% Bootstrap-t UCL			1.294
789					95% Hall's Bootstrap UCL	1.242			95% Percentile Bootstrap UCL			1.211
790					95% BCA Bootstrap UCL	1.25						
791					90% Chebyshev(Mean, Sd) UCL	1.45			95% Chebyshev(Mean, Sd) UCL			1.679
792					97.5% Chebyshev(Mean, Sd) UCL	1.998			99% Chebyshev(Mean, Sd) UCL			2.625
793												
794	**Suggested UCL to Use**											
795					95% Adjusted Gamma UCL	1.34						
796												
797	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
798	Recommendations are based upon data size, data distribution, and skewness.											
799	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
800	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
801												

	A	B	C	D	E	F	G	H	I	J	K	L
802	Nickel											
803												
804	General Statistics											
805					Total Number of Observations	22				Number of Distinct Observations		11
806					Number of Detects	9				Number of Non-Detects		13
807					Number of Distinct Detects	9				Number of Distinct Non-Detects		2
808					Minimum Detect	2.1				Minimum Non-Detect		1.9
809					Maximum Detect	14				Maximum Non-Detect		2
810					Variance Detects	14.48				Percent Non-Detects		59.09%
811					Mean Detects	4.756				SD Detects		3.805
812					Median Detects	3.7				CV Detects		0.8
813					Skewness Detects	2.182				Kurtosis Detects		4.98
814					Mean of Logged Detects	1.36				SD of Logged Detects		0.619
815												
816	Normal GOF Test on Detects Only											
817					Shapiro Wilk Test Statistic	0.715	Shapiro Wilk GOF Test					
818					5% Shapiro Wilk Critical Value	0.829	Detected Data Not Normal at 5% Significance Level					
819					Lilliefors Test Statistic	0.325	Lilliefors GOF Test					
820					5% Lilliefors Critical Value	0.274	Detected Data Not Normal at 5% Significance Level					
821	Detected Data Not Normal at 5% Significance Level											
822												
823	Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs											
824					KM Mean	3.068				KM Standard Error of Mean		0.608
825					KM SD	2.69				95% KM (BCA) UCL		4.177
826					95% KM (t) UCL	4.115				95% KM (Percentile Bootstrap) UCL		4.195
827					95% KM (z) UCL	4.069				95% KM Bootstrap t UCL		6.08
828					90% KM Chebyshev UCL	4.893				95% KM Chebyshev UCL		5.72
829					97.5% KM Chebyshev UCL	6.867				99% KM Chebyshev UCL		9.121
830												
831	Gamma GOF Tests on Detected Observations Only											
832					A-D Test Statistic	0.645	Anderson-Darling GOF Test					
833					5% A-D Critical Value	0.728	Detected data appear Gamma Distributed at 5% Significance Level					
834					K-S Test Statistic	0.259	Kolmogorov-Smirnov GOF					
835					5% K-S Critical Value	0.282	Detected data appear Gamma Distributed at 5% Significance Level					
836	Detected data appear Gamma Distributed at 5% Significance Level											
837												
838	Gamma Statistics on Detected Data Only											
839					k hat (MLE)	2.658				k star (bias corrected MLE)		1.846
840					Theta hat (MLE)	1.789				Theta star (bias corrected MLE)		2.576
841					nu hat (MLE)	47.84				nu star (bias corrected)		33.22
842					Mean (detects)	4.756						
843												
844	Gamma ROS Statistics using Imputed Non-Detects											
845	GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs											
846	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)											
847	For such situations, GROS method may yield incorrect values of UCLs and BTVs											
848	This is especially true when the sample size is small.											
849	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates											
850					Minimum	0.01				Mean		1.951
851					Maximum	14				Median		0.01
852					SD	3.35				CV		1.717
853					k hat (MLE)	0.251				k star (bias corrected MLE)		0.247

	A	B	C	D	E	F	G	H	I	J	K	L
854					Theta hat (MLE)	7.788					Theta star (bias corrected MLE)	7.91
855					nu hat (MLE)	11.03					nu star (bias corrected)	10.86
856					Adjusted Level of Significance (β)	0.0386						
857					Approximate Chi Square Value (10.86, α)	4.483					Adjusted Chi Square Value (10.86, β)	4.181
858					95% Gamma Approximate UCL (use when n>=50)	4.725					95% Gamma Adjusted UCL (use when n<50)	5.067
859												
860					**Estimates of Gamma Parameters using KM Estimates**							
861					Mean (KM)	3.068					SD (KM)	2.69
862					Variance (KM)	7.237					SE of Mean (KM)	0.608
863					k hat (KM)	1.301					k star (KM)	1.154
864					nu hat (KM)	57.24					nu star (KM)	50.76
865					theta hat (KM)	2.359					theta star (KM)	2.659
866					80% gamma percentile (KM)	4.876					90% gamma percentile (KM)	6.82
867					95% gamma percentile (KM)	8.742					99% gamma percentile (KM)	13.16
868												
869					**Gamma Kaplan-Meier (KM) Statistics**							
870					Approximate Chi Square Value (50.76, α)	35.4					Adjusted Chi Square Value (50.76, β)	34.45
871					95% Gamma Approximate KM-UCL (use when n>=50)	4.399					95% Gamma Adjusted KM-UCL (use when n<50)	4.522
872												
873					**Lognormal GOF Test on Detected Observations Only**							
874					Shapiro Wilk Test Statistic	0.885			**Shapiro Wilk GOF Test**			
875					5% Shapiro Wilk Critical Value	0.829			Detected Data appear Lognormal at 5% Significance Level			
876					Lilliefors Test Statistic	0.214			**Lilliefors GOF Test**			
877					5% Lilliefors Critical Value	0.274			Detected Data appear Lognormal at 5% Significance Level			
878					**Detected Data appear Lognormal at 5% Significance Level**							
879												
880					**Lognormal ROS Statistics Using Imputed Non-Detects**							
881					Mean in Original Scale	2.327					Mean in Log Scale	0.192
882					SD in Original Scale	3.142					SD in Log Scale	1.176
883					95% t UCL (assumes normality of ROS data)	3.479					95% Percentile Bootstrap UCL	3.434
884					95% BCA Bootstrap UCL	3.858					95% Bootstrap t UCL	4.608
885					95% H-UCL (Log ROS)	5.004						
886												
887					**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**							
888					KM Mean (logged)	0.935					KM Geo Mean	2.548
889					KM SD (logged)	0.514					95% Critical H Value (KM-Log)	2.01
890					KM Standard Error of Mean (logged)	0.116					95% H-UCL (KM -Log)	3.642
891					KM SD (logged)	0.514					95% Critical H Value (KM-Log)	2.01
892					KM Standard Error of Mean (logged)	0.116						
893												
894					**DL/2 Statistics**							
895					**DL/2 Normal**				**DL/2 Log-Transformed**			
896					Mean in Original Scale	2.527					Mean in Log Scale	0.547
897					SD in Original Scale	3.02					SD in Log Scale	0.791
898					95% t UCL (Assumes normality)	3.635					95% H-Stat UCL	3.518
899					**DL/2 is not a recommended method, provided for comparisons and historical reasons**							
900												
901					**Nonparametric Distribution Free UCL Statistics**							
902					**Detected Data appear Gamma Distributed at 5% Significance Level**							
903												

	A	B	C	D	E	F	G	H	I	J	K	L
904	**Suggested UCL to Use**											
905					95% KM Adjusted Gamma UCL	4.522				95% GROS Adjusted Gamma UCL		5.067
906												
907	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
908	Recommendations are based upon data size, data distribution, and skewness.											
909	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
910	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
911												
912												
913	**Selenium**											
914												
915	**General Statistics**											
916					Total Number of Observations	22				Number of Distinct Observations		21
917										Number of Missing Observations		0
918					Minimum	5.4				Mean		30.47
919					Maximum	77				Median		20.5
920					SD	20.63				Std. Error of Mean		4.398
921					Coefficient of Variation	0.677				Skewness		0.943
922												
923	**Normal GOF Test**											
924					Shapiro Wilk Test Statistic	0.888				**Shapiro Wilk GOF Test**		
925					5% Shapiro Wilk Critical Value	0.911				Data Not Normal at 5% Significance Level		
926					Lilliefors Test Statistic	0.222				**Lilliefors GOF Test**		
927					5% Lilliefors Critical Value	0.184				Data Not Normal at 5% Significance Level		
928	**Data Not Normal at 5% Significance Level**											
929												
930	**Assuming Normal Distribution**											
931					**95% Normal UCL**					**95% UCLs (Adjusted for Skewness)**		
932					95% Student's-t UCL	38.04				95% Adjusted-CLT UCL (Chen-1995)		38.65
933										95% Modified-t UCL (Johnson-1978)		38.19
934												
935	**Gamma GOF Test**											
936					A-D Test Statistic	0.414				**Anderson-Darling Gamma GOF Test**		
937					5% A-D Critical Value	0.754				Detected data appear Gamma Distributed at 5% Significance Level		
938					K-S Test Statistic	0.17				**Kolmogorov-Smirnov Gamma GOF Test**		
939					5% K-S Critical Value	0.187				Detected data appear Gamma Distributed at 5% Significance Level		
940	**Detected data appear Gamma Distributed at 5% Significance Level**											
941												
942	**Gamma Statistics**											
943					k hat (MLE)	2.388				k star (bias corrected MLE)		2.093
944					Theta hat (MLE)	12.76				Theta star (bias corrected MLE)		14.56
945					nu hat (MLE)	105.1				nu star (bias corrected)		92.09
946					MLE Mean (bias corrected)	30.47				MLE Sd (bias corrected)		21.06
947										Approximate Chi Square Value (0.05)		70.96
948					Adjusted Level of Significance	0.0386				Adjusted Chi Square Value		69.58
949												
950	**Assuming Gamma Distribution**											
951					95% Approximate Gamma UCL (use when n>=50)	39.55				95% Adjusted Gamma UCL (use when n<50)		40.33
952												

	A	B	C	D	E	F	G	H	I	J	K	L
953						Lognormal GOF Test						
954					Shapiro Wilk Test Statistic	0.97	Shapiro Wilk Lognormal GOF Test					
955					5% Shapiro Wilk Critical Value	0.911	Data appear Lognormal at 5% Significance Level					
956					Lilliefors Test Statistic	0.129	Lilliefors Lognormal GOF Test					
957					5% Lilliefors Critical Value	0.184	Data appear Lognormal at 5% Significance Level					
958					Data appear Lognormal at 5% Significance Level							
959												
960						Lognormal Statistics						
961					Minimum of Logged Data	1.686				Mean of logged Data		3.193
962					Maximum of Logged Data	4.344				SD of logged Data		0.702
963												
964						Assuming Lognormal Distribution						
965					95% H-UCL	43.71				90% Chebyshev (MVUE) UCL		45.55
966					95% Chebyshev (MVUE) UCL	52.26				97.5% Chebyshev (MVUE) UCL		61.56
967					99% Chebyshev (MVUE) UCL	79.83						
968												
969						Nonparametric Distribution Free UCL Statistics						
970						Data appear to follow a Discernible Distribution at 5% Significance Level						
971												
972						Nonparametric Distribution Free UCLs						
973					95% CLT UCL	37.71				95% Jackknife UCL		38.04
974					95% Standard Bootstrap UCL	37.8				95% Bootstrap-t UCL		39.7
975					95% Hall's Bootstrap UCL	38.44				95% Percentile Bootstrap UCL		37.7
976					95% BCA Bootstrap UCL	38.09						
977					90% Chebyshev(Mean, Sd) UCL	43.67				95% Chebyshev(Mean, Sd) UCL		49.64
978					97.5% Chebyshev(Mean, Sd) UCL	57.94				99% Chebyshev(Mean, Sd) UCL		74.23
979												
980						Suggested UCL to Use						
981					95% Adjusted Gamma UCL	40.33						
982												
983					Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.							
984					Recommendations are based upon data size, data distribution, and skewness.							
985					These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).							
986					However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.							
987												
988	Silver											
989												
990						General Statistics						
991					Total Number of Observations	22				Number of Distinct Observations		15
992					Number of Detects	13				Number of Non-Detects		9
993					Number of Distinct Detects	13				Number of Distinct Non-Detects		2
994					Minimum Detect	3				Minimum Non-Detect		2.4
995					Maximum Detect	20				Maximum Non-Detect		2.5
996					Variance Detects	30.03				Percent Non-Detects		40.91%
997					Mean Detects	8.377				SD Detects		5.48
998					Median Detects	5.2				CV Detects		0.654
999					Skewness Detects	0.987				Kurtosis Detects		-0.0592
1000					Mean of Logged Detects	1.936				SD of Logged Detects		0.637
1001												

	A	B	C	D	E	F	G	H	I	J	K	L
1002	**Normal GOF Test on Detects Only**											
1003					Shapiro Wilk Test Statistic	0.866	**Shapiro Wilk GOF Test**					
1004					5% Shapiro Wilk Critical Value	0.866	Detected Data appear Normal at 5% Significance Level					
1005					Lilliefors Test Statistic	0.257	**Lilliefors GOF Test**					
1006					5% Lilliefors Critical Value	0.234	Detected Data Not Normal at 5% Significance Level					
1007	**Detected Data appear Approximate Normal at 5% Significance Level**											
1008												
1009	**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**											
1010					KM Mean	5.932	KM Standard Error of Mean					1.11
1011					KM SD	5.001	95% KM (BCA) UCL					7.768
1012					95% KM (t) UCL	7.842	95% KM (Percentile Bootstrap) UCL					7.877
1013					95% KM (z) UCL	7.757	95% KM Bootstrap t UCL					8.665
1014					90% KM Chebyshev UCL	9.261	95% KM Chebyshev UCL					10.77
1015					97.5% KM Chebyshev UCL	12.86	99% KM Chebyshev UCL					16.97
1016												
1017	**Gamma GOF Tests on Detected Observations Only**											
1018					A-D Test Statistic	0.527	**Anderson-Darling GOF Test**					
1019					5% A-D Critical Value	0.74	Detected data appear Gamma Distributed at 5% Significance Level					
1020					K-S Test Statistic	0.241	**Kolmogorov-Smirnov GOF**					
1021					5% K-S Critical Value	0.238	Detected Data Not Gamma Distributed at 5% Significance Level					
1022	**Detected data follow Appr. Gamma Distribution at 5% Significance Level**											
1023												
1024	**Gamma Statistics on Detected Data Only**											
1025					k hat (MLE)	2.791	k star (bias corrected MLE)					2.199
1026					Theta hat (MLE)	3.001	Theta star (bias corrected MLE)					3.81
1027					nu hat (MLE)	72.58	nu star (bias corrected)					57.16
1028					Mean (detects)	8.377						
1029												
1030	**Gamma ROS Statistics using Imputed Non-Detects**											
1031	GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs											
1032	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)											
1033	For such situations, GROS method may yield incorrect values of UCLs and BTVs											
1034	This is especially true when the sample size is small.											
1035	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates											
1036					Minimum	0.01	Mean					4.961
1037					Maximum	20	Median					3.45
1038					SD	5.9	CV					1.189
1039					k hat (MLE)	0.31	k star (bias corrected MLE)					0.298
1040					Theta hat (MLE)	16.01	Theta star (bias corrected MLE)					16.65
1041					nu hat (MLE)	13.63	nu star (bias corrected)					13.11
1042					Adjusted Level of Significance (β)	0.0386						
1043					Approximate Chi Square Value (13.11, α)	5.965	Adjusted Chi Square Value (13.11, β)					5.607
1044					95% Gamma Approximate UCL (use when n>=50)	10.9	95% Gamma Adjusted UCL (use when n<50)					11.6
1045												
1046	**Estimates of Gamma Parameters using KM Estimates**											
1047					Mean (KM)	5.932	SD (KM)					5.001
1048					Variance (KM)	25.01	SE of Mean (KM)					1.11
1049					k hat (KM)	1.407	k star (KM)					1.245
1050					nu hat (KM)	61.9	nu star (KM)					54.79
1051					theta hat (KM)	4.217	theta star (KM)					4.764
1052					80% gamma percentile (KM)	9.358	90% gamma percentile (KM)					12.94
1053					95% gamma percentile (KM)	16.46	99% gamma percentile (KM)					24.51

	A	B	C	D	E	F	G	H	I	J	K	L
1054												
1055						Gamma Kaplan-Meier (KM) Statistics						
1056					Approximate Chi Square Value (54.79, α)	38.78				Adjusted Chi Square Value (54.79, β)		37.77
1057				95% Gamma Approximate KM-UCL (use when n>=50)		8.381				95% Gamma Adjusted KM-UCL (use when n<50)		8.604
1058												
1059						Lognormal GOF Test on Detected Observations Only						
1060					Shapiro Wilk Test Statistic	0.924				Shapiro Wilk GOF Test		
1061					5% Shapiro Wilk Critical Value	0.866				Detected Data appear Lognormal at 5% Significance Level		
1062					Lilliefors Test Statistic	0.212				Lilliefors GOF Test		
1063					5% Lilliefors Critical Value	0.234				Detected Data appear Lognormal at 5% Significance Level		
1064						Detected Data appear Lognormal at 5% Significance Level						
1065												
1066						Lognormal ROS Statistics Using Imputed Non-Detects						
1067					Mean in Original Scale	5.524				Mean in Log Scale		1.25
1068					SD in Original Scale	5.44				SD in Log Scale		1.007
1069					95% t UCL (assumes normality of ROS data)	7.52				95% Percentile Bootstrap UCL		7.578
1070					95% BCA Bootstrap UCL	7.75				95% Bootstrap t UCL		8.23
1071					95% H-UCL (Log ROS)	10.26						
1072												
1073						Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution						
1074					KM Mean (logged)	1.502				KM Geo Mean		4.491
1075					KM SD (logged)	0.702				95% Critical H Value (KM-Log)		2.205
1076					KM Standard Error of Mean (logged)	0.156				95% H-UCL (KM -Log)		8.056
1077					KM SD (logged)	0.702				95% Critical H Value (KM-Log)		2.205
1078					KM Standard Error of Mean (logged)	0.156						
1079												
1080						DL/2 Statistics						
1081					DL/2 Normal					DL/2 Log-Transformed		
1082					Mean in Original Scale	5.452				Mean in Log Scale		1.228
1083					SD in Original Scale	5.486				SD in Log Scale		0.995
1084					95% t UCL (Assumes normality)	7.465				95% H-Stat UCL		9.802
1085						DL/2 is not a recommended method, provided for comparisons and historical reasons						
1086												
1087						Nonparametric Distribution Free UCL Statistics						
1088						Detected Data appear Approximate Normal Distributed at 5% Significance Level						
1089												
1090						Suggested UCL to Use						
1091					95% KM (t) UCL	7.842						
1092												
1093						When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test						
1094						When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL						
1095												
1096						Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.						
1097						Recommendations are based upon data size, data distribution, and skewness.						
1098						These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).						
1099						However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.						
1100												
1101												

	A	B	C	D	E	F	G	H	I	J	K	L
1102	Zinc											
1103												
1104						General Statistics						
1105					Total Number of Observations	22				Number of Distinct Observations		19
1106										Number of Missing Observations		0
1107					Minimum	57				Mean		304.7
1108					Maximum	1800				Median		235
1109					SD	356.8				Std. Error of Mean		76.08
1110					Coefficient of Variation	1.171				Skewness		3.807
1111												
1112						Normal GOF Test						
1113					Shapiro Wilk Test Statistic	0.535				Shapiro Wilk GOF Test		
1114					5% Shapiro Wilk Critical Value	0.911				Data Not Normal at 5% Significance Level		
1115					Lilliefors Test Statistic	0.313				Lilliefors GOF Test		
1116					5% Lilliefors Critical Value	0.184				Data Not Normal at 5% Significance Level		
1117						Data Not Normal at 5% Significance Level						
1118												
1119						Assuming Normal Distribution						
1120					95% Normal UCL					95% UCLs (Adjusted for Skewness)		
1121					95% Student's-t UCL	435.6				95% Adjusted-CLT UCL (Chen-1995)		495.8
1122										95% Modified-t UCL (Johnson-1978)		445.9
1123												
1124						Gamma GOF Test						
1125					A-D Test Statistic	0.954				Anderson-Darling Gamma GOF Test		
1126					5% A-D Critical Value	0.758				Data Not Gamma Distributed at 5% Significance Level		
1127					K-S Test Statistic	0.194				Kolmogorov-Smirnov Gamma GOF Test		
1128					5% K-S Critical Value	0.188				Data Not Gamma Distributed at 5% Significance Level		
1129						Data Not Gamma Distributed at 5% Significance Level						
1130												
1131						Gamma Statistics						
1132					k hat (MLE)	1.726				k star (bias corrected MLE)		1.521
1133					Theta hat (MLE)	176.5				Theta star (bias corrected MLE)		200.4
1134					nu hat (MLE)	75.93				nu star (bias corrected)		66.91
1135					MLE Mean (bias corrected)	304.7				MLE Sd (bias corrected)		247.1
1136										Approximate Chi Square Value (0.05)		49.09
1137					Adjusted Level of Significance	0.0386				Adjusted Chi Square Value		47.95
1138												
1139						Assuming Gamma Distribution						
1140					95% Approximate Gamma UCL (use when n>=50))	415.3				95% Adjusted Gamma UCL (use when n<50)		425.2
1141												
1142						Lognormal GOF Test						
1143					Shapiro Wilk Test Statistic	0.948				Shapiro Wilk Lognormal GOF Test		
1144					5% Shapiro Wilk Critical Value	0.911				Data appear Lognormal at 5% Significance Level		
1145					Lilliefors Test Statistic	0.131				Lilliefors Lognormal GOF Test		
1146					5% Lilliefors Critical Value	0.184				Data appear Lognormal at 5% Significance Level		
1147						Data appear Lognormal at 5% Significance Level						
1148												
1149						Lognormal Statistics						
1150					Minimum of Logged Data	4.043				Mean of logged Data		5.402
1151					Maximum of Logged Data	7.496				SD of logged Data		0.735
1152												

	A	B	C	D	E	F	G	H	I	J	K	L
1153	**Assuming Lognormal Distribution**											
1154					95% H-UCL	416.6				90% Chebyshev (MVUE) UCL		431.3
1155					95% Chebyshev (MVUE) UCL	497				97.5% Chebyshev (MVUE) UCL		588.1
1156					99% Chebyshev (MVUE) UCL	767.2						
1157												
1158	**Nonparametric Distribution Free UCL Statistics**											
1159	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
1160												
1161	**Nonparametric Distribution Free UCLs**											
1162					95% CLT UCL	429.8				95% Jackknife UCL		435.6
1163					95% Standard Bootstrap UCL	427.1				95% Bootstrap-t UCL		651.9
1164					95% Hall's Bootstrap UCL	938.9				95% Percentile Bootstrap UCL		446.8
1165					95% BCA Bootstrap UCL	526.7						
1166					90% Chebyshev(Mean, Sd) UCL	532.9				95% Chebyshev(Mean, Sd) UCL		636.3
1167					97.5% Chebyshev(Mean, Sd) UCL	779.8				99% Chebyshev(Mean, Sd) UCL		1062
1168												
1169	**Suggested UCL to Use**											
1170					95% H-UCL	416.6						
1171												
1172	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
1173	Recommendations are based upon data size, data distribution, and skewness.											
1174	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
1175	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
1176												
1177	**ProUCL computes and outputs H-statistic based UCLs for historical reasons only.**											
1178	**H-statistic often results in unstable (both high and low) values of UCL95 as shown in examples in the Technical Guide.**											
1179	**It is therefore recommended to avoid the use of H-statistic based 95% UCLs.**											
1180	**Use of nonparametric methods are preferred to compute UCL95 for skewed data sets which do not follow a gamma distribution.**											
1181												

	A	B	C	D	E	F	G	H	I	J	K	L	M
1				General Statistics on Uncensored Data: Exposure Area 2									
2			Date/Time of Computation	ProUCL 5.110/17/2019 3:08:45 PM									
3			User Selected Options										
4			From File	ProUCL Input 3_EA2_rev083019.xls									
5			Full Precision	OFF									
6													
7	From File: ProUCL Input 3_EA2_rev083019.xls												
8													
9	General Statistics for Censored Data Set (with NDs) using Kaplan Meier Method												
10													
11	Variable		NumObs	# Missing	Num Ds	NumNDs	% NDs	Min ND	Max ND	KM Mean	KM Var	KM SD	KM CV
12	Antimony		14	0	8	6	42.86%	4.9	5	16.25	200.8	14.17	0.872
13	Arsenic		14	0	14	0	0.00%	N/A	N/A	203.1	20684	143.8	0.708
14	Barium		14	0	11	3	21.43%	4.9	99	67.44	5022	70.87	1.051
15	Cadmium		14	0	8	6	42.86%	0.49	0.5	5.566	272.1	16.49	2.964
16	Chromium		14	0	10	4	28.57%	2	200	10.93	67.4	8.21	0.751
17	Copper		14	0	14	0	0.00%	N/A	N/A	7977	61489776	7842	0.983
18	Lead		14	0	14	0	0.00%	N/A	N/A	243.9	106225	325.9	1.336
19	Manganese		14	0	14	0	0.00%	N/A	N/A	292.9	27668	166.3	0.568
20	Mercury		14	0	14	0	0.00%	N/A	N/A	2.554	20.03	4.475	1.752
21	Nickel		14	0	11	3	21.43%	2	2	8.6	38	6.164	0.717
22	Selenium0823		14	0	14	0	0.00%	N/A	N/A	35.24	319.4	17.87	0.507
23	Silver		14	0	13	1	7.14%	2.5	2.5	7.1	13.86	3.723	0.524
24	Zinc		14	0	14	0	0.00%	N/A	N/A	1277	15623230	3953	3.095
25													
26	General Statistics for Raw Data Sets using Detected Data Only												
27													
28	Variable		NumObs	# Missing	Minimum	Maximum	Mean	Median	Var	SD	MAD/0.675	Skewness	CV
29	Antimony		8	0	5.3	42	24.76	23.5	208.4	14.44	21.65	-0.108	0.583
30	Arsenic		14	0	31	430	203.1	120	20684	143.8	104.5	0.527	0.708
31	Barium		11	0	6.7	270	81.52	74	5837	76.4	71.16	1.588	0.937
32	Cadmium		8	0	0.67	65	9.373	1.45	505.5	22.48	0.808	2.826	2.399
33	Chromium		10	0	2.7	30	13.61	13.5	62.79	7.924	6.597	0.773	0.582
34	Copper		14	0	880	24000	7977	5750	61489776	7842	6449	1.119	0.983
35	Lead		14	0	18	1200	243.9	108.5	106225	325.9	131.9	2.21	1.336
36	Manganese		14	0	120	700	292.9	250	27668	166.3	74.13	1.713	0.568
37	Mercury		14	0	0.17	14	2.554	0.825	20.03	4.475	0.689	2.264	1.752
38	Nickel		11	0	3.1	22	10.4	8.4	36.56	6.047	3.706	1.191	0.581
39	Selenium0823		14	0	8.3	59	35.24	32.5	319.4	17.87	27.43	-0.117	0.507
40	Silver		13	0	2.5	14	7.454	5.9	14.27	3.777	5.041	0.268	0.507
41	Zinc		14	0	55	15000	1277	210	15623230	3953	213.5	3.732	3.095
42													

	A	B	C	D	E	F	G	H	I	J	K	L	M
43	Percentiles using all Detects (Ds) and Non-Detects (NDs)												
44													
45	Variable		NumObs	# Missing	10%ile	20%ile	25%ile(Q1)	50%ile(Q2)	75%ile(Q3)	80%ile	90%ile	95%ile	99%ile
46		Antimony	14	0	4.9	4.96	5	6.05	23.75	28.8	40.2	42	42
47		Arsenic	14	0	73.4	87.2	91	120	322.5	358	407	417	427.4
48		Barium	14	0	5.51	9.88	14.25	66	97.5	107.4	134	185.5	253.1
49		Cadmium	14	0	0.49	0.496	0.5	0.79	1.475	1.7	2.14	24.18	56.84
50		Chromium	14	0	2	2.42	3.35	11.2	16	18	27.3	89.5	177.9
51		Copper	14	0	1060	1260	1475	5750	9675	14000	20000	21400	23480
52		Lead	14	0	24.3	33.2	35.75	108.5	292.5	366	534	790.5	1118
53		Manganese	14	0	149	194	215	250	297.5	330	535	641.5	688.3
54		Mercury	14	0	0.328	0.376	0.39	0.825	1.45	1.7	9	12.7	13.74
55		Nickel	14	0	2	2.66	3.8	7.15	11.2	12	18.3	21.35	21.87
56		Selenium0823	14	0	12.3	16.6	21	32.5	51	52.2	56.8	58.35	58.87
57		Silver	14	0	2.83	3.66	3.825	5.6	10.75	11	11	12.05	13.61
58		Zinc	14	0	65.6	70	74.75	210	397.5	412	465	5562	13112

	A	B	C	D	E	F	G	H	I	J	K	L
1	UCL Statistics for Data Sets with Non-Detects: Exposure Area 2											
2												
3	User Selected Options											
4	Date/Time of Computation			ProUCL 5.110/17/2019 3:10:47 PM								
5	From File			ProUCL Input 3_EA2_rev083019.xls								
6	Full Precision			OFF								
7	Confidence Coefficient			95%								
8	Number of Bootstrap Operations			2000								
9												
10	Antimony											
11												
12	General Statistics											
13	Total Number of Observations					14	Number of Distinct Observations					9
14	Number of Detects					8	Number of Non-Detects					6
15	Number of Distinct Detects					7	Number of Distinct Non-Detects					2
16	Minimum Detect					5.3	Minimum Non-Detect					4.9
17	Maximum Detect					42	Maximum Non-Detect					5
18	Variance Detects					208.4	Percent Non-Detects					42.86%
19	Mean Detects					24.76	SD Detects					14.44
20	Median Detects					23.5	CV Detects					0.583
21	Skewness Detects					-0.108	Kurtosis Detects					-1.417
22	Mean of Logged Detects					2.988	SD of Logged Detects					0.795
23												
24	Normal GOF Test on Detects Only											
25	Shapiro Wilk Test Statistic					0.907	Shapiro Wilk GOF Test					
26	5% Shapiro Wilk Critical Value					0.818	Detected Data appear Normal at 5% Significance Level					
27	Lilliefors Test Statistic					0.157	Lilliefors GOF Test					
28	5% Lilliefors Critical Value					0.283	Detected Data appear Normal at 5% Significance Level					
29	Detected Data appear Normal at 5% Significance Level											
30												
31	Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs											
32	KM Mean					16.25	KM Standard Error of Mean					4.049
33	KM SD					14.17	95% KM (BCA) UCL					23.31
34	95% KM (t) UCL					23.42	95% KM (Percentile Bootstrap) UCL					22.8
35	95% KM (z) UCL					22.91	95% KM Bootstrap t UCL					24.2
36	90% KM Chebyshev UCL					28.4	95% KM Chebyshev UCL					33.9
37	97.5% KM Chebyshev UCL					41.54	99% KM Chebyshev UCL					56.54
38												
39	Gamma GOF Tests on Detected Observations Only											
40	A-D Test Statistic					0.465	Anderson-Darling GOF Test					
41	5% A-D Critical Value					0.723	Detected data appear Gamma Distributed at 5% Significance Level					
42	K-S Test Statistic					0.181	Kolmogorov-Smirnov GOF					
43	5% K-S Critical Value					0.297	Detected data appear Gamma Distributed at 5% Significance Level					
44	Detected data appear Gamma Distributed at 5% Significance Level											
45												
46	Gamma Statistics on Detected Data Only											
47	k hat (MLE)					2.409	k star (bias corrected MLE)					1.589
48	Theta hat (MLE)					10.28	Theta star (bias corrected MLE)					15.58
49	nu hat (MLE)					38.55	nu star (bias corrected)					25.43
50	Mean (detects)					24.76						
51												

	A	B	C	D	E	F	G	H	I	J	K	L
52	**Gamma ROS Statistics using Imputed Non-Detects**											
53	GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs											
54	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)											
55	For such situations, GROS method may yield incorrect values of UCLs and BTVs											
56	This is especially true when the sample size is small.											
57	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates											
58					Minimum	0.01				Mean		14.44
59					Maximum	42				Median		6.05
60					SD	16.3				CV		1.128
61					k hat (MLE)	0.314				k star (bias corrected MLE)		0.295
62					Theta hat (MLE)	45.96				Theta star (bias corrected MLE)		49.04
63					nu hat (MLE)	8.798				nu star (bias corrected)		8.246
64					Adjusted Level of Significance (β)	0.0312						
65					Approximate Chi Square Value (8.25, α)	2.878				Adjusted Chi Square Value (8.25, β)		2.474
66					95% Gamma Approximate UCL (use when n>=50)	41.37				95% Gamma Adjusted UCL (use when n<50)		48.13
67												
68	**Estimates of Gamma Parameters using KM Estimates**											
69					Mean (KM)	16.25				SD (KM)		14.17
70					Variance (KM)	200.8				SE of Mean (KM)		4.049
71					k hat (KM)	1.315				k star (KM)		1.081
72					nu hat (KM)	36.82				nu star (KM)		30.26
73					theta hat (KM)	12.36				theta star (KM)		15.04
74					80% gamma percentile (KM)	25.98				90% gamma percentile (KM)		36.71
75					95% gamma percentile (KM)	47.37				99% gamma percentile (KM)		71.98
76												
77	**Gamma Kaplan-Meier (KM) Statistics**											
78					Approximate Chi Square Value (30.26, α)	18.7				Adjusted Chi Square Value (30.26, β)		17.5
79					95% Gamma Approximate KM-UCL (use when n>=50)	26.3				95% Gamma Adjusted KM-UCL (use when n<50)		28.1
80												
81	**Lognormal GOF Test on Detected Observations Only**											
82					Shapiro Wilk Test Statistic	0.852				**Shapiro Wilk GOF Test**		
83					5% Shapiro Wilk Critical Value	0.818				Detected Data appear Lognormal at 5% Significance Level		
84					Lilliefors Test Statistic	0.228				**Lilliefors GOF Test**		
85					5% Lilliefors Critical Value	0.283				Detected Data appear Lognormal at 5% Significance Level		
86	**Detected Data appear Lognormal at 5% Significance Level**											
87												
88	**Lognormal ROS Statistics Using Imputed Non-Detects**											
89					Mean in Original Scale	15.43				Mean in Log Scale		2.14
90					SD in Original Scale	15.42				SD in Log Scale		1.207
91					95% t UCL (assumes normality of ROS data)	22.73				95% Percentile Bootstrap UCL		22.21
92					95% BCA Bootstrap UCL	22.65				95% Bootstrap t UCL		24.25
93					95% H-UCL (Log ROS)	50.57						
94												
95	**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**											
96					KM Mean (logged)	2.388				KM Geo Mean		10.9
97					KM SD (logged)	0.892				95% Critical H Value (KM-Log)		2.618
98					KM Standard Error of Mean (logged)	0.255				95% H-UCL (KM -Log)		30.99
99					KM SD (logged)	0.892				95% Critical H Value (KM-Log)		2.618
100					KM Standard Error of Mean (logged)	0.255						
101												

	A	B	C	D	E	F	G	H	I	J	K	L
102	**DL/2 Statistics**											
103	**DL/2 Normal**						**DL/2 Log-Transformed**					
104					Mean in Original Scale	15.21					Mean in Log Scale	2.096
105					SD in Original Scale	15.6					SD in Log Scale	1.218
106					95% t UCL (Assumes normality)	22.59					95% H-Stat UCL	49.77
107	**DL/2 is not a recommended method, provided for comparisons and historical reasons**											
108												
109	**Nonparametric Distribution Free UCL Statistics**											
110	**Detected Data appear Normal Distributed at 5% Significance Level**											
111												
112	**Suggested UCL to Use**											
113					95% KM (t) UCL	23.42						
114												
115	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
116	Recommendations are based upon data size, data distribution, and skewness.											
117	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
118	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
119												
120												
121	**Arsenic**											
122												
123	**General Statistics**											
124					Total Number of Observations	14					Number of Distinct Observations	13
125											Number of Missing Observations	0
126					Minimum	31					Mean	203.1
127					Maximum	430					Median	120
128					SD	143.8					Std. Error of Mean	38.44
129					Coefficient of Variation	0.708					Skewness	0.527
130												
131	**Normal GOF Test**											
132					Shapiro Wilk Test Statistic	0.854	**Shapiro Wilk GOF Test**					
133					5% Shapiro Wilk Critical Value	0.874	Data Not Normal at 5% Significance Level					
134					Lilliefors Test Statistic	0.266	**Lilliefors GOF Test**					
135					5% Lilliefors Critical Value	0.226	Data Not Normal at 5% Significance Level					
136	**Data Not Normal at 5% Significance Level**											
137												
138	**Assuming Normal Distribution**											
139	**95% Normal UCL**						**95% UCLs (Adjusted for Skewness)**					
140					95% Student's-t UCL	271.1					95% Adjusted-CLT UCL (Chen-1995)	272.1
141											95% Modified-t UCL (Johnson-1978)	272
142												
143	**Gamma GOF Test**											
144					A-D Test Statistic	0.641	**Anderson-Darling Gamma GOF Test**					
145					5% A-D Critical Value	0.746	Detected data appear Gamma Distributed at 5% Significance Level					
146					K-S Test Statistic	0.203	**Kolmogorov-Smirnov Gamma GOF Test**					
147					5% K-S Critical Value	0.232	Detected data appear Gamma Distributed at 5% Significance Level					
148	**Detected data appear Gamma Distributed at 5% Significance Level**											
149												

	A	B	C	D	E	F	G	H	I	J	K	L
150						Gamma Statistics						
151					k hat (MLE)	1.976					k star (bias corrected MLE)	1.6
152					Theta hat (MLE)	102.8					Theta star (bias corrected MLE)	126.9
153					nu hat (MLE)	55.32					nu star (bias corrected)	44.8
154					MLE Mean (bias corrected)	203.1					MLE Sd (bias corrected)	160.5
155											Approximate Chi Square Value (0.05)	30.44
156					Adjusted Level of Significance	0.0312					Adjusted Chi Square Value	28.88
157												
158						Assuming Gamma Distribution						
159					95% Approximate Gamma UCL (use when n>=50)	298.8					95% Adjusted Gamma UCL (use when n<50)	315
160												
161						Lognormal GOF Test						
162					Shapiro Wilk Test Statistic	0.916					Shapiro Wilk Lognormal GOF Test	
163					5% Shapiro Wilk Critical Value	0.874					Data appear Lognormal at 5% Significance Level	
164					Lilliefors Test Statistic	0.162					Lilliefors Lognormal GOF Test	
165					5% Lilliefors Critical Value	0.226					Data appear Lognormal at 5% Significance Level	
166						Data appear Lognormal at 5% Significance Level						
167												
168						Lognormal Statistics						
169					Minimum of Logged Data	3.434					Mean of logged Data	5.04
170					Maximum of Logged Data	6.064					SD of logged Data	0.809
171												
172						Assuming Lognormal Distribution						
173					95% H-UCL	374.9					90% Chebyshev (MVUE) UCL	351.7
174					95% Chebyshev (MVUE) UCL	416.7					97.5% Chebyshev (MVUE) UCL	507
175					99% Chebyshev (MVUE) UCL	684.3						
176												
177						Nonparametric Distribution Free UCL Statistics						
178						Data appear to follow a Discernible Distribution at 5% Significance Level						
179												
180						Nonparametric Distribution Free UCLs						
181					95% CLT UCL	266.3					95% Jackknife UCL	271.1
182					95% Standard Bootstrap UCL	264.3					95% Bootstrap-t UCL	283.8
183					95% Hall's Bootstrap UCL	261.7					95% Percentile Bootstrap UCL	264.5
184					95% BCA Bootstrap UCL	273.4						
185					90% Chebyshev(Mean, Sd) UCL	318.4					95% Chebyshev(Mean, Sd) UCL	370.6
186					97.5% Chebyshev(Mean, Sd) UCL	443.1					99% Chebyshev(Mean, Sd) UCL	585.5
187												
188						Suggested UCL to Use						
189					95% Adjusted Gamma UCL	315						
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												

	A	B	C	D	E	F	G	H	I	J	K	L
196	**Barium**											
197												
198	**General Statistics**											
199					Total Number of Observations	14			Number of Distinct Observations			14
200					Number of Detects	11			Number of Non-Detects			3
201					Number of Distinct Detects	11			Number of Distinct Non-Detects			3
202					Minimum Detect	6.7			Minimum Non-Detect			4.9
203					Maximum Detect	270			Maximum Non-Detect			99
204					Variance Detects	5837			Percent Non-Detects			21.43%
205					Mean Detects	81.52			SD Detects			76.4
206					Median Detects	74			CV Detects			0.937
207					Skewness Detects	1.588			Kurtosis Detects			3.118
208					Mean of Logged Detects	3.931			SD of Logged Detects			1.125
209												
210	**Normal GOF Test on Detects Only**											
211					Shapiro Wilk Test Statistic	0.853		**Shapiro Wilk GOF Test**				
212					5% Shapiro Wilk Critical Value	0.85		Detected Data appear Normal at 5% Significance Level				
213					Lilliefors Test Statistic	0.168		**Lilliefors GOF Test**				
214					5% Lilliefors Critical Value	0.251		Detected Data appear Normal at 5% Significance Level				
215	**Detected Data appear Normal at 5% Significance Level**											
216												
217	**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**											
218					KM Mean	67.44			KM Standard Error of Mean			20.03
219					KM SD	70.87			95% KM (BCA) UCL			102.8
220					95% KM (t) UCL	102.9			95% KM (Percentile Bootstrap) UCL			99.96
221					95% KM (z) UCL	100.4			95% KM Bootstrap t UCL			115.9
222					90% KM Chebyshev UCL	127.5			95% KM Chebyshev UCL			154.7
223					97.5% KM Chebyshev UCL	192.5			99% KM Chebyshev UCL			266.7
224												
225	**Gamma GOF Tests on Detected Observations Only**											
226					A-D Test Statistic	0.2		**Anderson-Darling GOF Test**				
227					5% A-D Critical Value	0.748		Detected data appear Gamma Distributed at 5% Significance Level				
228					K-S Test Statistic	0.13		**Kolmogorov-Smirnov GOF**				
229					5% K-S Critical Value	0.261		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)	1.204			k star (bias corrected MLE)			0.937
234					Theta hat (MLE)	67.68			Theta star (bias corrected MLE)			87.04
235					nu hat (MLE)	26.5			nu star (bias corrected)			20.6
236					Mean (detects)	81.52						
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	0.01			Mean			65.93
245					Maximum	270			Median			42.15
246					SD	74.06			CV			1.123
247					k hat (MLE)	0.427			k star (bias corrected MLE)			0.383

	A	B	C	D	E	F	G	H	I	J	K	L
248					Theta hat (MLE)	154.3					Theta star (bias corrected MLE)	172
249					nu hat (MLE)	11.96					nu star (bias corrected)	10.73
250					Adjusted Level of Significance (β)	0.0312						
251					Approximate Chi Square Value (10.73, α)	4.405					Adjusted Chi Square Value (10.73, β)	3.881
252					95% Gamma Approximate UCL (use when n>=50)	160.6					95% Gamma Adjusted UCL (use when n<50)	182.3
253												
254					**Estimates of Gamma Parameters using KM Estimates**							
255					Mean (KM)	67.44					SD (KM)	70.87
256					Variance (KM)	5022					SE of Mean (KM)	20.03
257					k hat (KM)	0.906					k star (KM)	0.759
258					nu hat (KM)	25.36					nu star (KM)	21.26
259					theta hat (KM)	74.47					theta star (KM)	88.83
260					80% gamma percentile (KM)	110.5					90% gamma percentile (KM)	166.1
261					95% gamma percentile (KM)	222.9					99% gamma percentile (KM)	357.8
262												
263					**Gamma Kaplan-Meier (KM) Statistics**							
264					Approximate Chi Square Value (21.26, α)	11.78					Adjusted Chi Square Value (21.26, β)	10.86
265					95% Gamma Approximate KM-UCL (use when n>=50)	121.7					95% Gamma Adjusted KM-UCL (use when n<50)	132
266												
267					**Lognormal GOF Test on Detected Observations Only**							
268					Shapiro Wilk Test Statistic	0.956			**Shapiro Wilk GOF Test**			
269					5% Shapiro Wilk Critical Value	0.85			Detected Data appear Lognormal at 5% Significance Level			
270					Lilliefors Test Statistic	0.182			**Lilliefors GOF Test**			
271					5% Lilliefors Critical Value	0.251			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	66.33					Mean in Log Scale	3.528
276					SD in Original Scale	73.61					SD in Log Scale	1.324
277					95% t UCL (assumes normality of ROS data)	101.2					95% Percentile Bootstrap UCL	100.8
278					95% BCA Bootstrap UCL	107.4					95% Bootstrap t UCL	121.6
279					95% H-UCL (Log ROS)	280.7						
280												
281					**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**							
282					KM Mean (logged)	3.538					KM Geo Mean	34.4
283					KM SD (logged)	1.292					95% Critical H Value (KM-Log)	3.302
284					KM Standard Error of Mean (logged)	0.373					95% H-UCL (KM -Log)	258.9
285					KM SD (logged)	1.292					95% Critical H Value (KM-Log)	3.302
286					KM Standard Error of Mean (logged)	0.373						
287												
288					**DL/2 Statistics**							
289					**DL/2 Normal**				**DL/2 Log-Transformed**			
290					Mean in Original Scale	67.94					Mean in Log Scale	3.497
291					SD in Original Scale	73.02					SD in Log Scale	1.476
292					95% t UCL (Assumes normality)	102.5					95% H-Stat UCL	436.5
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	102.9						

	A	B	C	D	E	F	G	H	I	J	K	L
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	**Cadmium**											
307												
308	**General Statistics**											
309	Total Number of Observations					14	Number of Distinct Observations					10
310	Number of Detects					8	Number of Non-Detects					6
311	Number of Distinct Detects					8	Number of Distinct Non-Detects					2
312	Minimum Detect					0.67	Minimum Non-Detect					0.49
313	Maximum Detect					65	Maximum Non-Detect					0.5
314	Variance Detects					505.5	Percent Non-Detects					42.86%
315	Mean Detects					9.373	SD Detects					22.48
316	Median Detects					1.45	CV Detects					2.399
317	Skewness Detects					2.826	Kurtosis Detects					7.988
318	Mean of Logged Detects					0.771	SD of Logged Detects					1.429
319												
320	**Normal GOF Test on Detects Only**											
321	Shapiro Wilk Test Statistic					0.44	**Shapiro Wilk GOF Test**					
322	5% Shapiro Wilk Critical Value					0.818	Detected Data Not Normal at 5% Significance Level					
323	Lilliefors Test Statistic					0.5	**Lilliefors GOF Test**					
324	5% Lilliefors Critical Value					0.283	Detected Data Not Normal at 5% Significance Level					
325	**Detected Data Not Normal at 5% Significance Level**											
326												
327	**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**											
328	KM Mean					5.566	KM Standard Error of Mean					4.713
329	KM SD					16.49	95% KM (BCA) UCL					14.76
330	95% KM (t) UCL					13.91	95% KM (Percentile Bootstrap) UCL					14.67
331	95% KM (z) UCL					13.32	95% KM Bootstrap t UCL					164.8
332	90% KM Chebyshev UCL					19.7	95% KM Chebyshev UCL					26.11
333	97.5% KM Chebyshev UCL					35	99% KM Chebyshev UCL					52.46
334												
335	**Gamma GOF Tests on Detected Observations Only**											
336	A-D Test Statistic					1.81	**Anderson-Darling GOF Test**					
337	5% A-D Critical Value					0.773	Detected Data Not Gamma Distributed at 5% Significance Level					
338	K-S Test Statistic					0.473	**Kolmogorov-Smirnov GOF**					
339	5% K-S Critical Value					0.311	Detected Data Not Gamma Distributed at 5% Significance Level					
340	**Detected Data Not Gamma Distributed at 5% Significance Level**											
341												
342	**Gamma Statistics on Detected Data Only**											
343	k hat (MLE)					0.441	k star (bias corrected MLE)					0.359
344	Theta hat (MLE)					21.23	Theta star (bias corrected MLE)					26.09
345	nu hat (MLE)					7.064	nu star (bias corrected)					5.748
346	Mean (detects)					9.373						
347												

	A	B	C	D	E	F	G	H	I	J	K	L
348	**Gamma ROS Statistics using Imputed Non-Detects**											
349	GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs											
350	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)											
351	For such situations, GROS method may yield incorrect values of UCLs and BTVs											
352	This is especially true when the sample size is small.											
353	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates											
354					Minimum	0.01				Mean		5.36
355					Maximum	65				Median		0.79
356					SD	17.18				CV		3.206
357					k hat (MLE)	0.225				k star (bias corrected MLE)		0.224
358					Theta hat (MLE)	23.83				Theta star (bias corrected MLE)		23.89
359					nu hat (MLE)	6.297				nu star (bias corrected)		6.281
360					Adjusted Level of Significance (β)	0.0312						
361					Approximate Chi Square Value (6.28, α)	1.785				Adjusted Chi Square Value (6.28, β)		1.487
362					95% Gamma Approximate UCL (use when n>=50)	18.86				95% Gamma Adjusted UCL (use when n<50)		22.65
363												
364	**Estimates of Gamma Parameters using KM Estimates**											
365					Mean (KM)	5.566				SD (KM)		16.49
366					Variance (KM)	272.1				SE of Mean (KM)		4.713
367					k hat (KM)	0.114				k star (KM)		0.137
368					nu hat (KM)	3.188				nu star (KM)		3.838
369					theta hat (KM)	48.88				theta star (KM)		40.6
370					80% gamma percentile (KM)	5.599				90% gamma percentile (KM)		16.26
371					95% gamma percentile (KM)	31.14				99% gamma percentile (KM)		75.15
372												
373	**Gamma Kaplan-Meier (KM) Statistics**											
374					Approximate Chi Square Value (3.84, α)	0.659				Adjusted Chi Square Value (3.84, β)		0.51
375					95% Gamma Approximate KM-UCL (use when n>=50)	32.42				95% Gamma Adjusted KM-UCL (use when n<50)		41.9
376												
377	**Lognormal GOF Test on Detected Observations Only**											
378					Shapiro Wilk Test Statistic	0.684				**Shapiro Wilk GOF Test**		
379					5% Shapiro Wilk Critical Value	0.818				Detected Data Not Lognormal at 5% Significance Level		
380					Lilliefors Test Statistic	0.37				**Lilliefors GOF Test**		
381					5% Lilliefors Critical Value	0.283				Detected Data Not Lognormal at 5% Significance Level		
382	**Detected Data Not Lognormal at 5% Significance Level**											
383												
384	**Lognormal ROS Statistics Using Imputed Non-Detects**											
385					Mean in Original Scale	5.395				Mean in Log Scale		-0.69
386					SD in Original Scale	17.17				SD in Log Scale		2.101
387					95% t UCL (assumes normality of ROS data)	13.52				95% Percentile Bootstrap UCL		14.54
388					95% BCA Bootstrap UCL	19.23				95% Bootstrap t UCL		133.4
389					95% H-UCL (Log ROS)	78.28						
390												
391	**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**											
392					KM Mean (logged)	0.135				KM Geo Mean		1.144
393					KM SD (logged)	1.249				95% Critical H Value (KM-Log)		3.224
394					KM Standard Error of Mean (logged)	0.357				95% H-UCL (KM -Log)		7.628
395					KM SD (logged)	1.249				95% Critical H Value (KM-Log)		3.224
396					KM Standard Error of Mean (logged)	0.357						
397												

	A	B	C	D	E	F	G	H	I	J	K	L
398						DL/2 Statistics						
399					DL/2 Normal					DL/2 Log-Transformed		
400					Mean in Original Scale	5.462				Mean in Log Scale		-0.158
401					SD in Original Scale	17.15				SD in Log Scale		1.529
402					95% t UCL (Assumes normality)	13.58				95% H-Stat UCL		13.46
403					DL/2 is not a recommended method, provided for comparisons and historical reasons							
404												
405					Nonparametric Distribution Free UCL Statistics							
406					Data do not follow a Discernible Distribution at 5% Significance Level							
407												
408					Suggested UCL to Use							
409					95% KM (Chebyshev) UCL	26.11						
410												
411					Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.							
412					Recommendations are based upon data size, data distribution, and skewness.							
413					These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).							
414					However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.							
415												
416	Chromium											
417												
418					General Statistics							
419					Total Number of Observations	14				Number of Distinct Observations		11
420					Number of Detects	10				Number of Non-Detects		4
421					Number of Distinct Detects	9				Number of Distinct Non-Detects		2
422					Minimum Detect	2.7				Minimum Non-Detect		2
423					Maximum Detect	30				Maximum Non-Detect		200
424					Variance Detects	62.79				Percent Non-Detects		28.57%
425					Mean Detects	13.61				SD Detects		7.924
426					Median Detects	13.5				CV Detects		0.582
427					Skewness Detects	0.773				Kurtosis Detects		0.922
428					Mean of Logged Detects	2.426				SD of Logged Detects		0.697
429												
430					Normal GOF Test on Detects Only							
431					Shapiro Wilk Test Statistic	0.956				Shapiro Wilk GOF Test		
432					5% Shapiro Wilk Critical Value	0.842				Detected Data appear Normal at 5% Significance Level		
433					Lilliefors Test Statistic	0.181				Lilliefors GOF Test		
434					5% Lilliefors Critical Value	0.262				Detected Data appear Normal at 5% Significance Level		
435					Detected Data appear Normal at 5% Significance Level							
436												
437					Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs							
438					KM Mean	10.93				KM Standard Error of Mean		2.4
439					KM SD	8.21				95% KM (BCA) UCL		14.95
440					95% KM (t) UCL	15.18				95% KM (Percentile Bootstrap) UCL		14.65
441					95% KM (z) UCL	14.88				95% KM Bootstrap t UCL		15.68
442					90% KM Chebyshev UCL	18.13				95% KM Chebyshev UCL		21.39
443					97.5% KM Chebyshev UCL	25.92				99% KM Chebyshev UCL		34.81
444												
445					Gamma GOF Tests on Detected Observations Only							
446					A-D Test Statistic	0.196				Anderson-Darling GOF Test		
447					5% A-D Critical Value	0.733				Detected data appear Gamma Distributed at 5% Significance Level		
448					K-S Test Statistic	0.149				Kolmogorov-Smirnov GOF		
449					5% K-S Critical Value	0.269				Detected data appear Gamma Distributed at 5% Significance Level		

	A	B	C	D	E	F	G	H	I	J	K	L
450	**Detected data appear Gamma Distributed at 5% Significance Level**											
451												
452	**Gamma Statistics on Detected Data Only**											
453					k hat (MLE)	2.861			k star (bias corrected MLE)			2.069
454					Theta hat (MLE)	4.757			Theta star (bias corrected MLE)			6.577
455					nu hat (MLE)	57.22			nu star (bias corrected)			41.39
456					Mean (detects)	13.61						
457												
458	**Gamma ROS Statistics using Imputed Non-Detects**											
459	GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs											
460	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)											
461	For such situations, GROS method may yield incorrect values of UCLs and BTVs											
462	This is especially true when the sample size is small.											
463	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates											
464					Minimum	0.01			Mean			10.45
465					Maximum	30			Median			9.164
466					SD	8.641			CV			0.827
467					k hat (MLE)	0.566			k star (bias corrected MLE)			0.492
468					Theta hat (MLE)	18.46			Theta star (bias corrected MLE)			21.23
469					nu hat (MLE)	15.84			nu star (bias corrected)			13.78
470					Adjusted Level of Significance (β)	0.0312						
471					Approximate Chi Square Value (13.78, α)	6.421			Adjusted Chi Square Value (13.78, β)			5.767
472					95% Gamma Approximate UCL (use when n>=50)	22.42			95% Gamma Adjusted UCL (use when n<50)			24.96
473												
474	**Estimates of Gamma Parameters using KM Estimates**											
475					Mean (KM)	10.93			SD (KM)			8.21
476					Variance (KM)	67.4			SE of Mean (KM)			2.4
477					k hat (KM)	1.773			k star (KM)			1.441
478					nu hat (KM)	49.64			nu star (KM)			40.33
479					theta hat (KM)	6.166			theta star (KM)			7.588
480					80% gamma percentile (KM)	16.99			90% gamma percentile (KM)			23
481					95% gamma percentile (KM)	28.86			99% gamma percentile (KM)			42.13
482												
483	**Gamma Kaplan-Meier (KM) Statistics**											
484					Approximate Chi Square Value (40.33, α)	26.78			Adjusted Chi Square Value (40.33, β)			25.32
485					95% Gamma Approximate KM-UCL (use when n>=50)	16.46			95% Gamma Adjusted KM-UCL (use when n<50)			17.41
486												
487	**Lognormal GOF Test on Detected Observations Only**											
488					Shapiro Wilk Test Statistic	0.946			**Shapiro Wilk GOF Test**			
489					5% Shapiro Wilk Critical Value	0.842			Detected Data appear Lognormal at 5% Significance Level			
490					Lilliefors Test Statistic	0.179			**Lilliefors GOF Test**			
491					5% Lilliefors Critical Value	0.262			Detected Data appear Lognormal at 5% Significance Level			
492	**Detected Data appear Lognormal at 5% Significance Level**											
493												
494	**Lognormal ROS Statistics Using Imputed Non-Detects**											
495					Mean in Original Scale	10.78			Mean in Log Scale			2.052
496					SD in Original Scale	8.181			SD in Log Scale			0.906
497					95% t UCL (assumes normality of ROS data)	14.65			95% Percentile Bootstrap UCL			14.82
498					95% BCA Bootstrap UCL	14.62			95% Bootstrap t UCL			15.68
499					95% H-UCL (Log ROS)	22.77						
500												

	A	B	C	D	E	F	G	H	I	J	K	L
501	**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**											
502					KM Mean (logged)	2.026					KM Geo Mean	7.584
503					KM SD (logged)	0.932					95% Critical H Value (KM-Log)	2.682
504					KM Standard Error of Mean (logged)	0.273					95% H-UCL (KM -Log)	23.43
505					KM SD (logged)	0.932					95% Critical H Value (KM-Log)	2.682
506					KM Standard Error of Mean (logged)	0.273						
507												
508	**DL/2 Statistics**											
509	**DL/2 Normal**						**DL/2 Log-Transformed**					
510					Mean in Original Scale	17.08					Mean in Log Scale	2.062
511					SD in Original Scale	25.32					SD in Log Scale	1.384
512					95% t UCL (Assumes normality)	29.06					95% H-Stat UCL	77.75
513	**DL/2 is not a recommended method, provided for comparisons and historical reasons**											
514												
515	**Nonparametric Distribution Free UCL Statistics**											
516	**Detected Data appear Normal Distributed at 5% Significance Level**											
517												
518	**Suggested UCL to Use**											
519					95% KM (t) UCL	15.18						
520												
521	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
522	Recommendations are based upon data size, data distribution, and skewness.											
523	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
524	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
525												
526												
527	**Copper**											
528												
529	**General Statistics**											
530					Total Number of Observations	14					Number of Distinct Observations	13
531											Number of Missing Observations	0
532					Minimum	880					Mean	7977
533					Maximum	24000					Median	5750
534					SD	7842					Std. Error of Mean	2096
535					Coefficient of Variation	0.983					Skewness	1.119
536												
537	**Normal GOF Test**											
538					Shapiro Wilk Test Statistic	0.821	**Shapiro Wilk GOF Test**					
539					5% Shapiro Wilk Critical Value	0.874	Data Not Normal at 5% Significance Level					
540					Lilliefors Test Statistic	0.218	**Lilliefors GOF Test**					
541					5% Lilliefors Critical Value	0.226	Data appear Normal at 5% Significance Level					
542	**Data appear Approximate Normal at 5% Significance Level**											
543												
544	**Assuming Normal Distribution**											
545	**95% Normal UCL**						**95% UCLs (Adjusted for Skewness)**					
546					95% Student's-t UCL	11689					95% Adjusted-CLT UCL (Chen-1995)	12094
547											95% Modified-t UCL (Johnson-1978)	11793
548												

	A	B	C	D	E	F	G	H	I	J	K	L
549	**Gamma GOF Test**											
550					A-D Test Statistic	0.439	**Anderson-Darling Gamma GOF Test**					
551					5% A-D Critical Value	0.759	Detected data appear Gamma Distributed at 5% Significance Level					
552					K-S Test Statistic	0.149	**Kolmogorov-Smirnov Gamma GOF Test**					
553					5% K-S Critical Value	0.235	Detected data appear Gamma Distributed at 5% Significance Level					
554	**Detected data appear Gamma Distributed at 5% Significance Level**											
555												
556	**Gamma Statistics**											
557					k hat (MLE)	1.065			k star (bias corrected MLE)			0.884
558					Theta hat (MLE)	7490			Theta star (bias corrected MLE)			9019
559					nu hat (MLE)	29.82			nu star (bias corrected)			24.77
560					MLE Mean (bias corrected)	7977			MLE Sd (bias corrected)			8482
561									Approximate Chi Square Value (0.05)			14.43
562					Adjusted Level of Significance	0.0312			Adjusted Chi Square Value			13.39
563												
564	**Assuming Gamma Distribution**											
565					95% Approximate Gamma UCL (use when n>=50))	13689			95% Adjusted Gamma UCL (use when n<50)			14750
566												
567	**Lognormal GOF Test**											
568					Shapiro Wilk Test Statistic	0.917	**Shapiro Wilk Lognormal GOF Test**					
569					5% Shapiro Wilk Critical Value	0.874	Data appear Lognormal at 5% Significance Level					
570					Lilliefors Test Statistic	0.15	**Lilliefors Lognormal GOF Test**					
571					5% Lilliefors Critical Value	0.226	Data appear Lognormal at 5% Significance Level					
572	**Data appear Lognormal at 5% Significance Level**											
573												
574	**Lognormal Statistics**											
575					Minimum of Logged Data	6.78			Mean of logged Data			8.446
576					Maximum of Logged Data	10.09			SD of logged Data			1.158
577												
578	**Assuming Lognormal Distribution**											
579					95% H-UCL	24353			90% Chebyshev (MVUE) UCL			17161
580					95% Chebyshev (MVUE) UCL	21093			97.5% Chebyshev (MVUE) UCL			26550
581					99% Chebyshev (MVUE) UCL	37270						
582												
583	**Nonparametric Distribution Free UCL Statistics**											
584	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
585												
586	**Nonparametric Distribution Free UCLs**											
587					95% CLT UCL	11424			95% Jackknife UCL			11689
588					95% Standard Bootstrap UCL	11238			95% Bootstrap-t UCL			13232
589					95% Hall's Bootstrap UCL	11438			95% Percentile Bootstrap UCL			11334
590					95% BCA Bootstrap UCL	11699						
591					90% Chebyshev(Mean, Sd) UCL	14264			95% Chebyshev(Mean, Sd) UCL			17112
592					97.5% Chebyshev(Mean, Sd) UCL	21065			99% Chebyshev(Mean, Sd) UCL			28829
593												
594	**Suggested UCL to Use**											
595					95% Student's-t UCL	11689						
596												
597	When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test											
598	When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL											
599												

	A	B	C	D	E	F	G	H	I	J	K	L
600	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
601	Recommendations are based upon data size, data distribution, and skewness.											
602	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
603	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
604												
605												
606	**Lead**											
607												
608	**General Statistics**											
609					Total Number of Observations	14			Number of Distinct Observations			13
610									Number of Missing Observations			0
611					Minimum	18			Mean			243.9
612					Maximum	1200			Median			108.5
613					SD	325.9			Std. Error of Mean			87.11
614					Coefficient of Variation	1.336			Skewness			2.21
615												
616	**Normal GOF Test**											
617					Shapiro Wilk Test Statistic	0.72			**Shapiro Wilk GOF Test**			
618					5% Shapiro Wilk Critical Value	0.874			Data Not Normal at 5% Significance Level			
619					Lilliefors Test Statistic	0.244			**Lilliefors GOF Test**			
620					5% Lilliefors Critical Value	0.226			Data Not Normal at 5% Significance Level			
621	**Data Not Normal at 5% Significance Level**											
622												
623	**Assuming Normal Distribution**											
624					**95% Normal UCL**				**95% UCLs (Adjusted for Skewness)**			
625					95% Student's-t UCL	398.2			95% Adjusted-CLT UCL (Chen-1995)			442.2
626									95% Modified-t UCL (Johnson-1978)			406.8
627												
628	**Gamma GOF Test**											
629					A-D Test Statistic	0.584			**Anderson-Darling Gamma GOF Test**			
630					5% A-D Critical Value	0.771			Detected data appear Gamma Distributed at 5% Significance Level			
631					K-S Test Statistic	0.225			**Kolmogorov-Smirnov Gamma GOF Test**			
632					5% K-S Critical Value	0.238			Detected data appear Gamma Distributed at 5% Significance Level			
633	**Detected data appear Gamma Distributed at 5% Significance Level**											
634												
635	**Gamma Statistics**											
636					k hat (MLE)	0.747			k star (bias corrected MLE)			0.635
637					Theta hat (MLE)	326.3			Theta star (bias corrected MLE)			384.2
638					nu hat (MLE)	20.93			nu star (bias corrected)			17.78
639					MLE Mean (bias corrected)	243.9			MLE Sd (bias corrected)			306.1
640									Approximate Chi Square Value (0.05)			9.231
641					Adjusted Level of Significance	0.0312			Adjusted Chi Square Value			8.424
642												
643	**Assuming Gamma Distribution**											
644					95% Approximate Gamma UCL (use when n>=50)	469.8			95% Adjusted Gamma UCL (use when n<50)			514.8
645												
646	**Lognormal GOF Test**											
647					Shapiro Wilk Test Statistic	0.925			**Shapiro Wilk Lognormal GOF Test**			
648					5% Shapiro Wilk Critical Value	0.874			Data appear Lognormal at 5% Significance Level			
649					Lilliefors Test Statistic	0.188			**Lilliefors Lognormal GOF Test**			
650					5% Lilliefors Critical Value	0.226			Data appear Lognormal at 5% Significance Level			
651	**Data appear Lognormal at 5% Significance Level**											

	A	B	C	D	E	F	G	H	I	J	K	L
652												
653						Lognormal Statistics						
654					Minimum of Logged Data	2.89				Mean of logged Data		4.696
655					Maximum of Logged Data	7.09				SD of logged Data		1.361
656												
657						Assuming Lognormal Distribution						
658					95% H-UCL	1009				90% Chebyshev (MVUE) UCL		550.3
659					95% Chebyshev (MVUE) UCL	687.3				97.5% Chebyshev (MVUE) UCL		877.6
660					99% Chebyshev (MVUE) UCL	1251						
661												
662						Nonparametric Distribution Free UCL Statistics						
663						Data appear to follow a Discernible Distribution at 5% Significance Level						
664												
665						Nonparametric Distribution Free UCLs						
666					95% CLT UCL	387.2				95% Jackknife UCL		398.2
667					95% Standard Bootstrap UCL	385.3				95% Bootstrap-t UCL		545.7
668					95% Hall's Bootstrap UCL	976.3				95% Percentile Bootstrap UCL		391.7
669					95% BCA Bootstrap UCL	448.6						
670					90% Chebyshev(Mean, Sd) UCL	505.2				95% Chebyshev(Mean, Sd) UCL		623.6
671					97.5% Chebyshev(Mean, Sd) UCL	787.9				99% Chebyshev(Mean, Sd) UCL		1111
672												
673						Suggested UCL to Use						
674					95% Adjusted Gamma UCL	514.8						
675												
676					Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.							
677					Recommendations are based upon data size, data distribution, and skewness.							
678					These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).							
679					However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.							
680												
681												
682	Manganese											
683												
684						General Statistics						
685					Total Number of Observations	14				Number of Distinct Observations		12
686										Number of Missing Observations		0
687					Minimum	120				Mean		292.9
688					Maximum	700				Median		250
689					SD	166.3				Std. Error of Mean		44.46
690					Coefficient of Variation	0.568				Skewness		1.713
691												
692						Normal GOF Test						
693					Shapiro Wilk Test Statistic	0.78				Shapiro Wilk GOF Test		
694					5% Shapiro Wilk Critical Value	0.874				Data Not Normal at 5% Significance Level		
695					Lilliefors Test Statistic	0.293				Lilliefors GOF Test		
696					5% Lilliefors Critical Value	0.226				Data Not Normal at 5% Significance Level		
697						Data Not Normal at 5% Significance Level						
698												
699						Assuming Normal Distribution						
700					95% Normal UCL					95% UCLs (Adjusted for Skewness)		
701					95% Student's-t UCL	371.6				95% Adjusted-CLT UCL (Chen-1995)		387.7
702										95% Modified-t UCL (Johnson-1978)		375
703												

	A	B	C	D	E	F	G	H	I	J	K	L
704	**Gamma GOF Test**											
705					A-D Test Statistic	0.755	**Anderson-Darling Gamma GOF Test**					
706					5% A-D Critical Value	0.739	Data Not Gamma Distributed at 5% Significance Level					
707					K-S Test Statistic	0.247	**Kolmogorov-Smirnov Gamma GOF Test**					
708					5% K-S Critical Value	0.23	Data Not Gamma Distributed at 5% Significance Level					
709	**Data Not Gamma Distributed at 5% Significance Level**											
710												
711	**Gamma Statistics**											
712					k hat (MLE)	4.345			k star (bias corrected MLE)			3.461
713					Theta hat (MLE)	67.4			Theta star (bias corrected MLE)			84.6
714					nu hat (MLE)	121.7			nu star (bias corrected)			96.92
715					MLE Mean (bias corrected)	292.9			MLE Sd (bias corrected)			157.4
716									Approximate Chi Square Value (0.05)			75.21
717					Adjusted Level of Significance	0.0312			Adjusted Chi Square Value			72.68
718												
719	**Assuming Gamma Distribution**											
720					95% Approximate Gamma UCL (use when n>=50))	377.4			95% Adjusted Gamma UCL (use when n<50)			390.5
721												
722	**Lognormal GOF Test**											
723					Shapiro Wilk Test Statistic	0.925	**Shapiro Wilk Lognormal GOF Test**					
724					5% Shapiro Wilk Critical Value	0.874	Data appear Lognormal at 5% Significance Level					
725					Lilliefors Test Statistic	0.214	**Lilliefors Lognormal GOF Test**					
726					5% Lilliefors Critical Value	0.226	Data appear Lognormal at 5% Significance Level					
727	**Data appear Lognormal at 5% Significance Level**											
728												
729	**Lognormal Statistics**											
730					Minimum of Logged Data	4.787			Mean of logged Data			5.56
731					Maximum of Logged Data	6.551			SD of logged Data			0.487
732												
733	**Assuming Lognormal Distribution**											
734					95% H-UCL	383.6			90% Chebyshev (MVUE) UCL			406
735					95% Chebyshev (MVUE) UCL	458.6			97.5% Chebyshev (MVUE) UCL			531.6
736					99% Chebyshev (MVUE) UCL	674.9						
737												
738	**Nonparametric Distribution Free UCL Statistics**											
739	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
740												
741	**Nonparametric Distribution Free UCLs**											
742					95% CLT UCL	366			95% Jackknife UCL			371.6
743					95% Standard Bootstrap UCL	363.7			95% Bootstrap-t UCL			466.1
744					95% Hall's Bootstrap UCL	838.1			95% Percentile Bootstrap UCL			371.4
745					95% BCA Bootstrap UCL	376.4						
746					90% Chebyshev(Mean, Sd) UCL	426.2			95% Chebyshev(Mean, Sd) UCL			486.6
747					97.5% Chebyshev(Mean, Sd) UCL	570.5			99% Chebyshev(Mean, Sd) UCL			735.2
748												
749	**Suggested UCL to Use**											
750					95% Student's-t UCL	371.6			or 95% Modified-t UCL			375
751					or 95% H-UCL	383.6						
752												
753	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
754	Recommendations are based upon data size, data distribution, and skewness.											
755	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											

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

ProUCL computes and outputs H-statistic based UCLs for historical reasons only.

H-statistic often results in unstable (both high and low) values of UCL95 as shown in examples in the Technical Guide.

It is therefore recommended to avoid the use of H-statistic based 95% UCLs.

Use of nonparametric methods are preferred to compute UCL95 for skewed data sets which do not follow a gamma distribution.

Mercury

General Statistics

Total Number of Observations	14	Number of Distinct Observations	14
		Number of Missing Observations	0
Minimum	0.17	Mean	2.554
Maximum	14	Median	0.825
SD	4.475	Std. Error of Mean	1.196
Coefficient of Variation	1.752	Skewness	2.264

Normal GOF Test

Shapiro Wilk Test Statistic	0.546	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.874	Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.406	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.226	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	4.672	95% Adjusted-CLT UCL (Chen-1995)	5.295
		95% Modified-t UCL (Johnson-1978)	4.793

Gamma GOF Test

A-D Test Statistic	1.454	**Anderson-Darling Gamma GOF Test**
5% A-D Critical Value	0.781	Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.267	**Kolmogorov-Smirnov Gamma GOF Test**
5% K-S Critical Value	0.239	Data Not Gamma Distributed at 5% Significance Level

Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics

k hat (MLE)	0.635	k star (bias corrected MLE)	0.546
Theta hat (MLE)	4.023	Theta star (bias corrected MLE)	4.674
nu hat (MLE)	17.78	nu star (bias corrected)	15.3
MLE Mean (bias corrected)	2.554	MLE Sd (bias corrected)	3.455
		Approximate Chi Square Value (0.05)	7.471
Adjusted Level of Significance	0.0312	Adjusted Chi Square Value	6.757

Assuming Gamma Distribution

95% Approximate Gamma UCL (use when n>=50))	5.231	95% Adjusted Gamma UCL (use when n<50)	5.784

Lognormal GOF Test

Shapiro Wilk Test Statistic	0.886	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk Critical Value	0.874	Data appear Lognormal at 5% Significance Level

	A	B	C	D	E	F	G	H	I	J	K	L
807					Lilliefors Test Statistic	0.169	**Lilliefors Lognormal GOF Test**					
808					5% Lilliefors Critical Value	0.226	Data appear Lognormal at 5% Significance Level					
809	**Data appear Lognormal at 5% Significance Level**											
810												
811	**Lognormal Statistics**											
812					Minimum of Logged Data	-1.772				Mean of logged Data		-0.0274
813					Maximum of Logged Data	2.639				SD of logged Data		1.302
814												
815	**Assuming Lognormal Distribution**											
816					95% H-UCL	7.529				90% Chebyshev (MVUE) UCL		4.457
817					95% Chebyshev (MVUE) UCL	5.543				97.5% Chebyshev (MVUE) UCL		7.05
818					99% Chebyshev (MVUE) UCL	10.01						
819												
820	**Nonparametric Distribution Free UCL Statistics**											
821	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
822												
823	**Nonparametric Distribution Free UCLs**											
824					95% CLT UCL	4.522				95% Jackknife UCL		4.672
825					95% Standard Bootstrap UCL	4.45				95% Bootstrap-t UCL		16.85
826					95% Hall's Bootstrap UCL	16.89				95% Percentile Bootstrap UCL		4.759
827					95% BCA Bootstrap UCL	5.162						
828					90% Chebyshev(Mean, Sd) UCL	6.142				95% Chebyshev(Mean, Sd) UCL		7.768
829					97.5% Chebyshev(Mean, Sd) UCL	10.02				99% Chebyshev(Mean, Sd) UCL		14.45
830												
831	**Suggested UCL to Use**											
832					95% Chebyshev (Mean, Sd) UCL	7.768						
833												
834	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
835	Recommendations are based upon data size, data distribution, and skewness.											
836	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
837	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
838												
839	**Nickel**											
840												
841	**General Statistics**											
842					Total Number of Observations	14				Number of Distinct Observations		10
843					Number of Detects	11				Number of Non-Detects		3
844					Number of Distinct Detects	9				Number of Distinct Non-Detects		1
845					Minimum Detect	3.1				Minimum Non-Detect		2
846					Maximum Detect	22				Maximum Non-Detect		2
847					Variance Detects	36.56				Percent Non-Detects		21.43%
848					Mean Detects	10.4				SD Detects		6.047
849					Median Detects	8.4				CV Detects		0.581
850					Skewness Detects	1.191				Kurtosis Detects		0.55
851					Mean of Logged Detects	2.198				SD of Logged Detects		0.564
852												
853	**Normal GOF Test on Detects Only**											
854					Shapiro Wilk Test Statistic	0.844	**Shapiro Wilk GOF Test**					
855					5% Shapiro Wilk Critical Value	0.85	Detected Data Not Normal at 5% Significance Level					
856					Lilliefors Test Statistic	0.241	**Lilliefors GOF Test**					
857					5% Lilliefors Critical Value	0.251	Detected Data appear Normal at 5% Significance Level					
858	**Detected Data appear Approximate Normal at 5% Significance Level**											

	A	B	C	D	E	F	G	H	I	J	K	L
859												
860	**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**											
861					KM Mean	8.6				KM Standard Error of Mean		1.728
862					KM SD	6.164				95% KM (BCA) UCL		11.54
863					95% KM (t) UCL	11.66				95% KM (Percentile Bootstrap) UCL		11.55
864					95% KM (z) UCL	11.44				95% KM Bootstrap t UCL		13.26
865					90% KM Chebyshev UCL	13.78				95% KM Chebyshev UCL		16.13
866					97.5% KM Chebyshev UCL	19.39				99% KM Chebyshev UCL		25.79
867												
868	**Gamma GOF Tests on Detected Observations Only**											
869					A-D Test Statistic	0.442	**Anderson-Darling GOF Test**					
870					5% A-D Critical Value	0.733	Detected data appear Gamma Distributed at 5% Significance Level					
871					K-S Test Statistic	0.189	**Kolmogorov-Smirnov GOF**					
872					5% K-S Critical Value	0.257	Detected data appear Gamma Distributed at 5% Significance Level					
873	**Detected data appear Gamma Distributed at 5% Significance Level**											
874												
875	**Gamma Statistics on Detected Data Only**											
876					k hat (MLE)	3.638				k star (bias corrected MLE)		2.706
877					Theta hat (MLE)	2.859				Theta star (bias corrected MLE)		3.843
878					nu hat (MLE)	80.03				nu star (bias corrected)		59.54
879					Mean (detects)	10.4						
880												
881	**Gamma ROS Statistics using Imputed Non-Detects**											
882	GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs											
883	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)											
884	For such situations, GROS method may yield incorrect values of UCLs and BTVs											
885	This is especially true when the sample size is small.											
886	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates											
887					Minimum	0.01				Mean		8.243
888					Maximum	22				Median		7.15
889					SD	6.823				CV		0.828
890					k hat (MLE)	0.594				k star (bias corrected MLE)		0.514
891					Theta hat (MLE)	13.87				Theta star (bias corrected MLE)		16.02
892					nu hat (MLE)	16.64				nu star (bias corrected)		14.4
893					Adjusted Level of Significance (β)	0.0312						
894					Approximate Chi Square Value (14.40, α)	6.849				Adjusted Chi Square Value (14.40, β)		6.169
895					95% Gamma Approximate UCL (use when n>=50)	17.34				95% Gamma Adjusted UCL (use when n<50)		19.25
896												
897	**Estimates of Gamma Parameters using KM Estimates**											
898					Mean (KM)	8.6				SD (KM)		6.164
899					Variance (KM)	38				SE of Mean (KM)		1.728
900					k hat (KM)	1.946				k star (KM)		1.577
901					nu hat (KM)	54.5				nu star (KM)		44.16
902					theta hat (KM)	4.418				theta star (KM)		5.453
903					80% gamma percentile (KM)	13.23				90% gamma percentile (KM)		17.7
904					95% gamma percentile (KM)	22.03				99% gamma percentile (KM)		31.77
905												
906	**Gamma Kaplan-Meier (KM) Statistics**											
907					Approximate Chi Square Value (44.16, α)	29.92				Adjusted Chi Square Value (44.16, β)		28.37
908					95% Gamma Approximate KM-UCL (use when n>=50)	12.69				95% Gamma Adjusted KM-UCL (use when n<50)		13.39
909												

	A	B	C	D	E	F	G	H	I	J	K	L
910					Lognormal GOF Test on Detected Observations Only							
911					Shapiro Wilk Test Statistic	0.946	Shapiro Wilk GOF Test					
912					5% Shapiro Wilk Critical Value	0.85	Detected Data appear Lognormal at 5% Significance Level					
913					Lilliefors Test Statistic	0.153	Lilliefors GOF Test					
914					5% Lilliefors Critical Value	0.251	Detected Data appear Lognormal at 5% Significance Level					
915					Detected Data appear Lognormal at 5% Significance Level							
916												
917					Lognormal ROS Statistics Using Imputed Non-Detects							
918					Mean in Original Scale	8.69				Mean in Log Scale		1.912
919					SD in Original Scale	6.304				SD in Log Scale		0.761
920					95% t UCL (assumes normality of ROS data)	11.67				95% Percentile Bootstrap UCL		11.54
921					95% BCA Bootstrap UCL	11.51				95% Bootstrap t UCL		13.06
922					95% H-UCL (Log ROS)	15.06						
923												
924					Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution							
925					KM Mean (logged)	1.876				KM Geo Mean		6.525
926					KM SD (logged)	0.78				95% Critical H Value (KM-Log)		2.45
927					KM Standard Error of Mean (logged)	0.219				95% H-UCL (KM -Log)		15.03
928					KM SD (logged)	0.78				95% Critical H Value (KM-Log)		2.45
929					KM Standard Error of Mean (logged)	0.219						
930												
931					DL/2 Statistics							
932					DL/2 Normal		DL/2 Log-Transformed					
933					Mean in Original Scale	8.386				Mean in Log Scale		1.727
934					SD in Original Scale	6.644				SD in Log Scale		1.059
935					95% t UCL (Assumes normality)	11.53				95% H-Stat UCL		23.01
936					DL/2 is not a recommended method, provided for comparisons and historical reasons							
937												
938					Nonparametric Distribution Free UCL Statistics							
939					Detected Data appear Approximate Normal Distributed at 5% Significance Level							
940												
941					Suggested UCL to Use							
942					95% KM (t) UCL	11.66						
943												
944					When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test							
945					When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL							
946												
947					Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.							
948					Recommendations are based upon data size, data distribution, and skewness.							
949					These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).							
950					However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.							
951												
952												
953	Selenium0823											
954												
955					General Statistics							
956					Total Number of Observations	14				Number of Distinct Observations		13
957										Number of Missing Observations		0
958					Minimum	8.3				Mean		35.24
959					Maximum	59				Median		32.5
960					SD	17.87				Std. Error of Mean		4.776
961					Coefficient of Variation	0.507				Skewness		-0.117

	A	B	C	D	E	F	G	H	I	J	K	L
962												
963						Normal GOF Test						
964					Shapiro Wilk Test Statistic	0.919	Shapiro Wilk GOF Test					
965					5% Shapiro Wilk Critical Value	0.874	Data appear Normal at 5% Significance Level					
966					Lilliefors Test Statistic	0.168	Lilliefors GOF Test					
967					5% Lilliefors Critical Value	0.226	Data appear Normal at 5% Significance Level					
968					Data appear Normal at 5% Significance Level							
969												
970					Assuming Normal Distribution							
971				95% Normal UCL			95% UCLs (Adjusted for Skewness)					
972					95% Student's-t UCL	43.69	95% Adjusted-CLT UCL (Chen-1995)					42.93
973							95% Modified-t UCL (Johnson-1978)					43.67
974												
975					Gamma GOF Test							
976					A-D Test Statistic	0.528	Anderson-Darling Gamma GOF Test					
977					5% A-D Critical Value	0.742	Detected data appear Gamma Distributed at 5% Significance Level					
978					K-S Test Statistic	0.17	Kolmogorov-Smirnov Gamma GOF Test					
979					5% K-S Critical Value	0.23	Detected data appear Gamma Distributed at 5% Significance Level					
980					Detected data appear Gamma Distributed at 5% Significance Level							
981												
982					Gamma Statistics							
983					k hat (MLE)	3.242	k star (bias corrected MLE)					2.595
984					Theta hat (MLE)	10.87	Theta star (bias corrected MLE)					13.58
985					nu hat (MLE)	90.78	nu star (bias corrected)					72.66
986					MLE Mean (bias corrected)	35.24	MLE Sd (bias corrected)					21.87
987							Approximate Chi Square Value (0.05)					54.03
988					Adjusted Level of Significance	0.0312	Adjusted Chi Square Value					51.91
989												
990					Assuming Gamma Distribution							
991					95% Approximate Gamma UCL (use when n>=50))	47.38	95% Adjusted Gamma UCL (use when n<50)					49.33
992												
993					Lognormal GOF Test							
994					Shapiro Wilk Test Statistic	0.888	Shapiro Wilk Lognormal GOF Test					
995					5% Shapiro Wilk Critical Value	0.874	Data appear Lognormal at 5% Significance Level					
996					Lilliefors Test Statistic	0.165	Lilliefors Lognormal GOF Test					
997					5% Lilliefors Critical Value	0.226	Data appear Lognormal at 5% Significance Level					
998					Data appear Lognormal at 5% Significance Level							
999												
1000					Lognormal Statistics							
1001					Minimum of Logged Data	2.116	Mean of logged Data					3.4
1002					Maximum of Logged Data	4.078	SD of logged Data					0.644
1003												
1004					Assuming Lognormal Distribution							
1005					95% H-UCL	55.31	90% Chebyshev (MVUE) UCL					55.76
1006					95% Chebyshev (MVUE) UCL	64.61	97.5% Chebyshev (MVUE) UCL					76.88
1007					99% Chebyshev (MVUE) UCL	101						
1008												
1009					Nonparametric Distribution Free UCL Statistics							
1010					Data appear to follow a Discernible Distribution at 5% Significance Level							
1011												

	A	B	C	D	E	F	G	H	I	J	K	L
1012	**Nonparametric Distribution Free UCLs**											
1013					95% CLT UCL	43.09				95% Jackknife UCL		43.69
1014					95% Standard Bootstrap UCL	42.94				95% Bootstrap-t UCL		43.69
1015					95% Hall's Bootstrap UCL	42.41				95% Percentile Bootstrap UCL		42.5
1016					95% BCA Bootstrap UCL	42.64						
1017					90% Chebyshev(Mean, Sd) UCL	49.56				95% Chebyshev(Mean, Sd) UCL		56.06
1018					97.5% Chebyshev(Mean, Sd) UCL	65.06				99% Chebyshev(Mean, Sd) UCL		82.76
1019												
1020	**Suggested UCL to Use**											
1021					95% Student's-t UCL	43.69						
1022												
1023	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
1024	Recommendations are based upon data size, data distribution, and skewness.											
1025	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
1026	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
1027												
1028	**Note: For highly negatively-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be**											
1029	**reliable. Chen's and Johnson's methods provide adjustments for positvely skewed data sets.**											
1030												
1031	**Silver**											
1032												
1033	**General Statistics**											
1034					Total Number of Observations	14				Number of Distinct Observations		11
1035					Number of Detects	13				Number of Non-Detects		1
1036					Number of Distinct Detects	11				Number of Distinct Non-Detects		1
1037					Minimum Detect	2.5				Minimum Non-Detect		2.5
1038					Maximum Detect	14				Maximum Non-Detect		2.5
1039					Variance Detects	14.27				Percent Non-Detects		7.143%
1040					Mean Detects	7.454				SD Detects		3.777
1041					Median Detects	5.9				CV Detects		0.507
1042					Skewness Detects	0.268				Kurtosis Detects		-1.49
1043					Mean of Logged Detects	1.875				SD of Logged Detects		0.555
1044												
1045	**Normal GOF Test on Detects Only**											
1046					Shapiro Wilk Test Statistic	0.893				**Shapiro Wilk GOF Test**		
1047					5% Shapiro Wilk Critical Value	0.866				Detected Data appear Normal at 5% Significance Level		
1048					Lilliefors Test Statistic	0.203				**Lilliefors GOF Test**		
1049					5% Lilliefors Critical Value	0.234				Detected Data appear Normal at 5% Significance Level		
1050	**Detected Data appear Normal at 5% Significance Level**											
1051												
1052	**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**											
1053					KM Mean	7.1				KM Standard Error of Mean		1.036
1054					KM SD	3.723				95% KM (BCA) UCL		8.929
1055					95% KM (t) UCL	8.934				95% KM (Percentile Bootstrap) UCL		8.707
1056					95% KM (z) UCL	8.803				95% KM Bootstrap t UCL		9.096
1057					90% KM Chebyshev UCL	10.21				95% KM Chebyshev UCL		11.61
1058					97.5% KM Chebyshev UCL	13.57				99% KM Chebyshev UCL		17.4
1059												
1060	**Gamma GOF Tests on Detected Observations Only**											
1061					A-D Test Statistic	0.629				**Anderson-Darling GOF Test**		
1062					5% A-D Critical Value	0.737				Detected data appear Gamma Distributed at 5% Significance Level		

	A	B	C	D	E	F	G	H	I	J	K	L
1063					K-S Test Statistic	0.236	**Kolmogorov-Smirnov GOF**					
1064					5% K-S Critical Value	0.238	Detected data appear Gamma Distributed at 5% Significance Level					
1065	**Detected data appear Gamma Distributed at 5% Significance Level**											
1066												
1067	**Gamma Statistics on Detected Data Only**											
1068					k hat (MLE)	3.908				k star (bias corrected MLE)		3.057
1069					Theta hat (MLE)	1.907				Theta star (bias corrected MLE)		2.438
1070					nu hat (MLE)	101.6				nu star (bias corrected)		79.49
1071					Mean (detects)	7.454						
1072												
1073	**Gamma ROS Statistics using Imputed Non-Detects**											
1074	GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs											
1075	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)											
1076	For such situations, GROS method may yield incorrect values of UCLs and BTVs											
1077	This is especially true when the sample size is small.											
1078	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates											
1079					Minimum	0.951				Mean		6.989
1080					Maximum	14				Median		5.6
1081					SD	4.024				CV		0.576
1082					k hat (MLE)	2.575				k star (bias corrected MLE)		2.071
1083					Theta hat (MLE)	2.714				Theta star (bias corrected MLE)		3.375
1084					nu hat (MLE)	72.1				nu star (bias corrected)		57.98
1085					Adjusted Level of Significance (β)	0.0312						
1086					Approximate Chi Square Value (57.98, α)	41.48				Adjusted Chi Square Value (57.98, β)		39.63
1087					95% Gamma Approximate UCL (use when n>=50)	9.771				95% Gamma Adjusted UCL (use when n<50)		10.23
1088												
1089	**Estimates of Gamma Parameters using KM Estimates**											
1090					Mean (KM)	7.1				SD (KM)		3.723
1091					Variance (KM)	13.86				SE of Mean (KM)		1.036
1092					k hat (KM)	3.638				k star (KM)		2.906
1093					nu hat (KM)	101.9				nu star (KM)		81.37
1094					theta hat (KM)	1.952				theta star (KM)		2.443
1095					80% gamma percentile (KM)	10.17				90% gamma percentile (KM)		12.68
1096					95% gamma percentile (KM)	15.04				99% gamma percentile (KM)		20.15
1097												
1098	**Gamma Kaplan-Meier (KM) Statistics**											
1099					Approximate Chi Square Value (81.37, α)	61.58				Adjusted Chi Square Value (81.37, β)		59.3
1100					95% Gamma Approximate KM-UCL (use when n>=50)	9.381				95% Gamma Adjusted KM-UCL (use when n<50)		9.742
1101												
1102	**Lognormal GOF Test on Detected Observations Only**											
1103					Shapiro Wilk Test Statistic	0.912	**Shapiro Wilk GOF Test**					
1104					5% Shapiro Wilk Critical Value	0.866	Detected Data appear Lognormal at 5% Significance Level					
1105					Lilliefors Test Statistic	0.235	**Lilliefors GOF Test**					
1106					5% Lilliefors Critical Value	0.234	Detected Data Not Lognormal at 5% Significance Level					
1107	**Detected Data appear Approximate Lognormal at 5% Significance Level**											
1108												
1109	**Lognormal ROS Statistics Using Imputed Non-Detects**											
1110					Mean in Original Scale	7.045				Mean in Log Scale		1.78
1111					SD in Original Scale	3.939				SD in Log Scale		0.641
1112					95% t UCL (assumes normality of ROS data)	8.909				95% Percentile Bootstrap UCL		8.707
1113					95% BCA Bootstrap UCL	8.781				95% Bootstrap t UCL		9.058
1114					95% H-UCL (Log ROS)	10.9						

	A	B	C	D	E	F	G	H	I	J	K	L
1115												
1116						Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution						
1117						KM Mean (logged)	1.807				KM Geo Mean	6.091
1118						KM SD (logged)	0.57				95% Critical H Value (KM-Log)	2.128
1119						KM Standard Error of Mean (logged)	0.159				95% H-UCL (KM -Log)	10.03
1120						KM SD (logged)	0.57				95% Critical H Value (KM-Log)	2.128
1121						KM Standard Error of Mean (logged)	0.159					
1122												
1123						DL/2 Statistics						
1124						DL/2 Normal					DL/2 Log-Transformed	
1125						Mean in Original Scale	7.011				Mean in Log Scale	1.757
1126						SD in Original Scale	3.99				SD in Log Scale	0.692
1127						95% t UCL (Assumes normality)	8.899				95% H-Stat UCL	11.52
1128						DL/2 is not a recommended method, provided for comparisons and historical reasons						
1129												
1130						Nonparametric Distribution Free UCL Statistics						
1131						Detected Data appear Normal Distributed at 5% Significance Level						
1132												
1133						Suggested UCL to Use						
1134						95% KM (t) UCL	8.934					
1135												
1136						Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.						
1137						Recommendations are based upon data size, data distribution, and skewness.						
1138						These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).						
1139						However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.						
1140												
1141												
1142	Zinc											
1143												
1144						General Statistics						
1145						Total Number of Observations	14				Number of Distinct Observations	14
1146											Number of Missing Observations	0
1147						Minimum	55				Mean	1277
1148						Maximum	15000				Median	210
1149						SD	3953				Std. Error of Mean	1056
1150						Coefficient of Variation	3.095				Skewness	3.732
1151												
1152						Normal GOF Test						
1153						Shapiro Wilk Test Statistic	0.33				Shapiro Wilk GOF Test	
1154						5% Shapiro Wilk Critical Value	0.874				Data Not Normal at 5% Significance Level	
1155						Lilliefors Test Statistic	0.508				Lilliefors GOF Test	
1156						5% Lilliefors Critical Value	0.226				Data Not Normal at 5% Significance Level	
1157						Data Not Normal at 5% Significance Level						
1158												
1159						Assuming Normal Distribution						
1160						95% Normal UCL					95% UCLs (Adjusted for Skewness)	
1161						95% Student's-t UCL	3148				95% Adjusted-CLT UCL (Chen-1995)	4141
1162											95% Modified-t UCL (Johnson-1978)	3324
1163												

	A	B	C	D	E	F	G	H	I	J	K	L
1164	Gamma GOF Test											
1165					A-D Test Statistic	2.54	Anderson-Darling Gamma GOF Test					
1166					5% A-D Critical Value	0.815	Data Not Gamma Distributed at 5% Significance Level					
1167					K-S Test Statistic	0.415	Kolmogorov-Smirnov Gamma GOF Test					
1168					5% K-S Critical Value	0.245	Data Not Gamma Distributed at 5% Significance Level					
1169	Data Not Gamma Distributed at 5% Significance Level											
1170												
1171	Gamma Statistics											
1172					k hat (MLE)	0.386			k star (bias corrected MLE)			0.351
1173					Theta hat (MLE)	3312			Theta star (bias corrected MLE)			3643
1174					nu hat (MLE)	10.8			nu star (bias corrected)			9.818
1175					MLE Mean (bias corrected)	1277			MLE Sd (bias corrected)			2157
1176									Approximate Chi Square Value (0.05)			3.828
1177					Adjusted Level of Significance	0.0312			Adjusted Chi Square Value			3.347
1178												
1179	Assuming Gamma Distribution											
1180					95% Approximate Gamma UCL (use when n>=50))	3276			95% Adjusted Gamma UCL (use when n<50)			3747
1181												
1182	Lognormal GOF Test											
1183					Shapiro Wilk Test Statistic	0.795	Shapiro Wilk Lognormal GOF Test					
1184					5% Shapiro Wilk Critical Value	0.874	Data Not Lognormal at 5% Significance Level					
1185					Lilliefors Test Statistic	0.233	Lilliefors Lognormal GOF Test					
1186					5% Lilliefors Critical Value	0.226	Data Not Lognormal at 5% Significance Level					
1187	Data Not Lognormal at 5% Significance Level											
1188												
1189	Lognormal Statistics											
1190					Minimum of Logged Data	4.007			Mean of logged Data			5.436
1191					Maximum of Logged Data	9.616			SD of logged Data			1.44
1192												
1193	Assuming Lognormal Distribution											
1194					95% H-UCL	2701			90% Chebyshev (MVUE) UCL			1309
1195					95% Chebyshev (MVUE) UCL	1644			97.5% Chebyshev (MVUE) UCL			2108
1196					99% Chebyshev (MVUE) UCL	3021						
1197												
1198	Nonparametric Distribution Free UCL Statistics											
1199	Data do not follow a Discernible Distribution (0.05)											
1200												
1201	Nonparametric Distribution Free UCLs											
1202					95% CLT UCL	3015			95% Jackknife UCL			3148
1203					95% Standard Bootstrap UCL	2940			95% Bootstrap-t UCL			33015
1204					95% Hall's Bootstrap UCL	15944			95% Percentile Bootstrap UCL			3373
1205					95% BCA Bootstrap UCL	4408						
1206					90% Chebyshev(Mean, Sd) UCL	4446			95% Chebyshev(Mean, Sd) UCL			5882
1207					97.5% Chebyshev(Mean, Sd) UCL	7874			99% Chebyshev(Mean, Sd) UCL			11788
1208												
1209	Suggested UCL to Use											
1210					95% Chebyshev (Mean, Sd) UCL	5882						
1211												
1212	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
1213	Recommendations are based upon data size, data distribution, and skewness.											
1214	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
1215	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											

	A	B	C	D	E	F	G	H	I	J	K	L	M
1				General Statistics on Uncensored Data: Hull Canyon Wash									
2		Date/Time of Computation		ProUCL 5.110/18/2019 10:50:15 AM									
3		User Selected Options											
4			From File	ProUCL Input_HCW.xls									
5			Full Precision	OFF									
6													
7	From File: ProUCL Input_HCW.xls												
8													
9	General Statistics for Censored Data Set (with NDs) using Kaplan Meier Method												
10													
11	Variable		NumObs	# Missing	Num Ds	NumNDs	% NDs	Min ND	Max ND	KM Mean	KM Var	KM SD	KM CV
12		Antimony	4	0	0	4	100.00%	4.8	5	N/A	N/A	N/A	N/A
13		Arsenic	4	0	3	1	25.00%	4.8	4.8	19.88	174.7	13.22	0.665
14		Barium	4	0	4	0	0.00%	N/A	N/A	55.25	911.6	30.19	0.546
15		Beryllium	4	0	1	3	75.00%	0.48	0.5	0.685	0.126	0.355	0.518
16		Cadmium	4	0	4	0	0.00%	N/A	N/A	0.708	0.0268	0.164	0.231
17		Chromium	4	0	4	0	0.00%	N/A	N/A	18.93	326.7	18.07	0.955
18		Copper	4	0	4	0	0.00%	N/A	N/A	1001	1138564	1067	1.066
19		Lead	4	0	4	0	0.00%	N/A	N/A	21.75	88.92	9.43	0.434
20		Manganese	4	0	4	0	0.00%	N/A	N/A	362.5	58958	242.8	0.67
21		Mercury	4	0	2	2	50.00%	0.093	0.1	0.304	0.115	0.339	1.115
22		Nickel	4	0	4	0	0.00%	N/A	N/A	19.7	316	17.78	0.902
23		Selenium	4	0	3	1	25.00%	4.8	4.8	8.325	8.017	2.831	0.34
24		Silver	4	0	0	4	100.00%	2.4	2.5	N/A	N/A	N/A	N/A
25		Thallium	4	0	0	4	100.00%	4.8	5	N/A	N/A	N/A	N/A
26		Zinc	4	0	4	0	0.00%	N/A	N/A	157	9036	95.06	0.605
27													
28	General Statistics for Raw Data Sets using Detected Data Only												
29													
30	Variable		NumObs	# Missing	Minimum	Maximum	Mean	Median	Var	SD	MAD/0.675	Skewness	CV
31		Antimony	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
32		Arsenic	3	0	8.7	34	24.9	32	197.8	14.07	2.965	-1.693	0.565
33		Barium	4	0	34	100	55.25	43.5	911.6	30.19	8.154	1.856	0.546
34		Beryllium	1	0	1.3	1.3	1.3	1.3	N/A	N/A	0	N/A	N/A
35		Cadmium	4	0	0.57	0.93	0.708	0.665	0.0268	0.164	0.119	1.09	0.231
36		Chromium	4	0	8.7	46	18.93	10.5	326.7	18.07	1.705	1.984	0.955
37		Copper	4	0	64	2200	1001	870	1138564	1067	1139	0.262	1.066
38		Lead	4	0	11	33	21.75	21.5	88.92	9.43	10.38	0.13	0.434
39		Manganese	4	0	120	690	362.5	320	58958	242.8	192.7	0.922	0.67
40		Mercury	2	0	0.14	0.89	0.515	0.515	0.281	0.53	0.556	N/A	1.03
41		Nickel	4	0	6.8	46	19.7	13	316	17.78	4.596	1.833	0.902
42		Selenium	3	0	6.5	12	9.5	10	7.75	2.784	2.965	-0.782	0.293
43		Silver	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
44		Thallium	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
45		Zinc	4	0	48	270	157	155	9036	95.06	105.3	0.103	0.605
46													

	A	B	C	D	E	F	G	H	I	J	K	L	M
47	Percentiles using all Detects (Ds) and Non-Detects (NDs)												
48													
49	Variable		NumObs	# Missing	10%ile	20%ile	25%ile(Q1)	50%ile(Q2)	75%ile(Q3)	80%ile	90%ile	95%ile	99%ile
50		Antimony	4	0	4.83	4.86	4.875	4.9	4.925	4.94	4.97	4.985	4.997
51		Arsenic	4	0	5.97	7.14	7.725	20.35	32.5	32.8	33.4	33.7	33.94
52		Barium	4	0	36.4	38.8	40	43.5	58.75	67	83.5	91.75	98.35
53		Beryllium	4	0	0.48	0.48	0.48	0.49	0.7	0.82	1.06	1.18	1.276
54		Cadmium	4	0	0.579	0.588	0.593	0.665	0.78	0.81	0.87	0.9	0.924
55		Chromium	4	0	9.09	9.48	9.675	10.5	19.75	25	35.5	40.75	44.95
56		Copper	4	0	86.8	109.6	121	870	1750	1840	2020	2110	2182
57		Lead	4	0	13.1	15.2	16.25	21.5	27	28.2	30.6	31.8	32.76
58		Manganese	4	0	162	204	225	320	457.5	504	597	643.5	680.7
59		Mercury	4	0	0.0951	0.0972	0.0983	0.12	0.328	0.44	0.665	0.778	0.868
60		Nickel	4	0	8.66	10.52	11.45	13	21.25	26.2	36.1	41.05	45.01
61		Selenium	4	0	5.31	5.82	6.075	8.25	10.5	10.8	11.4	11.7	11.94
62		Silver	4	0	2.43	2.46	2.475	2.5	2.5	2.5	2.5	2.5	2.5
63		Thallium	4	0	4.83	4.86	4.875	4.95	5	5	5	5	5
64		Zinc	4	0	69.6	91.2	102	155	210	222	246	258	267.6

APPENDIX E

DATA VERIFICATION MEMO

Data Verification Memorandum

7720 N. 16th Street
Suite 100
Phoenix, Arizona 85020
602.371.1100 Tel
602.371.1615 Fax

Action **Info** **File**

To: Frances Ackerman 550-105830-1

From: Steve Szocik, QA/QC

Date: September 6, 2018

Subject : Data Verification of Verde Central – 2018 Sampling Event

This report summarizes the verification of analytical data for total metals on 10 soil samples and two field duplicate samples plus three samples selected and also analyzed for synthetic precipitation leachate procedure (SPLP) collected during the 2018 sampling events for the Verde Central site. The sample identification numbers, sample collection dates, and analyses are summarized in Table 1. The samples were analyzed by Test America (TA) located in Phoenix, Arizona. TA operates under laboratory licensure number AZ0728. It should be noted that due to limited quality assurance and quality control (QA/QC) criteria stated in the analytical methods for percent moisture, data verification was not performed for percent moisture.

The following comments refer to the performance of TA in meeting the QA/QC specifications outlined in the analytical methods and the criteria specified in the EPA documents: National Functional Guidelines for Superfund Inorganic Methods Data Review (January 2010). The qualifiers and reason codes used to identify data that did not meet the criteria set forth in the previously referenced documents are listed in Appendix A.

A list of the data review parameters is given in Section 1.0. A preceding "►" signifies areas where issues were raised during the course of the validation review, and should be considered to determine any impact on data quality and usability.

Executive Summary

The data are acceptable in all areas of review and are useable for their intended purpose (except for method 6010C selenium discussed in Section 1.4) with qualifications summarized below.

Sample ID	Parameters	Probable Bias Direction	Qualifier, Reason Code	Reference Section
SC-SS-3	Antimony	Low	J,m	1.4
	Barium	Unknown	J,m	1.4
	Thallium	Low	UJ,m	1.4
SC-SS-3, SC-SWC-3-MS, SC-SWC-3, SC-T4, SC-SS-1, SC-SS-2,SC-SS-7, SC-SS-4 SC-TS-5, SC-SS-5, SC-SS-6, SC-TS-D SC-SWC-3-MS	Selenium	Low	R,m	1.4

Sample ID	Parameters	Probable Bias Direction	Qualifier, Reason Code	Reference Section
SC-SWC-3/SC-SWC-3MS	Chromium	Unknown	J,f	1.7

During review the total selenium results analyzed by Method 6010C were found to be significantly affected by the matrix and were rejected. The extremely low MS/MSD recoveries indicate that selenium if present likely was not detected. This was confirmed with the method 6020B analysis. Twelve of the 213 reported results were rejected but were replaced with the supplemental 6020B results; therefore the analytical completeness for this data group is 100%.

1.0 Metals - Solid

Data Completeness
Preservation and Holding Times
Blanks
►Matrix Spike/Matrix Spike Duplicate (MS/MSD)
Laboratory Control Sample/Laboratory Control Sample Duplicate (LCS/LCSD)
Calibration
►Field Duplicates

1.1 Data Completeness

The analyses were performed as requested on the Chain-of-Custody (COC) Records. Sample SC-SWC-3-MS was selected to be analyzed as a MS/MSD. However, the laboratory processed the sample as a normal sample. Consequently, SC-SWC-3-MS was evaluated as a field duplicate sample. Completeness was not affected because the laboratory used sample SC-SS-3 for the batch MS/MSD. Sample SC-T5-D was reported as SC-TS-D by the laboratory. Because SC-T5-D is a duplicate of SC-T5, SC-T5-D was used as the final sample identifier. The COC listed SPLP and metals analysis. The laboratory was directed to prepare and analyze three of the soil samples using SPLP and the SPLP results are discussed in Section 2.

1.2 Preservation and Holding Times

TA recorded the temperature upon receipt for the samples in SDG 550-105830-1 to be 1.3°C and 1.4°C. Although the recorded temperatures were outside the acceptance range of 4°C $\pm$ 2 °C, this slight deviation from the acceptable temperature range is not considered likely to adversely affect the quality of the analytical results. The samples were analyzed within the method specified holding time.

1.3 Blanks

The associated method blanks were reported as non-detect for all target analytes.

1.4 Matrix Spike/ Matrix Spike Duplicate (MS/MSD)

The MS/MSD analyses were performed on an appropriate number of project samples. With the following exceptions, the MS/MSD percent recoveries and RPD values were within the laboratory control limits.

Spiked Sample	Method 6010C Analyte	MS/MSD % Recovery (limits)	Affected Sample	Qualifier(s)
SC-SS-3	Antimony	54/64 (75-125)	SC-SS-3	J,m
	Arsenic	132/61 (75-125)	None[1]	None[1]
	Barium	104/28 (75-125)	SC-SS-3	J,m
	Copper	1218/NM (75-125)	None[1]	None[1]
	Selenium	5/NM (75-125)	All	R,m
	Thallium	67/69 (75-125)	SC-SS-3	UJ,m
None[1] The sample concentration was greater than 4x the spike value. NM – Not measurable				

1.5 Laboratory Control Sample/Laboratory Control Sample Duplicate (LCS/LCSD)

The LCS/LCSD percent recoveries and RPD values were within the method specified control limits.

1.6 Calibration

The low level continuing calibration verification was greater than the upper acceptance limit for beryllium. Beryllium was not detected in the associated samples, the results were not affected and qualification was not required.

1.7 Field Duplicates

The field duplicates (FD) for this sampling event were collected at an appropriate number of sample locations. Precision is evaluated by measuring the agreement among individual measurements of the same property under similar conditions and is expressed as RPD. The RPD criteria for the field duplicate pair as follows:

- Criterion of $\leq$35% RPD was applied for cases in which both the primary sample (PS) and FD values were greater than 5 times the reporting limit (RL).
- When either value was below 5 times the DL, the absolute difference between the PS and FD results was compared to the criteria of ± 3 times the RL.

With the following exceptions, the field duplicate pair met the criteria stated above.

Sample ID	Analyte	PS (mg/Kg)	FD (mg/Kg)	RPD	Qualifier, Reason Code
SC-SWC-3/SC-SWC-3-MS	Chromium (6010C)	11	16	37.0%	J,f
SC-SWC-3/SC-SWC-3-MS	Selenium (6020B)	17	31	58.3%	J,f

2.0 Metals – SPLP

Data Completeness
Preservation and Holding Times
Blanks
Matrix Spike/Matrix Spike Duplicate (MS/MSD)
Laboratory Control Sample/Laboratory Control Sample Duplicate (LCS/LCSD)
Calibration
Field Duplicates

2.1 Data Completeness

The COC listed SPLP analysis to be placed on hold. After the total metals results were reported the laboratory was directed to analyze samples SC-SS-3, SC-SS-7, and SC-SS-5 for SPLP analysis of aluminum, beryllium, cobalt, copper, silver, zinc, and mercury.

2.2 Preservation and Holding Times

TA recorded the temperature upon receipt for the samples in SDG 550-105830-1 to be 1.3°C and 1.4°C. Although the recorded temperatures were outside the acceptance range of 4°C $\pm$ 2 °C, this slight deviation from the acceptable temperature range is not considered likely to adversely affect the quality of the analytical results. The samples were analyzed within the method specified holding time.

2.3 Blanks

The associated method blanks were reported as non-detect for all target analytes.

2.4 Matrix Spike/ Matrix Spike Duplicate (MS/MSD)

A MS/MSD sample was not selected.

2.5 Laboratory Control Sample/Laboratory Control Sample Duplicate (LCS/LCSD)

The LCS/LCSD percent recoveries and RPD values were within the method specified control limits.

2.6 Calibration

The laboratory case narrative did not identify any calibration outliers and qualification was not required.

2.7 Field Duplicates

A field duplicate sample was not selected for the SPLP analysis. An evaluation could not be made.

APPENDIX A
DATA VALIDATION QUALIFIER DEFINITIONS AND INTERPRETATION KEY ASSIGNED BY AECOM'S DATA REVIEW TEAM

DATA QUALIFIER DEFINITIONS

U The analyte was analyzed for, but was not detected above the reported sample quantitation limit.

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

N The analysis indicates the presence of an analyte for which there is presumptive evidence to make a "tentative identification."

NJ The analysis indicates the presence of an analyte that has been "tentatively identified" and the associated numerical value represents its approximate concentration.

UJ The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.

R The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.

REASON CODE DEFINITIONS

a Analytical sequence deficiency or omission.
b Gross compound breakdown (4,4'-DDT/Endrin).
c Calibration failure; poor or unstable response.
d Laboratory duplicate imprecision.
e Laboratory duplicate control sample imprecision.
f Field duplicate imprecision.
g Poor chromatography.
h Holding time violation.
i Internal standard failure.
j Poor mass spectrographic performance.
k Serial dilution imprecision.
l Laboratory control sample recovery failure.
m Matrix spike/matrix spike duplicate recovery failure.
n Interference check sample recovery failure.
o Calibration blank contamination (metals/inorganics only).
p Preparation blank contamination (metals/inorganics only).
q Quantitation outside of linear range.
r Linearity failure in initial calibration.
s Surrogate spike recovery failure (organics only).
t Instrument tuning failure.
u No confirmation column present (GC organics only).
w Retention time (RT) outside of RT window.
x Equipment blank contamination.
y Trip blank contamination.
z Method blank contamination.
Q Other

TABLE 1

Consultant: AECOM Corporation

Project: Verde Central

Laboratory: Test America (Phoenix, Arizona)

Field Sample Identification	Laboratory Identification Number	Sample Date	Total PP Metals plus barium and manganese (Methods 6010C and7471B)	Total Selenium (Methods 6020B)	SPLP Metals (Aluminum, Beryllium, Cobalt, Copper, Silver, Zinc, Mercury)	Percent moisture (Standard Method 2540G)*
SC-SS-3	550-105830-1	7/11/18	X	X	X	X
SC-SWC-3-MS (Duplicate of SC-SWC-3)	550-105830-2	7/11/18	X	X		X
SC-SWC-3	550-105830-3	7/11/18	X	X		X
SC-T4	550-105830-4	7/11/18	X	X		X
SC-SS-1	550-105830-5	7/11/18	X	X		X
SC-SS-2	550-105830-6	7/11/18	X	X		X
SC-SS-7	550-105830-7	7/11/18	X	X	X	X
SC-SS-4	550-105830-8	7/11/18	X	X		X
SC-T5	550-105830-9	7/11/18	X	X		X
SC-SS-5	550-105830-10	7/11/18	X	X	X	X
SC-SS-6	550-105830-11	7/11/18	X	X		X
SC-T5-D (Duplicate of SC-T5)	550-105830-12	7/11/18	X	X		X

PP: Priority Pollutants = Arsenic, antimony, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc

*Due to limited QA/QC criteria stated in the analytical methods, data verification was not performed

Note: Level IV Data Validation was not performed on any of the samples listed.

APPENDIX F

CALCULATION OF MINIMUM GPL FOR BENZO (A) PYRENE

1/1/2013

Model Inputs

			Calculation values	Data Enter
Select chemical name from drop down list				Enter chemical properties
Ct = Initial total soil contamination, ug/kg (ug/kg = (ug/l)/Pb)			0.1	0.1
Kh (dimensionless)			0.0000463	4.63E-05
S (water solubility, mg/l)			0.00162	1.62E-03
Koc (L/Kg)			1020000	1.02E+06
T1/2 (d) (vadose zone)	(enter 100,000 if no biodegradation, 1000 for BTEX)		100000	100000
T1/2 (d) (groundwater zone)	(enter 100,000 if no biodegradation, 1000 for BTEX)		100000	100000
Select Soil Type from drop down list				GPL Defaults
Φ(total porosity)		(minimum GPL default = .25)	0.25	0.1
Pb (g/cm^3) (dry bulk density)		(minimum GPL default = 1.5	1.5	1.5
foc (vadose zone)		(minimum GPL default = .001)	0.001	0.001
foc (aquifer)			0.001	0.001
$Dg^{a\ (cm2/d)}$	(gaseous diffusion coefficient)	(7000 = default)	7000	7000
$D1^{w(cm2/d)}$	(liquid diffusion coefficient)	(.7 = default)	0.7	0.7
d(diffusion layer thickness,cm)		(.5 = default)	0.5	0.5
θ (vol/vol)= moisture content		(minimum GPL default = .15)	0.15	0.15
Jw (water flux- cm/d)		(minimum GPL default = .007)	0.007	0.007
time step (days) vary until output graphs shows complete curve, Jury 1 solution)			50	50
L (cm)(depth of incorporation- Jury 1 solution)			1000	1000
Z -cm(depth to water, or depth of interest, Jury 1 solution)			1000	1000
depth profile time (d), Jury 2 solution)			3650	3650
total vadose zone depth (cm, Jury 2 solution)			5000	5000
Distance to compliance point (Sc) (meters)		(minimum GPL default = 30)	30.5	30.5
Release width (w) (meters)		(minimum GPL default = 10)	10	10
Well screen interval (s) (meters)		(minimum GPL default = 8.2)	8.2	8.2
Water Quality Standard (ug/l)- see note regarding standard			0.2	0.2
Groundwater velocity (cm/d) (actual velocity not Darcy velocity)		(minimum GPL default = 10)	10	10
Infiltration rate outside of source area (cm/d)		(minimum GPL default = .007)	0.007	0.007

Run GPL

Enter chemical properties

GPL (mg/kg) = 3090980099.62

Saturation conc. (mg/kg) 1.65

GPL exceeds saturation, discuss with specific ADEQ Program

GPL based upon risk based water quality standard

APPENDIX G

HUMAN HEALTH RISK ASSESSMENT

APPENDIX G

HUMAN HEALTH RISK ASSESSMENT VERDE CENTRAL MINE VOLUNTARY REMEDIATION PROGRAM

Near Jerome, Arizona

VRP Site Code: 508483-00

Prepared for
Freeport Minerals Corporation

April 17, 2020

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LIST OF ACRONYMS AND ABBREVIATIONS

AAC – Arizona Administrative Code

ADEQ – Arizona Department of Environmental Quality

ADHS – Arizona Department of Health Services

AECOM – AECOM Technical Services, Inc.

ALM –Adult Lead Model

amsl – above mean sea level

ATSDR – Agency for Toxic Substances and Disease Registry

bgs – below ground surface

BKSF – biokinetic slope factor

CDC – Centers for Disease Control

COPC – contaminants of potential concern

CSF – Cancer Slop Factor

CSM – conceptual site model

EPC- exposure point concentration

FMC – Freeport Minerals Corporation

GI – gastrointestinal

GPL – groundwater protection level

HHRA – Human Health Risk Assessment

IRIS – Integrated Risk Information System

IUR – Inhalation Unit Risk

LOAEL – lowest observed-adverse-effect level

MDC – maximum detected concentration

µg/dL – micrograms per deciliter

$\mu g/m^3$ – micrograms per cubic meter

mg/kg – milligrams per kilogram

mg/kg/d – milligrams per kilogram per day

mg/m^3 – milligrams per cubic meters

mg^3/kg – cubic milligrams per kilogram

mg/L – milligrams per liter

MRL – minimum reporting limit

NOAEL – no-observed-adverse-effect level

NWQS – Numeric Water Quality Standards

PbB – Blood lead

PBC – partial body contact

PEF – Particulate Emission Factor

PRG – Preliminary Remediation Goal

R – non-leachability ratio

RBA – Relative Bioavailability Factor

RfC – Reference Concentration

RfD – Reference Dose

RME – Reasonable Maximum Exposure

RSL – Regional Screening Level

SAP – Sampling and Analysis Plan

SCR – Site Characterization Report

SRL – Soil Remediation Level

SPLP – Synthetic Precipitation Leaching Procedure

UF – Uncertainty Factor

USEPA – United States Environmental Protection Agency

UCL – upper confidence limit

1.0 INTRODUCTION

Freeport Minerals Corporation (FMC) has retained AECOM Technical Services, Inc. (AECOM) to perform a human health risk assessment (HHRA) for the Verde Central Mine Voluntary Remediation Project located near Jerome, Arizona (Site). The HHRA is submitted as Appendix G of the Site Characterization Report (SCR) for the Verde Central Mine, and the results are summarized in Section 4.1 of the SCR.

This HHRA evaluates whether impacted Site media represent a potential risk to human health by performing a comparison of Site media concentrations to default residential screening levels. Chemicals detected in Site media at concentrations that exceed the default residential screening levels are further evaluated using site-specific remediation levels.

This document is organized as follows:

- Section 1 – Introduction. This section provides a brief explanation of the objectives and scope of the HHRA, the report format that will be used for the HHRA, and the primary guidance documents that will be used to conduct the HHRA.
- Section 2 – Site Description, Data Collection and Evaluation. This section provides a brief description for the Site, and describes the data collection process and how the data were evaluated in the HHRA.
- Section 3 – Identification of Constituents of Potential Concern (COPCs). This section describes the methods used in selecting COPCs and identifies all detected chemicals that were included in evaluating human health risks and hazards.
- Section 4 – Human Health Exposure Assessment. This section identifies the pathways by which humans could be exposed to Site contaminants, describes the process used to assess such exposures, and evaluates the magnitude, frequency, and duration of these exposures.
- Section 5 – Human Health Toxicity Assessment. This section summarizes the toxicity of the COPCs and the relationship between the exposure level and the occurrence of adverse health effects.
- Section 6 – Development of Site-Specific Soil Remediation Levels. This section integrates information from the exposure and toxicity assessments to develop site-specific soil remediation levels.
- Section 7 – Uncertainty Assessment. This section discusses the uncertainties and assumptions associated with the HHRA.

- Section 8 – Conclusions and Recommendations. This section discusses the main points and results of the HHRA and provides recommendations based on the results.

1.1 OBJECTIVES

The primary objective of the HHRA for the Site is to evaluate whether activities at the site have potentially impacted the soil, sediment and surface water at concentrations that exceed site-specific remediation standards. This assessment was conducted through the collection and evaluation of data for the Site as described in the Revised Project Work Plan (URS 2013) and outlined in the SCR. Data obtained during the field investigation activities conducted in 2014, 2015 and 2018 are used in the HHRA to make recommendations as to whether additional remediation is necessary at the Site.

1.2 GUIDANCE DOCUMENTS

The HHRA was conducted in accordance with the U.S. Environmental Protection Agency's (USEPA) Risk Assessment Guidance for Superfund [RAGS], Volume I (Parts A, B, E, and F) (USEPA 1989, 1991, 2004, 2009a) and Arizona Administrative Code (AAC), Title 18, Environmental Quality, Chapter 7, Department of Environmental Quality Remedial Action. Additional guidance documentation includes the following:

- *Deterministic Risk Assessment Guidance* (Arizona Department of Health Services [ADHS] 2003)
- *Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors* (USEPA 1991)
- *Guidance for Exposure Assessment* (USEPA 1992)
- *Exposure Factors Handbook* (USEPA 2011)
- *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (USEPA 2002)
- *Human Health Toxicity Values in Superfund Risk Assessments* (USEPA 2003a)
- *Supplemental Guidance from Early-Life exposure to Carcinogens* (USEPA 2005)
- *USEPA online regional screening levels (RSLs)* (USEPA 2019a)
- *Human Health Evaluation Manual, Supplemental Guidance, Update of Standard Default Exposure Factors* (USEPA 2014)

2.0 SITE DESCRIPTION, DATA COLLECTION AND EVALUATION

This section provides a brief description for the Site, and describes the data collection process and how the data were evaluated for use in the HHRA.

2.1 SITE DESCRIPTION AND HISTORY

The Site is a former copper mine site located in central Arizona, approximately 0.7 miles southwest of the town of Jerome. The site is approximately 12 acres in size and is located on the south side of State Highway 89A (**Figure G-1**). The project area is approximately 6 acres in size and includes a mine rock stockpile comprised of waste rock and low-grade ore, miscellaneous mining residual materials (high grade ore, tailing and suspected waste concentrate from milling operations), multiple closed mine shafts/adits, and the foundation of a former mill. The project area is limited to areas impacted by mining and milling operations, which occurred from 1928 to 1930.

The Site is located in Hull Canyon, a steep, rocky canyon with relatively minimal soil development and difficult access. The elevation of the project varies from approximately 5,350 feet above mean sea level (amsl) at the lowest point in Hull Canyon, to 5,520 feet amsl at the highest elevations of the remnant building foundations.

An unnamed ephemeral streambed referred to as Hull Canyon Wash, exists at the base of the canyon and toe of the rock stockpile located within the Site. Flow in the wash, when present, is from southwest to northeast across the Site; flow is generally only present in response to precipitation events.

2.2 IDENTIFICATION OF RELEVANT DATASETS

Target analytes were established in the Sampling and Analysis Plan (SAP) in order to collect a dataset of sufficient quality to support the HHRA. The HHRA incorporated analytical results surface soil (0 to 4 inches below ground surface [bgs] per the SAP), sediment, and surface water. The samples used in the HHRA are presented in **Table G-1** and discussed by media below:

- **Soil.** Surface soil samples (0 to 4 inches bgs) from 36 locations within the overall Site.
- **Sediment.** Sediment samples from four locations were collected within the overall Site.
- **Surface Water.** Surface water samples from five locations were collected from Hull Canyon Wash.

Anthropogenic background soil data from ten locations were collected in 2014 and 2015 at the Site as part of the original SCR (**Figure G-2**). In general, these data are intended to be used to characterize the presence of inorganic contaminants in areas not impacted by site activities. Background concentrations were subsequently developed using EPA ProUCL version 5.1 (EPA, 2016a) and are presented in the SCR. Consideration of site concentrations relative to background data is conducted as part of the COPC screening process. Additional discussion of the application of background data is provided in **Section 3.0**.

All sample locations used in the HHRA are illustrated in **Figure G-3** for Exposure Area 1 and **Figure G-4** for Exposure Area 2, respectively.

2.3 DATA EVALUATION AND VALIDATION

Data collected for use in the HHRA are validated to provide data quality assurance. Quality assurance and quality control procedures were performed on the laboratory data for each sampling event to determine the level of precision, accuracy, completeness, representativeness, and comparability of the data collected. Data verification reports completed by URS Corps Inc. and AECOM for samples collected during the site characterization field events conducted in 2014, 2015 and 2018 are presented in Appendix E of the SCR. A detailed discussion of the data evaluation and validation processes is presented in Section 3 of the SCR.

Data included in the HHRA were considered acceptable by the data validation processes and therefore used in the HHRA. Soil, sediment and surface water data used in the HHRA are presented in **Attachment G-1**.

3.0 IDENTIFICATION OF HUMAN HEALTH CONTAMINANTS OF POTENTIAL CONCERN

The process for developing COPCs is a step-wise approach that evaluates data from Site media and compares these data to conservative default screening levels. In general, COPCs are defined as any chemical with a maximum detected concentration (MDC) that exceeds selected screening levels. Those COPCs retained following the screening evaluation are evaluated in more detail which serves to focus the HHRA on those COPCs most likely to contribute to Site risks.

3.1 COPC SELECTION CRITERIA

The default screening values used to identify COPCs represent the concentrations below which no adverse health effects are likely to occur for direct contact (e.g., incidental ingestion and dermal contact) exposure pathways. The default screening values for soil use conservative assumptions based on residential exposure that overestimate the types of exposure expected at this site. For example, residential exposure assumes a human receptor is potentially exposed to Site media, e.g., soil, for 350 days per year for 26 years.

The following screening levels were used to identify direct contact COPCs in soil, sediment and surface water:

- Surface Soil (0-4 inches) and Sediment: Residential Soil Remediation Levels (SRLs) as listed in Appendix A of AAC Title 18, Chapter 7 (AAC 2009a)
- Surface Water: Partial Body Contact (PBC) - Numeric Water Quality Standards (NWQS) as listed in Table 1 of Appendix A of AAC Title 18, Chapter 11 (AAC 2009b)

The following screening levels were used to identify soil-to-groundwater leaching COPCs in soil and sediment:

- Surface Soil (0-4 inches) and Sediment: Groundwater Protection Limits (GPLs) as listed in A Screening Method To Determine Soil Concentrations Protective of Groundwater Quality, Arizona Dept. of Environmental Quality (ADEQ 1996).
- Surface Soil and Sediment Synthetic Precipitation Leaching Procedure (SPLP) Results: PBC-NWQC (AAC 2009b).

In addition to the screening values listed above, soil results were compared to the 95 percent upper confidence limit (UCL) of the mean for the site-specific background soil remediation level to evaluate whether detected concentrations of are consistent with naturally occurring concentrations.

3.2 IDENTIFICATION OF COPCS

For detected analytes, the MDC was used for comparison to the screening level. For non-detected analytes, the minimum reporting limit (MRL) concentration was used for comparison to the screening level. For soil, the screening of COPCs was performed for each exposure area. The screening of COPCs for sediment and surface water was based on all results collected from the Hull Canyon Wash Area, without regard to boundaries of Exposure Areas 1 or 2.

A summary of COPCs identified for soil in Exposure Areas 1 and 2, as well as sediment and surface water are presented below.

3.2.1 Soil

3.2.1.1 Exposure Area 1

As presented in **Table G-2**, the following analytes detected in surface soil samples collected from Exposure Area 1 exceeded the residential SRLs

- Arsenic
- Copper

As presented in **Table G-2**, no analytes detected in surface soil samples collected from Exposure Area 1 exceeded their respective GPL.

As presented in **Table G-3**, the following analytes had SPLP results from surface soil samples collected from Exposure Area 1 that exceeded the PBC-NWQS:

- Arsenic
- Copper
- Lead

3.2.1.2 Exposure Area 2

As presented in **Table G-4**, the following analytes detected in surface soil samples collected from Exposure Area 2 exceeded the residential SRLs:

- Antimony
- Arsenic
- Cadmium
- Copper
- Lead

As presented in **Table G-4**, the following analytes detected in surface soil samples collected from Exposure Area 2 exceeded the GPL:

- Antimony
- Arsenic
- Cadmium
- Lead
- Mercury

As presented in **Table G-5**, the following analytes had SPLP results from surface soil samples collected from Exposure Area 2 that exceeded the PBC-NWQS:

- Arsenic
- Copper
- Lead

3.2.2 Sediment

As presented in **Table G-6**, the following analytes detected in sediment samples collected from the Hull Canyon Wash Area exceeded the residential SRLs:

- Arsenic

As presented in **Table G-6**, no analytes detected in sediment samples collected from the Hull Canyon Wash Area exceeded their respective GPL.

As presented in **Table G-7**, the following analytes had SPLP results from sediment samples collected from the Hull Canyon Wash Area that exceeded the PBC-NWQS:

- Arsenic
- Copper
- Lead

3.2.3 Surface Water

As presented in **Table G-8**, the following analytes detected in surface water samples collected from the Hull Canyon Wash Area exceeded the PBC NWQS:

- Lead

Chemicals that do not exceed the screening levels are excluded from further evaluation, as they are below concentrations that may pose a potential risk to human health receptors. Chemicals identified as COPCs from the soil, sediment and surface water direct contact screening are retained for further evaluation which includes the development of site-specific SRLs. COPCs identified from the soil-to-groundwater leaching pathway are retained for further evaluation which includes the development of alternative GPLs. The comparison of soil and sediment SPLP results with the PBC-NWQC was used to confirm the chemicals that may be leaching to groundwater at concentrations that may be harmful to human health. COPCs for the direct contact exposure pathway and the soil-to-groundwater leaching COPCs are discussed in more detail with regard to Site locations, number of exceedances, etc., in **Section 3.3**.

3.3 SUMMARY OF COPCS

3.3.1 Direct Contact Soil COPCs

3.3.1.1 Antimony

In Exposure Area 1, antimony was not identified as a direct contact COPC in soil.

In Exposure Area 2, antimony concentrations ranged from 5.3 milligram per kilogram (mg/kg) to 42 mg/kg. The MDC of antimony (42 mg/kg) exceeded the residential SRL of 31 mg/kg. No background value is available for antimony.

3.3.1.2 Arsenic

In Exposure Area 1, arsenic concentrations ranged from 19 mg/kg to 250 mg/kg. The MDC of arsenic (250 mg/kg) exceeded the residential SRL of 10 mg/kg and the 95 percent UCL background concentration of 24.71 mg/kg.

In Exposure Area 2, arsenic concentration ranged from 31 mg/kg to 430 mg/kg. The MDC of arsenic (430 mg/kg) exceeded the residential SRL of 10 mg/kg and the 95 percent UCL background concentration of 24.71 mg/kg.

3.3.1.3 Cadmium

In Exposure Area 1, cadmium was not identified as a direct contact COPC in soil.

In Exposure Area 2, cadmium concentrations ranged from 0.67 mg/kg to 65 mg/kg. The MDC of cadmium (65 mg/kg) exceeded the residential SRL of 39 mg/kg and the 95 percent UCL background concentration of 3.518 mg/kg.

3.3.1.4 Copper

In Exposure Area 1, copper concentrations ranged from 240 mg/kg to 22,000 mg/kg. The MDC of copper (22,000 mg/kg) exceeded the residential SRL of 3,100 mg/kg and the 95 percent UCL background concentration of 348.5 mg/kg.

In Exposure Area 2, copper concentrations ranged from 880 mg/kg to 24,000 mg/kg. The MDC of copper (24,000 mg/kg) exceeded the residential SRL of 3,100 mg/kg and the 95 percent UCL background concentration of 348.5 mg/kg.

3.3.1.5 Lead

In Exposure Area 1, lead was not identified as a direct contact COPC in soil.

In Exposure Area 2, lead concentrations ranged from 18 mg/kg to 1200 mg/kg. The MDC of lead (1200 mg/kg) exceeded the residential SRL of 400 mg/kg and the 95 percent UCL background value of 59.43 mg/kg.

3.3.2 **Leaching to Groundwater Soil COPC**

3.3.2.1 Antimony

In Exposure Area 1, antimony was not identified as a leaching to groundwater COPC in soil.

In Exposure Area 2, the MDC of antimony (42 mg/kg) exceeded the GPL of 35 mg/kg. No background value is available for antimony.

3.3.2.2 Arsenic

In Exposure Area 1, arsenic was not identified as a leaching to groundwater COPC in soil.

In Exposure Area 2, the MDC of arsenic (430 mg/kg) exceeded the GPL of 290 mg/kg and the 95 percent UCL background value of 24.71 mg/kg.

3.3.2.3 Cadmium

In Exposure Area 1, cadmium was not identified as a leaching to groundwater COPC in soil.

In Exposure Area 2, the MDC of cadmium (65 mg/kg) exceeded the GPL of 29 mg/kg and the 95 percent UCL background value of 3.518 mg/kg.

3.3.2.4 Copper

Copper does not have an established GPL. However, in Exposure Areas 1 and 2, copper is detected at concentrations ranging from 240 mg/kg to 24,000 mg/kg, some of which are above the 95 percent UCL background value of 348.5 mg/kg.

Soil and sediment SPLP results were evaluated for the potential migration of soil and sediment contaminants to surface water via runoff of leachate. The MDCs of SPLP results for copper in soil in Exposure Areas 1 and 2 and sediment in the Hull Canyon Wash Area exceeded the PCB-NWQS for copper. Consequently, copper was retained for further evaluation as a leaching to groundwater COPC.

3.3.2.5 Lead

In Exposure Area 1, lead was not identified as a leaching to groundwater COPC in soil.

In Exposure Area 2, the MDC of lead (1200 mg/kg) exceeded the GPL of 290 mg/kg and the 95 percent UCL background value of 59.43 mg/kg.

3.3.2.6 Mercury

In Exposure Area 1, mercury was not identified as a leaching to groundwater COPC in soil.

In Exposure Area 2, the MDC of mercury (14 mg/kg) exceeded the GPL of 12 mg/kg and the 95 percent UCL background value of 0.166 mg/kg.

3.3.3 **Direct Contact Sediment COPCs**

Sediment samples were collected from four locations along the Hull Canyon Wash. Arsenic concentrations in sediment ranged from 8.7 mg/kg to 34 mg/kg. The MDC of arsenic in sediment (34 mg/kg) exceeded the residential SRL of 10 mg/kg.

3.3.4 **Leaching to Groundwater Sediment COPCs**

No chemicals were present in sediment at concentrations exceeding GPLs.

3.3.5 **Direct Contact Surface Water COPCs**

Surface water samples were collected from four locations along the Hull Canyon Wash. One metal in surface water (lead) was detected at concentrations that exceeded its PBC NWQS of 0.015 milligram per liter (mg/L). Lead concentrations in surface water ranging from 0.022 mg/L to 0.12 mg/L exceeded the PBC NWQS of 0.015 mg/L at two locations, HCW-3 and HCW-4

For lead, the PBC NWQC is based on the lead action level of 0.015 mg/L, which is designed to be protective of exposures to lead in drinking water. Because the Hull Canyon Wash is an ephemeral streambed that is often dry, it is likely that exposure to surface water is intermittent, minimal and of short duration.

In addition, the samples with lead PBC NWQS exceedances were collected in September and October 2014. Subsequent samples collected from the same locations in May 2015 were reported as nondetections. Additional surface water sample collection was attempted in July 2018; however, the streambed was dry and no surface water could be collected.

The magnitude of exceedance of the drinking water action level for lead are less than an order of magnitude, ranging from slightly less than a factor of 2 (0.022 mg/L at HCW-3), to a factor of 8 (0.12 mg/L at HCW-4). Lead concentrations in surface water over the screening level are not significant enough to warrant concern for the brief and limited exposure to surface water that could occur at the Site. Levels of exposure to surface water in the wash are significantly less than the level of exposure to drinking water sources. Specifically, exposure is expected to be limited to minimal dermal contact, only a few days per year (after a significant precipitation event). Therefore, the lead exceedances of the PBC-NWQS are not considered to represent a potential risk to human health. Consequently, no further evaluation of lead in surface water is warranted.

3.4 CONCLUSIONS

Antimony, arsenic, cadmium, copper, and lead are direct contact surface soil and/or sediment COPCs retained for further evaluation which includes the development of site-specific SRLs.

Antimony, arsenic, cadmium, lead and mercury are soil leaching to groundwater COPCs retained for further evaluation which includes the development of alternate GPLs. Copper was also retained for further evaluation for the leaching to groundwater pathway based on SPLP results that exceeded the PBC-NWQS.

Lead was identified as a surface water direct contact COPC; however, based on lines of evidence provided in **Section 3.3.5**, no further evaluation of lead in surface water is warranted.

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4.0 EXPOSURE ASSESSMENT

This human health exposure assessment section identifies land uses and potential receptors that currently, or in the future, are likely to use the Site and, as a result, may potentially contact the COPCs identified in the previous sections. The land uses and potential receptors are presented in **Section 4.1**. **Section 4.2** briefly describes the exposure assumptions for the potential receptors. **Section 4.3** presents and evaluates the routes or pathways in which exposure could occur; and quantifies the magnitude, frequency, and duration of potential exposures. The potential receptors evaluated and the pathways by which they may be potentially exposed are presented in the conceptual site model (CSM) (**Figure G-5**).

4.1 LAND USE AND RECEPTORS

As discussed in **Section 2.1**, the Site is located in a steep, rocky canyon with difficult access. Vehicle access to the site is limited to an unpaved four-wheel drive road on the south side of Highway 89A. Currently, a locked metal gate controls site access and a 6-foot high chain link fence controls access to former building foundations. Because the Site is an abandoned mine, no industrial or maintenance workers are present on Site. No industrial entities are located in the area. Future land use is expected to remain the same as current.

Based on the Site conditions as described above, the HHRA evaluates the following receptors for potential exposure to impacted media at the Site:

- Current/future on-site adolescent (7 – 16 years of age) trespasser

4.2 EXPOSURE ASSUMPTIONS FOR THE ADOLESCENT TRESPASSER

The use of upper-bound exposure conditions results in the Reasonable Maximum Exposure (RME). The RME is the highest exposure that is reasonably expected to occur at a site (USEPA 1989). The intent of the RME, as defined by the USEPA, is to estimate a conservative exposure case (i.e., well above the average case) that is still within the possible range of exposures. This approach is designed so there is high confidence that the actual risk is not underestimated.

USEPA guidance, site-specific information and professional judgment were used to derive RME exposure parameters for the adolescent trespasser at the Site. Professional judgment was used to determine exposure frequency and exposure time. Because the adolescent trespasser is expected to be in school during nine months of the year (September through May), it is assumed that for those nine months this receptor may visit the Site one day a month. During the summer months (June through August) the adolescent trespasser may visit the Site with slightly more frequency, e.g., two days per month. The total exposure frequency for the adolescent trespasser is 15 days per

year. Because of the remoteness and restricted access of the Site, 15 days per year adequately represents the RME for the exposure frequency. Due to the Site's small size and restricted access, it is assumed that the adolescent trespasser would have a limited exposure time and only spend two hours at the Site. The RME exposure parameters for the adolescent trespasser are presented in **Table G-9**.

4.3 EXPOSURE AREAS

The Site was divided into two exposure areas based on historical site use, current habitat conditions and environmental setting, and potential future site use for the purposes of determining COPCs and evaluating potential risk. The adolescent trespasser is assumed to have access to and be exposed to Site media in both exposure areas. The rationale for each area is briefly described below:

- **Exposure Area 1:** The main area of the site comprised of the steep slopes of the waste rock stockpiles and the low-grade ore rock stockpiles and the smaller areas of the high-grade ore and the suspected waste concentrate. The tailings pile is also part of Exposure Area 1 (**Figure G-3**).
- **Exposure Area 2:** The area of the Site comprised of the former building foundations located south of the Site access road (**Figure G-4**).

4.4 DEVELOPMENT OF THE CONCEPTUAL SITE MODEL

This section briefly describes the CSM diagram developed for the Site. The primary purpose of the CSM diagram in this risk evaluation is to present chemical sources, potential pathways, and potential exposure routes that may result in human health risks. Consequently, the CSM is used to guide the evaluation of potential exposures for human health so that relevant pathways, exposure routes, and ultimately risks can be evaluated in the HHRA. The fate and transport pathways identified in the CSM include direct contact and leaching. The exposure routes are defined by the manner in which a chemical enters the human body and include ingestion, dermal contact, and inhalation. Only potentially complete exposure pathways, shown in **Figure G-5** are evaluated quantitatively in an HHRA, consistent with USEPA guidance (USEPA 1989).

A potentially complete exposure pathway includes all of the following elements:

- Sources and type of chemicals present
- Affected media
- Chemical release and transport mechanisms
- Known and potential routes of exposure

- Known or potential human and environmental receptors

The absence of any one of these elements results in an incomplete exposure pathway. Thus, for an incomplete pathway with no potential human exposure, the potential for adverse health effects would be deemed negligible and would not warrant further evaluation. Incomplete and/or insignificant exposure pathways for this site are discussed in **Section 4.4.1**.

Uncertainties associated with exposure estimates are carried through the exposure assessment and evaluated qualitatively in **Section 7**. Further discussion of potentially complete exposure pathways is presented in **Section 4.4.2**.

4.4.1 Incomplete/Insignificant Exposure Pathways

Of those exposure pathways that are presented on **Figure G-5** several have been deemed incomplete, insignificant, or not applicable to the HHRA. Thus, these pathways do not warrant quantitative assessment. The rationale for excluding a pathway from further evaluation is as follows:

- *Surface Soil (0-4 inches bgs).* The bioaccumulation of chemicals via ingestion of plants and animals in surface soil are incomplete pathways for the current/future adolescent trespasser because there are no agricultural activities on site and the Site is not expected to be used for agricultural activities in the future. In addition, no vegetation or plants have been observed on the Site, eliminating the possibility of plant ingestion as a potential exposure pathway.
- *Subsurface Soil (>4 inches bgs).* The ingestion, dermal contact, and inhalation of particulates in ambient air from subsurface soil are incomplete for the current/future adolescent trespasser. Current/future adolescent trespassers are not expected to be involved in any activities that may disturb the soil. Furthermore, characterization of the exposed rock, tailing and mill wastes is one of the SCR project objectives. There is no basis for assuming that samples at depth in a stockpile are likely to have higher concentrations of metals than those samples collected from 0-4 inches. Consequently, surface soil samples are assumed to represent the highest concentrations of COPCs and no subsurface soil samples were collected.
- *Groundwater*. The ingestion of and dermal contact with groundwater are incomplete exposure pathways for the current/future adolescent trespasser. This receptor is unlikely to come into contact with Site groundwater because groundwater is encountered at a depth of approximately 100 feet bgs and this receptor is not expected to perform excavation activities that would allow them to be exposed to groundwater.

4.4.2 Potentially Complete Exposure Pathways

Based on analysis of the CSM, the following complete exposure pathways were considered for evaluation:

- *Surface Soil (0—4 inches bgs)*. Incidental ingestion, dermal contact, and inhalation of particulates in surface soil are considered potentially complete exposure pathways for the current/future adolescent trespasser.
- *Sediment*. Incidental ingestion, dermal contact, and inhalation of particulates in sediment are considered potentially complete exposure pathways for the current/future adolescent trespasser.
- *Surface Water.* Incidental ingestion and dermal contact of surface water is considered potentially complete exposure pathway for the current/future adolescent trespasser.

4.5 ESTIMATION OF EXPOSURE POINT CONCENTRATIONS

Exposure point concentrations (EPCs) were calculated for each COPC to compare to site-specific risk-based remediation goals. The calculation of EPCs was performed per USEPA guidance (USEPA 1992). The EPC is selected in order to characterize the RME for a receptor group where the RME is defined as "…the highest exposure that is reasonably expected to occur at a site" (USEPA 1989).

An EPC is the concentration of a COPC at the point of contact made between the COPC and a human receptor. In long-term exposures (e.g., years), a receptor can be expected to contact the exposure medium (e.g., surface soil) at all locations within an exposure area. As a result, the contaminant concentrations contacted by a receptor are best represented by the average contaminant concentration (i.e., arithmetic mean) within the exposure area. Therefore, the concentration term should be an estimate of the arithmetic mean at the site; however, there is uncertainty associated with estimating the true arithmetic mean concentration at a site (e.g., confidence in the true average concentration is limited by sample size). Typically, to address this uncertainty, the upper confidence limit (UCL) (95 percent or greater) of the arithmetic mean is used as a best estimate of the true arithmetic mean concentration (USEPA 1992). To derive the 95 percent UCL and to minimize uncertainties that may arise with derivation of statistics, ProUCL Version 5.1.002 (USEPA 2016a) was used to calculate the 95 percent UCLs and the summary statistics.

ProUCL is designed to test the normality of a data set and compute a conservative and stable UCL of the true population mean while considering sample size, the distribution of the data, and the skewness of the data. ProUCL calculates UCLs of the mean with a specific confidence level (95

percent or greater) using 15 computational methods and recommends the most appropriate UCL based on the data. In general, the first UCL recommended by ProUCL was selected as the EPC. In some cases, the recommended UCLs may be artificially elevated due to limited sample size. In cases where the UCL (95 percent or greater) recommended by ProUCL exceeds the MDC, the MDC was the EPC, in accordance with USEPA guidance (USEPA 1989). The maximum concentration was also used as the EPC in cases where ProUCL cannot calculate a UCL because of limited data. It is recommended that 10 samples with 5 detected observations be used to determine an EPC (USEPA 2013). If fewer than ten samples are available, or there are less than six observations noted over the reporting limit, the MDC was used as the EPC. For all exposure areas (Exposure Areas 1 and 2, and Hull Canyon Wash), site data were reduced prior to running statistics in ProUCL by conservatively selecting the maximum of the duplicate and normal sample results to avoid underestimation of sample variance and the 95% UCL.

USEPA guidance (USEPA 2002) was followed to derive air EPC (i.e., concentrations of COPCs in air due to generation of fugitive dust/particulates and volatilization from soils) based on soil EPCs. A particulate emission factor (PEF) relates the concentration of a non-volatile constituent in soil to the concentration of dust particles in the air that may be inhaled (USEPA 2002). USEPA PEF values (USEPA 2002) for estimating particulate emissions due to wind erosion were used for receptors at the Site. For example, a PEF value of 1.36E+09 cubic meters per kilogram (m^3/kg) was applied for the adolescent trespasser at the Site.

EPCs for COPCs in surface soil for both exposure areas and sediment for the Hull Canyon Wash Area are presented in **Table G-10**. ProUCL inputs/outputs are provided in **Attachment G-2**.

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5.0 HUMAN HEALTH TOXICITY ASSESSMENT

The purpose of the toxicity assessment is to weigh the available evidence regarding the potential for chemicals to cause adverse health effects and to provide a quantitative estimate of the relationship between the magnitude of exposure and the likelihood or severity of adverse health effects (i.e., dose-response assessment [USEPA 1989]).

Toxicity values are used to provide a quantitative estimate of the relationship between the magnitude of exposure and the potential for adverse health effects. Toxicity values were obtained for each COPC and include carcinogenic slope factors (CSFs) and inhalation unit risks (IURs) used to evaluate carcinogenic risks, as well as reference doses (RfDs) and inhalation reference concentrations (RfCs) used to evaluate non-carcinogenic hazards. Per the USEPA Office of Solid Waste and Emergency Response Directive 9285.7-53 (USEPA 2003a), the current hierarchy for human toxicity values is as follows:

- *Tier 1.* USEPA's Integrated Risk Information System (IRIS) (USEPA 2019b).
- *Tier 2.* USEPA's Provisional Peer-Reviewed Toxicity Values obtained from USEPA via the USEPA National Center for Environmental Assessment in Cincinnati, Ohio (USEPA 2015).
- *Tier 3.* Toxicity Values from other sources, including USEPA's Health Effects Assessment Summary Tables (USEPA 1997), California EPA's Office of Environmental Health and Hazard Assessment Toxicity Criteria Database, and Minimal Risk Levels published by the Agency for Toxic Substances and Disease Registry (ATSDR 2013).

Toxicity values used in this HHRA are presented in **Table G-11**.

5.1 TOXICITY VALUES FOR CARCINOGENS

In USEPA's linear low dose model for carcinogenesis, it is assumed that the relationship between exposure to a carcinogen and cancer risk is linear over the entire dose range, except at very high doses (USEPA 1989). This linearity assumes there is no threshold-of-exposure dose below which harmful effects will not occur. Because of this, carcinogenic effects are considered to be cumulative across age groups when considering lifetime exposures. More recent USEPA guidance suggests that a threshold mechanism may be operative, especially if the cancer is a "…secondary effect of toxicity or of an induced physiological change that is itself a threshold" (USEPA 2005); however, data are not yet sufficient to apply the "threshold" concept in the development of risk assessments for carcinogens that are intended to be protective of the potentially exposed receptor group. Thus, the linear low-dose model is still considered applicable.

Oral carcinogenic slope factors (CSFo), are expressed as the proportion of a population affected per intake dose and are typically reported in units of milligram per kilogram per day (mg/kg-day)$^{-1}$. Inhalation cancer toxicity values are expressed as a unit risk (UR) per mg of chemical per cubic meter of air [mg/m^3]$^{-1}$ or per micrograms per cubic meter [µg/m^3]$^{-1}$.

5.2 TOXICITY VALUES FOR NON-CARCINOGENS

Oral RfDs (expressed in units of mg/kg-day) are used to evaluate the potential for adverse noncancer health effects from the ingestion of chemicals. Chronic RfDs are specifically developed to be protective for long-term exposure to a chemical and are generally used to evaluate the potential noncancer effects associated with exposure periods between 7 years and a lifetime (USEPA 1989).

The RfD is derived from a no-observed-adverse-effect level (NOAEL) or a lowest observed-adverse-effect level (LOAEL). For the risk assessment, a NOAEL is the key datum obtained from a study of a dose-response relationship. It is the highest level tested at which no adverse effects were demonstrated. In some studies, only a LOAEL (rather than a NOAEL) is available. However, the use of a LOAEL requires additional uncertainty factors (UFs) and modifying factors (MFs) to ensure that a health-protective toxicity value is used (USEPA 1993).

UFs are typically 10-fold factors used for estimating RfDs from the laboratory to account for: (1) variation in sensitivity among the members of the human population (i.e., inter-human or intraspecies variability); (2) uncertainty in extrapolating animal data to humans (i.e., interspecies variability); (3) uncertainty in extrapolating from data obtained in a study with less-than-lifetime exposure to lifetime exposure (i.e., extrapolating from sub-chronic to chronic exposure); (4) uncertainty in extrapolating from a LOAEL rather than from a NOAEL; and (5) uncertainty associated with extrapolation from animal data when the database is incomplete.

The reference values from inhalation studies are generally reported as an RfC in air (mg/m^3), as the actual analysis of inhalation exposures is more complex than that for oral exposures to account for the inhaled dose in the experimental design of laboratory studies.

5.3 AVAILABILITY OF TOXICITY VALUES

Some chemicals may exhibit both carcinogenic and non-carcinogenic health effects. Toxicity values are generally available for the oral route of exposure. Inhalation toxicity values have also been developed for some constituents.

Chemical disposition in the body may determine the dose of a toxicant that reaches the target organ, confounding the interpretation of toxicity values. For instance, toxicity values for the oral

exposure pathway are based on applied or administered doses, whereas those for dermal exposures, which rarely result in the entire applied dose entering systemic circulation, should ideally be based on absorbed doses. Because this phenomenon is poorly quantified, toxicity values for evaluating risk from dermal exposure often require an oral-to-dermal adjustment that accounts for the differences between applied and absorbed doses. USEPA has not developed specific toxicity values for the dermal pathway. Therefore, in accordance with the USEPA dermal guidance (USEPA 2004), dermal values are derived by adjusting oral toxicity factors by chemical-specific gastrointestinal (GI) absorption factors, as shown in **Table G-11**. Dermal toxicity values are derived according to the following equations:

$$CSF_d = \frac{CSF_o}{ABS_{GI}} \quad \text{or } RfD_d = RfD_o \times ASB_{GI}$$

Where:

ABS_{GI} = Fraction of contaminant absorbed through the GI tract

CSF_d = Dermal carcinogenic slope factor

CSF_o = Oral carcinogenic slope factor

RfD_d = Dermal reference dose

RfD_o = Oral reference dose

Per USEPA guidance (2004), dermal adjustment of toxicity values would be conducted only for those chemicals with GI absorption of less than 50 percent (ABS_{GI} below 0.5).

5.4 RELATIVE BIOAVAILABILITY FACTOR FOR ARSENIC

The relative bioavailability factor (RBA) accounts for differences in the bioavailability of a contaminant between the medium of exposure (e.g., soil) and the media associated with the toxicity value. Site-specific bioavailability estimates for arsenic in soil-like material reported by the ATSDR vary from 0 to 98 percent, and in many instances were very low (<10 percent) (ATSDR, 2007). Therefore, it is common practice in human health risk evaluations to derive site-specific RBA estimates to account for lower availability (and toxicity) of arsenic in soil-like material. The USEPA has recently begun using a default RBA of 60 percent to calculate soil RSLs for the ingestion pathway (USEPA, 2019a). The oral RBA of 60 percent for arsenic in soil is empirically-based and represents an upper-bound estimate from numerous studies where the oral RBA of soil-borne arsenic in samples collected from across the U.S. was experimentally determined against the water-soluble form used in toxicity studies. For this site, literature RBA values were reviewed to identify an RBA appropriate for this evaluation; these literature sources and values are included as

Appendix I of the Site Characterization Report. Literature values specific to mining-related soil-like material were preferentially selected. RBAs for mining-related soil-like material range from 3 to 57 percent. Percentile values were derived for the RBAs available for mining-related soils and a high-end percentile RBA value of 40 percent (0.40) was selected as a conservative RBA for this site. The RBA only applies to the ingestion pathway.

6.0 RISK CHARACTERIZATION

6.1 CALCULATION OF SITE-SPECIFIC SRLS

Site–specific adolescent trespasser SRLs are developed for the soil and sediment direct contact COPCs. The site-specific SRLs are based on target cancer risk levels of 1 x 10^{-4}, 1 x 10^{-5}, 1 x 10^{-6} (which represent the acceptable cancer risk range of 1x10^{-4} to 1 x10^{-6} allowed by the Arizona VRP) and a target HQ of 1. The site-specific SRL based on a target cancer risk level of 1 x 10^{-5} is used for comparison to concentrations of COPCs in soil and sediment. **Table G-12** presents the ingestion, dermal and inhalation carcinogenic and noncarcinogenic intake factor equations and the site-specific SRLs for the COPCs in soil and sediment.

The equations used in calculating the site-specific SRLs for noncarcinogenic and carcinogenic COPCs are presented below.

6.1.1 Noncancer SRL Equations

The noncancer site-specific SRL is presented in Equation 1 below.

$$SRL_{nc} = \frac{THI}{\frac{IF_{ing}}{RfD_o} + \frac{IF_{derm}}{RfD_d} + \frac{IF_{inh}}{RfC}} \tag{1}$$

Where:

SRL_{nc}	=	Soil Remediation Level, noncancer effects (mg/kg)
THI	=	Target hazard index (unitless) = 1
IF_{ing}	=	Ingestion Intake Factor (kg-soil/kg-BW-day) (see Table G-12)
RfD_o	=	Oral Reference Dose (mg/kg-day)
IF_{derm}	=	Dermal Intake Factor (kg-soil/kg-BW-day) (see Table G-12)
RfD_d	=	Dermal Reference Dose (mg/kg-day)
IF_{inh}	=	Inhalation Intake Factor (kg/m^3) (see Table G-12)
RfC_{inh}	=	Inhalation Reference Concentration (mg/m^3)

6.1.2 Carcinogenic SRL Equations

The carcinogenic site-specific SRL is presented in Equation 2 below.

$$SRL_c = \frac{TRL}{(IF_{ing} \times CSF_o) + (IF_{derm} \times CSF_d) + (IF_{inh} \times IUR \times CF)} \quad (2)$$

Where:

SRL_c	=	Soil Remediation Level, cancer effects (mg/kg)
TRL	=	Target risk level (unitless) = $1x10^{-5}$
IF_{ing}	=	Ingestion Intake Factor (kg-soil/kg-BW-day) (see Table G-12)
CSF_{ol}	=	Oral Cancer Slope Factor ($(mg/kg\text{-}day)^{-1}$)
IF_{derm}	=	Dermal Intake Factor (kg-soil/kg-BW-day) (see Table G-12)
CSF_d	=	Dermal Cancer Slope Factor ($(mg/kg\text{-}day)^{-1}$)
IF_{inh}	=	Inhalation intake factor (kg/m^3) (see Table G-12)
IUR	=	Inhalation Unit Risk $(\mu g/m^3)^{-1}$
CF	=	Conversion Factor (1,000 µg/mg)

6.2 COMPARISON OF SITE-SPECIFIC SRLS TO COPC CONCENTRATIONS

As discussed in **Section 3.4**, antimony, arsenic, cadmium, copper and lead were identified as soil and/or sediment direct contact COPCs and retained for further evaluation. **Table G-13** presents the site-specific adolescent trespasser SRL for each COPC and its comparison to the COPC MDC in each exposure area. Note that lead is evaluated separately in **Section 6.3** based on its unique toxicological properties.

Because the adolescent trespasser is expected to move around the Site rather than spend all of their time at one location, the comparison of the 95 percent UCL to the site-specific SRL is a more realistic evaluation of exposure. The MDCs and 95 percent UCLs of antimony, arsenic, cadmium, and copper in each exposure area were well below the adolescent trespasser SRLs, suggesting that concentrations of these chemicals are unlikely to cause adverse health effects to the adolescent trespasser who may be intermittently exposed to Site soil. Consequently, no further evaluation of antimony, arsenic, cadmium and copper with regard to direct contact exposure to soil in Exposure Area 1 and Exposure Area 2 is warranted.

6.3 LEAD EVALUATION

The MDC of lead in Exposure Area 2 (1200 mg/kg) exceeded the residential SRL of 400 mg/kg; thus, lead was identified as a direct contact COPC in surface soil. The evaluation of lead is conducted differently from other constituents because of lead's unique toxicological properties. The most sensitive receptors to lead exposures are children and pregnant women (developing fetus). The USEPA and the Centers for Disease Control and Prevention (CDC) have determined that the childhood blood-lead (PbB) concentrations at or above 10 micrograms per deciliter (µg/dL) of blood present risks to children's health. The generally accepted methodology is to estimate PbB levels based on soil exposures and to compare the estimated PbB levels to PbB levels considered to be protective of adverse health effects. For this evaluation, USEPA's Adult Lead Model (ALM) (USEPA 2003b, 2017) was used to estimate PbB levels for the adolescent trespasser.

While USEPA's Technical Review Workgroup for Lead has cautioned that lead risk assessments that include non-residential land use should report new toxicity information from USEPA indicating adverse health effects at PbB levels below 10 µg/dL down to 5 µg/dL and possibly lower (USEPA 2010). The USEPA currently considers 10 µg/dL to be the PbB level of concern for fetuses and children. The CDC has replaced its former Level of Concern of 10 µg/dL with a reference value of 5 µg/dL (CDC 2012). Because of the limited and intermittent amount of lead exposure for the adolescent trespasser considered in this HHRA, although both 5 µg/dL (reference value) and 10 µg/dL (level of concern) scenarios are considered, the final conclusions and recommendations focused on the 10 µg/dL level of concern. This is consistent with the USEPA's risk reduction goal for contaminated sites to limit the probability of a child's PbB concentration exceeding 10 µg/dL to 5 percent or less after cleanup (as described in the 1994 Office of Solid Waste and Emergency Response Directive (USEPA 1994) and is consistent with the underlying assumptions associated with the USEPA soil RSL of 400 mg/kg lead for residential exposure (USEPA 2019a).

6.3.1 Lead Approach for the Adolescent Trespasser

In this HHRA, the ALM was used to evaluate non-child exposure to lead in soil in Exposure Area 2. The use of the ALM model to evaluate adolescent receptors was conducted consistent with USEPA's frequently asked questions on the ALM (USEPA 2009b).[1] For Exposure Area 2, models

[1]https://www.epa.gov/superfund/lead-superfund-sites-frequent-questions-risk-assessors-adult-lead-methodology#ALM

were run for soil under the reference value target risk of 5 µg/dL and under the level of concern target risk of 10 µg/dL.

The following equation is used in the ALM to estimate quasi-steady state PbBs:

$$PbB_{GM} = PbB_0 + \frac{PbS \times BKSF \times IR \times AF \times EF}{AT}$$

Where:

PbB_{GM}	=	geometric mean (or 50th percentile) of the lognormal distribution of PbBs in adult workers (µg/dL)
PbB_0	=	baseline PbB due to exposure to non-site-related sources of lead (µg/dL)
PbS	=	soil lead concentration (mg/kg)
BKSF	=	biokinetic slope factor (µg/dL per micrograms per day)
IR	=	soil ingestion rate (grams per day [g/day])
AF	=	gastrointestinal absorption fraction for lead in soil (unitless)
EF	=	exposure frequency (days per year)
AT	=	averaging time (days)

The receptor of concern in the ALM is the fetus of an adult worker. The USEPA assumes a linear relationship between PbB in the adult woman and the fetus. Therefore, the geometric mean PbB in the fetus is equal to PbB_{GM} multiplied by a constant, R.

Baseline Blood Lead Concentration (PbB_0)

The baseline PbB is intended to represent the best estimate of a reasonable central value of PbB in women of child-bearing age who are not exposed to lead-contaminated non-residential soil or dust at the site. A default baseline value of 0.64 µg/dL was used in the ALM, which represents the updated estimate of PbB_0 for women 17-45 years of age (USEPA 2017).

Soil Lead Concentration

The EPC used in the lead evaluation and is equal to the arithmetic mean concentration of lead in Exposure Area 2 (230 mg/kg) developed using ProUCL (USEPA 2016a), in accordance with USEPA guidance (2003b).

Geometric Standard Deviation

The GSD_i represents a measure of the inter-individual variability in blood lead concentrations in a population whose members are exposed to the same non-residential environmental lead levels (USEPA 2017). A GSD_i of 1.8 was used in this lead evaluation to reflect the updated estimate for women 17-45 years of age (USEPA 2017).

Biokinetic Slope Factor

The Biokinetic Slope Factor (BKSF) represents the increase in typical adult PbB due to average daily lead uptake. The USEPA (2003b) recommends a default value of 0.4 µg lead/dL blood per µg lead absorbed per day for the BKSF. This value is based on empirical data on the relationship between tap-water lead concentrations and PbBs for a sample group of adult males. This default value was used for all exposure pathways in this evaluation.

Soil Ingestion Rate (IRs)

A soil ingestion rate of 25 mg/day was used to evaluate a potential adolescent trespasser which is consistent with the ingestion rate used for soil ingestion in the development of site-specific SRLs, as described in Section 4.2 and presented on Table G-9.

Exposure Frequency and Averaging Time

The exposure frequency of 15 days per year used for the adolescent trespasser represents a short-term exposure and is incompatible with the use of the ALM which was not designed to assess exposures less than 90 days (USEPA 2016b). Consequently, an exposure frequency of 90 days was used in the ALM to represent the minimum number of days to produce a quasi-steady-state blood lead concentration. The averaging time used in this lead evaluation was consistent with values used in the HHRA (**Table G-9**).

Lead Absorption Fraction

This evaluation used a lead absorption fraction of 0.12, which is the default value recommended by the USEPA (2003b, 2009b). This value is based on experimental studies of the bioavailability

of ingested lead in adults with considerations for the following three major sources of variability: 1) effect of food on lead bioavailability, 2) nonlinearity in PbB, and 3) effect of lead form and particle size on bioavailability. The value assumes a relative bioavailability of 0.6 for lead in site-related media as compared to soluble lead, and also assumes an absorption fraction (AF) of 0.2 for soluble lead. Thus, the final AF is 0.12 (i.e., AF = 0.6 x 0.2 = 0.12).

Fetal/Maternal Blood Lead Concentration ($R_{fetal/maternal}$)

This evaluation used a fetal/maternal blood lead ratio of 0.9 for adult receptors, which is the default value recommended by the USEPA (2003b) based on studies that have explored the relationship between umbilical cord and maternal PbBs.

6.3.2 Adult Lead Model Results

Preliminary remediation goals (PRGs) were calculated for the adolescent trespasser in Exposure Area 2 for target fetal PbB concentrations of 5 and 10 µg/dL. The ALM spreadsheets are included as **Attachment G-3**.

The PRG for the adolescent trespasser based on a target fetal blood lead concentration of 5 ug/dL is 5,100 mg/kg. The EPC for lead in Exposure Area 2 (230 mg/kg) is well below this PRG.

The PRG for the adolescent trespasser based on a target fetal blood lead concentration of 10 ug/dL is 12,000 mg/kg. The EPC for lead in Exposure Area 2 (230 mg/kg) is well below this PRG.

No further evaluation of lead with respect to direct contact soil exposure is warranted.

6.4 LEACHING TO GROUNDWATER

Soil impacts could migrate to underlying groundwater through the infiltration due to precipitation, thereby impacting groundwater quality. As presented in **Figure G-5**, the adolescent exposure to groundwater is considered an incomplete pathway. The adolescent trespasser it not expected to perform any excavation activities that would enable them to encounter groundwater. In addition, groundwater is not known to reach the surface at the Site. However, because some metals in soil were detected at concentrations that exceeded their default GPLs, an evaluation of the leaching to groundwater pathway was included in this HHRA.

6.4.1 Alternative Groundwater Protection Levels

To further evaluate potential groundwater impacts from copper and the metals that exceeded minimum GPL values, methods outlined in *Screening Method To Determine Soil Concentrations Protective of Groundwater Quality* (ADEQ, 1996) were used to calculate alternative GPLs.

Default GPLs used in the COPC screening process were calculated based on an assumed non-leachability ratio 'R' of 20. This ratio represents the resistance of a particular contaminant to partition into leachate and consequently become mobilized from soils to groundwater, and can be calculated as the ratio of the solid phase concentration (mg/kg) to the leachate concentration (mg/L) as determined via SPLP. Therefore, the higher the R value, the lower the particular contaminant's propensity for leaching. The R value is then multiplied by a human health based groundwater standard (e.g., the maximum contaminant level), and a constant value (292.9) that incorporates numerous assumptions about the depth to groundwater, physical mixing of leachate in groundwater via dispersion, well head dilution, etc. (ADEQ 1996). Site-specific R values were calculated for antimony, arsenic, cadmium, copper, lead and mercury and presented on **Table G-14**.

Alternative GPLs for antimony, arsenic, cadmium, copper, lead and mercury are presented in **Table G-14.** As shown in **Table G-14**, the soil concentrations for these chemicals are well below their respective alternative GPLs, indicating that chemicals are not leaching to groundwater at levels that may cause adverse health effects. No further evaluation of antimony, arsenic, cadmium, copper, lead and mercury with respect to the leaching to groundwater pathway is warranted.

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7.0 UNCERTAINTY ASSESSMENT

Uncertainty and limitations are inherent in the risk assessment process. The assumptions made in the HHRA for the Verde Central Mine Project introduce some uncertainty in the findings of the HHRA. This section describes the uncertainties inherent in the human health evaluation.

7.1 UNCERTAINTIES IN DATA ASSESSMENT

Limitations may exist with respect to the type, quantity, and quality of available data that may lead to uncertainties in estimating the overall risk posed by a site. These limitations are the product of both the collection of data and the ability to strictly evaluate the data according to EPA guidelines. Also, reporting limits differ among similar datasets. This factor alone does not invalidate the data nor imply that the data are unusable for risk assessment. Measurement variability among reporting limits may introduce uncertainty into the estimate of potential risk associated with low concentrations of chemicals at the sites.

7.1.1 Sample Collection

The process of environmental sampling and analysis results in uncertainties from several sources, including errors inherent in sampling procedures or analytical methods. One area of uncertainty is sampling procedures. Because it is not possible to sample the entire area of interest at the Site, several samples are collected from a medium within each exposure area, and the results are considered representative of the chemicals present throughout the exposure area. For this HHRA, sample locations are limited and biased to source areas where higher metal concentrations are expected. As the samples were collected in a judgmental manner in high concentration areas, the 95% UCLs calculated from the combined datasets likely represent a very conservative exposure scenario, and an underestimation of exposure point concentrations is unlikely to occur. Therefore, this sampling assumption likely overestimates potential risk. Because the sampling locations are likely representative of maximum metal concentrations, the sampling locations used in the HHRA are adequate to support the purpose and conclusions of the HHRA.

Soil samples in each exposure area were collected from a depth interval of 0-4 inches. This interval meets the objectives of the site characterization which is to characterize the exposed rock, tailings and mill wastes resulting from historic mining and milling operations at the Site. Adolescent trespassers are assumed to be exposed to soils in the shallow depth range, i.e., 0-4 inches for this Site. Concentrations of chemicals generally may show a trend with depth (increasing or decreasing) which may lead to high or low biases in the estimates of exposure concentrations if the majority of contact is expected to be with the top layer of soil. Should erosion occur at the Site, soils presently at depth may be brought to the surface and become exposed, allowing potential

contact to the adolescent trespasser. There is no basis to assume that concentrations of metals significantly differ with depth, given the timeframe over which source materials have been exposed to the elements and the nature of sources (primarily rocky/limited erodible material) and how they were initially deposited, suggesting that the uncertainty associated with shallow sample depth collection is low.

7.1.2 Reporting Limit Evaluations

A number of chemicals were not detected in any of the collected samples. These chemicals may not have been detected because they truly are not present, or because the RL was not low enough to detect their presence. The RL is the lowest concentration that must be present in a sample to be detected at a 99 percent confidence level. To ascertain the importance of the lack of detected concentrations on assessing risk from these chemicals, the minimum RL for all non-detected chemicals were compared to available screening levels. These comparisons are presented in the COPC screening tables for each media.

For the majority of chemicals that were not detected in any sample, the RLs were less than the screening level. The uncertainty associated with the lack of actual detected concentrations is not important in these cases because the RL is the maximum limit of each unknown concentration. However, a number of chemicals had a MRL that exceeded their corresponding screening level in SPLP results. The identification of SPLP results with a MRL that exceeded the screening level did not identify any SPLP COPCs that were not already identified in the soil to leaching groundwater COPC process. The uncertainty associated with including using the MRL to identify COPCs for nondetected results for this HHRA is low.

7.1.3 Use of Screening Levels to Identify COPCs

The screening process eliminated chemicals that were below screening levels that are based on a cancer risk of 1×10^{-6} or a noncancer target HI of 1. Elimination of analytes below screening levels may result in an under-estimation of risk. However, the potential under-estimation is slight as chemicals below conservative default screening levels do not contribute significantly to cumulative risk.

Because screening levels are not available for some chemicals, surrogate or chemicals that may have similar physical and chemical properties may be utilized. Comparison to such screening levels would more accurately characterize the risk as opposed to not screening the COPCs against any screening level at all. However, depending on the nature of the physical and chemical properties of the surrogate chemical, which may not match that of the COPC, inclusion of the

surrogate could overestimate or underestimate the risk. For this HHRA, the chemicals without screening levels were not replaced with a surrogate screening level.

In this HHRA, four chemicals (copper, manganese, silver and zinc) lack a leaching screening level (GPL). These chemicals were not carried forward in the risk assessment process because they were not determined to be leaching to groundwater COPCs. The exclusion of these chemicals could potentially underestimate risk. However, SPLP results for these metals were also evaluated to determine leaching potential. Copper was the only chemical with SPLP results that exceed the PCB-NWQS. Consequently, copper was retained for further evaluation and included in the development of alternative GPLs. The uncertainty associated with the lack of leaching to groundwater screening levels for copper, manganese, silver and zinc is low.

7.2 UNCERTAINTIES IN EXPOSURE ASSESSMENT

Uncertainty in the exposure assessment is a function of several factors. Such factors include, but are not limited to, completeness/representativeness of the site data; identification of COPCs; assumptions regarding actual current and/or future site land use; and identification of relevant receptor groups and activities.

7.2.1 Selection of Exposure Parameters

Estimates of intake include the uncertainties associated with the concentration of chemicals in each medium, upper-bound estimate for intake rate, exposure frequency and duration, an average value for body weight, and an averaging time (typically 70 years for carcinogens). These standard factors are intended for calculation of RME estimates (the 95th percentile) of each applicable scenario at a site. A determination of "reasonable" cannot be based solely on quantitative information, but also requires the use of professional judgment.

For example, the exposure frequency for the trespasser is based on the assumption of 1 visit per month for 9 months of the year and two visits per month for three months of the year for a total of 15 days per year. This is a conservative assumption that most likely overestimates exposure and risk.

7.2.2 Exposure Point Concentration

Greater uncertainty exists in the estimate of mean concentrations as the size of the dataset decreases (USEPA 2006). Smaller datasets often lead to higher variability of the data, which in turn can lead to higher estimates of mean concentrations. While the use of these UCLs could potentially overestimate the EPC, the effect is minimized by defaulting to the maximum detected concentrations for smaller datasets. As presented in **Table G-10**, 95 percent UCLs of the mean

were developed for COPCs in surface soil for each exposure area. The data sets for COPCs in surface soil were sufficient to calculate a reliable UCL to estimate the mean chemical concentration for those COPCs. The dataset for sediment is comprised of four sample results. Although the sediment dataset was too small to develop a reliable 95 percent UCL of the mean, the MDC for the direct contact sediment COPC (arsenic) was less than the site-specific adolescent trespasser SRL and did not require the comparison of a statistically derived EPC. The uncertainty associated with the size of the datasets and use of EPCs in this HHRA is low.

The calculations of the 95% UCLs used in the HHRA were performed for surface soil (0-4 inches bgs) at each exposure area assuming a single sample population; that is, considering the various potential source types sampled within each exposure area belong to the same population or statistical distribution (i.e., Exposure Area 1 - low grade ore, tailings, and waste rock; and Exposure Area 2 - high grade ore, waste concentrate, tailings, and surface soil). It is acknowledged that considering the data on a by-source basis or through other EPC calculation approaches (e.g., area-weighted average or weighted 95% UCLs of the mean) may yield a more notionally robust EPC at sites where multiple sources are present and/or where there was a desire or need to characterize each source material separately. However, the sampling strategy used to obtain data (i.e., judgmental sampling, focused in high concentration areas) is considered highly conservative (i.e., more protective to the environment and public health) and unlikely to lead to an underestimation of EPCs and resulting risk and hazard estimates (e.g., via comparison of site concentrations to site-specific SRLs). The uncertainty associated with the EPCs used underestimating risks and hazards is therefore low.

To verify that combining various source types is appropriate for 95% UCL calculation, the analytical results for metals of concern in each exposure area were reviewed graphically using normal quantile plots (Q-Q plots) and by evaluation of statistical distributions (see Appendix D of the SCR). Combining data from truly different populations usually results in a non-parametric statistical determination because multiple modes are present in the distribution. However, the results do not show evidence of a bi- or multi-modal distribution, but rather, follow a parametric distribution (normal, gamma, or lognormal) for all but two data sets (cadmium and zinc at Exposure Area 2). For these analytes, the non-parametric assumption is explained by the relatively high number of non-detected cadmium concentrations and the presence of an elevated zinc concentration value, which skewed these distributions.

Although some minor breaks or gaps were observed in the data points displayed on the Q-Q plots for some analytes (e.g., arsenic at Exposure Area 1 and Exposure Area 2) that may suggest potentially separate populations, the data are distributed parametrically (normal and gamma

distributions, respectively), which were confirmed by statistical goodness-of-fit tests. Review of by-source results for arsenic indicate that concentrations for the various source types are intermixed with each other (i.e., when concentrations are arranged from lowest to highest concentration irrespective of source type) and no one particular source type is dominant at the high-end or the low-end of the detected concentrations. For metals with parametric distributions, none of the data points for any metals fall outside of the upper or lower confidence bands (i.e., dotted lines displayed on Q-Q plots presented in Appendix D of the SCR), which indicates a high degree of confidence that all data points closely fit the straight line (with constant slope), and thus, the combined data sets are representative of a single data population and calculation of 95% UCLs by combining material types is appropriate for this site. It is notable that MDCs for all analytes identified as COPCs where below the SRLs, developed irrespective of site concentrations, that are protective of site trespassers calculated for the HHRA.

7.2.3 Exposure Models

Uncertainties associated with exposure assessment are introduced from estimates of chemical concentration at the receptor location and the assumptions used in the exposure models. These estimates are influenced by uncertainties in source concentrations, source release rates, and parameters defining movement along the migration pathway. Model assumptions related to exposure scenarios and the degree of model complexity (in contrast with available data) can have a profound effect on the uncertainties. For example, selection of mathematical exposure models and the necessary parameter values to obtain estimates may be knowingly biased to yield a conservative estimate that is unrealistic.

Biokinetic assumptions, the bioavailability of soil lead, especially soil particle size and chemical form, and the amount of soil ingested may provide differing levels of blood lead estimates in the ALM. The ALM assumes a soil ingestion rate that includes the ingestion of soil-derived indoor dust which is not applicable for the lead evaluation for the adolescent trespasser at the Site and contributes to uncertainty with the lead evaluation results. Assumptions of exposure frequency may also contribute to uncertainty in the representativeness of the estimated blood lead levels. Because short term exposures (i.e., less than 90 days) are incompatible with the use of the ALM (USEPA 2016b), an exposure frequency of 90 days was used for the adolescent trespasser. These factors overestimate potential risk from lead for the adolescent trespasser at the Site.

7.3 UNCERTAINTIES IN TOXICITY ASSESSMENT

Toxicity assessment involves the selection of noncancer toxicity indices (i.e., RfDs) and CSFs, each of which includes a degree of protectiveness needed to account for uncertainty in its derivation. Uncertainties associated with the toxicological parameters are largely due to the fact

that toxicity values are often derived from laboratory animal studies. A major uncertainty associated with laboratory studies is the extrapolation of toxic effects observed at high doses to effects that might occur at much lower, environmentally relevant doses. Another uncertainty is the extrapolation from toxic effects in laboratory animals to toxic effects in humans. Uncertainties also arise from use of the NOAEL for the development of the RfDs, as is often done.

7.3.1 Reference Doses

RfDs are developed using animal data that must be applied to human receptors for the risk assessment. The process typically involves application of several UFs to animal test data that lower the RfD, given the extrapolation from animal tests to HHRA. For instance, UFs of 10 are often applied to animal data to reduce a threshold dose 10-fold to arrive at the RfD. This application of the UFs likely overestimates non-carcinogenic toxicity by a low to moderate degree as noted by Dourson et al. (1997) and certainly does not reflect probabilities of excess exposures when exceedances of the RfD are noted (Clewell and Crump 2005).

7.3.2 Cancer Slope Factors

CSFs developed by the USEPA are conservative and represent an upper bound (i.e., approaching the upper 95 percent UCL) probability of a cancer response occurring. Thus, the actual carcinogenic risk due to exposure to selected chemicals is likely to be lower than the actual risk experienced by the receptor. Another source of uncertainty in the toxicity assessment lies in extrapolating experimental carcinogenic observations at high doses to the low doses experienced by the human population of interest. Because there is no empirical way to detect risks below the 5 percent to 10 percent dose range, assumptions must be made about the shape of the dose-response curve in the low dose region (Rodricks 1992). Because the standard default is to assume that all carcinogens have a linear no threshold dose-response curve, the cancer potency for carcinogenic COPCs is likely overestimated by a low to moderate degree.

7.3.3 Chemicals with Non-integrated Risk Information System Toxicity Values

USEPA IRIS (USEPA 2019b) is the primary source of toxicity information. When a toxicity value is not available in IRIS, other sources of toxicity information can be considered in accordance with USEPA guidance (USEPA 2003a); these other sources are often considered "provisional." In this assessment, the toxicity values for some carcinogenic and non-carcinogenic chemicals (e.g., arsenic, cadmium and copper) were based on provisional toxicity values.

Because the provisional toxicity values are not final IRIS values, the overall effect on the site-specific SRLs for this HHRA could be overestimated or underestimated. However, as provisional values are often set to ensure protectiveness in associated evaluations, this use of provisional

values likely overestimates the values for the SRLs. The effect of this extrapolation in this assessment is considered low.

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8.0 CONCLUSIONS AND RECOMMENDATIONS

This HHRA for the Site was conducted in accordance with USEPA and ADHS guidance. Data sets from discrete surface soil, sediment and surface water samples collected during sampling events conducted between 2014, 2015 and 2018 were used in the HHRA.

This HHRA evaluated whether impacted Site media represent a potential risk to human health by performing a comparison of Site media concentrations to default residential screening levels. Chemicals detected in Site media at concentrations that exceed the default residential screening levels and the site-specific background concentrations are retained for further evaluation.

Antimony, arsenic, cadmium, copper, and lead were identified as direct contact surface soil and/or sediment COPCs retained for further evaluation which included the development of site-specific adolescent trespasser SRLs. Site–specific adolescent trespasser SRLs were developed for the soil and sediment direct contact COPCs. The site-specific SRLs are based on a target cancer risk level of 1×10^{-5} and a target HQ of 1 and take into consideration site-specific exposure parameters for the adolescent trespasser, e.g., exposure time of 2 hours per day, exposure frequency of 15 days per year, and exposure duration of 10 years. The MDCs and 95 percent UCLs of antimony, arsenic, cadmium, and copper in each exposure area were well below the site-specific adolescent trespasser SRLs, suggesting that concentrations of these chemicals are unlikely to cause adverse health effects to the adolescent trespasser who may be intermittently exposed to Site soil.

Lead was identified as a soil direct contact COPC in Exposure Area 2. Lead was evaluated using the USEPA ALM. A lead PRG was developed based on a target fetal blood lead level of 10 ug/dL (12,000 mg/kg). The EPC of lead in Exposure Area 2 is well below the lead PRG. Consequently, lead concentrations in Site soil are unlikely to cause adverse health effects for the adolescent trespasser and no further evaluation of lead is warranted.

Antimony, arsenic, cadmium, lead and mercury were identified as soil leaching to groundwater COPCs retained for further evaluation which includes the development of alternative GPLs. Copper was also retained for further evaluation for the leaching to groundwater pathway based on SPLP results that exceeded the PBC-NWQS. Alternative GPLs were developed for antimony, arsenic, cadmium, copper lead and mercury. A comparison of the MDCs of these six chemicals in soil to the alternative GPLs shows that Site concentrations of antimony, arsenic, cadmium, copper, lead and mercury are well below the alternative GPLs, indicating that chemicals in soil are not leaching to groundwater at concentrations that would pose unacceptable risk to human health.

Lead was identified as a surface water direct contact COPC; however, based on lines of evidence provided in Section 3.3.5, no further evaluation of lead in surface water is warranted.

Based on the overall findings of this HHRA, no further remediation of surface soil in Exposure Area 1 or Exposure 2 or surface water and sediment in the Hull Canyon Wash is required.

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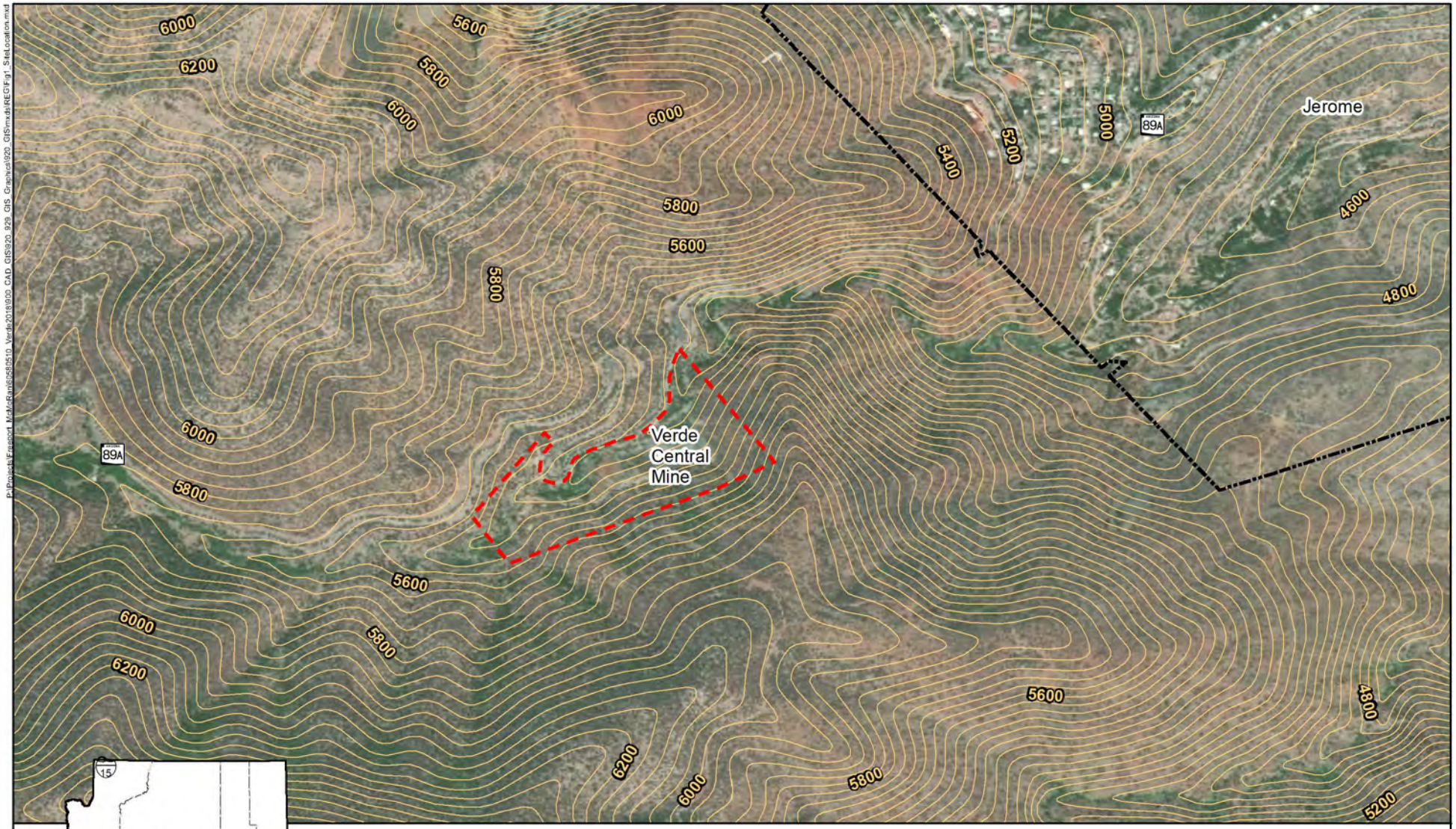
FIGURES



LEGEND

- Verde Central Mine Site
- Town Boundary
- USGS Elevation Contour

Base Map: ALRIS 2016
Project Area: URS 2007
Elevation Contours: U.S. Geologic Survey DEM
Imagery: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

0 500 1,000
Feet

Figure G-1

Site Location Map

Freeport Minerals Corporation

Updated Site Characterization Report
Verde Central Mine, Near Jerome, Arizona

AECOM

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LEGEND

Mine Features

- Verde Central Voluntary Remediation Site
- Closed Mine Shaft or Adit
- Project Exposure Areas
- Approximate Extent of Waste Rock Stockpile
- Approximate Extent of Low-Grade Ore Rock Stockpile
- Mill Building Foundation
- Tailing[1]
- Waste Concentrate[1]
- High Grade Ore[1]
- USGS Elevation Contour

[1] The extent of tailing, waste concentrate, and high grade ore shown above was estimated during planning stages or the project.

Sample Type

- Background Soil

General Features

- Ephemeral Stream Bed

N

0 100 200
Feet

Hydrology and Mine Features: URS 2008
Elevation Contours: U.S.Geological Survey DEM
Imagery: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure G - 2

Project Area and Background Sample Locations

Freeport Minerals Corporation
Updated Site Characterization Report
Verde Central Mine, Near Jerome, Arizona

AECOM

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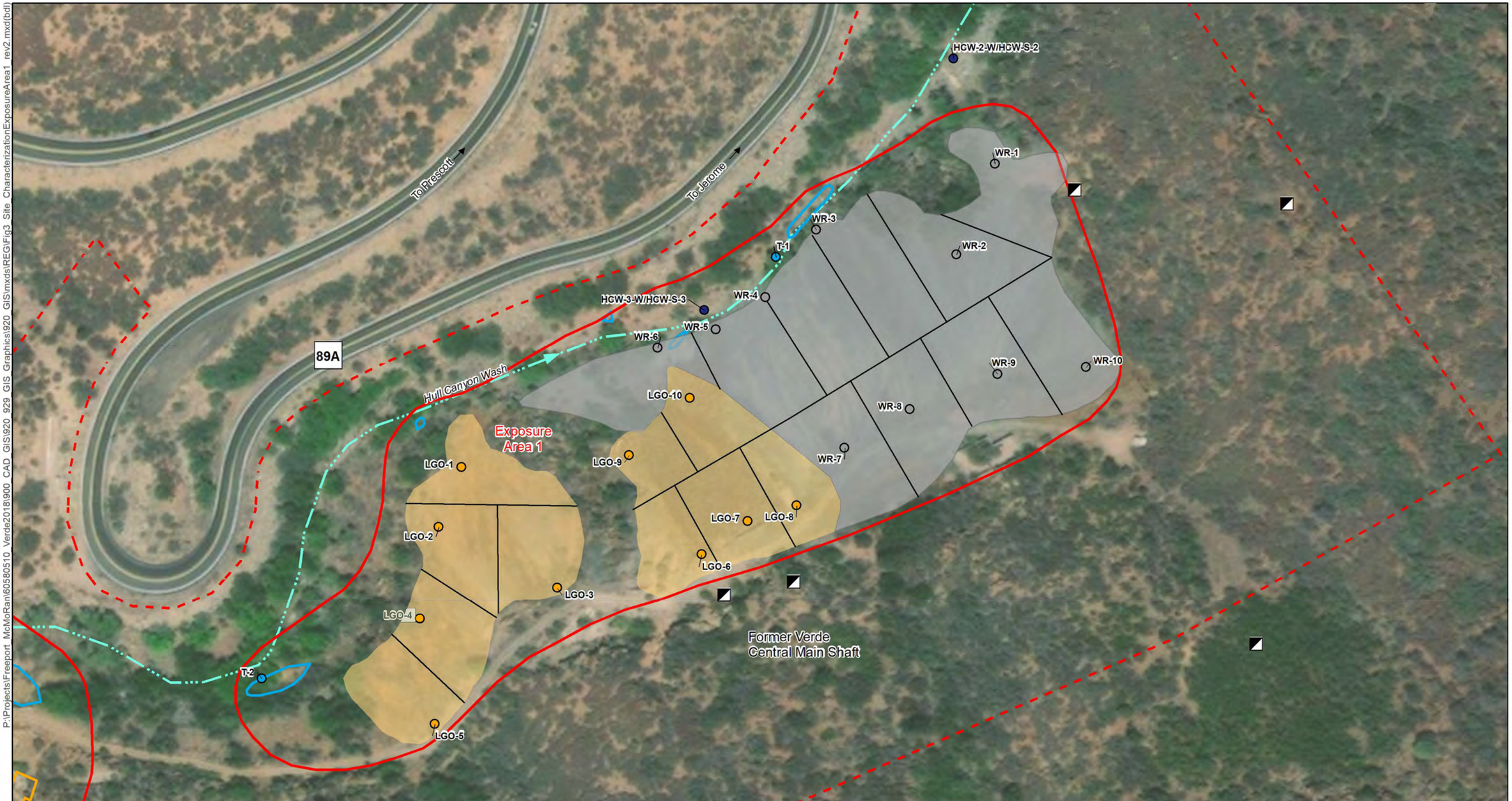

LEGEND

- Verde Central Mine Site
- Project Exposure Areas
- Closed Mine Shaft or Adit
- Approximate Extent of Waste Rock Stockpile
- Approximate Extent of Low-Grade Ore Rock Stockpile
- Mill Building Foundation
- Tailing[1]

Sample Type

- Low Grade Ore Stockpile
- Tailing Stockpile
- Waste Rock Stockpile
- Hull Canyon Wash

General Features

- Ephemeral Stream Bed

N

0 50 100
Feet
1 inch = 100 feet

[1] The extent of tailing shown above was estimated during planning stages of the project. Some sample locations were modified to coincide with tailing observed at the time of the sampling.

Source:
Hydrology and Mine Features: URS 2008
Imagery: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure G - 3

Site Characterization Sample Locations Exposure Area 1

Freeport Minerals Corporation
Updated Site Characterization Report
Verde Central Mine, Near Jerome, Arizona

AECOM

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LEGEND

- Verde Central Mine Site
- Project Exposure Areas

SampleType

- High Grade Ore Stockpile
- Hull Canyon Wash
- Tailing Stockpile
- Waste Concentrate Stockpile
- Soil

- Mill Building Foundation
- Tailing[1]
- Ephemeral Stream Bed

N

0 50 100

Feet

1 inch = 100 feet

[1]The extent of tailing shown above was estimated during planning stages of the project.
Some sample locations were modified to coincide with tailing observed at the time of the sampling.

Figure G - 4

Site Characterization Sample Locations Exposure Area 2

Freeport Minerals Corporation
Updated Site Characterization Report
Verde Central Mine, Near Jerome, Arizona

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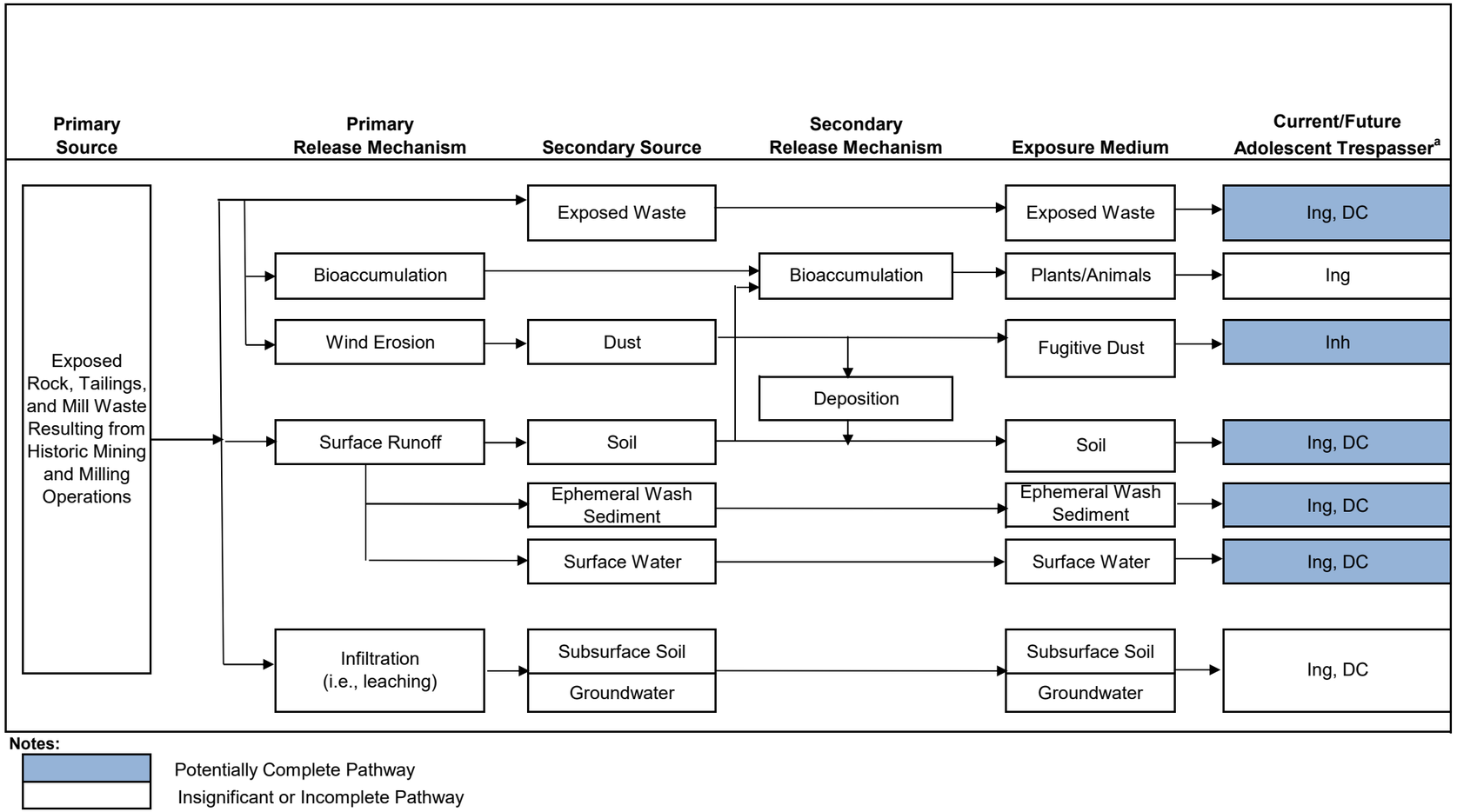
Figure G-5
Human Health Conceptual Site Model



Notes:

Potentially Complete Pathway

Insignificant or Incomplete Pathway

[a] An adolescent trespasser may be exposed to contaminants through incidental ingestion and dermal contact of surficial soil/exposed waste, ephemeral sediment and surface water at Hull Canyon Wash. In addition, current/future adolescent trespassers may be exposed to contaminants via inhalation of fugitive dust. The current/future adolescent trespasser is not expected to ingest on-site plants/animals. Lastly, the current/future adolescent trespasser is not expected to come into contact with groundwater.

DC = dermal contact route of exposure

Ing = incidental ingestion route of exposure

Inh = inhalation route of exposure

TABLES

Table G-1
Summary of Sample Locations Used in the HHRA

Exposure Area	Sample ID	Matrix	Analyzed Matrix	Sample Date	Start Depth (ft.)	End Depth (ft.)
Exposure Area 1	SC-LGO-1	SO	SO	24-Jul-14	0	0.33
Exposure Area 1	SC-LGO-10	SO	SO	24-Jul-14	0	0.33
Exposure Area 1	SC-LGO-11	SO	SO	24-Jul-14	0	0.33
Exposure Area 1	SC-LGO-2	SO	SO	24-Jul-14	0	0.33
Exposure Area 1	SC-LGO-3	SO	SO	24-Jul-14	0	0.33
Exposure Area 1	SC-LGO-4	SO	SO	24-Jul-14	0	0.33
Exposure Area 1	SC-LGO-5	SO	SO	24-Jul-14	0	0.33
Exposure Area 1	SC-LGO-6	SO	SO	24-Jul-14	0	0.33
Exposure Area 1	SC-LGO-7	SO	SO	24-Jul-14	0	0.33
Exposure Area 1	SC-LGO-8	SO	SO	24-Jul-14	0	0.33
Exposure Area 1	SC-LGO-9	SO	SO	24-Jul-14	0	0.33
Exposure Area 1	SC-T-1	SO	SO	23-Jul-14	0	0.33
Exposure Area 1	SC-T-2	SO	SO	23-Jul-14	0	0.33
Exposure Area 1	SC-WR-1	SO	SO	22-Jul-14	0	0.33
Exposure Area 1	SC-WR-10	SO	SO	24-Jul-14	0	0.33
Exposure Area 1	SC-WR-11	SO	SO	24-Jul-14	0	0.33
Exposure Area 1	SC-WR-2	SO	SO	23-Jul-14	0	0.33
Exposure Area 1	SC-WR-3	SO	SO	23-Jul-14	0	0.33
Exposure Area 1	SC-WR-4	SO	SO	23-Jul-14	0	0.33
Exposure Area 1	SC-WR-5	SO	SO	23-Jul-14	0	0.33
Exposure Area 1	SC-WR-6	SO	SO	23-Jul-14	0	0.33
Exposure Area 1	SC-WR-7	SO	SO	24-Jul-14	0	0.33
Exposure Area 1	SC-WR-8	SO	SO	24-Jul-14	0	0.33
Exposure Area 1	SC-WR-9	SO	SO	24-Jul-14	0	0.33
Exposure Area 2	SC-HGO-1	SO	SO	25-Jul-14	0	0.33
Exposure Area 2	SC-SS-1	SO	SO	11-Jul-18	0	0.33
Exposure Area 2	SC-SS-2	SO	SO	11-Jul-18	0	0.33
Exposure Area 2	SC-SS-3	SO	SO	11-Jul-18	0	0.33
Exposure Area 2	SC-SS-4	SO	SO	11-Jul-18	0	0.33
Exposure Area 2	SC-SS-5	SO	SO	11-Jul-18	0	0.33
Exposure Area 2	SC-SS-6	SO	SO	11-Jul-18	0	0.33
Exposure Area 2	SC-SS-7	SO	SO	11-Jul-18	0	0.33
Exposure Area 2	SC-SWC-1	SO	SO	25-Jul-14	0	0.33
Exposure Area 2	SC-SWC-2	SO	SO	25-Jul-14	0	0.33
Exposure Area 2	SC-SWC-3	SO	SO	11-Jul-18	0	0.33
Exposure Area 2	SC-SWC-3-MS	SO	SO	11-Jul-18	0	0.33
Exposure Area 2	SC-T-3	SO	SO	23-Jul-14	0	0.33
Exposure Area 2	SC-T4	SO	SO	11-Jul-18	0	0.33
Exposure Area 2	SC-T5	SO	SO	11-Jul-18	0	0.33
Exposure Area 2	SC-TS-D	SO	SO	11-Jul-18	0	0.33
Hull Canyon Wash	SC-HCW-S-1	SE	SO	23-Jul-14	0	0.33
Hull Canyon Wash	SC-HCW-S-2	SE	SO	23-Jul-14	0	0.33
Hull Canyon Wash	SC-HCW-S-3	SE	SO	23-Jul-14	0	0.33
Hull Canyon Wash	SC-HCW-S-4	SE	SO	25-Jul-14	0	0.33
Hull Canyon Wash	SC-HCW-S-5	SE	SO	25-Jul-14	0	0.33
Exposure Area 2	SC-SS-1	SO	Soil Moisture	11-Jul-18	0	0.33
Exposure Area 2	SC-SS-2	SO	Soil Moisture	11-Jul-18	0	0.33
Exposure Area 2	SC-SS-3	SO	Soil Moisture	11-Jul-18	0	0.33
Exposure Area 2	SC-SS-4	SO	Soil Moisture	11-Jul-18	0	0.33
Exposure Area 2	SC-SS-5	SO	Soil Moisture	11-Jul-18	0	0.33
Exposure Area 2	SC-SS-6	SO	Soil Moisture	11-Jul-18	0	0.33
Exposure Area 2	SC-SS-7	SO	Soil Moisture	11-Jul-18	0	0.33
Exposure Area 2	SC-SWC-3	SO	Soil Moisture	11-Jul-18	0	0.33
Exposure Area 2	SC-SWC-3-MS	SO	Soil Moisture	11-Jul-18	0	0.33
Exposure Area 2	SC-T4	SO	Soil Moisture	11-Jul-18	0	0.33
Exposure Area 2	SC-T5	SO	Soil Moisture	11-Jul-18	0	0.33
Exposure Area 2	SC-T5-D	SO	Soil Moisture	11-Jul-18	0	0.33
Exposure Area 1	SC-T-1	SO	SPLP	23-Jul-14	0	0.33
Exposure Area 1	SC-T-2	SO	SPLP	23-Jul-14	0	0.33

Table G-1
Summary of Sample Locations Used in the HHRA

Exposure Area	Sample ID	Matrix	Analyzed Matrix	Sample Date	Start Depth (ft.)	End Depth (ft.)
Exposure Area 2	SC-HGO-1	SO	SPLP	25-Jul-14	0	0.33
Exposure Area 2	SC-SWC-1	SO	SPLP	25-Jul-14	0	0.33
Exposure Area 2	SC-SWC-2	SO	SPLP	25-Jul-14	0	0.33
Exposure Area 2	SC-T-3	SO	SPLP	23-Jul-14	0	0.33
Hull Canyon Wash	SC-HCW-S-1	SE	SPLP	23-Jul-14	0	0.33
Hull Canyon Wash	SC-HCW-S-2	SE	SPLP	23-Jul-14	0	0.33
Hull Canyon Wash	SC-HCW-S-3	SE	SPLP	23-Jul-14	0	0.33
Hull Canyon Wash	SC-HCW-S-4	SE	SPLP	25-Jul-14	0	0.33
Hull Canyon Wash	SC-HCW-S-5	SE	SPLP	25-Jul-14	0	0.33
Hull Canyon Wash	HCW-1-W	WS	WS	16-Sep-14	NA	NA
Hull Canyon Wash	HCW-1-W	WS	WS	04-Dec-14	NA	NA
Hull Canyon Wash	HCW-3-W	WS	WS	16-Sep-14	NA	NA
Hull Canyon Wash	HCW-3-W	WS	WS	02-Oct-14	NA	NA
Hull Canyon Wash	HCW-3-W	WS	WS	04-Dec-14	NA	NA
Hull Canyon Wash	HCW-4-W	WS	WS	16-Sep-14	NA	NA
Hull Canyon Wash	HCW-4-W	WS	WS	02-Oct-14	NA	NA
Hull Canyon Wash	HCW-4-W	WS	WS	04-Dec-14	NA	NA
Hull Canyon Wash	SC-HCW-1-FILTER-20150520	WS	WS	20-May-15	NA	NA
Hull Canyon Wash	SC-HCW-1-UNFILT-20150520	WS	WS	20-May-15	NA	NA
Hull Canyon Wash	SC-HCW-2-FILTER-20150520	WS	WS	20-May-15	NA	NA
Hull Canyon Wash	SC-HCW-2-UNFILT-20150520	WS	WS	20-May-15	NA	NA
Hull Canyon Wash	SC-HCW-3-UNFILT-20150520	WS	WS	20-May-15	NA	NA
Hull Canyon Wash	SC-HCW-4-FILTER-20150520	WS	WS	20-May-15	NA	NA
Hull Canyon Wash	SC-HCW-4-UNFILT-20150520	WS	WS	20-May-15	NA	NA
Hull Canyon Wash	SC-HCW-5-FILTER-20150520	WS	WS	20-May-15	NA	NA
Hull Canyon Wash	SC-HCW-5-UNFILT-20150520	WS	WS	20-May-15	NA	NA
Background	SC-B-1	SO	SO	23-Jul-14	0	0.33
Background	SC-B-10	SO	SO	24-Jul-14	0	0.33
Background	SC-B-11	SO	SO	23-Jul-14	0	0.33
Background	SC-B-2	SO	SO	22-Jul-14	0	0.33
Background	SC-B-3	SO	SO	22-Jul-14	0	0.33
Background	SC-B-4	SO	SO	22-Jul-14	0	0.33
Background	SC-B-5	SO	SO	23-Jul-14	0	0.33
Background	SC-B-6	SO	SO	23-Jul-14	0	0.33
Background	SC-B-7	SO	SO	24-Jul-14	0	0.33
Background	SC-B-8	SO	SO	22-Jul-14	0	0.33
Background	SC-B-9	SO	SO	22-Jul-14	0	0.33

Notes:
Background samples were not included in the risk assessment dataset but were considered as part of the evaluation
ft = feet
NA = not applicable
SE = sediment. Samples obtained from ephemeral Hull Canyon Wash, which is predominantly dry
SO = soil
WS = surface water
ft. = feet
SPLP = Synthetic Precipitation Leaching Procedure

Table G-2
Descriptive Statistics and Soil COPC Determination: Exposure Area 1

ANALYTE	CAS Number	Number of Samples	Number of Detects	Detection Frequency (%)	Median	Mean	Standard Deviation	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)	Minimum Reporting Limit (mg/kg)	Maximum Reporting Limit (mg/kg)	Background 95% UCL (mgkg)	MDC Exceeds Background Value?	Residential Soil Remediation Level (mgkg)	MDC or MRL Exceeds Residential SRL?	Groundwater Protection Limit (mgkg)	MDC or MRL Exceeds GPL?
Antimony	7440-36-0	22	4	18	6.3	6.275	0.814	5.3	7.2	4.8	5	NE	NA	31	No	35	No
Arsenic	7440-38-2	22	22	100	120	115.1	76.61	19	250	4.8	5	24.71	Yes	10	Yes	290	No
Barium	7440-39-3	22	22	100	23	27.6	15.6	6.7	64	4.8	5	111.3	No	15000	No	12000	No
Beryllium	7440-41-7	22	0	0	NA	NA	NA	NA	NA	0.48	0.5	0.695	No	150	No	23	No
Cadmium	7440-43-9	22	9	41	1.3	1.823	1.91	0.75	6.8	0.48	0.5	3.518	Yes	39	No	29	No
Chromium[a]	7440-47-3	22	7	32	6.3	6.157	3.932	2	14	1.9	2	11.21	Yes	120000	No	590	No
Copper	7440-50-8	22	22	100	2200	3260	4520	240	22000	4.8	50	348.5	Yes	3100	Yes	NE	NA
Lead	7439-92-1	22	22	100	22	36.15	31.21	5.7	140	4.8	5	59.43	Yes	400	No	290	No
Manganese	7439-96-5	22	22	100	395	623.6	519.3	150	2400	1.9	100	1036	Yes	3300	No	NE	NA
Mercury[b]	7439-97-6	22	22	100	0.625	0.942	0.793	0.14	2.7	0.089	0.1	0.159	Yes	23	No	12	No
Nickel	7440-02-0	22	9	41	3.7	4.756	3.805	2.1	14	1.9	2	8.35	Yes	1600	No	590	No
Selenium	7782-49-2	22	22	100	20.5	30.47	20.63	5.4	77	4.8	5	7.23	Yes	390	No	290	No
Silver	7440-22-4	22	13	59	5.2	8.377	5.48	3	20	2.4	2.5	NE	NA	390	No	NE	NA
Thallium	7440-28-0	22	0	0	NA	NA	NA	NA	NA	4.8	240	NE	NA	5.2	No	12	No
Zinc	7440-66-6	22	22	100	235	304.7	356.8	57	1800	9.7	10	178.3	Yes	23000	No	NE	NA

Notes:
Shading indicates soil direct contact COPC and/or leaching to groundwater COPC. COPC determined by comparing the MDC (or the MRL for 100 % nondetected results) to the SRL and GPL.
[a] Chromium compared to SRL for chromium III.
[b] Mercury assumed to be mercuric chloride.
% = percent
CAS = Chemical Abstract Service
COPC= Chemical of Potential Concern
GPL= groundwater protection limit
MDC = maximum detected concentration
mg/kg = milligrams per kilogram
MRL = minimum reporting limit
NA = not available
NE = not established
SRL = Soil Remediation Level
UCL = Upper Confidence Limit

Table G-3
Descriptive Statistics and Soil SPLP COPC Determination: Exposure Area 1

ANALYTE	CAS Number	Number of Samples	Number of Detects	Detection Frequency (%)	Minimum Detected Concentration (mg/L)	Maximum Detected Concentration (mg/L)	Minimum Reporting Limit (mg/L)	Maximum Reporting Limit (mg/L)	PBC-NWQC (mg/L)	MDC or MRL Exceeds PBC-NWQC?
Antimony	7440-36-0	2	0	0	NA	NA	0.015	0.015	0.747	No
Arsenic	7440-38-2	4	2	50	0.024	0.54	0.015	0.5	0.28	Yes
Barium	7440-39-3	2	0	0	NA	NA	10	10	98	No
Beryllium	7440-41-7	2	0	0	NA	NA	0.25	0.25	1.867	No
Cadmium	7440-43-9	2	0	0	NA	NA	0.25	0.25	0.7	No
Chromium[a]	7440-47-3	2	0	0	NA	NA	0.5	0.5	2.8	No
Copper	7440-50-8	2	1	50	2.2	2.2	0.5	0.5	1.3	Yes
Lead	7439-92-1	2	0	0	NA	NA	0.5	0.5	0.015	Yes
Manganese	7439-96-5	2	0	0	NA	NA	0.5	0.5	130.7	No
Mercury[b]	7439-97-6	2	1	50	0.0009	0.0009	0.0005	0.0005	0.28	No
Nickel	7440-02-0	2	0	0	NA	NA	0.5	0.5	28	No
Selenium	7782-49-2	2	0	0	NA	NA	0.005	0.005	4.667	No
Silver	7440-22-4	2	0	0	NA	NA	0.25	0.25	4.667	No
Thallium	7440-28-0	2	0	0	NA	NA	0.005	0.005	0.075	No
Zinc	7440-66-6	2	0	0	NA	NA	2	2	280	No

Notes:
Shading indicates soil SPLP COPC. COPC determined by comparing the MDC (or the MRL for 100 % nondetected results) to the PBC-NWQS.
[a] Chromium compared to PBC for chromium VI.
[b] Mercury assumed to be mercuric chloride.
% = percent
CAS = Chemical Abstract Service
COPC= Chemical of Potential Concern
MDC = maximum detected concentration
mg/L = milligrams per liter
MRL = minimum reporting limit
NA = not available
PBC-NWQC = Partial Body Contact- Numerical Water Quality Criteria

Table G-4
Descriptive Statistics and Soil COPC Determination: Exposure Area 2

ANALYTE	CAS Number	Number of Samples	Number of Detects	Detection Frequency (%)	Median	Mean	Standard Deviation	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)	Minimum Reporting Limit (mg/kg)	Maximum Reporting Limit (mg/kg)	Background 95% UCL (mgkg)	MDC Exceeds Background Value?	Residential Soil Remediation Level (mgkg)	MDC or MRL Exceeds Residential SRL?	Groundwater Protection Limit (mgkg)	MDC or MRL Exceeds GPL?
Antimony	7440-36-0	14	8	57	23.5	24.76	14.44	5.3	42	4.9	5	NE	NA	31	Yes	35	Yes
Arsenic	7440-38-2	14	14	100	120	203.1	143.8	31	430	2.9	60	24.71	Yes	10	Yes	290	Yes
Barium	7440-39-3	14	11	79	74	81.52	76.4	6.7	270	4.9	99	111.3	Yes	15000	No	12000	No
Beryllium	7440-41-7	14	0	0	NA	NA	NA	NA	NA	0.49	0.5	0.695	No	150	No	23	No
Cadmium	7440-43-9	14	8	57	1.45	9.373	22.48	0.67	65	0.49	0.5	3.518	Yes	39	Yes	29	Yes
Chromium[b]	7440-47-3	14	10	71	13.5	13.61	7.924	2.7	30	1.9	200	11.21	Yes	120000	No	590	No
Copper	7440-50-8	14	14	100	5750	7977	7842	880	24000	2.4	100	348.5	Yes	3100	Yes	NE	NA
Lead	7439-92-1	14	14	100	108.5	243.9	325.9	18	1200	0.97	5	59.43	Yes	400	Yes	290	Yes
Manganese	7439-96-5	14	14	100	250	292.9	166.3	120	700	1.9	39	1036	No	3300	No	NE	NA
Mercury[c]	7439-97-6	14	14	100	0.825	2.554	4.475	0.17	14	0.056	0.1	0.159	Yes	23	No	12	Yes
Nickel	7440-02-0	14	11	79	8.4	10.4	6.047	3.1	22	1.9	2	8.35	Yes	1600	No	590	No
Selenium	7782-49-2	14	4	29	52.5	49	11.8	32	59	4.9	5	7.23	Yes	390	No	290	No
Silver	7440-22-4	14	13	93	5.9	7.454	3.777	2.5	14	2.4	2.5	NE	NA	390	No	NE	NA
Thallium	7440-28-0	14	0	0	NA	NA	NA	NA	NA	4.9	500	NE	NA	5.2	No	12	No
Zinc	7440-66-6	14	14	100	210	1277	3953	55	15000	4.9	200	178.3	Yes	23000	No	NE	NA

Notes:
Shading indicates soil direct contact COPC and/or leaching to groundwater COPC. COPC determined by comparing the MDC (or the MRL for 100 % nondetected results) to the SRL and GPL.
[a] Number of samples includes two duplicate results.
[b] Chromium compared to SRL for chromium III.
[c] Mercury assumed to be mercuric chloride.
% = percent
CAS = Chemical Abstract Service
COPC= Chemical of Potential Concern
GPL = groundwater protection limit
MDC = maximum detected concentration
mg/kg = milligrams per kilogram
MRL = minimum reporting limit
NA = not available
NE = not established
SRL = Soil Remediation Limit
UCL = Upper Confidence Limit

Table G-5
Descriptive Statistics and Soil SPLP COPC Determination: Exposure Area 2

ANALYTE	CAS Number	Number of Samples	Number of Detects	Detection Frequency (%)	Minimum Detected Concentration (mg/L)	Maximum Detected Concentration (mg/L)	Minimum Reporting Limit (mg/L)	Maximum Reporting Limit (mg/L)	PBC-NWQC (mg/L)	MDC or MRL Exceeds PBC-NWQC?
Antimony	7440-36-0	4	0	0	NA	NA	0.015	0.015	0.747	No
Arsenic	7440-38-2	8	0	0	NA	NA	0.015	0.5	0.28	Yes
Barium	7440-39-3	4	0	0	NA	NA	10	10	98	No
Beryllium	7440-41-7	4	0	0	NA	NA	0.25	0.25	1.867	No
Cadmium	7440-43-9	4	0	0	NA	NA	0.25	0.25	0.7	No
Chromium[a]	7440-47-3	4	0	0	NA	NA	0.5	0.5	2.8	No
Copper	7440-50-8	4	4	100	1.5	34	0.5	0.5	1.3	Yes
Lead	7439-92-1	4	0	0	NA	NA	0.5	0.5	0.015	Yes
Manganese	7439-96-5	4	1	25	1.1	1.1	0.5	0.5	130.7	No
Mercury[b]	7439-97-6	4	0	0	NA	NA	0.0005	0.0005	0.28	No
Nickel	7440-02-0	4	0	0	NA	NA	0.5	0.5	28	No
Selenium	7782-49-2	4	3	75	0.0057	0.012	0.005	0.005	4.667	No
Silver	7440-22-4	4	0	0	NA	NA	0.25	0.25	4.667	No
Thallium	7440-28-0	4	0	0	NA	NA	0.005	0.005	0.075	No
Zinc	7440-66-6	4	1	25	4.2	4.2	2	2	280	No

Notes:
Shading indicates soil SPLP COPC. COPC determined by comparing the MDC (or the MRL for 100 % nondetected results) to the PBC-NWQS.
[a] Chromium compared to PBC for chromium VI.
[b] Mercury assumed to be mercuric chloride.
% = percent
CAS = Chemical Abstract Service
COPC= Chemical of Potential Concern
MDC = maximum detected concentration
mg/L = milligrams per liter
MRL = minimum reporting limit
NA = not available
PBC-NWQC = Partial Body Contact- Numerical Water Quality Criteria
RL = reporting limit

Table G-6
Descriptive Statistics and Sediment COPC Determination: Hull Canyon Wash Area

ANALYTE	CAS Number	Number of Samples[a]	Number of Detects	Detection Frequency (%)	Median	Mean	Standard Deviation	Minimum Detected Concentration (mg/kg)	Maximum Detected Concentration (mg/kg)	Minimum Reporting Limit (mg/kg)	Maximum Reporting Limit (mg/kg)	Residential Soil Remediation Level (mgkg)	MDC or MRL Exceeds Residential SRL?	Groundwater Protection Limit (mgkg)	MDC or MRL Exceeds GPL?
Antimony	7440-36-0	4	0	0	NA	NA	NA	NA	NA	4.8	5	31	No	35	No
Arsenic	7440-38-2	4	3	75	32	24.9	14.07	8.7	34	4.8	5	10	Yes	290	No
Barium	7440-39-3	4	4	100	43.5	55.25	30.19	34	100	4.8	5	15000	No	12000	No
Beryllium	7440-41-7	4	1	25	1.3	1.3	NA	1.3	1.3	0.48	0.5	150	No	23	No
Cadmium	7440-43-9	4	4	100	0.665	0.708	0.164	0.57	0.93	0.48	0.5	39	No	29	No
Chromium[b]	7440-47-3	4	4	100	10.5	18.93	18.07	8.7	46	1.9	2	120000	No	590	No
Copper	7440-50-8	4	4	100	870	1001	1067	64	2200	4.8	5	3100	No	NE	NA
Lead	7439-92-1	4	4	100	21.5	21.75	9.43	11	33	4.8	5	400	No	290	No
Manganese	7439-96-5	4	4	100	320	362.5	242.8	120	690	1.9	20	3300	No	NE	NA
Mercury[c]	7439-97-6	4	2	50	0.515	0.515	0.53	0.14	0.89	0.089	0.1	23	No	12	No
Nickel	7440-02-0	4	4	100	13	19.7	17.78	6.8	46	1.9	2	1600	No	590	No
Selenium	7782-49-2	4	3	75	10	9.5	2.784	6.5	12	4.8	5	390	No	290	No
Silver	7440-22-4	4	0	0	NA	NA	NA	NA	NA	2.4	2.5	390	No	NE	NA
Thallium	7440-28-0	4	0	0	NA	NA	NA	NA	NA	4.8	5	5.2	No	12	No
Zinc	7440-66-6	4	4	100	155	157	95.06	48	270	9.6	10	23000	No	NE	NA

Notes:
Shading indicates sediment direct contact COPC and/or leaching to groundwater COPC. COPC determined by comparing the MDC (or the minimum reporting limit [MRL] for 100 % nondetected results) to the SRL and GPL.
[a] Number of samples includes one duplicate result.
[b] Chromium compared to SRL for chromium III.
[c] Mercury assumed to be mercuric chloride.
% = percent
CAS = Chemical Abstract Service
COPC= Chemical of Potential Concern
GPL = groundwater protection limit
MDC = maximum detected concentration
mg/kg = milligrams per kilogram
MRL = minimum reporting limit
NA = not available
NE = not established
UCL = Upper Confidence Limit

Table G-7
Descriptive Statistics and Sediment SPLP COPC Determination: Hull Canyon Wash Area

ANALYTE	CAS Number	Number of Samples	Number of Detects	Detection Frequency (%)	Minimum Detected Concentration (mg/L)	Maximum Detected Concentration (mg/L)	Minimum Reporting Limit (mg/L)	Maximum Reporting Limit (mg/L)	PBC-NWQC (mg/L)	MDC or MRL Exceeds PBC-NWQC?
Antimony	7440-36-0	5	0	0	NA	NA	0.015	0.015	0.747	No
Arsenic	7440-38-2	10	2	20	0.019	0.023	0.015	0.5	0.28	Yes
Barium	7440-39-3	5	0	0	NA	NA	10	10	98	No
Beryllium	7440-41-7	5	0	0	NA	NA	0.25	0.25	1.867	No
Cadmium	7440-43-9	5	0	0	NA	NA	0.25	0.25	0.7	No
Chromium[a]	7440-47-3	5	0	0	NA	NA	0.5	0.5	2.8	No
Copper	7440-50-8	5	3	60	0.98	3.7	0.5	0.5	1.3	Yes
Lead	7439-92-1	5	0	0	NA	NA	0.5	0.5	0.015	Yes
Manganese	7439-96-5	5	0	0	NA	NA	0.5	0.5	130.7	No
Mercury[b]	7439-97-6	5	0	0	NA	NA	0.0005	0.0005	0.28	No
Nickel	7440-02-0	5	0	0	NA	NA	0.5	0.5	28	No
Selenium	7782-49-2	5	0	0	NA	NA	0.005	0.005	4.667	No
Silver	7440-22-4	5	0	0	NA	NA	0.25	0.25	4.667	No
Thallium	7440-28-0	5	0	0	NA	NA	0.005	0.005	0.075	No
Zinc	7440-66-6	5	0	0	NA	NA	2	2	280	No

Notes:
Shading indicates sediment SPLP COPC. COPC determined by comparing the MDC (or the minimum reporting limit [MRL] for 100 % nondetected results) to the PBC-NWQS.
[a] Chromium compared to the PBC for chromium VI.
[b] Mercury assumed to be mercuric chloride.
% = percent
CAS = Chemical Abstract Service
COPC= Chemical of Potential Concern
MDC = maximum detected concentration
mg/L = milligrams per liter
MRL = minimum reporting limit
NA = not available
PBC-NWQC = Partial Body Contact- Numerical Water Quality Criteria
RL = reporting limit

Table G-8
Descriptive Statistics and Surface Water COPC Determination: Hull Canyon Wash Area

Analyte	CAS Number	Number of Samples	Number of Detections	Detection Frequency (%)	Minimum Detected Concentration (mg/L)	Maximum Detected Concentration (mg/L)	Minimum Reporting Limit (mg/L)	Maximum Reporting Limit (mg/L)	PBC-NWQS (mg/L)	MDC Exceeds PBC-NWQS?	MRL Exceeds PBC-NWQS?
Antimony	7440-36-0	12	2	16.7	0.0035	0.0035	0.003	0.003	0.747	No	No
Antimony, Dissolved	7440-36-0	10	0	0.0	NA	NA	0.003	0.03	NA	NA	NA
Arsenic	7440-38-2	12	5	41.7	0.0031	0.03	0.003	0.003	0.28	No	No
Arsenic, Dissolved	7440-38-2	10	1	10.0	0.0074	0.0074	0.003	0.03	NA	NA	NA
Barium	7440-39-3	12	11	91.7	0.012	0.13	0.01	0.01	98	No	No
Barium, Dissolved	7440-39-3	10	7	70.0	0.013	0.027	0.01	0.1	NA	NA	NA
Beryllium	7440-41-7	12	0	0.0	NA	NA	0.001	0.001	1.867	No	No
Beryllium, Dissolved	7440-41-7	10	0	0.0	NA	NA	0.001	0.01	NA	NA	NA
Cadmium	7440-43-9	12	1	8.3	0.0015	0.0015	0.001	0.001	0.7	No	No
Cadmium, Dissolved	7440-43-9	10	0	0.0	NA	NA	0.001	0.01	NA	NA	NA
Chromium	7440-47-3	12	3	25.0	0.011	0.014	0.01	0.01	2.8	No	No
Chromium, Dissolved	7440-47-3	10	0	0.0	NA	NA	0.01	0.1	NA	NA	NA
Copper	7440-50-8	12	10	83.3	0.012	1.3	0.01	0.01	1.3	No	No
Copper, Dissolved	7440-50-8	10	6	60.0	0.013	0.087	0.01	0.1	NA	NA	NA
Mercury	7439-97-6	12	2	16.7	0.00044	0.00068	0.0002	0.0002	0.28	No	No
Mercury, Dissolved	7439-97-6	10	1	10.0	0.00028	0.00028	0.0002	0.0002	NA	NA	NA
Lead	7439-92-1	12	4	33.3	0.022	0.12	0.015	0.015	0.015	**Yes**	No
Lead, Dissolved	7439-92-1	10	0	0.0	NA	NA	0.015	0.15	NA	NA	NA
Manganese	7439-96-5	12	7	58.3	0.015	0.53	0.01	0.01	130.7	No	No
Manganese, Dissolved	7439-96-5	10	2	20.0	0.018	0.026	0.01	0.1	NA	NA	NA
Nickel	7440-02-0	12	1	8.3	0.012	0.012	0.01	0.01	28	No	No
Nickel, Dissolved	7440-02-0	10	0	0.0	NA	NA	0.01	0.1	NA	NA	NA
Selenium	7782-49-2	12	5	41.7	0.0042	0.0093	0.002	0.002	4.667	No	No
Selenium, Dissolved	7782-49-2	10	5	50.0	0.002	0.011	0.002	0.02	NA	NA	NA
Silver	7440-22-4	12	0	0.0	NA	NA	0.01	0.01	4.667	No	No
Silver, Dissolved	7440-22-4	10	0	0.0	NA	NA	0.01	0.1	NA	NA	NA
Thallium	7440-28-0	12	0	0.0	NA	NA	0.001	0.001	0.075	No	No
Thallium, Dissolved	7440-28-0	10	0	0.0	NA	NA	0.001	0.01	NA	NA	NA
Zinc	7440-66-6	12	5	41.7	0.078	0.65	0.05	0.05	280	No	No
Zinc, Dissolved	7440-66-6	10	0	0.0	NA	NA	0.05	0.5	NA	NA	NA

Notes:
Shading indicates surface water COPC. COPC determined by comparing the MDC (or the minimum reporting limit [MRL] for 100 % nondetected results) to the PBC-NWQS.
[a] Chromium compared to the PBC for chromium VI.
[b] Mercury assumed to be mercuric chloride.
% = percent
CAS = Chemical Abstract Service
COPC= Chemical of Potential Concern
MDC = maximum detected concentration
mg/L = milligrams per liter
MRL = minimum reporting limit
NA = not available or not applicable (PBC-NWQC only compared to total metal results)
PBC-NWQC = Partial Body Contact- Numerical Water Quality Criteria

Table G-9
Summary of Exposure Assumptions for the Current/Future Adolescent Trespasser

General Assumptions	Site-specific	Reference
BW (body weight)	46 kg	Mean body weight for adolescents (USEPA 2011)
AT (averaging times):		
Carcinogenic effects	70 yrs	Life expectancy; recommended exposure factor (USEPA, 1989, 2014)
Chronic effects (noncarc.) - adolescent	10 yrs	Based on adolescent exposure 7-16 years old [professional judgement]
Surface Soil/Sediment Exposure Assumptions [1]		
EF (exposure frequency)	15 days/yr	Based on assumption of 1 visit per month for 9 months (September - May [school attendance]) of the year = 9 days/year and 2 visits per month for 3 months of the year (June- August [summer vacation]) = 6 days per year for a total of 15 days per year.
ED (exposure duration)	10 yrs	Based on adolescent exposure 7 -16 years old [professional judgement]
Dermal Contact		
EV (exposure event)	1 event/day	Recommended RME value for a resident (USEPA, 2004; Exhibit 3-5)
BSAE (body surface area exposed)	6,032 cm^2	Recommended value for a adult resident (USEPA, 2011; USEPA, 2014)
FBE (fraction of body exposed)	100%	Assumes complete contact with exposed skin
AF (soil adherence factor)	0.07 mg/cm^2	Recommended USEPA default value for an adult resident (USEPA, 2014)
FC (fraction of site soil potentially impacted)	100%	Assumes 100% of on-site areas are potentially impacted
ABS (absorption fraction from soil)	chemical-specific	Chemical-specific (USEPA, 2004)
Incidental Ingestion		
IR (ingestion rate) - adult	100 mg/day	Standard default exposure factor for adult resident (USEPA 2014)
FI (fraction ingested)	25%	Assumes 2 hr/day exposure based on potential trespasser activities at the site [i.e., 25% of soil ingested is from site - professional judgment]
Inhalation of Dust/Particulates		
ET (exposure time)	2 hr/day	Based on potential trespasser activities [professional judgment]

Notes:
[1] Exposed sediments in ephemeral water bodies located on site are assumed to be soils.

% = percent
cm^2 = centimeter squared
hr = hour
kg = kilogram
mg = milligram
RME = Reasonable Maximum Exposure
USEPA = United States Environmental Protection Agency
yr = year

Source:
USEPA 1989. Risk Assessment Guidance for Superfund Volume 1: Human Health Evaluation Manual (Part A) Interim Final. Office of Emergency and Remedial Response. EPA/540/1-89/002.
USEPA 2004. Risk Assessment Guidance for Superfund Volume 1: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final. OSWER 9285.7-02EP. July
USEPA 2011. Exposure Factors Handbook: 2011 Edition. United States Environmental Protection Agency. Office of Research and Development, Washington, DC. National Center for Environmental Assessment. EPA/600/R-090/052F. September 2011
USEPA 2014. Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors, February 2014. United States Environmental Protection Agency. Office of Solid Waste and Emergency Response, Washington, DC. February.

Table G-10
Exposure Point Concentrations for COPCs in Soil and Sediment

COPC	Exposure Area 1	Exposure Area 2	Hull Canyon Wash
	Surface Soil EPC[a] (mg/kg)	Surface Soil EPC[a] (mg/kg)	Sediment EPC[b] (mg/kg)
Antimony	NA	23.42	NA
Arsenic	143.2	315	34
Cadmium	NA	26.11	NA
Copper	5077	11,689	NA
Lead	NA	514.8	NA

Notes:

[a] Surface soil EPCs are 95 percent UCLs of the mean developed by ProUCL and presented in Attachment B.

[b] Because of the small sample size for sediment, the MDC for arsenic in sediment is used as the EPC.

COPC = contaminant of potential concern

EPC = exposure point concentration

MDC = maximum detected concentration

mg/kg = milligram per kilogram

NA = not applicable (Antimony, cadmium, and lead are not identified as soil COPCs in Exposure Area 1 and antimony, cadmium, copper and lead are not identified as sediment COPCs.)

UCL = upper confidence limit

Table G-11
Toxicity Values for COPCs

COPC	CAS Number	Oral Cancer Slope Factor $(mg/kg/d)^{-1}$	Cancer Slope Factor $(mg/kg/d)^{-1}$ (Dermal) = Oral CSF / GIABS	Inhalation Unit Risk $(ug/m^3)^{-1}$	Oral Reference Dose (mg/kg/d)	Reference Dose (mg/kg/d) (Dermal) = Oral RfD x GIABS	Inhalation Reference Concentration (mg/m^3)	Volatile	Volatilization Factor (m^3/kg)	Mutagen	GIABS	Dermal ABS	RBA (Oral)
Antimony	7440-36-0	NA	NA	NA	4.00E-04	6.00E-05	NA	No	NA	No	0.15	NA	1
Arsenic	7440-38-2	1.50E+00	1.5E+00	4.30E-03	3.00E-04	3.0E-04	1.50E-05	No	NA	No	1	0.03	0.4
Cadmium	7440-43-9	NA	NA	1.8E-03	1.00E-03	2.5E-05	1.00E-05	No	NA	No	0.025	0.001	1
Copper	7440-50-8	NA	NA	NA	4.00E-02	4.00E-02	NA	No	NA	No	1	NA	1
Lead	7439-92-1	NA	NA	NA	NA	NA	NA	No	NA	No	NA	NA	1
Mercury[a]	7439-97-6	NA	NA	NA	3.0E-04	2.10E-05	3.0E-04	No	NA	No	0.07	NA	1

Notes:
Toxicity information obtained from April 2019 RSL Table (USEPA 2019a). All toxicity values are from the Integrated Risk Information System (IRIS) except for the following:
The inhalation reference concentration for arsenic (California Environmental Protection Agency)
The inhalation reference concentration for cadmium (ATSDR)
The oral reference dose for copper (HEAST)
[a] The toxicity information for mercury is based on mercuric chloride.
ABS = Absorption Factor
ATSDR = Agency for Toxic Substance and Disease Registry
CAS = Chemical Abstract Service
COPC = Chemical of Potential Concern
GI = gastrointestinal
HEAST = Health Effects Assessment Summary Table
mg/kg/d = milligram per kilogram per day
mg/m^3 = milligram per cubic meter
m^3/kg = cubic meters per kilogram
ug/m^3 = microgram per cubic meter
NA = not applicable
RBA = Relative Bioavailability Factor
RfC = reference concentration
RfD = reference dose
RSL= Regional Screening Level
USEPA = United States Environmental Protection Agency

Table G-12
Site-Specific Soil Remediation Levels for COPCs in Soil and Sediment

General Assumptions		
BW	Mean Body Weight (Kg):	46
AT	Averaging time (years):	
	Carcinogenic	70
	Noncarcinogenic	
	Days/year	365
	Years	10
ADAF	Age-dependent adjustment factor (mutagens)	3
Incidental Ingestion		
IR	Incidental Ingestion Rate (mg-soil/day):	100
FI	Fraction Ingested of Daily Total (unitless):	0.25
EF	Exposure Frequency (days/year):	15
ED	Exposure Duration (years):	10
CF	Conversion Factor (Kg-soil/mg-soil):	1.00E-06
	Intake Factor (carc, Kg-soil/Kg-BW-day)	**3.19E-09**
	Intake Factor (noncarc, Kg-soil/Kg-BW-day)	**2.23E-08**
Dermal Contact		
BSAE	Body Surface Area Exposed (cm^2):	6,032
AF	Adherence Factor (mg-soil/cm^2-event):	0.07
EV	Event Frequency (events/day)	1
EF	Exposure Frequency (days/year):	15
ED	Exposure Duration (years):	10
CF	Conversion Factor (Kg-soil/mg-soil):	1.00E-06
	Intake Factor (carc, Kg-soil-/Kg-BW-day)	**5.39E-08**
	Intake Factor (noncarc, Kg-soil/Kg-BW-day)	**3.77E-07**
Inhalation		
ET	Exposure Time (hours/day):	2
FI	Fraction Inhaled of Daily Total (unitless):	0
EF	Exposure Frequency (days/year):	15
ED	Exposure Duration (years):	10
	Intake Factor (carc, unitless)	**1.22E-04**
	Intake Factor (noncarc, unitless)	**8.56E-04**

COPC	Cancer Slope Factor (mg/kg/day)$^{-1}$	Cancer Slope Factor (mg/kg/day)$^{-1}$	Unit Risk (ug/m^3)$^{-1}$	Reference Dose (mg/kg/day)	Reference Dose (mg/kg/day)	Reference Concentration (mg/m^3)	Volatile	MUTAGENIC	USEPA Mutagenic ADAF	ABS	Default PEF (kg/m^3)	NONE
	(Oral)	(Dermal)	(Inhalation)	(Oral)	(Dermal)	(Inhalation)	V = Volatile N = Not Volatile	M = Mutagenic N = Nonmutagenic	Unitless	(Dermal)	(kg/m^3)	(kg/m^3)
Antimony	NA	NA	NA	4.00E-04	6.00E-05	NA	N	N	1	NA	7.35E-10	NA
Arsenic	1.50E+00	1.50E+00	4.30E-03	3.00E-04	3.00E-04	1.50E-05	N	N	1	0.03	7.35E-10	NA
Cadmium	NA	NA	1.80E-03	1.00E-03	2.50E-05	1.00E-05	N	N	1	0.001	7.35E-10	NA
Copper	NA	NA	NA	4.00E-02	4.00E-02	NA	N	N	1	NA	7.35E-10	NA

COPC	NON CANCER INTAKES			CANCER INTAKES			SRLs: Noncancer Effects (HI=1)[g]				SRLs: Cancer Effects (TRL = $1x10^{-5}$)[h]				Minimum Site-Specific SRL (TRL = 1 X 10^{-6}) (mg/kg)	Minimum Site-Specific SRL (TRL = 1 X 10^{-5}) (mg/kg)	Minimum Site-Specific SRL (TRL = 1 X 10^{-4}) (mg/kg)
	Oral Soil Intake (Kg-soil/Kg-BW-day)[d]	Dermal Soil Intake (Kg-soil/Kg-BW-day)[b]	Inhalation Soil Intake (kg/m^3)[e]	Oral Soil Intake (Kg-soil/Kg-BW-day)[d]	Dermal Soil Intake (Kg-soil/Kg-BW)[f]	Inhalation Soil Intake (kg/m^3)[f]	Ingestion (mg/kg)	Dermal (mg/kg)	Inhalation (mg/kg)	Combined (mg/kg)	Ingestion (mg/kg)	Dermal (mg/kg)	Inhalation (mg/kg)	Combined (mg/kg)			
Antimony	2.23E-08	NA	6.29E-13	3.19E-09	NA	8.99E-14	1.8E+04	NA	NA	1.8E+04	NA	NA	NA	NA	**1.8E+04**	**1.8E+04**	**1.8E+04**
Arsenic	8.93E-09	1.13E-08	6.29E-13	1.28E-09	1.62E-09	8.99E-14	3.4E+04	2.7E+04	2.4E+07	1.5E+04	5.2E+03	4.1E+03	2.6E+07	2.3E+03	**2.30E+02**	**2.30E+03**	**1.5E+04**
Cadmium	2.23E-08	3.77E-10	6.29E-13	3.19E-09	5.39E-11	8.99E-14	4.5E+04	6.6E+04	1.6E+07	2.7E+04	NA	NA	6.2E+07	6.2E+07	**2.7E+04**	**2.7E+04**	**2.7E+04**
Copper	2.23E-08	NA	6.29E-13	3.19E-09	NA	8.99E-14	1.8E+06	NA	NA	1.8E+06	NA	NA	NA	NA	**1.8E+06**	**1.8E+06**	**1.8E+06**

Notes:
Shading represents the minimum site-specific SRL based on a TRL of 1 x 10^{-5} and HI of 1. This value will be used for comparison to COPC concentrations.
ABS = absorption factor
COPC = chemical of potential concern
HI = hazard index
IF = intake factor
kg = kilogram
kg/m^3 = kilogram per cubic meter
mg/kg = milligram per kilogram
mg/m^3 = milligrams per cubic meter
NA = not applicable
TRL = target risk level
SRL = soil remediation level

[a] IFnoncancer = (IR*FI*EF*ED*CF)/(BW*ATnoncarc*365)
[b] IFnoncancer = (BSAE*AF*ABSder*FC*EF*ED*EV*CF)/(BW*ATnoncancer*365)
[c] IF noncancer = [PEF (non-volatiles) or VF (volatiles)] * [(ET*FI*EF*ED)]/(24*ATnoncancer*365)
[d] IFcancer = (IR*FI*EF*ED*CF)/(BW*ATcarc*365) *ADAF
[e] IFcancer = (BSAE*AF*ABSder*FC*EF*ED*EV*CF)/(BW*ATcarc*365) * ADAF
[f] IFcancer = [PEF (non-volatiles) or VF (volatiles)] * [(ET*FI*EF*ED)]/(24*ATcarc*365) *ADAF
[g] The noncancer SRLequation is presented in Section 6.1.1 of the HHRA
[h] The carcinogenic SRL equation is presented in Section 6.1.2 of the HHRA.

Table G-13
Comparison of Site-Specific Soil Remediation Levels to COPCs in Soil and Sediment

COPC	Site-Specific Adolescent Trespasser SRL (TRL = 1 x 10^{-4}, HQ = 1) (mg/kg)	Site-Specific Adolescent Trespasser SRL (TRL = 1 x 10^{-6}, HQ = 1) (mg/kg)	Site-Specific Adolescent Trespasser SRL (TRL = 1 x 10^{-5}, HQ = 1)[a] (mg/kg)	Exposure Area 1			Exposure Area 2			Hull Canyon Wash
				Soil MDC in Exposure Area 1 (mg/kg)	95% UCL of the Mean in Exposure Area 1 (mg/kg)	Does the Soil MDC or 95% UCL of the Mean Exceed the Site-Specific SRL?	Soil MDC in Exposure Area 2 (mg/kg)	95% UCL of the Mean in Exposure Area 2 (mg/kg)	Does the Soil MDC or 95% UCL of the Mean Exceed the Site-Specific SRL?	Sediment MDC
Antimony	18,000	18,000	**18,000**	NA	NA	No	42	23.42	No	NA
Arsenic	15,000	230	**2,300**	250	143.2	No	430	315	No	34
Cadmium	27,000	27,000	**27,000**	NA	NA	No	65	26.11	No	NA
Copper	1,800,000	1,800,000	**1,800,000**	22,000	5077	No	24,000	11,689	No	NA
Lead[b]	18,000	18,000	**18,000**	NA	NA	NA	1200	514.8	No	NA

Notes:
Shading denotes exceedance of site-specific adolescent trespasser SRL.

[a] Because the Arizona VRP allows for a target risk level of 1 x 10^{-5}, the Site-Specific Adolescent Trespasser SRL used for comparison to COPC concentrations is based on a target risk level of 1 x 10^{-5} or HQ of 1. The site-specific adolescent trespasser SRLs based on target risk levels of 1 x 10^{-4} and 1 x 10^{-6} are representative of the USEPA acceptable risk range and are for informational purposes only.

[b] Lead is evaluated separately, as presented in Section 6.3 of the HHRA. However, the Preliminary Remediation Goal developed for lead using the Adult Lead Model (ALM) and based on a 10 microgram per deciliter target blood lead level is listed here. The outputs from the ALM is presented as Attachment C of the Human Health Risk Assessment.
COPC = Chemical of Potential Concern
HHRA = Human Health Risk Assessment
HQ = hazard quotient
MDC = maximum detected concentration
mg/kg = milligram per kilogram
NA = not applicable (Antimony, cadmium, and lead are not considered soil COPCs in Exposure Area 1 and antimony, cadmium, copper and lead are not considered sediment COPCs.)
SRL = Soil Remediation Level
TRL = target risk level
UCL = upper confidence limit

Table G-14
Determination of Alternative Groundwater Protection Levels

Exposure Area	Analyte	Sample ID	Soil Sample Result Exceeding GPLs [1] (mg/kg)	SPLP Result [2] (mg/L)	R value (L/kg)	Cw [3] (mg/L)	Alternative GPL (mg/kg)
Exposure Area 1	Copper	SC-LGO-3	22,000	12	1,833.3	1.3	698,078
Exposure Area 1	Copper	SC-T-1	1,300	2.2	590.9	1.3	225,000
Exposure Area 2	Antimony	SC-SWC-1 & SC-SWC-2	42	0.015	2800.0	0.006	4,920
Exposure Area 2	Arsenic	SC-HGO-1	410	0.015	27,333.3	0.01	80,000
Exposure Area 2	Arsenic	SC-SWC-2	300	0.015	20000.0	0.01	58,580
Exposure Area 2	Cadmium	SC-SWC-1	65	0.0098	6632.7	0.005	9,713
Exposure Area 2	Copper	SC-T-3	1,000	1.5	666.7	1.3	253,846
Exposure Area 2	Copper	SC-HGO-1	4,600	4.4	1,045.5	1.3	398,077
Exposure Area 2	Copper	SC-SWC-1 & SC-SWC-2	20,000	3.5	5,714.3	1.3	2,175,828
Exposure Area 2	Lead	SC-SWC-1 & SC-SWC-2	310	0.021	14761.9	0.05	216,000
Exposure Area 2	Mercury[4]	SC-SS-3	14	0.0005	28000.0	0.0005	4,100
Hull Canyon Wash (sediment)	Copper	2	910	1.1	827.3	1.3	315,000

Notes:

Alternative GPLs determined per Section IV, A Screening Method to Determine Soil Concentrations Protective of Groundwater Quality. Arizona Dept. of Environmental Quality. September, 1996.

Alternative GPL = $(292.9)*R*C_w$

C = concentration

GPL = Groundwater Protection Limit

ID = identification

L/kg = liters per kilogram

MCL - Maximum Contaminant Level

mg/kg = milligrams per kilogram

mg/L = milligrams per liter

PBC-NWQS = Partial Body Contact- Numeric Water Quality Standard

$R = C_{soil} / C_{leachate}$

SPLP = Synthetic Precipitation Leachate Procedure

[1] Copper has no GPL for comparison; however, it was retained for further evaluation because SPLP results exceeded the PBC-NWQS.

[2] Where two samples exceeded the default GPL, as a conservative approach the lowest soil sample concentration was used to calculate R. If the SPLP result was reported as a nondetection, the laboratory reporting limit was used to calculate R.

[3] Cw is a health-based action level, such as MCL. The value for arsenic is based on the secondary MCL. Other values used are based on AWQS.

[4] Because no SPLP result for mercury was associated with location SC-SS-3, the SPLP results from nearby locations were evaluated to use in its place. All SPLP results for mercury in nearby locations SWC-1, SWC-2, and HGO were reported as nondetections. The reporting limit of 0.0005 mg/L was used to represent the SPLP concentration for mercury.

ATTACHMENT G-1

ANALYTICAL DATA USED IN THE HHRA

Table G-1.1
Summary of Soil Sample Results Used in the HHRA

ANALYTE	CAS NUMBER	UNITS	Matrix	Background SC-B-1 7/23/2014 0 - 0.33 ft	Background SC-B-10 7/24/2014 0 - 0.33 ft	Background SC-B-11 7/23/2014 0 - 0.33 ft	Background SC-B-2 7/22/2014 0 - 0.33 ft	Background SC-B-3 7/22/2014 0 - 0.33 ft	Background SC-B-4 7/22/2014 0 - 0.33 ft	Background SC-B-5 7/23/2014 0 - 0.33 ft	Background SC-B-6 7/23/2014 0 - 0.33 ft	Background SC-B-7 7/24/2014 0 - 0.33 ft	Background SC-B-8 7/22/2014 0 - 0.33 ft	Background SC-B-9 7/22/2014 0 - 0.33 ft	Exposure Area 1 SC-LGO-1 7/24/2014 0 - 0.33 ft	Exposure Area 1 SC-LGO-10 7/24/2014 0 - 0.33 ft
Antimony	7440-36-0	mg/Kg	SO	<4.9	<5	<5	<4.9	<4.9	<5	<4.9	<5	<4.9	<4.9	<4.9	5.3	6
Arsenic	7440-38-2	mg/Kg	SO	14	21	36	5	19	25	31	23	33	13	12	240	200
Barium	7440-39-3	mg/Kg	SO	100	73	180	33	130	39	160	110	100	78	58	24	45
Beryllium	7440-41-7	mg/Kg	SO	<0.49	0.73	0.75	<0.49	0.77	<0.49	0.67	0.84	0.64	<0.48	0.56	<0.48	<0.49
Cadmium	7440-43-9	mg/Kg	SO	1	2	6.5	<0.49	0.86	2.4	5.9	4.3	5	0.87	<0.49	<0.48	<0.49
Chromium	7440-47-3	mg/Kg	SO	8.9	14	11	2.4	10	10	9.8	12	11	9.4	6.1	<1.9	<2
Copper	7440-50-8	mg/Kg	SO	79	150	590	29	98	270	510	380	590	190	25	4100	480
Lead	7439-92-1	mg/Kg	SO	83	20	94	<4.9	8.3	50	85	42	83	16	5.3	59	60
Manganese	7439-96-5	mg/Kg	SO	330	330	2800	88	690	230	2500	910	770	170	170	300	260
Mercury	7439-97-6	mg/Kg	SO	0.12	<0.089	0.24	<0.088	<0.1	<0.097	0.16	0.11	0.28	<0.094	<0.092	0.49	0.31
Nickel	7440-02-0	mg/Kg	SO	6.9	8.6	9.4	<2	8.3	4.9	8.4	8.8	8.4	8.7	5.1	<1.9	2.1
Selenium	7782-49-2	mg/Kg	SO	5.2	7.8	7.7	<4.9	7.3	<4.9	6.5	7.3	9.3	<4.8	<4.9	77	38
Silver	7440-22-4	mg/Kg	SO	<2.4	<2.4	<2.5	<2.5	<2.5	<2.5	<2.4	<2.4	<2.5	<2.4	<2.4	14	3.4
Thallium	7440-28-0	mg/Kg	SO	<4.9	<4.9	<490	<4.9	<4.9	<4.9	<480	<4.9	<5	<4.8	<4.9	<240	<4.9
Zinc	7440-66-6	mg/Kg	SO	110	120	320	47	140	160	290	130	220	64	71	180	110
Antimony	7440-36-0	mg/L	SPLP													
Arsenic	7440-38-2	mg/L	SPLP													
Barium	7440-39-3	mg/L	SPLP													
Beryllium	7440-41-7	mg/L	SPLP													
Cadmium	7440-43-9	mg/L	SPLP													
Chromium	7440-47-3	mg/L	SPLP													
Copper	7440-50-8	mg/L	SPLP													
Lead	7439-92-1	mg/L	SPLP													
Manganese	7439-96-5	mg/L	SPLP													
Mercury	7439-97-6	mg/L	SPLP													
Nickel	7440-02-0	mg/L	SPLP													
Selenium	7782-49-2	mg/L	SPLP													
Silver	7440-22-4	mg/L	SPLP													
Thallium	7440-28-0	mg/L	SPLP													
Zinc	7440-66-6	mg/L	SPLP													

Notes:
CAS = Chemical Abstract Service
ft = feet
HHRA = Human Health Risk Assessment
mg/kg = milligram per kilogram
mg/L = milligrams per liter
SO = soil
SPLP = Synthetic Precipitation Leaching Procedure

Table G-1.1
Summary of Soil Sample Results Used in the HHRA

ANALYTE	CAS NUMBER	UNITS	Exposure Area 1 SC-LGO-11 7/24/2014 0 - 0.33 ft	Exposure Area 1 SC-LGO-2 7/24/2014 0 - 0.33 ft	Exposure Area 1 SC-LGO-3 7/24/2014 0 - 0.33 ft	Exposure Area 1 SC-LGO-4 7/24/2014 0 - 0.33 ft	Exposure Area 1 SC-LGO-5 7/24/2014 0 - 0.33 ft	Exposure Area 1 SC-LGO-6 7/24/2014 0 - 0.33 ft	Exposure Area 1 SC-LGO-7 7/24/2014 0 - 0.33 ft	Exposure Area 1 SC-LGO-8 7/24/2014 0 - 0.33 ft	Exposure Area 1 SC-LGO-9 7/24/2014 0 - 0.33 ft	Exposure Area 1 SC-T-1 7/23/2014 0 - 0.33 ft	Exposure Area 1 SC-T-2 7/23/2014 0 - 0.33 ft	Exposure Area 1 SC-WR-1 7/22/2014 0 - 0.33 ft	Exposure Area 1 SC-WR-10 7/24/2014 0 - 0.33 ft	Exposure Area 1 SC-WR-11 7/24/2014 0 - 0.33 ft
Antimony	7440-36-0	mg/Kg	7.2	<5	<4.9	<5	<4.9	<4.9	6.6	7.1	<4.9	<5	<4.9	<5	<4.9	<5
Arsenic	7440-38-2	mg/Kg	140	94	250	36	140	180	250	140	120	180	120	100	69	33
Barium	7440-39-3	mg/Kg	38	64	22	51	25	16	13	39	21	13	6.7	13	50	39
Beryllium	7440-41-7	mg/Kg	<0.49	<0.49	<0.5	<0.49	<0.49	<0.49	<0.5	<0.49	<0.5	<0.48	<0.5	<0.48	<0.5	<0.48
Cadmium	7440-43-9	mg/Kg	0.79	<0.49	<0.5	<0.49	<0.49	<0.49	<0.5	0.58	<0.5	<0.48	<0.5	0.77	1.1	6.8
Chromium	7440-47-3	mg/Kg	12	5.5	<2	6.3	<1.9	<2	<2	14	<2	2.5	<2	<1.9	<2	<1.9
Copper	7440-50-8	mg/Kg	4500	4500	22000	1300	1300	4300	3900	6000	2900	1300	680	3600	2500	3000
Lead	7439-92-1	mg/Kg	140	45	68	22	40	46	68	130	40	15	18	16	12	48
Manganese	7439-96-5	mg/Kg	600	230	380	230	1000	330	340	480	400	220	150	620	1100	2400
Mercury	7439-97-6	mg/Kg	2.3	0.25	1.1	0.14	2.7	0.65	0.78	1.5	1	0.46	0.26	0.42	1.4	2.1
Nickel	7440-02-0	mg/Kg	11	3.9	2.2	4.3	<1.9	<2	<2	14	<2	<1.9	<2	<1.9	2.3	5.8
Selenium	7782-49-2	mg/Kg	46	33	61	16	34	69	58	45	44	21	30	18	20	19
Silver	7440-22-4	mg/Kg	10	5.2	16	<2.4	4.8	11	20	8.7	8.4	4.7	4.9	3	3.5	<2.4
Thallium	7440-28-0	mg/Kg	<4.9	<4.9	<5	<4.9	<240	<4.9	<5	<4.9	<5	<4.8	<5	<4.8	<5	<4.8
Zinc	7440-66-6	mg/Kg	300	120	310	86	350	180	250	280	190	110	57	220	270	1800
Antimony	7440-36-0	mg/L										<0.015	<0.015			
Arsenic	7440-38-2	mg/L										0.54	<0.5			
Barium	7440-39-3	mg/L										<10	<10			
Beryllium	7440-41-7	mg/L										<0.25	<0.25			
Cadmium	7440-43-9	mg/L										<0.25	<0.25			
Chromium	7440-47-3	mg/L										<0.5	<0.5			
Copper	7440-50-8	mg/L										2.2	<0.5			
Lead	7439-92-1	mg/L										<0.5	<0.5			
Manganese	7439-96-5	mg/L										<0.5	<0.5			
Mercury	7439-97-6	mg/L										0.0009	<0.0005			
Nickel	7440-02-0	mg/L										<0.5	<0.5			
Selenium	7782-49-2	mg/L										<0.005	<0.005			
Silver	7440-22-4	mg/L										<0.25	<0.25			
Thallium	7440-28-0	mg/L										<0.005	<0.005			
Zinc	7440-66-6	mg/L										<2	<2			

Notes:
CAS = Chemical Abstract Service
ft = feet
HHRA = Human Health Risk Assessment
mg/kg = milligram per kilogram
mg/L = milligrams per liter
SO = soil
SPLP = Synthetic Precipitation Leaching Procedure

Table G-1.1
Summary of Soil Sample Results Used in the HHRA

ANALYTE	CAS NUMBER	UNITS	Exposure Area 1 SC-WR-2 7/23/2014 0 - 0.33 ft	Exposure Area 1 SC-WR-3 7/23/2014 0 - 0.33 ft	Exposure Area 1 SC-WR-4 7/23/2014 0 - 0.33 ft	Exposure Area 1 SC-WR-5 7/23/2014 0 - 0.33 ft	Exposure Area 1 SC-WR-6 7/23/2014 0 - 0.33 ft	Exposure Area 1 SC-WR-7 7/24/2014 0 - 0.33 ft	Exposure Area 1 SC-WR-8 7/24/2014 0 - 0.33 ft	Exposure Area 1 SC-WR-9 7/24/2014 0 - 0.33 ft	Exposure Area 2 SC-HGO-1 7/25/2014 0 - 0.33 ft	Exposure Area 2 SC-SS-1 7/11/2018 0 - 0.33 ft	Exposure Area 2 SC-SS-2 7/11/2018 0 - 0.33 ft	Exposure Area 2 SC-SS-3 7/11/2018 0 - 0.33 ft	Exposure Area 2 SC-SS-4 7/11/2018 0 - 0.33 ft	Exposure Area 2 SC-SS-5 7/11/2018 0 - 0.33 ft
Antimony	7440-36-0	mg/Kg	<4.8	<5	<4.9	<4.9	<4.9	<5	<4.8	<4.8	5.3	<4.9	<5	6.8	24	19
Arsenic	7440-38-2	mg/Kg	27	24	120	51	19	34	19	120	410	110	31	330	430	250
Barium	7440-39-3	mg/Kg	7.6	33	20	21	27	40	41	15	6.7	58	93	140	<99	270
Beryllium	7440-41-7	mg/Kg	<0.5	<0.49	<0.49	<0.49	<0.49	<0.49	<0.49	<0.49	<0.5	<0.49	<0.5	<0.49	<0.5	<0.49
Cadmium	7440-43-9	mg/Kg	<0.5	1.3	0.75	1.3	<0.49	4.5	1.9	1.7	<0.5	0.91	<0.5	1.5	0.67	2
Chromium	7440-47-3	mg/Kg	<2	6.3	6.5	<2	<2	2	<2	<2	<200	8.7	13	14	30	9.4
Copper	7440-50-8	mg/Kg	650	460	2400	2000	240	5000	320	1800	4600	6000	1200	10000	5500	20000
Lead	7439-92-1	mg/Kg	5.7	9.7	13	22	7.9	56	18	14	41	42	32	240	160	570
Manganese	7439-96-5	mg/Kg	390	1200	1200	570	250	1200	880	670	260	610	250	140	240	250
Mercury	7439-97-6	mg/Kg	0.14	0.33	0.6	0.49	0.71	1.9	2.2	1.9	2	0.46	0.17	14	0.55	12
Nickel	7440-02-0	mg/Kg	<2	3.1	3.7	<2	<2	7.2	<2	<2	<2	8.8	7.4	6.9	21	6.9
Selenium	7782-49-2	mg/Kg	11	14	17	12	5.4	19	10	17	51	19	8.3	58	51	45
Silver	7440-22-4	mg/Kg	<2.5	<2.5	<2.4	<2.5	<2.5	<2.5	<2.4	<2.4	11	4.2	<2.5	14	9.9	11
Thallium	7440-28-0	mg/Kg	<5	<4.9	<4.9	<4.9	<4.9	<4.9	<4.9	<4.9	<500	<4.9	<5	<4.9	<5	<4.9
Zinc	7440-66-6	mg/Kg	120	320	260	290	140	1200	570	470	140	260	55	280	83	430
Antimony	7440-36-0	mg/L									<0.015					
Arsenic	7440-38-2	mg/L									<0.5					
Barium	7440-39-3	mg/L									<10					
Beryllium	7440-41-7	mg/L									<0.25			<0.25		<0.25
Cadmium	7440-43-9	mg/L									<0.25					
Chromium	7440-47-3	mg/L									<0.5					
Copper	7440-50-8	mg/L									4.4			1.2		<0.5
Lead	7439-92-1	mg/L									<0.5					
Manganese	7439-96-5	mg/L									<0.5					
Mercury	7439-97-6	mg/L									<0.0005			<0.0005		<0.0005
Nickel	7440-02-0	mg/L									<0.5					
Selenium	7782-49-2	mg/L									<0.005					
Silver	7440-22-4	mg/L									<0.25			<0.25		<0.25
Thallium	7440-28-0	mg/L									<0.005					
Zinc	7440-66-6	mg/L									<2			<2		<2

Notes:
CAS = Chemical Abstract Service
ft = feet
HHRA = Human Health Risk Assessment
mg/kg = milligram per kilogram
mg/L = milligrams per liter
SO = soil
SPLP = Synthetic Precipitation Leaching Procedure

Table G-1.1
Summary of Soil Sample Results Used in the HHRA

ANALYTE	CAS NUMBER	UNITS	Exposure Area 2 SC-SS-6 7/11/2018 0 - 0.33 ft	Exposure Area 2 SC-SS-7 7/11/2018 0 - 0.33 ft	Exposure Area 2 SC-SWC-1 7/25/2014 0 - 0.33 ft	Exposure Area 2 SC-SWC-2 7/25/2014 0 - 0.33 ft	Exposure Area 2 SC-SWC-3 7/11/2018 0 - 0.33 ft	Exposure Area 2 SC-SWC-3-MS 7/11/2018 0 - 0.33 ft	Exposure Area 2 SC-T-3 7/23/2014 0 - 0.33 ft	Exposure Area 2 SC-T4 7/11/2018 0 - 0.33 ft	Exposure Area 2 SC-T5 7/11/2018 0 - 0.33 ft	Exposure Area 2 SC-TS-D 7/11/2018 0 - 0.33 ft
Antimony	7440-36-0	mg/Kg	<5	36	42	42	23	9.5	<5	<4.9	<4.9	<5
Arsenic	7440-38-2	mg/Kg	400	88	110	300	86	68	100	130	59	68
Barium	7440-39-3	mg/Kg	<5	74	12	26	120	99	<4.9	21	76	74
Beryllium	7440-41-7	mg/Kg	<0.5	<0.49	<0.49	<0.5	<0.5	<0.49	<0.49	<0.49	<0.49	<0.5
Cadmium	7440-43-9	mg/Kg	<0.5	1.3	65	2.2	1.2	1.4	<0.49	<0.49	<0.49	<0.5
Chromium	7440-47-3	mg/Kg	<2	21	<2	2.7	16	11	<2	5.3	16	16
Copper	7440-50-8	mg/Kg	2000	8700	24000	20000	6500	5500	1000	880	1000	1300
Lead	7439-92-1	mg/Kg	21	450	1200	310	240	210	18	34	54	57
Manganese	7439-96-5	mg/Kg	360	250	700	310	210	190	170	120	180	230
Mercury	7439-97-6	mg/Kg	0.42	0.31	1.5	1.3	1.1	1.1	0.38	1.2	0.37	0.35
Nickel	7440-02-0	mg/Kg	<2	12	22	5.9	12	9	<2	3.1	8	8.4
Selenium	7782-49-2	mg/Kg	33	12	54	59	17	31	32	27	12	13
Silver	7440-22-4	mg/Kg	3.7	5.3	10	11	3.6	2.6	4.8	5.9	<2.5	2.5
Thallium	7440-28-0	mg/Kg	<5	<4.9	<98	<5	<5	<4.9	<4.9	<4.9	<4.9	<5
Zinc	7440-66-6	mg/Kg	160	390	15000	480	370	400	67	65	72	83
Antimony	7440-36-0	mg/L			<0.015	<0.015			<0.015			
Arsenic	7440-38-2	mg/L			<0.015	<0.015			<0.5			
Barium	7440-39-3	mg/L			<10	<10			<10			
Beryllium	7440-41-7	mg/L		<0.5	<0.25	<0.25			<0.25			
Cadmium	7440-43-9	mg/L			<0.25	<0.25			<0.25			
Chromium	7440-47-3	mg/L			<0.5	<0.5			<0.5			
Copper	7440-50-8	mg/L		<0.5	3.5	34			1.5			
Lead	7439-92-1	mg/L			<0.5	<0.5			<0.5			
Manganese	7439-96-5	mg/L			<0.5	1.1			<0.5			
Mercury	7439-97-6	mg/L		<0.0005	<0.0005	<0.0005			<0.0005			
Nickel	7440-02-0	mg/L			<0.5	<0.5			<0.5			
Selenium	7782-49-2	mg/L			0.0057	0.01			0.012			
Silver	7440-22-4	mg/L		<0.25	<0.25	<0.25			<0.25			
Thallium	7440-28-0	mg/L			<0.005	<0.005			<0.005			
Zinc	7440-66-6	mg/L		<2	4.2	<2			<2			

Notes:
CAS = Chemical Abstract Service
ft = feet
HHRA = Human Health Risk Assessment
mg/kg = milligram per kilogram
mg/L = milligrams per liter
SO = soil
SPLP = Synthetic Precipitation Leaching Procedure

Table G-1.2
Summary of Sediment Sample Results Used in the HHRA

ANALYTE	CAS NUMBER	UNITS	Matrix	Hull Canyon Wash SC-HCW-S-1 7/23/2014 0 - 0.33 ft	Hull Canyon Wash SC-HCW-S-2 7/23/2014 0 - 0.33 ft	Hull Canyon Wash SC-HCW-S-3 7/23/2014 0 - 0.33 ft	Hull Canyon Wash SC-HCW-S-4 7/25/2014 0 - 0.33 ft	Hull Canyon Wash SC-HCW-S-5 7/25/2014 0 - 0.33 ft
Antimony	7440-36-0	mg/Kg	SO	<5	<4.8	<4.9	<4.9	<5
Arsenic	7440-38-2	mg/Kg	SO	<4.8	34	8.7	31	32
Barium	7440-39-3	mg/Kg	SO	42	45	100	32	34
Beryllium	7440-41-7	mg/Kg	SO	<0.48	<0.5	1.3	<0.48	<0.49
Cadmium	7440-43-9	mg/Kg	SO	0.73	0.93	0.6	<0.48	0.57
Chromium	7440-47-3	mg/Kg	SO	10	11	46	8	8.7
Copper	7440-50-8	mg/Kg	SO	64	2200	140	910	1600
Lead	7439-92-1	mg/Kg	SO	11	18	25	33	33
Manganese	7439-96-5	mg/Kg	SO	120	690	380	240	260
Mercury	7439-97-6	mg/Kg	SO	<0.1	0.14	<0.093	0.17	0.89
Nickel	7440-02-0	mg/Kg	SO	13	13	46	6.8	6.4
Selenium	7782-49-2	mg/Kg	SO	<4.8	10	6.5	9.8	12
Silver	7440-22-4	mg/Kg	SO	<2.4	<2.5	<2.5	<2.4	<2.5
Thallium	7440-28-0	mg/Kg	SO	<4.8	<5	<5	<4.8	<4.9
Zinc	7440-66-6	mg/Kg	SO	48	270	190	88	120
Antimony	7440-36-0	mg/L	SPLP	<0.015	<0.015	<0.015	<0.015	<0.015
Arsenic	7440-38-2	mg/L	SPLP	<0.015	<0.5	<0.015	<0.5	0.023
Barium	7440-39-3	mg/L	SPLP	<10	<10	<10	<10	<10
Beryllium	7440-41-7	mg/L	SPLP	<0.25	<0.25	<0.25	<0.25	<0.25
Cadmium	7440-43-9	mg/L	SPLP	<0.25	<0.25	<0.25	<0.25	<0.25
Chromium	7440-47-3	mg/L	SPLP	<0.5	<0.5	<0.5	<0.5	<0.5
Copper	7440-50-8	mg/L	SPLP	<0.5	3.7	<0.5	1.1	0.98
Lead	7439-92-1	mg/L	SPLP	<0.5	<0.5	<0.5	<0.5	<0.5
Manganese	7439-96-5	mg/L	SPLP	<0.5	<0.5	<0.5	<0.5	<0.5
Mercury	7439-97-6	mg/L	SPLP	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Nickel	7440-02-0	mg/L	SPLP	<0.5	<0.5	<0.5	<0.5	<0.5
Selenium	7782-49-2	mg/L	SPLP	<0.005	<0.005	<0.005	<0.005	<0.005
Silver	7440-22-4	mg/L	SPLP	<0.25	<0.25	<0.25	<0.25	<0.25
Thallium	7440-28-0	mg/L	SPLP	<0.005	<0.005	<0.005	<0.005	<0.005
Zinc	7440-66-6	mg/L	SPLP	<2	<2	<2	<2	<2

Notes:
CAS = Chemical Abstract Service
ft = feet
HHRA = Human Health Risk Assessment
mg/kg = milligram per kilogram
mg/L = milligrams per liter
SO = soil
SPLP = Synthetic Precipiation Leaching Procedure

Table G-1.3
Summary of Surface Water Sample Results Used in the HHRA

ANALYTE	CAS NUMBER	UNITS	Hull Canyon Wash HCW-1-W 12/4/2014	Hull Canyon Wash HCW-1-W 9/16/2014	Hull Canyon Wash HCW-3-W 10/2/2014	Hull Canyon Wash HCW-3-W 12/4/2014	Hull Canyon Wash HCW-3-W 9/16/2014	Hull Canyon Wash HCW-4-W 10/2/2014	Hull Canyon Wash HCW-4-W 12/4/2014	Hull Canyon Wash HCW-4-W 9/16/2014
Antimony	7440-36-0	mg/L	<0.003	<0.003	<0.003		<0.003	0.0035	<0.003	0.0035
Antimony, Dissolved	7440-36-0	mg/L	<0.003	<0.003	<0.003	<0.03		<0.003	<0.003	
Arsenic	7440-38-2	mg/L	<0.003	<0.003	0.0031		0.011	0.027	<0.003	0.03
Arsenic, Dissolved	7440-38-2	mg/L	<0.003	<0.003	<0.003	<0.03		<0.003	<0.003	
Barium	7440-39-3	mg/L	0.012	0.022	0.028		0.063	0.099	0.024	0.13
Barium, Dissolved	7440-39-3	mg/L	0.013	0.013	<0.01	<0.1		0.015	0.027	
Beryllium	7440-41-7	mg/L	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001	<0.001
Beryllium, Dissolved	7440-41-7	mg/L	<0.001	<0.001	<0.001	<0.01		<0.001	<0.001	
Cadmium	7440-43-9	mg/L	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001	0.0015
Cadmium, Dissolved	7440-43-9	mg/L	<0.001	<0.001	<0.001	<0.01		<0.001	<0.001	
Calcium	7440-70-2	mg/L	71						74	
Calcium, Dissolved	7440-70-2	mg/L	74			<20			80	
Chromium	7440-47-3	mg/L	<0.01	<0.01	<0.01		0.014	0.011	<0.01	0.014
Chromium, Dissolved	7440-47-3	mg/L	<0.01	<0.01	<0.01	<0.1		<0.01	<0.01	
Copper	7440-50-8	mg/L	<0.01	0.012	0.058		0.065	0.87	0.075	1.3
Copper, Dissolved	7440-50-8	mg/L	<0.01	<0.01	0.013	<0.1		0.081	0.044	
Mercury	7439-97-6	mg/L	<0.0002	<0.0002	<0.0002		<0.0002	0.00044	<0.0002	0.00068
Mercury, Dissolved	7439-97-6	mg/L	<0.0002	0.00028	<0.0002	<0.0002		<0.0002	<0.0002	
Lead	7439-92-1	mg/L	<0.015	<0.015	0.022		0.05	0.09	<0.015	0.12
Lead, Dissolved	7439-92-1	mg/L	<0.015	<0.015	<0.015	<0.15		<0.015	<0.015	
Magnesium	7439-95-4	mg/L	39						36	
Magnesium, Dissolved	7439-95-4	mg/L	41			<20			38	
Manganese	7439-96-5	mg/L	<0.01	0.015	0.17		0.28	0.4	0.066	0.53
Manganese, Dissolved	7439-96-5	mg/L	<0.01	<0.01	0.018	<0.1		<0.01	0.026	
Nickel	7440-02-0	mg/L	<0.01	<0.01	<0.01		0.012	<0.01	<0.01	<0.01
Nickel, Dissolved	7440-02-0	mg/L	<0.01	<0.01	<0.01	<0.1		<0.01	<0.01	
Selenium	7782-49-2	mg/L	<0.002	<0.002	<0.002		<0.002	0.005	0.0042	0.0054
Selenium, Dissolved	7782-49-2	mg/L	0.0023	<0.002	<0.002	<0.02		0.002	0.0039	
Silver	7440-22-4	mg/L	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01
Silver, Dissolved	7440-22-4	mg/L	<0.01	<0.01	<0.01	<0.1		<0.01	<0.01	
Thallium	7440-28-0	mg/L	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001	<0.001
Thallium, Dissolved	7440-28-0	mg/L	<0.001	<0.001	<0.001	<0.01		<0.001	<0.001	
Zinc	7440-66-6	mg/L	<0.05	0.078	0.11		0.65	0.27	<0.05	0.4
Zinc, Dissolved	7440-66-6	mg/L	<0.05	<0.05	<0.05	<0.5		<0.05	<0.05	

Notes:
CAS = Chemical Abstract Service
HHRA = Human Health Risk Assessment
mg/L = milligrams per liter
SPLP = Synthetic Precipiation Leaching Procedure

Table G-1.3
Summary of Surface Water Sample Results Used in the HHRA

ANALYTE	CAS NUMBER	UNITS	Hull Canyon Wash SC-HCW-1-FILTER-20150520 5/20/2015	Hull Canyon Wash SC-HCW-1-UNFILT-20150520 5/20/2015	Hull Canyon Wash SC-HCW-2-FILTER-20150520 5/20/2015	Hull Canyon Wash SC-HCW-2-UNFILT-20150520 5/20/2015	Hull Canyon Wash SC-HCW-3-UNFILT-20150520 5/20/2015
Antimony	7440-36-0	mg/L		<0.003		<0.003	<0.003
Antimony, Dissolved	7440-36-0	mg/L	<0.003		<0.003		
Arsenic	7440-38-2	mg/L		<0.003		0.0059	<0.003
Arsenic, Dissolved	7440-38-2	mg/L	<0.003		0.0074		
Barium	7440-39-3	mg/L		<0.01		0.016	0.018
Barium, Dissolved	7440-39-3	mg/L	<0.01		0.016		
Beryllium	7440-41-7	mg/L		<0.001		<0.001	<0.001
Beryllium, Dissolved	7440-41-7	mg/L	<0.001		<0.001		
Cadmium	7440-43-9	mg/L		<0.001		<0.001	<0.001
Cadmium, Dissolved	7440-43-9	mg/L	<0.001		<0.001		
Calcium	7440-70-2	mg/L		38		76	89
Calcium, Dissolved	7440-70-2	mg/L	37		81		
Chromium	7440-47-3	mg/L		<0.01		<0.01	<0.01
Chromium, Dissolved	7440-47-3	mg/L	<0.01		<0.01		
Copper	7440-50-8	mg/L		<0.01		0.1	0.044
Copper, Dissolved	7440-50-8	mg/L	<0.01		0.087		
Mercury	7439-97-6	mg/L		<0.0002		<0.0002	<0.0002
Mercury, Dissolved	7439-97-6	mg/L	<0.0002		<0.0002		
Lead	7439-92-1	mg/L		<0.015		<0.015	<0.015
Lead, Dissolved	7439-92-1	mg/L	<0.015		<0.015		
Magnesium	7439-95-4	mg/L		31		38	29
Magnesium, Dissolved	7439-95-4	mg/L	30		41		
Manganese	7439-96-5	mg/L		<0.01		<0.01	0.025
Manganese, Dissolved	7439-96-5	mg/L	<0.01		<0.01		
Nickel	7440-02-0	mg/L		<0.01		<0.01	<0.01
Nickel, Dissolved	7440-02-0	mg/L	<0.01		<0.01		
Selenium	7782-49-2	mg/L		<0.002		0.0093	0.0047
Selenium, Dissolved	7782-49-2	mg/L	<0.002		0.011		
Silver	7440-22-4	mg/L		<0.01		<0.01	<0.01
Silver, Dissolved	7440-22-4	mg/L	<0.01		<0.01		
Thallium	7440-28-0	mg/L		<0.001		<0.001	<0.001
Thallium, Dissolved	7440-28-0	mg/L	<0.001		<0.001		
Zinc	7440-66-6	mg/L		<0.05		<0.05	<0.05
Zinc, Dissolved	7440-66-6	mg/L	<0.05		<0.05		

Notes:
CAS = Chemical Abstract Service
HHRA = Human Health Risk Assessment
mg/L = milligrams per liter
SPLP = Synthetic Precipiation Leaching Procedure

Table G-1.3
Summary of Surface Water Sample Results Used in the HHRA

ANALYTE	CAS NUMBER	UNITS	Hull Canyon Wash SC-HCW-4-FILTER-20150520 5/20/2015	Hull Canyon Wash SC-HCW-4-UNFILT-20150520 5/20/2015	Hull Canyon Wash SC-HCW-5-FILTER-20150520 5/20/2015	Hull Canyon Wash SC-HCW-5-UNFILT-20150520 5/20/2015
Antimony	7440-36-0	mg/L		<0.003		<0.003
Antimony, Dissolved	7440-36-0	mg/L	<0.003		<0.003	
Arsenic	7440-38-2	mg/L		<0.003		<0.003
Arsenic, Dissolved	7440-38-2	mg/L	<0.003		<0.003	
Barium	7440-39-3	mg/L		0.021		0.021
Barium, Dissolved	7440-39-3	mg/L	0.02		0.02	
Beryllium	7440-41-7	mg/L		<0.001		<0.001
Beryllium, Dissolved	7440-41-7	mg/L	<0.001		<0.001	
Cadmium	7440-43-9	mg/L		<0.001		<0.001
Cadmium, Dissolved	7440-43-9	mg/L	<0.001		<0.001	
Calcium	7440-70-2	mg/L		65		64
Calcium, Dissolved	7440-70-2	mg/L	66		65	
Chromium	7440-47-3	mg/L		<0.01		<0.01
Chromium, Dissolved	7440-47-3	mg/L	<0.01		<0.01	
Copper	7440-50-8	mg/L		0.034		0.033
Copper, Dissolved	7440-50-8	mg/L	0.03		0.029	
Mercury	7439-97-6	mg/L		<0.0002		<0.0002
Mercury, Dissolved	7439-97-6	mg/L	<0.0002		<0.0002	
Lead	7439-92-1	mg/L		<0.015		<0.015
Lead, Dissolved	7439-92-1	mg/L	<0.015		<0.015	
Magnesium	7439-95-4	mg/L		41		41
Magnesium, Dissolved	7439-95-4	mg/L	41		41	
Manganese	7439-96-5	mg/L		<0.01		<0.01
Manganese, Dissolved	7439-96-5	mg/L	<0.01		<0.01	
Nickel	7440-02-0	mg/L		<0.01		<0.01
Nickel, Dissolved	7440-02-0	mg/L	<0.01		<0.01	
Selenium	7782-49-2	mg/L		<0.002		<0.002
Selenium, Dissolved	7782-49-2	mg/L	0.002		<0.002	
Silver	7440-22-4	mg/L		<0.01		<0.01
Silver, Dissolved	7440-22-4	mg/L	<0.01		<0.01	
Thallium	7440-28-0	mg/L		<0.001		<0.001
Thallium, Dissolved	7440-28-0	mg/L	<0.001		<0.001	
Zinc	7440-66-6	mg/L		<0.05		<0.05
Zinc, Dissolved	7440-66-6	mg/L	<0.05		<0.05	

Notes:
CAS = Chemical Abstract Service
HHRA = Human Health Risk Assessment
mg/L = milligrams per liter
SPLP = Synthetic Precipiation Leaching Procedure

ATTACHMENT G-2

PROUCL OUTPUTS

	A	B	C	D	E	F	G	H	I	J	K	L	M
1				General Statistics on Uncensored Data									
2			Date/Time of Computation	ProUCL 5.110/17/2019 3:03:46 PM									
3			User Selected Options										
4			From File	ProUCL Input 3_EA1_rev083019.xls									
5			Full Precision	OFF									
6													
7	From File: ProUCL Input 3_EA1_rev083019.xls												
8													
9	General Statistics for Censored Data Set (with NDs) using Kaplan Meier Method												
10													
11	Variable		NumObs	# Missing	Num Ds	NumNDs	% NDs	Min ND	Max ND	KM Mean	KM Var	KM SD	KM CV
12	Antimony		22	0	4	18	81.82%	4.8	5	5.068	0.414	0.643	0.127
13	Arsenic		22	0	22	0	0.00%	N/A	N/A	115.1	5868	76.61	0.665
14	Barium		22	0	22	0	0.00%	N/A	N/A	27.6	244.5	15.64	0.566
15	Cadmium		22	0	9	13	59.09%	0.48	0.5	1.03	1.763	1.328	1.29
16	Chromium		22	0	7	15	68.18%	1.9	2	3.255	8.148	2.854	0.877
17	Copper		22	0	22	0	0.00%	N/A	N/A	3260	20431643	4520	1.386
18	Lead		22	0	22	0	0.00%	N/A	N/A	36.15	973.9	31.21	0.863
19	Manganese		22	0	22	0	0.00%	N/A	N/A	623.6	269719	519.3	0.833
20	Mercury		22	0	22	0	0.00%	N/A	N/A	0.942	0.629	0.793	0.842
21	Nickel		22	0	9	13	59.09%	1.9	2	3.068	7.237	2.69	0.877
22	Selenium		22	0	22	0	0.00%	N/A	N/A	30.47	425.6	20.63	0.677
23	Silver		22	0	13	9	40.91%	2.4	2.5	5.932	25.01	5.001	0.843
24	Zinc		22	0	22	0	0.00%	N/A	N/A	304.7	127341	356.8	1.171
25													
26	General Statistics for Raw Data Sets using Detected Data Only												
27													
28	Variable		NumObs	# Missing	Minimum	Maximum	Mean	Median	Var	SD	MAD/0.675	Skewness	CV
29	Antimony		4	0	5.3	7.2	6.275	6.3	0.663	0.814	0.89	-0.151	0.13
30	Arsenic		22	0	19	250	115.1	120	5868	76.61	95.63	0.398	0.665
31	Barium		22	0	6.7	64	27.6	23	244.5	15.64	14.83	0.714	0.566
32	Cadmium		9	0	0.75	6.8	1.823	1.3	3.649	1.91	0.756	2.746	1.048
33	Chromium		7	0	2	14	6.157	6.3	15.46	3.932	1.186	1.387	0.639
34	Copper		22	0	240	22000	3260	2200	20431643	4520	2409	3.658	1.386
35	Lead		22	0	5.7	140	36.15	22	973.9	31.21	22.54	1.858	0.863
36	Manganese		22	0	150	2400	623.6	395	269719	519.3	259.5	2.113	0.833
37	Mercury		22	0	0.14	2.7	0.942	0.625	0.629	0.793	0.549	1.025	0.842
38	Nickel		9	0	2.1	14	4.756	3.7	14.48	3.805	2.076	2.182	0.8
39	Selenium		22	0	5.4	77	30.47	20.5	425.6	20.63	14.83	0.943	0.677
40	Silver		13	0	3	20	8.377	5.2	30.03	5.48	3.262	0.987	0.654
41	Zinc		22	0	57	1800	304.7	235	127341	356.8	133.4	3.807	1.171

	A	B	C	D	E	F	G	H	I	J	K	L	M
42													
43	Percentiles using all Detects (Ds) and Non-Detects (NDs)												
44													
45	Variable		NumObs	# Missing	10%ile	20%ile	25%ile(Q1)	50%ile(Q2)	75%ile(Q3)	80%ile	90%ile	95%ile	99%ile
46		Antimony	22	0	4.81	4.9	4.9	4.9	5	5	5.93	6.57	7.074
47		Arsenic	22	0	24.3	34.4	39.75	120	170	180	236	249.5	250
48		Barium	22	0	13	13.4	15.25	23	39.75	40.8	49.5	50.95	61.27
49		Cadmium	22	0	0.49	0.49	0.49	0.5	1.023	1.26	1.66	1.89	5.771
50		Chromium	22	0	1.91	2	2	2	2.375	4.9	6.3	6.49	12.43
51		Copper	22	0	462	656	835	2200	4050	4260	4950	5950	18640
52		Lead	22	0	9.93	13.2	14.25	22	53.5	58.4	67.2	68	124.9
53		Manganese	22	0	230	252	270	395	827.5	976	1190	1200	2148
54		Mercury	22	0	0.251	0.314	0.353	0.625	1.325	1.8	2.19	2.295	2.616
55		Nickel	22	0	1.9	2	2	2	2.9	3.58	4.26	7.055	12.57
56		Selenium	22	0	11.1	14.4	16.25	20.5	42.5	45.6	60.7	68.6	75.32
57		Silver	22	0	2.4	2.5	2.5	3.45	7.6	9.68	13.7	15.9	19.16
58		Zinc	22	0	110	120	125	235	307.5	318	458	565	1542

	A	B	C	D	E	F	G	H	I	J	K	L
1	**UCL Statistics for Data Sets with Non-Detects**											
2												
3	User Selected Options											
4	Date/Time of Computation			ProUCL 5.110/17/2019 3:06:06 PM								
5	From File			ProUCL Input 3_EA1_rev083019.xls								
6	Full Precision			OFF								
7	Confidence Coefficient			95%								
8	Number of Bootstrap Operations			2000								
9												
10	**Antimony**											
11												
12	**General Statistics**											
13	Total Number of Observations					22	Number of Distinct Observations					7
14	Number of Detects					4	Number of Non-Detects					18
15	Number of Distinct Detects					4	Number of Distinct Non-Detects					3
16	Minimum Detect					5.3	Minimum Non-Detect					4.8
17	Maximum Detect					7.2	Maximum Non-Detect					5
18	Variance Detects					0.663	Percent Non-Detects					81.82%
19	Mean Detects					6.275	SD Detects					0.814
20	Median Detects					6.3	CV Detects					0.13
21	Skewness Detects					-0.151	Kurtosis Detects					-0.949
22	Mean of Logged Detects					1.83	SD of Logged Detects					0.131
23												
24	**Normal GOF Test on Detects Only**											
25	Shapiro Wilk Test Statistic					0.995	**Shapiro Wilk GOF Test**					
26	5% Shapiro Wilk Critical Value					0.748	Detected Data appear Normal at 5% Significance Level					
27	Lilliefors Test Statistic					0.155	**Lilliefors GOF Test**					
28	5% Lilliefors Critical Value					0.375	Detected Data appear Normal at 5% Significance Level					
29	**Detected Data appear Normal at 5% Significance Level**											
30												
31	**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**											
32	KM Mean					5.068	KM Standard Error of Mean					0.158
33	KM SD					0.643	95% KM (BCA) UCL					N/A
34	95% KM (t) UCL					5.341	95% KM (Percentile Bootstrap) UCL					N/A
35	95% KM (z) UCL					5.329	95% KM Bootstrap t UCL					N/A
36	90% KM Chebyshev UCL					5.543	95% KM Chebyshev UCL					5.759
37	97.5% KM Chebyshev UCL					6.057	99% KM Chebyshev UCL					6.644
38												
39	**Gamma GOF Tests on Detected Observations Only**											
40	A-D Test Statistic					0.203	**Anderson-Darling GOF Test**					
41	5% A-D Critical Value					0.656	Detected data appear Gamma Distributed at 5% Significance Level					
42	K-S Test Statistic					0.187	**Kolmogorov-Smirnov GOF**					
43	5% K-S Critical Value					0.394	Detected data appear Gamma Distributed at 5% Significance Level					
44	**Detected data appear Gamma Distributed at 5% Significance Level**											
45												
46	**Gamma Statistics on Detected Data Only**											
47	k hat (MLE)					78.06	k star (bias corrected MLE)					19.68
48	Theta hat (MLE)					0.0804	Theta star (bias corrected MLE)					0.319
49	nu hat (MLE)					624.5	nu star (bias corrected)					157.4
50	Mean (detects)					6.275						
51												

	A	B	C	D	E	F	G	H	I	J	K	L
52	**Gamma ROS Statistics using Imputed Non-Detects**											
53	GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs											
54	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)											
55	For such situations, GROS method may yield incorrect values of UCLs and BTVs											
56	This is especially true when the sample size is small.											
57	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates											
58					Minimum	0.01				Mean		3.097
59					Maximum	7.2				Median		2.859
60					SD	1.962				CV		0.633
61					k hat (MLE)	1.367				k star (bias corrected MLE)		1.211
62					Theta hat (MLE)	2.265				Theta star (bias corrected MLE)		2.558
63					nu hat (MLE)	60.15				nu star (bias corrected)		53.28
64					Adjusted Level of Significance (β)	0.0386						
65					Approximate Chi Square Value (53.28, α)	37.51				Adjusted Chi Square Value (53.28, β)		36.52
66					95% Gamma Approximate UCL (use when n>=50)	4.399				95% Gamma Adjusted UCL (use when n<50)		N/A
67												
68	**Estimates of Gamma Parameters using KM Estimates**											
69					Mean (KM)	5.068				SD (KM)		0.643
70					Variance (KM)	0.414				SE of Mean (KM)		0.158
71					k hat (KM)	62.05				k star (KM)		53.62
72					nu hat (KM)	2730				nu star (KM)		2359
73					theta hat (KM)	0.0817				theta star (KM)		0.0945
74					80% gamma percentile (KM)	5.64				90% gamma percentile (KM)		5.973
75					95% gamma percentile (KM)	6.258				99% gamma percentile (KM)		6.816
76												
77	**Gamma Kaplan-Meier (KM) Statistics**											
78					Approximate Chi Square Value (N/A, α)	2247				Adjusted Chi Square Value (N/A, β)		2239
79					95% Gamma Approximate KM-UCL (use when n>=50)	5.32				95% Gamma Adjusted KM-UCL (use when n<50)		5.34
80												
81	**Lognormal GOF Test on Detected Observations Only**											
82					Shapiro Wilk Test Statistic	0.99				**Shapiro Wilk GOF Test**		
83					5% Shapiro Wilk Critical Value	0.748				Detected Data appear Lognormal at 5% Significance Level		
84					Lilliefors Test Statistic	0.168				**Lilliefors GOF Test**		
85					5% Lilliefors Critical Value	0.375				Detected Data appear Lognormal at 5% Significance Level		
86	**Detected Data appear Lognormal at 5% Significance Level**											
87												
88	**Lognormal ROS Statistics Using Imputed Non-Detects**											
89					Mean in Original Scale	3.831				Mean in Log Scale		1.285
90					SD in Original Scale	1.4				SD in Log Scale		0.344
91					95% t UCL (assumes normality of ROS data)	4.345				95% Percentile Bootstrap UCL		4.319
92					95% BCA Bootstrap UCL	4.402				95% Bootstrap t UCL		4.481
93					95% H-UCL (Log ROS)	4.413						
94												
95	**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**											
96					KM Mean (logged)	1.616				KM Geo Mean		5.034
97					KM SD (logged)	0.112				95% Critical H Value (KM-Log)		1.73
98					KM Standard Error of Mean (logged)	0.0276				95% H-UCL (KM -Log)		5.284
99					KM SD (logged)	0.112				95% Critical H Value (KM-Log)		1.73
100					KM Standard Error of Mean (logged)	0.0276						
101												

	A	B	C	D	E	F	G	H	I	J	K	L
102	DL/2 Statistics											
103	DL/2 Normal						DL/2 Log-Transformed					
104					Mean in Original Scale	3.152				Mean in Log Scale		1.069
105					SD in Original Scale	1.538				SD in Log Scale		0.371
106					95% t UCL (Assumes normality)	3.717				95% H-Stat UCL		3.634
107	DL/2 is not a recommended method, provided for comparisons and historical reasons											
108												
109	Nonparametric Distribution Free UCL Statistics											
110	Detected Data appear Normal Distributed at 5% Significance Level											
111												
112	Suggested UCL to Use											
113					95% KM (t) UCL	5.341						
114												
115	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
116	Recommendations are based upon data size, data distribution, and skewness.											
117	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
118	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
119												
120												
121	Arsenic											
122												
123	General Statistics											
124					Total Number of Observations	22				Number of Distinct Observations		15
125										Number of Missing Observations		0
126					Minimum	19				Mean		115.1
127					Maximum	250				Median		120
128					SD	76.61				Std. Error of Mean		16.33
129					Coefficient of Variation	0.665				Skewness		0.398
130												
131	Normal GOF Test											
132					Shapiro Wilk Test Statistic	0.92	Shapiro Wilk GOF Test					
133					5% Shapiro Wilk Critical Value	0.911	Data appear Normal at 5% Significance Level					
134					Lilliefors Test Statistic	0.122	Lilliefors GOF Test					
135					5% Lilliefors Critical Value	0.184	Data appear Normal at 5% Significance Level					
136	Data appear Normal at 5% Significance Level											
137												
138	Assuming Normal Distribution											
139	95% Normal UCL						95% UCLs (Adjusted for Skewness)					
140					95% Student's-t UCL	143.2				95% Adjusted-CLT UCL (Chen-1995)		143.5
141										95% Modified-t UCL (Johnson-1978)		143.5
142												
143	Gamma GOF Test											
144					A-D Test Statistic	0.587	Anderson-Darling Gamma GOF Test					
145					5% A-D Critical Value	0.757	Detected data appear Gamma Distributed at 5% Significance Level					
146					K-S Test Statistic	0.164	Kolmogorov-Smirnov Gamma GOF Test					
147					5% K-S Critical Value	0.188	Detected data appear Gamma Distributed at 5% Significance Level					
148	Detected data appear Gamma Distributed at 5% Significance Level											
149												

	A	B	C	D	E	F	G	H	I	J	K	L
150						Gamma Statistics						
151					k hat (MLE)	1.872					k star (bias corrected MLE)	1.647
152					Theta hat (MLE)	61.51					Theta star (bias corrected MLE)	69.91
153					nu hat (MLE)	82.36					nu star (bias corrected)	72.46
154					MLE Mean (bias corrected)	115.1					MLE Sd (bias corrected)	89.72
155											Approximate Chi Square Value (0.05)	53.86
156					Adjusted Level of Significance	0.0386					Adjusted Chi Square Value	52.67
157												
158						Assuming Gamma Distribution						
159					95% Approximate Gamma UCL (use when n>=50))	154.9					95% Adjusted Gamma UCL (use when n<50)	158.4
160												
161						Lognormal GOF Test						
162					Shapiro Wilk Test Statistic	0.9					Shapiro Wilk Lognormal GOF Test	
163					5% Shapiro Wilk Critical Value	0.911					Data Not Lognormal at 5% Significance Level	
164					Lilliefors Test Statistic	0.195					Lilliefors Lognormal GOF Test	
165					5% Lilliefors Critical Value	0.184					Data Not Lognormal at 5% Significance Level	
166						Data Not Lognormal at 5% Significance Level						
167												
168						Lognormal Statistics						
169					Minimum of Logged Data	2.944					Mean of logged Data	4.456
170					Maximum of Logged Data	5.521					SD of logged Data	0.861
171												
172						Assuming Lognormal Distribution						
173					95% H-UCL	195.7					90% Chebyshev (MVUE) UCL	195.9
174					95% Chebyshev (MVUE) UCL	229.4					97.5% Chebyshev (MVUE) UCL	275.8
175					99% Chebyshev (MVUE) UCL	367.1						
176												
177						Nonparametric Distribution Free UCL Statistics						
178						Data appear to follow a Discernible Distribution at 5% Significance Level						
179												
180						Nonparametric Distribution Free UCLs						
181					95% CLT UCL	142					95% Jackknife UCL	143.2
182					95% Standard Bootstrap UCL	141.7					95% Bootstrap-t UCL	145.7
183					95% Hall's Bootstrap UCL	144					95% Percentile Bootstrap UCL	141
184					95% BCA Bootstrap UCL	142.4						
185					90% Chebyshev(Mean, Sd) UCL	164.1					95% Chebyshev(Mean, Sd) UCL	186.3
186					97.5% Chebyshev(Mean, Sd) UCL	217.1					99% Chebyshev(Mean, Sd) UCL	277.6
187												
188						Suggested UCL to Use						
189					95% Student's-t UCL	143.2						
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												

	A	B	C	D	E	F	G	H	I	J	K	L
197	**Barium**											
198												
199						**General Statistics**						
200					Total Number of Observations	22				Number of Distinct Observations		19
201										Number of Missing Observations		0
202					Minimum	6.7				Mean		27.6
203					Maximum	64				Median		23
204					SD	15.64				Std. Error of Mean		3.334
205					Coefficient of Variation	0.566				Skewness		0.714
206												
207						**Normal GOF Test**						
208					Shapiro Wilk Test Statistic	0.933				**Shapiro Wilk GOF Test**		
209					5% Shapiro Wilk Critical Value	0.911				Data appear Normal at 5% Significance Level		
210					Lilliefors Test Statistic	0.157				**Lilliefors GOF Test**		
211					5% Lilliefors Critical Value	0.184				Data appear Normal at 5% Significance Level		
212						**Data appear Normal at 5% Significance Level**						
213												
214						**Assuming Normal Distribution**						
215					**95% Normal UCL**					**95% UCLs (Adjusted for Skewness)**		
216					95% Student's-t UCL	33.34				95% Adjusted-CLT UCL (Chen-1995)		33.63
217										95% Modified-t UCL (Johnson-1978)		33.43
218												
219						**Gamma GOF Test**						
220					A-D Test Statistic	0.267				**Anderson-Darling Gamma GOF Test**		
221					5% A-D Critical Value	0.749				Detected data appear Gamma Distributed at 5% Significance Level		
222					K-S Test Statistic	0.117				**Kolmogorov-Smirnov Gamma GOF Test**		
223					5% K-S Critical Value	0.187				Detected data appear Gamma Distributed at 5% Significance Level		
224						**Detected data appear Gamma Distributed at 5% Significance Level**						
225												
226						**Gamma Statistics**						
227					k hat (MLE)	3.171				k star (bias corrected MLE)		2.769
228					Theta hat (MLE)	8.705				Theta star (bias corrected MLE)		9.969
229					nu hat (MLE)	139.5				nu star (bias corrected)		121.8
230					MLE Mean (bias corrected)	27.6				MLE Sd (bias corrected)		16.59
231										Approximate Chi Square Value (0.05)		97.35
232					Adjusted Level of Significance	0.0386				Adjusted Chi Square Value		95.71
233												
234						**Assuming Gamma Distribution**						
235					95% Approximate Gamma UCL (use when n>=50))	34.55				95% Adjusted Gamma UCL (use when n<50)		35.14
236												
237						**Lognormal GOF Test**						
238					Shapiro Wilk Test Statistic	0.966				**Shapiro Wilk Lognormal GOF Test**		
239					5% Shapiro Wilk Critical Value	0.911				Data appear Lognormal at 5% Significance Level		
240					Lilliefors Test Statistic	0.116				**Lilliefors Lognormal GOF Test**		
241					5% Lilliefors Critical Value	0.184				Data appear Lognormal at 5% Significance Level		
242						**Data appear Lognormal at 5% Significance Level**						
243												
244						**Lognormal Statistics**						
245					Minimum of Logged Data	1.902				Mean of logged Data		3.152
246					Maximum of Logged Data	4.159				SD of logged Data		0.613
247												

	A	B	C	D	E	F	G	H	I	J	K	L
248	Assuming Lognormal Distribution											
249					95% H-UCL	37.41				90% Chebyshev (MVUE) UCL		39.51
250					95% Chebyshev (MVUE) UCL	44.75				97.5% Chebyshev (MVUE) UCL		52.02
251					99% Chebyshev (MVUE) UCL	66.3						
252												
253	Nonparametric Distribution Free UCL Statistics											
254	Data appear to follow a Discernible Distribution at 5% Significance Level											
255												
256	Nonparametric Distribution Free UCLs											
257					95% CLT UCL	33.09				95% Jackknife UCL		33.34
258					95% Standard Bootstrap UCL	32.84				95% Bootstrap-t UCL		33.76
259					95% Hall's Bootstrap UCL	33.64				95% Percentile Bootstrap UCL		32.77
260					95% BCA Bootstrap UCL	33.32						
261					90% Chebyshev(Mean, Sd) UCL	37.61				95% Chebyshev(Mean, Sd) UCL		42.14
262					97.5% Chebyshev(Mean, Sd) UCL	48.43				99% Chebyshev(Mean, Sd) UCL		60.78
263												
264	Suggested UCL to Use											
265					95% Student's-t UCL	33.34						
266												
267	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
268	Recommendations are based upon data size, data distribution, and skewness.											
269	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
270	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
271												
272	Cadmium											
273												
274	General Statistics											
275					Total Number of Observations	22				Number of Distinct Observations		11
276					Number of Detects	9				Number of Non-Detects		13
277					Number of Distinct Detects	8				Number of Distinct Non-Detects		3
278					Minimum Detect	0.75				Minimum Non-Detect		0.48
279					Maximum Detect	6.8				Maximum Non-Detect		0.5
280					Variance Detects	3.649				Percent Non-Detects		59.09%
281					Mean Detects	1.823				SD Detects		1.91
282					Median Detects	1.3				CV Detects		1.048
283					Skewness Detects	2.746				Kurtosis Detects		7.854
284					Mean of Logged Detects	0.325				SD of Logged Detects		0.687
285												
286	Normal GOF Test on Detects Only											
287					Shapiro Wilk Test Statistic	0.584				Shapiro Wilk GOF Test		
288					5% Shapiro Wilk Critical Value	0.829				Detected Data Not Normal at 5% Significance Level		
289					Lilliefors Test Statistic	0.373				Lilliefors GOF Test		
290					5% Lilliefors Critical Value	0.274				Detected Data Not Normal at 5% Significance Level		
291	Detected Data Not Normal at 5% Significance Level											
292												
293	Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs											
294					KM Mean	1.03				KM Standard Error of Mean		0.3
295					KM SD	1.328				95% KM (BCA) UCL		1.577
296					95% KM (t) UCL	1.546				95% KM (Percentile Bootstrap) UCL		1.568
297					95% KM (z) UCL	1.523				95% KM Bootstrap t UCL		2.496
298					90% KM Chebyshev UCL	1.93				95% KM Chebyshev UCL		2.338
299					97.5% KM Chebyshev UCL	2.905				99% KM Chebyshev UCL		4.017

	A	B	C	D	E	F	G	H	I	J	K	L
300												
301	**Gamma GOF Tests on Detected Observations Only**											
302					A-D Test Statistic	0.98	**Anderson-Darling GOF Test**					
303					5% A-D Critical Value	0.73	Detected Data Not Gamma Distributed at 5% Significance Level					
304					K-S Test Statistic	0.272	**Kolmogorov-Smirnov GOF**					
305					5% K-S Critical Value	0.283	Detected data appear Gamma Distributed at 5% Significance Level					
306	**Detected data follow Appr. Gamma Distribution at 5% Significance Level**											
307												
308	**Gamma Statistics on Detected Data Only**											
309					k hat (MLE)	1.964	k star (bias corrected MLE)					1.383
310					Theta hat (MLE)	0.928	Theta star (bias corrected MLE)					1.318
311					nu hat (MLE)	35.35	nu star (bias corrected)					24.9
312					Mean (detects)	1.823						
313												
314	**Gamma ROS Statistics using Imputed Non-Detects**											
315	GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs											
316	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)											
317	For such situations, GROS method may yield incorrect values of UCLs and BTVs											
318	This is especially true when the sample size is small.											
319	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates											
320					Minimum	0.01	Mean					0.752
321					Maximum	6.8	Median					0.01
322					SD	1.491	CV					1.983
323					k hat (MLE)	0.299	k star (bias corrected MLE)					0.289
324					Theta hat (MLE)	2.51	Theta star (bias corrected MLE)					2.602
325					nu hat (MLE)	13.18	nu star (bias corrected)					12.71
326					Adjusted Level of Significance (β)	0.0386						
327					Approximate Chi Square Value (12.71, α)	5.701	Adjusted Chi Square Value (12.71, β)					5.353
328					95% Gamma Approximate UCL (use when n>=50)	1.677	95% Gamma Adjusted UCL (use when n<50)					1.786
329												
330	**Estimates of Gamma Parameters using KM Estimates**											
331					Mean (KM)	1.03	SD (KM)					1.328
332					Variance (KM)	1.763	SE of Mean (KM)					0.3
333					k hat (KM)	0.601	k star (KM)					0.55
334					nu hat (KM)	26.45	nu star (KM)					24.18
335					theta hat (KM)	1.712	theta star (KM)					1.873
336					80% gamma percentile (KM)	1.696	90% gamma percentile (KM)					2.73
337					95% gamma percentile (KM)	3.824	99% gamma percentile (KM)					6.489
338												
339	**Gamma Kaplan-Meier (KM) Statistics**											
340					Approximate Chi Square Value (24.18, α)	13.99	Adjusted Chi Square Value (24.18, β)					13.41
341					95% Gamma Approximate KM-UCL (use when n>=50)	1.78	95% Gamma Adjusted KM-UCL (use when n<50)					1.857
342												
343	**Lognormal GOF Test on Detected Observations Only**											
344					Shapiro Wilk Test Statistic	0.82	**Shapiro Wilk GOF Test**					
345					5% Shapiro Wilk Critical Value	0.829	Detected Data Not Lognormal at 5% Significance Level					
346					Lilliefors Test Statistic	0.211	**Lilliefors GOF Test**					
347					5% Lilliefors Critical Value	0.274	Detected Data appear Lognormal at 5% Significance Level					
348	**Detected Data appear Approximate Lognormal at 5% Significance Level**											
349												

	A	B	C	D	E	F	G	H	I	J	K	L
350	**Lognormal ROS Statistics Using Imputed Non-Detects**											
351					Mean in Original Scale	0.865					Mean in Log Scale	-0.913
352					SD in Original Scale	1.436					SD in Log Scale	1.234
353				95% t UCL (assumes normality of ROS data)		1.392					95% Percentile Bootstrap UCL	1.417
354					95% BCA Bootstrap UCL	1.751					95% Bootstrap t UCL	2.163
355					95% H-UCL (Log ROS)	1.888						
356												
357	**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**											
358					KM Mean (logged)	-0.301					KM Geo Mean	0.74
359					KM SD (logged)	0.665					95% Critical H Value (KM-Log)	2.164
360					KM Standard Error of Mean (logged)	0.15					95% H-UCL (KM -Log)	1.264
361					KM SD (logged)	0.665					95% Critical H Value (KM-Log)	2.164
362					KM Standard Error of Mean (logged)	0.15						
363												
364	**DL/2 Statistics**											
365				**DL/2 Normal**						**DL/2 Log-Transformed**		
366					Mean in Original Scale	0.891					Mean in Log Scale	-0.695
367					SD in Original Scale	1.421					SD in Log Scale	0.967
368					95% t UCL (Assumes normality)	1.413					95% H-Stat UCL	1.36
369	**DL/2 is not a recommended method, provided for comparisons and historical reasons**											
370												
371	**Nonparametric Distribution Free UCL Statistics**											
372	**Detected Data appear Approximate Gamma Distributed at 5% Significance Level**											
373												
374	**Suggested UCL to Use**											
375					95% KM Adjusted Gamma UCL	1.857					95% GROS Adjusted Gamma UCL	1.786
376												
377	When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test											
378	When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL											
379												
380	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
381	Recommendations are based upon data size, data distribution, and skewness.											
382	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
383	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
384												
385	**Chromium**											
386												
387	**General Statistics**											
388					Total Number of Observations	22					Number of Distinct Observations	7
389					Number of Detects	7					Number of Non-Detects	15
390					Number of Distinct Detects	6					Number of Distinct Non-Detects	2
391					Minimum Detect	2					Minimum Non-Detect	1.9
392					Maximum Detect	14					Maximum Non-Detect	2
393					Variance Detects	15.46					Percent Non-Detects	68.18%
394					Mean Detects	6.157					SD Detects	3.932
395					Median Detects	6.3					CV Detects	0.639
396					Skewness Detects	1.387					Kurtosis Detects	2.921
397					Mean of Logged Detects	1.644					SD of Logged Detects	0.653
398												

	A	B	C	D	E	F	G	H	I	J	K	L
399	**Normal GOF Test on Detects Only**											
400					Shapiro Wilk Test Statistic	0.836	**Shapiro Wilk GOF Test**					
401					5% Shapiro Wilk Critical Value	0.803	Detected Data appear Normal at 5% Significance Level					
402					Lilliefors Test Statistic	0.322	**Lilliefors GOF Test**					
403					5% Lilliefors Critical Value	0.304	Detected Data Not Normal at 5% Significance Level					
404	**Detected Data appear Approximate Normal at 5% Significance Level**											
405												
406	**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**											
407					KM Mean	3.255	KM Standard Error of Mean					0.657
408					KM SD	2.854	95% KM (BCA) UCL					4.532
409					95% KM (t) UCL	4.386	95% KM (Percentile Bootstrap) UCL					4.364
410					95% KM (z) UCL	4.336	95% KM Bootstrap t UCL					4.876
411					90% KM Chebyshev UCL	5.227	95% KM Chebyshev UCL					6.12
412					97.5% KM Chebyshev UCL	7.36	99% KM Chebyshev UCL					9.795
413												
414	**Gamma GOF Tests on Detected Observations Only**											
415					A-D Test Statistic	0.466	**Anderson-Darling GOF Test**					
416					5% A-D Critical Value	0.712	Detected data appear Gamma Distributed at 5% Significance Level					
417					K-S Test Statistic	0.244	**Kolmogorov-Smirnov GOF**					
418					5% K-S Critical Value	0.314	Detected data appear Gamma Distributed at 5% Significance Level					
419	**Detected data appear Gamma Distributed at 5% Significance Level**											
420												
421	**Gamma Statistics on Detected Data Only**											
422					k hat (MLE)	3.032	k star (bias corrected MLE)					1.828
423					Theta hat (MLE)	2.031	Theta star (bias corrected MLE)					3.369
424					nu hat (MLE)	42.45	nu star (bias corrected)					25.59
425					Mean (detects)	6.157						
426												
427	**Gamma ROS Statistics using Imputed Non-Detects**											
428	GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs											
429	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)											
430	For such situations, GROS method may yield incorrect values of UCLs and BTVs											
431	This is especially true when the sample size is small.											
432	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates											
433					Minimum	0.01	Mean					1.979
434					Maximum	14	Median					0.01
435					SD	3.599	CV					1.819
436					k hat (MLE)	0.229	k star (bias corrected MLE)					0.228
437					Theta hat (MLE)	8.64	Theta star (bias corrected MLE)					8.676
438					nu hat (MLE)	10.08	nu star (bias corrected)					10.04
439					Adjusted Level of Significance (β)	0.0386						
440					Approximate Chi Square Value (10.04, α)	3.965	Adjusted Chi Square Value (10.04, β)					3.684
441					95% Gamma Approximate UCL (use when n>=50)	5.01	95% Gamma Adjusted UCL (use when n<50)					5.393
442												
443	**Estimates of Gamma Parameters using KM Estimates**											
444					Mean (KM)	3.255	SD (KM)					2.854
445					Variance (KM)	8.148	SE of Mean (KM)					0.657
446					k hat (KM)	1.3	k star (KM)					1.153
447					nu hat (KM)	57.2	nu star (KM)					50.73
448					theta hat (KM)	2.504	theta star (KM)					2.823
449					80% gamma percentile (KM)	5.173	90% gamma percentile (KM)					7.235
450					95% gamma percentile (KM)	9.275	99% gamma percentile (KM)					13.96

	A	B	C	D	E	F	G	H	I	J	K	L
451												
452						Gamma Kaplan-Meier (KM) Statistics						
453					Approximate Chi Square Value (50.73, α)	35.38			Adjusted Chi Square Value (50.73, β)			34.42
454					95% Gamma Approximate KM-UCL (use when n>=50)	4.667			95% Gamma Adjusted KM-UCL (use when n<50)			4.797
455												
456						Lognormal GOF Test on Detected Observations Only						
457					Shapiro Wilk Test Statistic	0.905			Shapiro Wilk GOF Test			
458					5% Shapiro Wilk Critical Value	0.803			Detected Data appear Lognormal at 5% Significance Level			
459					Lilliefors Test Statistic	0.252			Lilliefors GOF Test			
460					5% Lilliefors Critical Value	0.304			Detected Data appear Lognormal at 5% Significance Level			
461						Detected Data appear Lognormal at 5% Significance Level						
462												
463						Lognormal ROS Statistics Using Imputed Non-Detects						
464					Mean in Original Scale	2.447			Mean in Log Scale			0.109
465					SD in Original Scale	3.364			SD in Log Scale			1.313
466					95% t UCL (assumes normality of ROS data)	3.681			95% Percentile Bootstrap UCL			3.722
467					95% BCA Bootstrap UCL	4.091			95% Bootstrap t UCL			4.331
468					95% H-UCL (Log ROS)	6.318						
469												
470						Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution						
471					KM Mean (logged)	0.961			KM Geo Mean			2.613
472					KM SD (logged)	0.578			95% Critical H Value (KM-Log)			2.072
473					KM Standard Error of Mean (logged)	0.133			95% H-UCL (KM -Log)			4.011
474					KM SD (logged)	0.578			95% Critical H Value (KM-Log)			2.072
475					KM Standard Error of Mean (logged)	0.133						
476												
477						DL/2 Statistics						
478					DL/2 Normal				DL/2 Log-Transformed			
479					Mean in Original Scale	2.634			Mean in Log Scale			0.516
480					SD in Original Scale	3.238			SD in Log Scale			0.862
481					95% t UCL (Assumes normality)	3.822			95% H-Stat UCL			3.817
482						DL/2 is not a recommended method, provided for comparisons and historical reasons						
483												
484						Nonparametric Distribution Free UCL Statistics						
485						Detected Data appear Approximate Normal Distributed at 5% Significance Level						
486												
487						Suggested UCL to Use						
488					95% KM (t) UCL	4.386						
489												
490						When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test						
491						When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL						
492												
493						Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.						
494						Recommendations are based upon data size, data distribution, and skewness.						
495						These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).						
496						However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.						
497												
498												

	A	B	C	D	E	F	G	H	I	J	K	L
499	Copper											
500												
501						General Statistics						
502					Total Number of Observations	22				Number of Distinct Observations		20
503										Number of Missing Observations		0
504					Minimum	240				Mean		3260
505					Maximum	22000				Median		2200
506					SD	4520				Std. Error of Mean		963.7
507					Coefficient of Variation	1.386				Skewness		3.658
508												
509						Normal GOF Test						
510					Shapiro Wilk Test Statistic	0.565				Shapiro Wilk GOF Test		
511					5% Shapiro Wilk Critical Value	0.911				Data Not Normal at 5% Significance Level		
512					Lilliefors Test Statistic	0.259				Lilliefors GOF Test		
513					5% Lilliefors Critical Value	0.184				Data Not Normal at 5% Significance Level		
514						Data Not Normal at 5% Significance Level						
515												
516						Assuming Normal Distribution						
517					95% Normal UCL					95% UCLs (Adjusted for Skewness)		
518					95% Student's-t UCL	4919				95% Adjusted-CLT UCL (Chen-1995)		5649
519										95% Modified-t UCL (Johnson-1978)		5044
520												
521						Gamma GOF Test						
522					A-D Test Statistic	0.48				Anderson-Darling Gamma GOF Test		
523					5% A-D Critical Value	0.77				Detected data appear Gamma Distributed at 5% Significance Level		
524					K-S Test Statistic	0.125				Kolmogorov-Smirnov Gamma GOF Test		
525					5% K-S Critical Value	0.191				Detected data appear Gamma Distributed at 5% Significance Level		
526						Detected data appear Gamma Distributed at 5% Significance Level						
527												
528						Gamma Statistics						
529					k hat (MLE)	1.017				k star (bias corrected MLE)		0.909
530					Theta hat (MLE)	3206				Theta star (bias corrected MLE)		3588
531					nu hat (MLE)	44.75				nu star (bias corrected)		39.98
532					MLE Mean (bias corrected)	3260				MLE Sd (bias corrected)		3421
533										Approximate Chi Square Value (0.05)		26.49
534					Adjusted Level of Significance	0.0386				Adjusted Chi Square Value		25.67
535												
536						Assuming Gamma Distribution						
537					95% Approximate Gamma UCL (use when n>=50)	4920				95% Adjusted Gamma UCL (use when n<50)		5077
538												
539						Lognormal GOF Test						
540					Shapiro Wilk Test Statistic	0.966				Shapiro Wilk Lognormal GOF Test		
541					5% Shapiro Wilk Critical Value	0.911				Data appear Lognormal at 5% Significance Level		
542					Lilliefors Test Statistic	0.102				Lilliefors Lognormal GOF Test		
543					5% Lilliefors Critical Value	0.184				Data appear Lognormal at 5% Significance Level		
544						Data appear Lognormal at 5% Significance Level						
545												
546						Lognormal Statistics						
547					Minimum of Logged Data	5.481				Mean of logged Data		7.523
548					Maximum of Logged Data	9.999				SD of logged Data		1.102
549												

	A	B	C	D	E	F	G	H	I	J	K	L
550	**Assuming Lognormal Distribution**											
551					95% H-UCL	6536				90% Chebyshev (MVUE) UCL		5886
552					95% Chebyshev (MVUE) UCL	7077				97.5% Chebyshev (MVUE) UCL		8730
553					99% Chebyshev (MVUE) UCL	11976						
554												
555	**Nonparametric Distribution Free UCL Statistics**											
556	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
557												
558	**Nonparametric Distribution Free UCLs**											
559					95% CLT UCL	4846				95% Jackknife UCL		4919
560					95% Standard Bootstrap UCL	4775				95% Bootstrap-t UCL		6883
561					95% Hall's Bootstrap UCL	11160				95% Percentile Bootstrap UCL		4947
562					95% BCA Bootstrap UCL	6208						
563					90% Chebyshev(Mean, Sd) UCL	6152				95% Chebyshev(Mean, Sd) UCL		7461
564					97.5% Chebyshev(Mean, Sd) UCL	9279				99% Chebyshev(Mean, Sd) UCL		12849
565												
566	**Suggested UCL to Use**											
567					95% Adjusted Gamma UCL	5077						
568												
569	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
570	Recommendations are based upon data size, data distribution, and skewness.											
571	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
572	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
573												
574												
575	**Lead**											
576												
577	**General Statistics**											
578					Total Number of Observations	22				Number of Distinct Observations		18
579										Number of Missing Observations		0
580					Minimum	5.7				Mean		36.15
581					Maximum	140				Median		22
582					SD	31.21				Std. Error of Mean		6.653
583					Coefficient of Variation	0.863				Skewness		1.858
584												
585	**Normal GOF Test**											
586					Shapiro Wilk Test Statistic	0.805				**Shapiro Wilk GOF Test**		
587					5% Shapiro Wilk Critical Value	0.911				Data Not Normal at 5% Significance Level		
588					Lilliefors Test Statistic	0.22				**Lilliefors GOF Test**		
589					5% Lilliefors Critical Value	0.184				Data Not Normal at 5% Significance Level		
590	**Data Not Normal at 5% Significance Level**											
591												
592	**Assuming Normal Distribution**											
593					**95% Normal UCL**					**95% UCLs (Adjusted for Skewness)**		
594					95% Student's-t UCL	47.6				95% Adjusted-CLT UCL (Chen-1995)		49.91
595										95% Modified-t UCL (Johnson-1978)		48.04
596												
597	**Gamma GOF Test**											
598					A-D Test Statistic	0.55				**Anderson-Darling Gamma GOF Test**		
599					5% A-D Critical Value	0.758				Detected data appear Gamma Distributed at 5% Significance Level		
600					K-S Test Statistic	0.174				**Kolmogorov-Smirnov Gamma GOF Test**		
601					5% K-S Critical Value	0.188				Detected data appear Gamma Distributed at 5% Significance Level		

	A	B	C	D	E	F	G	H	I	J	K	L
602	**Detected data appear Gamma Distributed at 5% Significance Level**											
603												
604	**Gamma Statistics**											
605					k hat (MLE)	1.691			k star (bias corrected MLE)			1.491
606					Theta hat (MLE)	21.38			Theta star (bias corrected MLE)			24.25
607					nu hat (MLE)	74.41			nu star (bias corrected)			65.6
608					MLE Mean (bias corrected)	36.15			MLE Sd (bias corrected)			29.61
609									Approximate Chi Square Value (0.05)			47.96
610					Adjusted Level of Significance	0.0386			Adjusted Chi Square Value			46.83
611												
612	**Assuming Gamma Distribution**											
613					95% Approximate Gamma UCL (use when n>=50)	49.44			95% Adjusted Gamma UCL (use when n<50)			50.63
614												
615	**Lognormal GOF Test**											
616					Shapiro Wilk Test Statistic	0.963			**Shapiro Wilk Lognormal GOF Test**			
617					5% Shapiro Wilk Critical Value	0.911			Data appear Lognormal at 5% Significance Level			
618					Lilliefors Test Statistic	0.149			**Lilliefors Lognormal GOF Test**			
619					5% Lilliefors Critical Value	0.184			Data appear Lognormal at 5% Significance Level			
620	**Data appear Lognormal at 5% Significance Level**											
621												
622	**Lognormal Statistics**											
623					Minimum of Logged Data	1.74			Mean of logged Data			3.264
624					Maximum of Logged Data	4.942			SD of logged Data			0.836
625												
626	**Assuming Lognormal Distribution**											
627					95% H-UCL	57.06			90% Chebyshev (MVUE) UCL			57.58
628					95% Chebyshev (MVUE) UCL	67.21			97.5% Chebyshev (MVUE) UCL			80.58
629					99% Chebyshev (MVUE) UCL	106.8						
630												
631	**Nonparametric Distribution Free UCL Statistics**											
632	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
633												
634	**Nonparametric Distribution Free UCLs**											
635					95% CLT UCL	47.09			95% Jackknife UCL			47.6
636					95% Standard Bootstrap UCL	47			95% Bootstrap-t UCL			52.24
637					95% Hall's Bootstrap UCL	57.15			95% Percentile Bootstrap UCL			47.55
638					95% BCA Bootstrap UCL	49.47						
639					90% Chebyshev(Mean, Sd) UCL	56.11			95% Chebyshev(Mean, Sd) UCL			65.15
640					97.5% Chebyshev(Mean, Sd) UCL	77.7			99% Chebyshev(Mean, Sd) UCL			102.3
641												
642	**Suggested UCL to Use**											
643					95% Adjusted Gamma UCL	50.63						
644												
645	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
646	Recommendations are based upon data size, data distribution, and skewness.											
647	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
648	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
649												
650												

	A	B	C	D	E	F	G	H	I	J	K	L
651	**Manganese**											
652												
653						**General Statistics**						
654					Total Number of Observations	22				Number of Distinct Observations		20
655										Number of Missing Observations		0
656					Minimum	150				Mean		623.6
657					Maximum	2400				Median		395
658					SD	519.3				Std. Error of Mean		110.7
659					Coefficient of Variation	0.833				Skewness		2.113
660												
661						**Normal GOF Test**						
662					Shapiro Wilk Test Statistic	0.771				**Shapiro Wilk GOF Test**		
663					5% Shapiro Wilk Critical Value	0.911				Data Not Normal at 5% Significance Level		
664					Lilliefors Test Statistic	0.212				**Lilliefors GOF Test**		
665					5% Lilliefors Critical Value	0.184				Data Not Normal at 5% Significance Level		
666						**Data Not Normal at 5% Significance Level**						
667												
668						**Assuming Normal Distribution**						
669					**95% Normal UCL**					**95% UCLs (Adjusted for Skewness)**		
670					95% Student's-t UCL	814.2				95% Adjusted-CLT UCL (Chen-1995)		859.1
671										95% Modified-t UCL (Johnson-1978)		822.5
672												
673						**Gamma GOF Test**						
674					A-D Test Statistic	0.636				**Anderson-Darling Gamma GOF Test**		
675					5% A-D Critical Value	0.755				Detected data appear Gamma Distributed at 5% Significance Level		
676					K-S Test Statistic	0.186				**Kolmogorov-Smirnov Gamma GOF Test**		
677					5% K-S Critical Value	0.188				Detected data appear Gamma Distributed at 5% Significance Level		
678						**Detected data appear Gamma Distributed at 5% Significance Level**						
679												
680						**Gamma Statistics**						
681					k hat (MLE)	2.096				k star (bias corrected MLE)		1.841
682					Theta hat (MLE)	297.5				Theta star (bias corrected MLE)		338.8
683					nu hat (MLE)	92.23				nu star (bias corrected)		80.98
684					MLE Mean (bias corrected)	623.6				MLE Sd (bias corrected)		459.7
685										Approximate Chi Square Value (0.05)		61.25
686					Adjusted Level of Significance	0.0386				Adjusted Chi Square Value		59.97
687												
688						**Assuming Gamma Distribution**						
689					95% Approximate Gamma UCL (use when n>=50)	824.6				95% Adjusted Gamma UCL (use when n<50)		842.2
690												
691						**Lognormal GOF Test**						
692					Shapiro Wilk Test Statistic	0.959				**Shapiro Wilk Lognormal GOF Test**		
693					5% Shapiro Wilk Critical Value	0.911				Data appear Lognormal at 5% Significance Level		
694					Lilliefors Test Statistic	0.149				**Lilliefors Lognormal GOF Test**		
695					5% Lilliefors Critical Value	0.184				Data appear Lognormal at 5% Significance Level		
696						**Data appear Lognormal at 5% Significance Level**						
697												
698						**Lognormal Statistics**						
699					Minimum of Logged Data	5.011				Mean of logged Data		6.178
700					Maximum of Logged Data	7.783				SD of logged Data		0.71
701												

	A	B	C	D	E	F	G	H	I	J	K	L
702	**Assuming Lognormal Distribution**											
703					95% H-UCL	874			90% Chebyshev (MVUE) UCL			909.6
704					95% Chebyshev (MVUE) UCL	1044			97.5% Chebyshev (MVUE) UCL			1232
705					99% Chebyshev (MVUE) UCL	1600						
706												
707	**Nonparametric Distribution Free UCL Statistics**											
708	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
709												
710	**Nonparametric Distribution Free UCLs**											
711					95% CLT UCL	805.8			95% Jackknife UCL			814.2
712					95% Standard Bootstrap UCL	807			95% Bootstrap-t UCL			902.4
713					95% Hall's Bootstrap UCL	1007			95% Percentile Bootstrap UCL			823.6
714					95% BCA Bootstrap UCL	866.8						
715					90% Chebyshev(Mean, Sd) UCL	955.8			95% Chebyshev(Mean, Sd) UCL			1106
716					97.5% Chebyshev(Mean, Sd) UCL	1315			99% Chebyshev(Mean, Sd) UCL			1725
717												
718	**Suggested UCL to Use**											
719					95% Adjusted Gamma UCL	842.2						
720												
721	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
722	Recommendations are based upon data size, data distribution, and skewness.											
723	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
724	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
725												
726												
727	**Mercury**											
728												
729	**General Statistics**											
730					Total Number of Observations	22			Number of Distinct Observations			20
731									Number of Missing Observations			0
732					Minimum	0.14			Mean			0.942
733					Maximum	2.7			Median			0.625
734					SD	0.793			Std. Error of Mean			0.169
735					Coefficient of Variation	0.842			Skewness			1.025
736												
737	**Normal GOF Test**											
738					Shapiro Wilk Test Statistic	0.843			**Shapiro Wilk GOF Test**			
739					5% Shapiro Wilk Critical Value	0.911			Data Not Normal at 5% Significance Level			
740					Lilliefors Test Statistic	0.217			**Lilliefors GOF Test**			
741					5% Lilliefors Critical Value	0.184			Data Not Normal at 5% Significance Level			
742	**Data Not Normal at 5% Significance Level**											
743												
744	**Assuming Normal Distribution**											
745					**95% Normal UCL**				**95% UCLs (Adjusted for Skewness)**			
746					95% Student's-t UCL	1.233			95% Adjusted-CLT UCL (Chen-1995)			1.26
747									95% Modified-t UCL (Johnson-1978)			1.239
748												
749	**Gamma GOF Test**											
750					A-D Test Statistic	0.492			**Anderson-Darling Gamma GOF Test**			
751					5% A-D Critical Value	0.758			Detected data appear Gamma Distributed at 5% Significance Level			
752					K-S Test Statistic	0.13			**Kolmogorov-Smirnov Gamma GOF Test**			
753					5% K-S Critical Value	0.188			Detected data appear Gamma Distributed at 5% Significance Level			

	A	B	C	D	E	F	G	H	I	J	K	L
754	**Detected data appear Gamma Distributed at 5% Significance Level**											
755												
756	**Gamma Statistics**											
757					k hat (MLE)	1.554			k star (bias corrected MLE)			1.372
758					Theta hat (MLE)	0.606			Theta star (bias corrected MLE)			0.687
759					nu hat (MLE)	68.38			nu star (bias corrected)			60.39
760					MLE Mean (bias corrected)	0.942			MLE Sd (bias corrected)			0.804
761									Approximate Chi Square Value (0.05)			43.52
762					Adjusted Level of Significance	0.0386			Adjusted Chi Square Value			42.45
763												
764	**Assuming Gamma Distribution**											
765				95% Approximate Gamma UCL (use when n>=50)		1.308			95% Adjusted Gamma UCL (use when n<50)			1.34
766												
767	**Lognormal GOF Test**											
768					Shapiro Wilk Test Statistic	0.958			**Shapiro Wilk Lognormal GOF Test**			
769					5% Shapiro Wilk Critical Value	0.911			Data appear Lognormal at 5% Significance Level			
770					Lilliefors Test Statistic	0.109			**Lilliefors Lognormal GOF Test**			
771					5% Lilliefors Critical Value	0.184			Data appear Lognormal at 5% Significance Level			
772	**Data appear Lognormal at 5% Significance Level**											
773												
774	**Lognormal Statistics**											
775					Minimum of Logged Data	-1.966			Mean of logged Data			-0.414
776					Maximum of Logged Data	0.993			SD of logged Data			0.891
777												
778	**Assuming Lognormal Distribution**											
779					95% H-UCL	1.578			90% Chebyshev (MVUE) UCL			1.564
780					95% Chebyshev (MVUE) UCL	1.838			97.5% Chebyshev (MVUE) UCL			2.218
781					99% Chebyshev (MVUE) UCL	2.965						
782												
783	**Nonparametric Distribution Free UCL Statistics**											
784	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
785												
786	**Nonparametric Distribution Free UCLs**											
787					95% CLT UCL	1.22			95% Jackknife UCL			1.233
788					95% Standard Bootstrap UCL	1.213			95% Bootstrap-t UCL			1.294
789					95% Hall's Bootstrap UCL	1.242			95% Percentile Bootstrap UCL			1.211
790					95% BCA Bootstrap UCL	1.25						
791					90% Chebyshev(Mean, Sd) UCL	1.45			95% Chebyshev(Mean, Sd) UCL			1.679
792					97.5% Chebyshev(Mean, Sd) UCL	1.998			99% Chebyshev(Mean, Sd) UCL			2.625
793												
794	**Suggested UCL to Use**											
795					95% Adjusted Gamma UCL	1.34						
796												
797	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
798	Recommendations are based upon data size, data distribution, and skewness.											
799	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
800	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
801												

	A	B	C	D	E	F	G	H	I	J	K	L
802	Nickel											
803												
804	General Statistics											
805					Total Number of Observations	22				Number of Distinct Observations		11
806					Number of Detects	9				Number of Non-Detects		13
807					Number of Distinct Detects	9				Number of Distinct Non-Detects		2
808					Minimum Detect	2.1				Minimum Non-Detect		1.9
809					Maximum Detect	14				Maximum Non-Detect		2
810					Variance Detects	14.48				Percent Non-Detects		59.09%
811					Mean Detects	4.756				SD Detects		3.805
812					Median Detects	3.7				CV Detects		0.8
813					Skewness Detects	2.182				Kurtosis Detects		4.98
814					Mean of Logged Detects	1.36				SD of Logged Detects		0.619
815												
816	Normal GOF Test on Detects Only											
817					Shapiro Wilk Test Statistic	0.715	Shapiro Wilk GOF Test					
818					5% Shapiro Wilk Critical Value	0.829	Detected Data Not Normal at 5% Significance Level					
819					Lilliefors Test Statistic	0.325	Lilliefors GOF Test					
820					5% Lilliefors Critical Value	0.274	Detected Data Not Normal at 5% Significance Level					
821	Detected Data Not Normal at 5% Significance Level											
822												
823	Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs											
824					KM Mean	3.068				KM Standard Error of Mean		0.608
825					KM SD	2.69				95% KM (BCA) UCL		4.177
826					95% KM (t) UCL	4.115				95% KM (Percentile Bootstrap) UCL		4.195
827					95% KM (z) UCL	4.069				95% KM Bootstrap t UCL		6.08
828					90% KM Chebyshev UCL	4.893				95% KM Chebyshev UCL		5.72
829					97.5% KM Chebyshev UCL	6.867				99% KM Chebyshev UCL		9.121
830												
831	Gamma GOF Tests on Detected Observations Only											
832					A-D Test Statistic	0.645	Anderson-Darling GOF Test					
833					5% A-D Critical Value	0.728	Detected data appear Gamma Distributed at 5% Significance Level					
834					K-S Test Statistic	0.259	Kolmogorov-Smirnov GOF					
835					5% K-S Critical Value	0.282	Detected data appear Gamma Distributed at 5% Significance Level					
836	Detected data appear Gamma Distributed at 5% Significance Level											
837												
838	Gamma Statistics on Detected Data Only											
839					k hat (MLE)	2.658				k star (bias corrected MLE)		1.846
840					Theta hat (MLE)	1.789				Theta star (bias corrected MLE)		2.576
841					nu hat (MLE)	47.84				nu star (bias corrected)		33.22
842					Mean (detects)	4.756						
843												
844	Gamma ROS Statistics using Imputed Non-Detects											
845	GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs											
846	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)											
847	For such situations, GROS method may yield incorrect values of UCLs and BTVs											
848	This is especially true when the sample size is small.											
849	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates											
850					Minimum	0.01				Mean		1.951
851					Maximum	14				Median		0.01
852					SD	3.35				CV		1.717
853					k hat (MLE)	0.251				k star (bias corrected MLE)		0.247

	A	B	C	D	E	F	G	H	I	J	K	L
854					Theta hat (MLE)	7.788					Theta star (bias corrected MLE)	7.91
855					nu hat (MLE)	11.03					nu star (bias corrected)	10.86
856					Adjusted Level of Significance (β)	0.0386						
857					Approximate Chi Square Value (10.86, α)	4.483					Adjusted Chi Square Value (10.86, β)	4.181
858					95% Gamma Approximate UCL (use when n>=50)	4.725					95% Gamma Adjusted UCL (use when n<50)	5.067
859												
860					**Estimates of Gamma Parameters using KM Estimates**							
861					Mean (KM)	3.068					SD (KM)	2.69
862					Variance (KM)	7.237					SE of Mean (KM)	0.608
863					k hat (KM)	1.301					k star (KM)	1.154
864					nu hat (KM)	57.24					nu star (KM)	50.76
865					theta hat (KM)	2.359					theta star (KM)	2.659
866					80% gamma percentile (KM)	4.876					90% gamma percentile (KM)	6.82
867					95% gamma percentile (KM)	8.742					99% gamma percentile (KM)	13.16
868												
869					**Gamma Kaplan-Meier (KM) Statistics**							
870					Approximate Chi Square Value (50.76, α)	35.4					Adjusted Chi Square Value (50.76, β)	34.45
871					95% Gamma Approximate KM-UCL (use when n>=50)	4.399					95% Gamma Adjusted KM-UCL (use when n<50)	4.522
872												
873					**Lognormal GOF Test on Detected Observations Only**							
874					Shapiro Wilk Test Statistic	0.885			**Shapiro Wilk GOF Test**			
875					5% Shapiro Wilk Critical Value	0.829			Detected Data appear Lognormal at 5% Significance Level			
876					Lilliefors Test Statistic	0.214			**Lilliefors GOF Test**			
877					5% Lilliefors Critical Value	0.274			Detected Data appear Lognormal at 5% Significance Level			
878					**Detected Data appear Lognormal at 5% Significance Level**							
879												
880					**Lognormal ROS Statistics Using Imputed Non-Detects**							
881					Mean in Original Scale	2.327					Mean in Log Scale	0.192
882					SD in Original Scale	3.142					SD in Log Scale	1.176
883					95% t UCL (assumes normality of ROS data)	3.479					95% Percentile Bootstrap UCL	3.434
884					95% BCA Bootstrap UCL	3.858					95% Bootstrap t UCL	4.608
885					95% H-UCL (Log ROS)	5.004						
886												
887					**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**							
888					KM Mean (logged)	0.935					KM Geo Mean	2.548
889					KM SD (logged)	0.514					95% Critical H Value (KM-Log)	2.01
890					KM Standard Error of Mean (logged)	0.116					95% H-UCL (KM -Log)	3.642
891					KM SD (logged)	0.514					95% Critical H Value (KM-Log)	2.01
892					KM Standard Error of Mean (logged)	0.116						
893												
894					**DL/2 Statistics**							
895					**DL/2 Normal**				**DL/2 Log-Transformed**			
896					Mean in Original Scale	2.527					Mean in Log Scale	0.547
897					SD in Original Scale	3.02					SD in Log Scale	0.791
898					95% t UCL (Assumes normality)	3.635					95% H-Stat UCL	3.518
899					**DL/2 is not a recommended method, provided for comparisons and historical reasons**							
900												
901					**Nonparametric Distribution Free UCL Statistics**							
902					**Detected Data appear Gamma Distributed at 5% Significance Level**							
903												
904					**Suggested UCL to Use**							
905					95% KM Adjusted Gamma UCL	4.522					95% GROS Adjusted Gamma UCL	5.067

	A	B	C	D	E	F	G	H	I	J	K	L
906												
907	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
908	Recommendations are based upon data size, data distribution, and skewness.											
909	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
910	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
911												
912												
913	**Selenium**											
914												
915	**General Statistics**											
916					Total Number of Observations	22			Number of Distinct Observations			21
917									Number of Missing Observations			0
918					Minimum	5.4			Mean			30.47
919					Maximum	77			Median			20.5
920					SD	20.63			Std. Error of Mean			4.398
921					Coefficient of Variation	0.677			Skewness			0.943
922												
923	**Normal GOF Test**											
924					Shapiro Wilk Test Statistic	0.888			**Shapiro Wilk GOF Test**			
925					5% Shapiro Wilk Critical Value	0.911			Data Not Normal at 5% Significance Level			
926					Lilliefors Test Statistic	0.222			**Lilliefors GOF Test**			
927					5% Lilliefors Critical Value	0.184			Data Not Normal at 5% Significance Level			
928	**Data Not Normal at 5% Significance Level**											
929												
930	**Assuming Normal Distribution**											
931					**95% Normal UCL**				**95% UCLs (Adjusted for Skewness)**			
932					95% Student's-t UCL	38.04			95% Adjusted-CLT UCL (Chen-1995)			38.65
933									95% Modified-t UCL (Johnson-1978)			38.19
934												
935	**Gamma GOF Test**											
936					A-D Test Statistic	0.414			**Anderson-Darling Gamma GOF Test**			
937					5% A-D Critical Value	0.754			Detected data appear Gamma Distributed at 5% Significance Level			
938					K-S Test Statistic	0.17			**Kolmogorov-Smirnov Gamma GOF Test**			
939					5% K-S Critical Value	0.187			Detected data appear Gamma Distributed at 5% Significance Level			
940	**Detected data appear Gamma Distributed at 5% Significance Level**											
941												
942	**Gamma Statistics**											
943					k hat (MLE)	2.388			k star (bias corrected MLE)			2.093
944					Theta hat (MLE)	12.76			Theta star (bias corrected MLE)			14.56
945					nu hat (MLE)	105.1			nu star (bias corrected)			92.09
946					MLE Mean (bias corrected)	30.47			MLE Sd (bias corrected)			21.06
947									Approximate Chi Square Value (0.05)			70.96
948					Adjusted Level of Significance	0.0386			Adjusted Chi Square Value			69.58
949												
950	**Assuming Gamma Distribution**											
951					95% Approximate Gamma UCL (use when n>=50)	39.55			95% Adjusted Gamma UCL (use when n<50)			40.33
952												
953	**Lognormal GOF Test**											
954					Shapiro Wilk Test Statistic	0.97			**Shapiro Wilk Lognormal GOF Test**			
955					5% Shapiro Wilk Critical Value	0.911			Data appear Lognormal at 5% Significance Level			
956					Lilliefors Test Statistic	0.129			**Lilliefors Lognormal GOF Test**			
957					5% Lilliefors Critical Value	0.184			Data appear Lognormal at 5% Significance Level			

	A	B	C	D	E	F	G	H	I	J	K	L
958	Data appear Lognormal at 5% Significance Level											
959												
960	Lognormal Statistics											
961					Minimum of Logged Data	1.686				Mean of logged Data		3.193
962					Maximum of Logged Data	4.344				SD of logged Data		0.702
963												
964	Assuming Lognormal Distribution											
965					95% H-UCL	43.71				90% Chebyshev (MVUE) UCL		45.55
966					95% Chebyshev (MVUE) UCL	52.26				97.5% Chebyshev (MVUE) UCL		61.56
967					99% Chebyshev (MVUE) UCL	79.83						
968												
969	Nonparametric Distribution Free UCL Statistics											
970	Data appear to follow a Discernible Distribution at 5% Significance Level											
971												
972	Nonparametric Distribution Free UCLs											
973					95% CLT UCL	37.71				95% Jackknife UCL		38.04
974					95% Standard Bootstrap UCL	37.8				95% Bootstrap-t UCL		39.7
975					95% Hall's Bootstrap UCL	38.44				95% Percentile Bootstrap UCL		37.7
976					95% BCA Bootstrap UCL	38.09						
977					90% Chebyshev(Mean, Sd) UCL	43.67				95% Chebyshev(Mean, Sd) UCL		49.64
978					97.5% Chebyshev(Mean, Sd) UCL	57.94				99% Chebyshev(Mean, Sd) UCL		74.23
979												
980	Suggested UCL to Use											
981					95% Adjusted Gamma UCL	40.33						
982												
983	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
984	Recommendations are based upon data size, data distribution, and skewness.											
985	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
986	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
987												
988	Silver											
989												
990	General Statistics											
991					Total Number of Observations	22				Number of Distinct Observations		15
992					Number of Detects	13				Number of Non-Detects		9
993					Number of Distinct Detects	13				Number of Distinct Non-Detects		2
994					Minimum Detect	3				Minimum Non-Detect		2.4
995					Maximum Detect	20				Maximum Non-Detect		2.5
996					Variance Detects	30.03				Percent Non-Detects		40.91%
997					Mean Detects	8.377				SD Detects		5.48
998					Median Detects	5.2				CV Detects		0.654
999					Skewness Detects	0.987				Kurtosis Detects		-0.0592
1000					Mean of Logged Detects	1.936				SD of Logged Detects		0.637
1001												
1002	Normal GOF Test on Detects Only											
1003					Shapiro Wilk Test Statistic	0.866				Shapiro Wilk GOF Test		
1004					5% Shapiro Wilk Critical Value	0.866				Detected Data appear Normal at 5% Significance Level		
1005					Lilliefors Test Statistic	0.257				Lilliefors GOF Test		
1006					5% Lilliefors Critical Value	0.234				Detected Data Not Normal at 5% Significance Level		
1007	Detected Data appear Approximate Normal at 5% Significance Level											
1008												

	A	B	C	D	E	F	G	H	I	J	K	L
1009	**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**											
1010					KM Mean	5.932				KM Standard Error of Mean		1.11
1011					KM SD	5.001				95% KM (BCA) UCL		7.768
1012					95% KM (t) UCL	7.842				95% KM (Percentile Bootstrap) UCL		7.877
1013					95% KM (z) UCL	7.757				95% KM Bootstrap t UCL		8.665
1014					90% KM Chebyshev UCL	9.261				95% KM Chebyshev UCL		10.77
1015					97.5% KM Chebyshev UCL	12.86				99% KM Chebyshev UCL		16.97
1016												
1017	**Gamma GOF Tests on Detected Observations Only**											
1018					A-D Test Statistic	0.527	**Anderson-Darling GOF Test**					
1019					5% A-D Critical Value	0.74	Detected data appear Gamma Distributed at 5% Significance Level					
1020					K-S Test Statistic	0.241	**Kolmogorov-Smirnov GOF**					
1021					5% K-S Critical Value	0.238	Detected Data Not Gamma Distributed at 5% Significance Level					
1022	**Detected data follow Appr. Gamma Distribution at 5% Significance Level**											
1023												
1024	**Gamma Statistics on Detected Data Only**											
1025					k hat (MLE)	2.791				k star (bias corrected MLE)		2.199
1026					Theta hat (MLE)	3.001				Theta star (bias corrected MLE)		3.81
1027					nu hat (MLE)	72.58				nu star (bias corrected)		57.16
1028					Mean (detects)	8.377						
1029												
1030	**Gamma ROS Statistics using Imputed Non-Detects**											
1031	GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs											
1032	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)											
1033	For such situations, GROS method may yield incorrect values of UCLs and BTVs											
1034	This is especially true when the sample size is small.											
1035	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates											
1036					Minimum	0.01				Mean		4.961
1037					Maximum	20				Median		3.45
1038					SD	5.9				CV		1.189
1039					k hat (MLE)	0.31				k star (bias corrected MLE)		0.298
1040					Theta hat (MLE)	16.01				Theta star (bias corrected MLE)		16.65
1041					nu hat (MLE)	13.63				nu star (bias corrected)		13.11
1042					Adjusted Level of Significance (β)	0.0386						
1043					Approximate Chi Square Value (13.11, α)	5.965				Adjusted Chi Square Value (13.11, β)		5.607
1044					95% Gamma Approximate UCL (use when n>=50)	10.9				95% Gamma Adjusted UCL (use when n<50)		11.6
1045												
1046	**Estimates of Gamma Parameters using KM Estimates**											
1047					Mean (KM)	5.932				SD (KM)		5.001
1048					Variance (KM)	25.01				SE of Mean (KM)		1.11
1049					k hat (KM)	1.407				k star (KM)		1.245
1050					nu hat (KM)	61.9				nu star (KM)		54.79
1051					theta hat (KM)	4.217				theta star (KM)		4.764
1052					80% gamma percentile (KM)	9.358				90% gamma percentile (KM)		12.94
1053					95% gamma percentile (KM)	16.46				99% gamma percentile (KM)		24.51
1054												
1055	**Gamma Kaplan-Meier (KM) Statistics**											
1056					Approximate Chi Square Value (54.79, α)	38.78				Adjusted Chi Square Value (54.79, β)		37.77
1057					95% Gamma Approximate KM-UCL (use when n>=50)	8.381				95% Gamma Adjusted KM-UCL (use when n<50)		8.604
1058												

	A	B	C	D	E	F	G	H	I	J	K	L
1059	Lognormal GOF Test on Detected Observations Only											
1060					Shapiro Wilk Test Statistic	0.924	Shapiro Wilk GOF Test					
1061					5% Shapiro Wilk Critical Value	0.866	Detected Data appear Lognormal at 5% Significance Level					
1062					Lilliefors Test Statistic	0.212	Lilliefors GOF Test					
1063					5% Lilliefors Critical Value	0.234	Detected Data appear Lognormal at 5% Significance Level					
1064	Detected Data appear Lognormal at 5% Significance Level											
1065												
1066	Lognormal ROS Statistics Using Imputed Non-Detects											
1067					Mean in Original Scale	5.524				Mean in Log Scale		1.25
1068					SD in Original Scale	5.44				SD in Log Scale		1.007
1069					95% t UCL (assumes normality of ROS data)	7.52				95% Percentile Bootstrap UCL		7.578
1070					95% BCA Bootstrap UCL	7.75				95% Bootstrap t UCL		8.23
1071					95% H-UCL (Log ROS)	10.26						
1072												
1073	Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution											
1074					KM Mean (logged)	1.502				KM Geo Mean		4.491
1075					KM SD (logged)	0.702				95% Critical H Value (KM-Log)		2.205
1076					KM Standard Error of Mean (logged)	0.156				95% H-UCL (KM -Log)		8.056
1077					KM SD (logged)	0.702				95% Critical H Value (KM-Log)		2.205
1078					KM Standard Error of Mean (logged)	0.156						
1079												
1080	DL/2 Statistics											
1081			DL/2 Normal							DL/2 Log-Transformed		
1082					Mean in Original Scale	5.452				Mean in Log Scale		1.228
1083					SD in Original Scale	5.486				SD in Log Scale		0.995
1084					95% t UCL (Assumes normality)	7.465				95% H-Stat UCL		9.802
1085	DL/2 is not a recommended method, provided for comparisons and historical reasons											
1086												
1087	Nonparametric Distribution Free UCL Statistics											
1088	Detected Data appear Approximate Normal Distributed at 5% Significance Level											
1089												
1090	Suggested UCL to Use											
1091					95% KM (t) UCL	7.842						
1092												
1093	When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test											
1094	When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL											
1095												
1096	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
1097	Recommendations are based upon data size, data distribution, and skewness.											
1098	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
1099	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
1100												
1101												

	A	B	C	D	E	F	G	H	I	J	K	L
1102	Zinc											
1103												
1104						General Statistics						
1105					Total Number of Observations	22				Number of Distinct Observations		19
1106										Number of Missing Observations		0
1107					Minimum	57				Mean		304.7
1108					Maximum	1800				Median		235
1109					SD	356.8				Std. Error of Mean		76.08
1110					Coefficient of Variation	1.171				Skewness		3.807
1111												
1112						Normal GOF Test						
1113					Shapiro Wilk Test Statistic	0.535				Shapiro Wilk GOF Test		
1114					5% Shapiro Wilk Critical Value	0.911				Data Not Normal at 5% Significance Level		
1115					Lilliefors Test Statistic	0.313				Lilliefors GOF Test		
1116					5% Lilliefors Critical Value	0.184				Data Not Normal at 5% Significance Level		
1117						Data Not Normal at 5% Significance Level						
1118												
1119						Assuming Normal Distribution						
1120					95% Normal UCL					95% UCLs (Adjusted for Skewness)		
1121					95% Student's-t UCL	435.6				95% Adjusted-CLT UCL (Chen-1995)		495.8
1122										95% Modified-t UCL (Johnson-1978)		445.9
1123												
1124						Gamma GOF Test						
1125					A-D Test Statistic	0.954				Anderson-Darling Gamma GOF Test		
1126					5% A-D Critical Value	0.758				Data Not Gamma Distributed at 5% Significance Level		
1127					K-S Test Statistic	0.194				Kolmogorov-Smirnov Gamma GOF Test		
1128					5% K-S Critical Value	0.188				Data Not Gamma Distributed at 5% Significance Level		
1129						Data Not Gamma Distributed at 5% Significance Level						
1130												
1131						Gamma Statistics						
1132					k hat (MLE)	1.726				k star (bias corrected MLE)		1.521
1133					Theta hat (MLE)	176.5				Theta star (bias corrected MLE)		200.4
1134					nu hat (MLE)	75.93				nu star (bias corrected)		66.91
1135					MLE Mean (bias corrected)	304.7				MLE Sd (bias corrected)		247.1
1136										Approximate Chi Square Value (0.05)		49.09
1137					Adjusted Level of Significance	0.0386				Adjusted Chi Square Value		47.95
1138												
1139						Assuming Gamma Distribution						
1140					95% Approximate Gamma UCL (use when n>=50))	415.3				95% Adjusted Gamma UCL (use when n<50)		425.2
1141												
1142						Lognormal GOF Test						
1143					Shapiro Wilk Test Statistic	0.948				Shapiro Wilk Lognormal GOF Test		
1144					5% Shapiro Wilk Critical Value	0.911				Data appear Lognormal at 5% Significance Level		
1145					Lilliefors Test Statistic	0.131				Lilliefors Lognormal GOF Test		
1146					5% Lilliefors Critical Value	0.184				Data appear Lognormal at 5% Significance Level		
1147						Data appear Lognormal at 5% Significance Level						
1148												
1149						Lognormal Statistics						
1150					Minimum of Logged Data	4.043				Mean of logged Data		5.402
1151					Maximum of Logged Data	7.496				SD of logged Data		0.735
1152												

	A	B	C	D	E	F	G	H	I	J	K	L
1153					Assuming Lognormal Distribution							
1154					95% H-UCL	416.6				90% Chebyshev (MVUE) UCL		431.3
1155				95% Chebyshev (MVUE) UCL		497				97.5% Chebyshev (MVUE) UCL		588.1
1156				99% Chebyshev (MVUE) UCL		767.2						
1157												
1158					Nonparametric Distribution Free UCL Statistics							
1159					Data appear to follow a Discernible Distribution at 5% Significance Level							
1160												
1161					Nonparametric Distribution Free UCLs							
1162					95% CLT UCL	429.8				95% Jackknife UCL		435.6
1163				95% Standard Bootstrap UCL		427.1				95% Bootstrap-t UCL		651.9
1164				95% Hall's Bootstrap UCL		938.9				95% Percentile Bootstrap UCL		446.8
1165				95% BCA Bootstrap UCL		526.7						
1166				90% Chebyshev(Mean, Sd) UCL		532.9				95% Chebyshev(Mean, Sd) UCL		636.3
1167				97.5% Chebyshev(Mean, Sd) UCL		779.8				99% Chebyshev(Mean, Sd) UCL		1062
1168												
1169					Suggested UCL to Use							
1170					95% H-UCL	416.6						
1171												
1172					Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.							
1173					Recommendations are based upon data size, data distribution, and skewness.							
1174					These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).							
1175					However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.							
1176												
1177					ProUCL computes and outputs H-statistic based UCLs for historical reasons only.							
1178					H-statistic often results in unstable (both high and low) values of UCL95 as shown in examples in the Technical Guide.							
1179					It is therefore recommended to avoid the use of H-statistic based 95% UCLs.							
1180					Use of nonparametric methods are preferred to compute UCL95 for skewed data sets which do not follow a gamma distribution.							
1181												

	A	B	C	D	E	F	G	H	I	J	K	L	M
1				General Statistics on Uncensored Data									
2			Date/Time of Computation	ProUCL 5.110/17/2019 3:08:45 PM									
3			User Selected Options										
4			From File	ProUCL Input 3_EA2_rev083019.xls									
5			Full Precision	OFF									
6													
7	From File: ProUCL Input 3_EA2_rev083019.xls												
8													
9	General Statistics for Censored Data Set (with NDs) using Kaplan Meier Method												
10													
11	Variable		NumObs	# Missing	Num Ds	NumNDs	% NDs	Min ND	Max ND	KM Mean	KM Var	KM SD	KM CV
12	Antimony		14	0	8	6	42.86%	4.9	5	16.25	200.8	14.17	0.872
13	Arsenic		14	0	14	0	0.00%	N/A	N/A	203.1	20684	143.8	0.708
14	Barium		14	0	11	3	21.43%	4.9	99	67.44	5022	70.87	1.051
15	Cadmium		14	0	8	6	42.86%	0.49	0.5	5.566	272.1	16.49	2.964
16	Chromium		14	0	10	4	28.57%	2	200	10.93	67.4	8.21	0.751
17	Copper		14	0	14	0	0.00%	N/A	N/A	7977	61489776	7842	0.983
18	Lead		14	0	14	0	0.00%	N/A	N/A	243.9	106225	325.9	1.336
19	Manganese		14	0	14	0	0.00%	N/A	N/A	292.9	27668	166.3	0.568
20	Mercury		14	0	14	0	0.00%	N/A	N/A	2.554	20.03	4.475	1.752
21	Nickel		14	0	11	3	21.43%	2	2	8.6	38	6.164	0.717
22	Selenium0823		14	0	14	0	0.00%	N/A	N/A	35.24	319.4	17.87	0.507
23	Silver		14	0	13	1	7.14%	2.5	2.5	7.1	13.86	3.723	0.524
24	Zinc		14	0	14	0	0.00%	N/A	N/A	1277	15623230	3953	3.095
25													
26	General Statistics for Raw Data Sets using Detected Data Only												
27													
28	Variable		NumObs	# Missing	Minimum	Maximum	Mean	Median	Var	SD	MAD/0.675	Skewness	CV
29	Antimony		8	0	5.3	42	24.76	23.5	208.4	14.44	21.65	-0.108	0.583
30	Arsenic		14	0	31	430	203.1	120	20684	143.8	104.5	0.527	0.708
31	Barium		11	0	6.7	270	81.52	74	5837	76.4	71.16	1.588	0.937
32	Cadmium		8	0	0.67	65	9.373	1.45	505.5	22.48	0.808	2.826	2.399
33	Chromium		10	0	2.7	30	13.61	13.5	62.79	7.924	6.597	0.773	0.582
34	Copper		14	0	880	24000	7977	5750	61489776	7842	6449	1.119	0.983
35	Lead		14	0	18	1200	243.9	108.5	106225	325.9	131.9	2.21	1.336
36	Manganese		14	0	120	700	292.9	250	27668	166.3	74.13	1.713	0.568
37	Mercury		14	0	0.17	14	2.554	0.825	20.03	4.475	0.689	2.264	1.752
38	Nickel		11	0	3.1	22	10.4	8.4	36.56	6.047	3.706	1.191	0.581
39	Selenium0823		14	0	8.3	59	35.24	32.5	319.4	17.87	27.43	-0.117	0.507
40	Silver		13	0	2.5	14	7.454	5.9	14.27	3.777	5.041	0.268	0.507
41	Zinc		14	0	55	15000	1277	210	15623230	3953	213.5	3.732	3.095
42													

	A	B	C	D	E	F	G	H	I	J	K	L	M
43	Percentiles using all Detects (Ds) and Non-Detects (NDs)												
44													
45	Variable		NumObs	# Missing	10%ile	20%ile	25%ile(Q1)	50%ile(Q2)	75%ile(Q3)	80%ile	90%ile	95%ile	99%ile
46		Antimony	14	0	4.9	4.96	5	6.05	23.75	28.8	40.2	42	42
47		Arsenic	14	0	73.4	87.2	91	120	322.5	358	407	417	427.4
48		Barium	14	0	5.51	9.88	14.25	66	97.5	107.4	134	185.5	253.1
49		Cadmium	14	0	0.49	0.496	0.5	0.79	1.475	1.7	2.14	24.18	56.84
50		Chromium	14	0	2	2.42	3.35	11.2	16	18	27.3	89.5	177.9
51		Copper	14	0	1060	1260	1475	5750	9675	14000	20000	21400	23480
52		Lead	14	0	24.3	33.2	35.75	108.5	292.5	366	534	790.5	1118
53		Manganese	14	0	149	194	215	250	297.5	330	535	641.5	688.3
54		Mercury	14	0	0.328	0.376	0.39	0.825	1.45	1.7	9	12.7	13.74
55		Nickel	14	0	2	2.66	3.8	7.15	11.2	12	18.3	21.35	21.87
56		Selenium0823	14	0	12.3	16.6	21	32.5	51	52.2	56.8	58.35	58.87
57		Silver	14	0	2.83	3.66	3.825	5.6	10.75	11	11	12.05	13.61
58		Zinc	14	0	65.6	70	74.75	210	397.5	412	465	5562	13112

	A	B	C	D	E	F	G	H	I	J	K	L
1	**UCL Statistics for Data Sets with Non-Detects**											
2												
3	User Selected Options											
4	Date/Time of Computation			ProUCL 5.110/17/2019 3:10:47 PM								
5	From File			ProUCL Input 3_EA2_rev083019.xls								
6	Full Precision			OFF								
7	Confidence Coefficient			95%								
8	Number of Bootstrap Operations			2000								
9												
10	**Antimony**											
11												
12	**General Statistics**											
13	Total Number of Observations					14	Number of Distinct Observations					9
14	Number of Detects					8	Number of Non-Detects					6
15	Number of Distinct Detects					7	Number of Distinct Non-Detects					2
16	Minimum Detect					5.3	Minimum Non-Detect					4.9
17	Maximum Detect					42	Maximum Non-Detect					5
18	Variance Detects					208.4	Percent Non-Detects					42.86%
19	Mean Detects					24.76	SD Detects					14.44
20	Median Detects					23.5	CV Detects					0.583
21	Skewness Detects					-0.108	Kurtosis Detects					-1.417
22	Mean of Logged Detects					2.988	SD of Logged Detects					0.795
23												
24	**Normal GOF Test on Detects Only**											
25	Shapiro Wilk Test Statistic					0.907	**Shapiro Wilk GOF Test**					
26	5% Shapiro Wilk Critical Value					0.818	Detected Data appear Normal at 5% Significance Level					
27	Lilliefors Test Statistic					0.157	**Lilliefors GOF Test**					
28	5% Lilliefors Critical Value					0.283	Detected Data appear Normal at 5% Significance Level					
29	**Detected Data appear Normal at 5% Significance Level**											
30												
31	**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**											
32	KM Mean					16.25	KM Standard Error of Mean					4.049
33	KM SD					14.17	95% KM (BCA) UCL					23.31
34	95% KM (t) UCL					23.42	95% KM (Percentile Bootstrap) UCL					22.8
35	95% KM (z) UCL					22.91	95% KM Bootstrap t UCL					24.2
36	90% KM Chebyshev UCL					28.4	95% KM Chebyshev UCL					33.9
37	97.5% KM Chebyshev UCL					41.54	99% KM Chebyshev UCL					56.54
38												
39	**Gamma GOF Tests on Detected Observations Only**											
40	A-D Test Statistic					0.465	**Anderson-Darling GOF Test**					
41	5% A-D Critical Value					0.723	Detected data appear Gamma Distributed at 5% Significance Level					
42	K-S Test Statistic					0.181	**Kolmogorov-Smirnov GOF**					
43	5% K-S Critical Value					0.297	Detected data appear Gamma Distributed at 5% Significance Level					
44	**Detected data appear Gamma Distributed at 5% Significance Level**											
45												
46	**Gamma Statistics on Detected Data Only**											
47	k hat (MLE)					2.409	k star (bias corrected MLE)					1.589
48	Theta hat (MLE)					10.28	Theta star (bias corrected MLE)					15.58
49	nu hat (MLE)					38.55	nu star (bias corrected)					25.43
50	Mean (detects)					24.76						
51												

	A	B	C	D	E	F	G	H	I	J	K	L
52	**Gamma ROS Statistics using Imputed Non-Detects**											
53	GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs											
54	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)											
55	For such situations, GROS method may yield incorrect values of UCLs and BTVs											
56	This is especially true when the sample size is small.											
57	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates											
58					Minimum	0.01				Mean		14.44
59					Maximum	42				Median		6.05
60					SD	16.3				CV		1.128
61					k hat (MLE)	0.314				k star (bias corrected MLE)		0.295
62					Theta hat (MLE)	45.96				Theta star (bias corrected MLE)		49.04
63					nu hat (MLE)	8.798				nu star (bias corrected)		8.246
64					Adjusted Level of Significance (β)	0.0312						
65					Approximate Chi Square Value (8.25, α)	2.878				Adjusted Chi Square Value (8.25, β)		2.474
66					95% Gamma Approximate UCL (use when n>=50)	41.37				95% Gamma Adjusted UCL (use when n<50)		48.13
67												
68	**Estimates of Gamma Parameters using KM Estimates**											
69					Mean (KM)	16.25				SD (KM)		14.17
70					Variance (KM)	200.8				SE of Mean (KM)		4.049
71					k hat (KM)	1.315				k star (KM)		1.081
72					nu hat (KM)	36.82				nu star (KM)		30.26
73					theta hat (KM)	12.36				theta star (KM)		15.04
74					80% gamma percentile (KM)	25.98				90% gamma percentile (KM)		36.71
75					95% gamma percentile (KM)	47.37				99% gamma percentile (KM)		71.98
76												
77	**Gamma Kaplan-Meier (KM) Statistics**											
78					Approximate Chi Square Value (30.26, α)	18.7				Adjusted Chi Square Value (30.26, β)		17.5
79					95% Gamma Approximate KM-UCL (use when n>=50)	26.3				95% Gamma Adjusted KM-UCL (use when n<50)		28.1
80												
81	**Lognormal GOF Test on Detected Observations Only**											
82					Shapiro Wilk Test Statistic	0.852				**Shapiro Wilk GOF Test**		
83					5% Shapiro Wilk Critical Value	0.818				Detected Data appear Lognormal at 5% Significance Level		
84					Lilliefors Test Statistic	0.228				**Lilliefors GOF Test**		
85					5% Lilliefors Critical Value	0.283				Detected Data appear Lognormal at 5% Significance Level		
86	**Detected Data appear Lognormal at 5% Significance Level**											
87												
88	**Lognormal ROS Statistics Using Imputed Non-Detects**											
89					Mean in Original Scale	15.43				Mean in Log Scale		2.14
90					SD in Original Scale	15.42				SD in Log Scale		1.207
91					95% t UCL (assumes normality of ROS data)	22.73				95% Percentile Bootstrap UCL		22.21
92					95% BCA Bootstrap UCL	22.65				95% Bootstrap t UCL		24.25
93					95% H-UCL (Log ROS)	50.57						
94												
95	**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**											
96					KM Mean (logged)	2.388				KM Geo Mean		10.9
97					KM SD (logged)	0.892				95% Critical H Value (KM-Log)		2.618
98					KM Standard Error of Mean (logged)	0.255				95% H-UCL (KM -Log)		30.99
99					KM SD (logged)	0.892				95% Critical H Value (KM-Log)		2.618
100					KM Standard Error of Mean (logged)	0.255						
101												

	A	B	C	D	E	F	G	H	I	J	K	L
102	**DL/2 Statistics**											
103	**DL/2 Normal**						**DL/2 Log-Transformed**					
104					Mean in Original Scale	15.21				Mean in Log Scale		2.096
105					SD in Original Scale	15.6				SD in Log Scale		1.218
106					95% t UCL (Assumes normality)	22.59				95% H-Stat UCL		49.77
107	**DL/2 is not a recommended method, provided for comparisons and historical reasons**											
108												
109	**Nonparametric Distribution Free UCL Statistics**											
110	**Detected Data appear Normal Distributed at 5% Significance Level**											
111												
112	**Suggested UCL to Use**											
113					95% KM (t) UCL	23.42						
114												
115	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
116	Recommendations are based upon data size, data distribution, and skewness.											
117	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
118	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
119												
120												
121	**Arsenic**											
122												
123	**General Statistics**											
124					Total Number of Observations	14				Number of Distinct Observations		13
125										Number of Missing Observations		0
126					Minimum	31				Mean		203.1
127					Maximum	430				Median		120
128					SD	143.8				Std. Error of Mean		38.44
129					Coefficient of Variation	0.708				Skewness		0.527
130												
131	**Normal GOF Test**											
132					Shapiro Wilk Test Statistic	0.854	**Shapiro Wilk GOF Test**					
133					5% Shapiro Wilk Critical Value	0.874	Data Not Normal at 5% Significance Level					
134					Lilliefors Test Statistic	0.266	**Lilliefors GOF Test**					
135					5% Lilliefors Critical Value	0.226	Data Not Normal at 5% Significance Level					
136	**Data Not Normal at 5% Significance Level**											
137												
138	**Assuming Normal Distribution**											
139	**95% Normal UCL**						**95% UCLs (Adjusted for Skewness)**					
140					95% Student's-t UCL	271.1				95% Adjusted-CLT UCL (Chen-1995)		272.1
141										95% Modified-t UCL (Johnson-1978)		272
142												
143	**Gamma GOF Test**											
144					A-D Test Statistic	0.641	**Anderson-Darling Gamma GOF Test**					
145					5% A-D Critical Value	0.746	Detected data appear Gamma Distributed at 5% Significance Level					
146					K-S Test Statistic	0.203	**Kolmogorov-Smirnov Gamma GOF Test**					
147					5% K-S Critical Value	0.232	Detected data appear Gamma Distributed at 5% Significance Level					
148	**Detected data appear Gamma Distributed at 5% Significance Level**											
149												

	A	B	C	D	E	F	G	H	I	J	K	L
150						Gamma Statistics						
151					k hat (MLE)	1.976					k star (bias corrected MLE)	1.6
152					Theta hat (MLE)	102.8					Theta star (bias corrected MLE)	126.9
153					nu hat (MLE)	55.32					nu star (bias corrected)	44.8
154					MLE Mean (bias corrected)	203.1					MLE Sd (bias corrected)	160.5
155											Approximate Chi Square Value (0.05)	30.44
156					Adjusted Level of Significance	0.0312					Adjusted Chi Square Value	28.88
157												
158						Assuming Gamma Distribution						
159					95% Approximate Gamma UCL (use when n>=50)	298.8					95% Adjusted Gamma UCL (use when n<50)	315
160												
161						Lognormal GOF Test						
162					Shapiro Wilk Test Statistic	0.916					Shapiro Wilk Lognormal GOF Test	
163					5% Shapiro Wilk Critical Value	0.874					Data appear Lognormal at 5% Significance Level	
164					Lilliefors Test Statistic	0.162					Lilliefors Lognormal GOF Test	
165					5% Lilliefors Critical Value	0.226					Data appear Lognormal at 5% Significance Level	
166						Data appear Lognormal at 5% Significance Level						
167												
168						Lognormal Statistics						
169					Minimum of Logged Data	3.434					Mean of logged Data	5.04
170					Maximum of Logged Data	6.064					SD of logged Data	0.809
171												
172						Assuming Lognormal Distribution						
173					95% H-UCL	374.9					90% Chebyshev (MVUE) UCL	351.7
174					95% Chebyshev (MVUE) UCL	416.7					97.5% Chebyshev (MVUE) UCL	507
175					99% Chebyshev (MVUE) UCL	684.3						
176												
177						Nonparametric Distribution Free UCL Statistics						
178						Data appear to follow a Discernible Distribution at 5% Significance Level						
179												
180						Nonparametric Distribution Free UCLs						
181					95% CLT UCL	266.3					95% Jackknife UCL	271.1
182					95% Standard Bootstrap UCL	264.3					95% Bootstrap-t UCL	283.8
183					95% Hall's Bootstrap UCL	261.7					95% Percentile Bootstrap UCL	264.5
184					95% BCA Bootstrap UCL	273.4						
185					90% Chebyshev(Mean, Sd) UCL	318.4					95% Chebyshev(Mean, Sd) UCL	370.6
186					97.5% Chebyshev(Mean, Sd) UCL	443.1					99% Chebyshev(Mean, Sd) UCL	585.5
187												
188						Suggested UCL to Use						
189					95% Adjusted Gamma UCL	315						
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												

	A	B	C	D	E	F	G	H	I	J	K	L
196	**Barium**											
197												
198	**General Statistics**											
199	Total Number of Observations					14	Number of Distinct Observations					14
200	Number of Detects					11	Number of Non-Detects					3
201	Number of Distinct Detects					11	Number of Distinct Non-Detects					3
202	Minimum Detect					6.7	Minimum Non-Detect					4.9
203	Maximum Detect					270	Maximum Non-Detect					99
204	Variance Detects					5837	Percent Non-Detects					21.43%
205	Mean Detects					81.52	SD Detects					76.4
206	Median Detects					74	CV Detects					0.937
207	Skewness Detects					1.588	Kurtosis Detects					3.118
208	Mean of Logged Detects					3.931	SD of Logged Detects					1.125
209												
210	**Normal GOF Test on Detects Only**											
211	Shapiro Wilk Test Statistic					0.853	**Shapiro Wilk GOF Test**					
212	5% Shapiro Wilk Critical Value					0.85	Detected Data appear Normal at 5% Significance Level					
213	Lilliefors Test Statistic					0.168	**Lilliefors GOF Test**					
214	5% Lilliefors Critical Value					0.251	Detected Data appear Normal at 5% Significance Level					
215	**Detected Data appear Normal at 5% Significance Level**											
216												
217	**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**											
218	KM Mean					67.44	KM Standard Error of Mean					20.03
219	KM SD					70.87	95% KM (BCA) UCL					102.8
220	95% KM (t) UCL					102.9	95% KM (Percentile Bootstrap) UCL					99.96
221	95% KM (z) UCL					100.4	95% KM Bootstrap t UCL					115.9
222	90% KM Chebyshev UCL					127.5	95% KM Chebyshev UCL					154.7
223	97.5% KM Chebyshev UCL					192.5	99% KM Chebyshev UCL					266.7
224												
225	**Gamma GOF Tests on Detected Observations Only**											
226	A-D Test Statistic					0.2	**Anderson-Darling GOF Test**					
227	5% A-D Critical Value					0.748	Detected data appear Gamma Distributed at 5% Significance Level					
228	K-S Test Statistic					0.13	**Kolmogorov-Smirnov GOF**					
229	5% K-S Critical Value					0.261	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)					1.204	k star (bias corrected MLE)					0.937
234	Theta hat (MLE)					67.68	Theta star (bias corrected MLE)					87.04
235	nu hat (MLE)					26.5	nu star (bias corrected)					20.6
236	Mean (detects)					81.52						
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					0.01	Mean					65.93
245	Maximum					270	Median					42.15
246	SD					74.06	CV					1.123
247	k hat (MLE)					0.427	k star (bias corrected MLE)					0.383

	A	B	C	D	E	F	G	H	I	J	K	L
248					Theta hat (MLE)	154.3					Theta star (bias corrected MLE)	172
249					nu hat (MLE)	11.96					nu star (bias corrected)	10.73
250					Adjusted Level of Significance (β)	0.0312						
251					Approximate Chi Square Value (10.73, α)	4.405					Adjusted Chi Square Value (10.73, β)	3.881
252					95% Gamma Approximate UCL (use when n>=50)	160.6					95% Gamma Adjusted UCL (use when n<50)	182.3
253												
254					**Estimates of Gamma Parameters using KM Estimates**							
255					Mean (KM)	67.44					SD (KM)	70.87
256					Variance (KM)	5022					SE of Mean (KM)	20.03
257					k hat (KM)	0.906					k star (KM)	0.759
258					nu hat (KM)	25.36					nu star (KM)	21.26
259					theta hat (KM)	74.47					theta star (KM)	88.83
260					80% gamma percentile (KM)	110.5					90% gamma percentile (KM)	166.1
261					95% gamma percentile (KM)	222.9					99% gamma percentile (KM)	357.8
262												
263					**Gamma Kaplan-Meier (KM) Statistics**							
264					Approximate Chi Square Value (21.26, α)	11.78					Adjusted Chi Square Value (21.26, β)	10.86
265					95% Gamma Approximate KM-UCL (use when n>=50)	121.7					95% Gamma Adjusted KM-UCL (use when n<50)	132
266												
267					**Lognormal GOF Test on Detected Observations Only**							
268					Shapiro Wilk Test Statistic	0.956			**Shapiro Wilk GOF Test**			
269					5% Shapiro Wilk Critical Value	0.85			Detected Data appear Lognormal at 5% Significance Level			
270					Lilliefors Test Statistic	0.182			**Lilliefors GOF Test**			
271					5% Lilliefors Critical Value	0.251			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	66.33					Mean in Log Scale	3.528
276					SD in Original Scale	73.61					SD in Log Scale	1.324
277					95% t UCL (assumes normality of ROS data)	101.2					95% Percentile Bootstrap UCL	100.8
278					95% BCA Bootstrap UCL	107.4					95% Bootstrap t UCL	121.6
279					95% H-UCL (Log ROS)	280.7						
280												
281					**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**							
282					KM Mean (logged)	3.538					KM Geo Mean	34.4
283					KM SD (logged)	1.292					95% Critical H Value (KM-Log)	3.302
284					KM Standard Error of Mean (logged)	0.373					95% H-UCL (KM -Log)	258.9
285					KM SD (logged)	1.292					95% Critical H Value (KM-Log)	3.302
286					KM Standard Error of Mean (logged)	0.373						
287												
288					**DL/2 Statistics**							
289					**DL/2 Normal**				**DL/2 Log-Transformed**			
290					Mean in Original Scale	67.94					Mean in Log Scale	3.497
291					SD in Original Scale	73.02					SD in Log Scale	1.476
292					95% t UCL (Assumes normality)	102.5					95% H-Stat UCL	436.5
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	102.9						

	A	B	C	D	E	F	G	H	I	J	K	L
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	**Cadmium**											
307												
308	**General Statistics**											
309	Total Number of Observations					14	Number of Distinct Observations					10
310	Number of Detects					8	Number of Non-Detects					6
311	Number of Distinct Detects					8	Number of Distinct Non-Detects					2
312	Minimum Detect					0.67	Minimum Non-Detect					0.49
313	Maximum Detect					65	Maximum Non-Detect					0.5
314	Variance Detects					505.5	Percent Non-Detects					42.86%
315	Mean Detects					9.373	SD Detects					22.48
316	Median Detects					1.45	CV Detects					2.399
317	Skewness Detects					2.826	Kurtosis Detects					7.988
318	Mean of Logged Detects					0.771	SD of Logged Detects					1.429
319												
320	**Normal GOF Test on Detects Only**											
321	Shapiro Wilk Test Statistic					0.44	**Shapiro Wilk GOF Test**					
322	5% Shapiro Wilk Critical Value					0.818	Detected Data Not Normal at 5% Significance Level					
323	Lilliefors Test Statistic					0.5	**Lilliefors GOF Test**					
324	5% Lilliefors Critical Value					0.283	Detected Data Not Normal at 5% Significance Level					
325	**Detected Data Not Normal at 5% Significance Level**											
326												
327	**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**											
328	KM Mean					5.566	KM Standard Error of Mean					4.713
329	KM SD					16.49	95% KM (BCA) UCL					14.76
330	95% KM (t) UCL					13.91	95% KM (Percentile Bootstrap) UCL					14.67
331	95% KM (z) UCL					13.32	95% KM Bootstrap t UCL					164.8
332	90% KM Chebyshev UCL					19.7	95% KM Chebyshev UCL					26.11
333	97.5% KM Chebyshev UCL					35	99% KM Chebyshev UCL					52.46
334												
335	**Gamma GOF Tests on Detected Observations Only**											
336	A-D Test Statistic					1.81	**Anderson-Darling GOF Test**					
337	5% A-D Critical Value					0.773	Detected Data Not Gamma Distributed at 5% Significance Level					
338	K-S Test Statistic					0.473	**Kolmogorov-Smirnov GOF**					
339	5% K-S Critical Value					0.311	Detected Data Not Gamma Distributed at 5% Significance Level					
340	**Detected Data Not Gamma Distributed at 5% Significance Level**											
341												
342	**Gamma Statistics on Detected Data Only**											
343	k hat (MLE)					0.441	k star (bias corrected MLE)					0.359
344	Theta hat (MLE)					21.23	Theta star (bias corrected MLE)					26.09
345	nu hat (MLE)					7.064	nu star (bias corrected)					5.748
346	Mean (detects)					9.373						
347												

	A	B	C	D	E	F	G	H	I	J	K	L
348	**Gamma ROS Statistics using Imputed Non-Detects**											
349	GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs											
350	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)											
351	For such situations, GROS method may yield incorrect values of UCLs and BTVs											
352	This is especially true when the sample size is small.											
353	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates											
354					Minimum	0.01				Mean		5.36
355					Maximum	65				Median		0.79
356					SD	17.18				CV		3.206
357					k hat (MLE)	0.225				k star (bias corrected MLE)		0.224
358					Theta hat (MLE)	23.83				Theta star (bias corrected MLE)		23.89
359					nu hat (MLE)	6.297				nu star (bias corrected)		6.281
360					Adjusted Level of Significance (β)	0.0312						
361					Approximate Chi Square Value (6.28, α)	1.785				Adjusted Chi Square Value (6.28, β)		1.487
362					95% Gamma Approximate UCL (use when n>=50)	18.86				95% Gamma Adjusted UCL (use when n<50)		22.65
363												
364	**Estimates of Gamma Parameters using KM Estimates**											
365					Mean (KM)	5.566				SD (KM)		16.49
366					Variance (KM)	272.1				SE of Mean (KM)		4.713
367					k hat (KM)	0.114				k star (KM)		0.137
368					nu hat (KM)	3.188				nu star (KM)		3.838
369					theta hat (KM)	48.88				theta star (KM)		40.6
370					80% gamma percentile (KM)	5.599				90% gamma percentile (KM)		16.26
371					95% gamma percentile (KM)	31.14				99% gamma percentile (KM)		75.15
372												
373	**Gamma Kaplan-Meier (KM) Statistics**											
374					Approximate Chi Square Value (3.84, α)	0.659				Adjusted Chi Square Value (3.84, β)		0.51
375					95% Gamma Approximate KM-UCL (use when n>=50)	32.42				95% Gamma Adjusted KM-UCL (use when n<50)		41.9
376												
377	**Lognormal GOF Test on Detected Observations Only**											
378					Shapiro Wilk Test Statistic	0.684				**Shapiro Wilk GOF Test**		
379					5% Shapiro Wilk Critical Value	0.818				Detected Data Not Lognormal at 5% Significance Level		
380					Lilliefors Test Statistic	0.37				**Lilliefors GOF Test**		
381					5% Lilliefors Critical Value	0.283				Detected Data Not Lognormal at 5% Significance Level		
382	**Detected Data Not Lognormal at 5% Significance Level**											
383												
384	**Lognormal ROS Statistics Using Imputed Non-Detects**											
385					Mean in Original Scale	5.395				Mean in Log Scale		-0.69
386					SD in Original Scale	17.17				SD in Log Scale		2.101
387					95% t UCL (assumes normality of ROS data)	13.52				95% Percentile Bootstrap UCL		14.54
388					95% BCA Bootstrap UCL	19.23				95% Bootstrap t UCL		133.4
389					95% H-UCL (Log ROS)	78.28						
390												
391	**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**											
392					KM Mean (logged)	0.135				KM Geo Mean		1.144
393					KM SD (logged)	1.249				95% Critical H Value (KM-Log)		3.224
394					KM Standard Error of Mean (logged)	0.357				95% H-UCL (KM -Log)		7.628
395					KM SD (logged)	1.249				95% Critical H Value (KM-Log)		3.224
396					KM Standard Error of Mean (logged)	0.357						
397												

	A	B	C	D	E	F	G	H	I	J	K	L
398						DL/2 Statistics						
399					DL/2 Normal					DL/2 Log-Transformed		
400					Mean in Original Scale	5.462				Mean in Log Scale		-0.158
401					SD in Original Scale	17.15				SD in Log Scale		1.529
402					95% t UCL (Assumes normality)	13.58				95% H-Stat UCL		13.46
403					DL/2 is not a recommended method, provided for comparisons and historical reasons							
404												
405					Nonparametric Distribution Free UCL Statistics							
406					Data do not follow a Discernible Distribution at 5% Significance Level							
407												
408					Suggested UCL to Use							
409					95% KM (Chebyshev) UCL	26.11						
410												
411					Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.							
412					Recommendations are based upon data size, data distribution, and skewness.							
413					These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).							
414					However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.							
415												
416	Chromium											
417												
418					General Statistics							
419					Total Number of Observations	14				Number of Distinct Observations		11
420					Number of Detects	10				Number of Non-Detects		4
421					Number of Distinct Detects	9				Number of Distinct Non-Detects		2
422					Minimum Detect	2.7				Minimum Non-Detect		2
423					Maximum Detect	30				Maximum Non-Detect		200
424					Variance Detects	62.79				Percent Non-Detects		28.57%
425					Mean Detects	13.61				SD Detects		7.924
426					Median Detects	13.5				CV Detects		0.582
427					Skewness Detects	0.773				Kurtosis Detects		0.922
428					Mean of Logged Detects	2.426				SD of Logged Detects		0.697
429												
430					Normal GOF Test on Detects Only							
431					Shapiro Wilk Test Statistic	0.956				Shapiro Wilk GOF Test		
432					5% Shapiro Wilk Critical Value	0.842				Detected Data appear Normal at 5% Significance Level		
433					Lilliefors Test Statistic	0.181				Lilliefors GOF Test		
434					5% Lilliefors Critical Value	0.262				Detected Data appear Normal at 5% Significance Level		
435					Detected Data appear Normal at 5% Significance Level							
436												
437					Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs							
438					KM Mean	10.93				KM Standard Error of Mean		2.4
439					KM SD	8.21				95% KM (BCA) UCL		14.95
440					95% KM (t) UCL	15.18				95% KM (Percentile Bootstrap) UCL		14.65
441					95% KM (z) UCL	14.88				95% KM Bootstrap t UCL		15.68
442					90% KM Chebyshev UCL	18.13				95% KM Chebyshev UCL		21.39
443					97.5% KM Chebyshev UCL	25.92				99% KM Chebyshev UCL		34.81
444												
445					Gamma GOF Tests on Detected Observations Only							
446					A-D Test Statistic	0.196				Anderson-Darling GOF Test		
447					5% A-D Critical Value	0.733				Detected data appear Gamma Distributed at 5% Significance Level		
448					K-S Test Statistic	0.149				Kolmogorov-Smirnov GOF		
449					5% K-S Critical Value	0.269				Detected data appear Gamma Distributed at 5% Significance Level		

	A	B	C	D	E	F	G	H	I	J	K	L
450	**Detected data appear Gamma Distributed at 5% Significance Level**											
451												
452	**Gamma Statistics on Detected Data Only**											
453					k hat (MLE)	2.861			k star (bias corrected MLE)			2.069
454					Theta hat (MLE)	4.757			Theta star (bias corrected MLE)			6.577
455					nu hat (MLE)	57.22			nu star (bias corrected)			41.39
456					Mean (detects)	13.61						
457												
458	**Gamma ROS Statistics using Imputed Non-Detects**											
459	GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs											
460	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)											
461	For such situations, GROS method may yield incorrect values of UCLs and BTVs											
462	This is especially true when the sample size is small.											
463	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates											
464					Minimum	0.01			Mean			10.45
465					Maximum	30			Median			9.164
466					SD	8.641			CV			0.827
467					k hat (MLE)	0.566			k star (bias corrected MLE)			0.492
468					Theta hat (MLE)	18.46			Theta star (bias corrected MLE)			21.23
469					nu hat (MLE)	15.84			nu star (bias corrected)			13.78
470					Adjusted Level of Significance (β)	0.0312						
471					Approximate Chi Square Value (13.78, α)	6.421			Adjusted Chi Square Value (13.78, β)			5.767
472					95% Gamma Approximate UCL (use when n>=50)	22.42			95% Gamma Adjusted UCL (use when n<50)			24.96
473												
474	**Estimates of Gamma Parameters using KM Estimates**											
475					Mean (KM)	10.93			SD (KM)			8.21
476					Variance (KM)	67.4			SE of Mean (KM)			2.4
477					k hat (KM)	1.773			k star (KM)			1.441
478					nu hat (KM)	49.64			nu star (KM)			40.33
479					theta hat (KM)	6.166			theta star (KM)			7.588
480					80% gamma percentile (KM)	16.99			90% gamma percentile (KM)			23
481					95% gamma percentile (KM)	28.86			99% gamma percentile (KM)			42.13
482												
483	**Gamma Kaplan-Meier (KM) Statistics**											
484					Approximate Chi Square Value (40.33, α)	26.78			Adjusted Chi Square Value (40.33, β)			25.32
485					95% Gamma Approximate KM-UCL (use when n>=50)	16.46			95% Gamma Adjusted KM-UCL (use when n<50)			17.41
486												
487	**Lognormal GOF Test on Detected Observations Only**											
488					Shapiro Wilk Test Statistic	0.946			**Shapiro Wilk GOF Test**			
489					5% Shapiro Wilk Critical Value	0.842			Detected Data appear Lognormal at 5% Significance Level			
490					Lilliefors Test Statistic	0.179			**Lilliefors GOF Test**			
491					5% Lilliefors Critical Value	0.262			Detected Data appear Lognormal at 5% Significance Level			
492	**Detected Data appear Lognormal at 5% Significance Level**											
493												
494	**Lognormal ROS Statistics Using Imputed Non-Detects**											
495					Mean in Original Scale	10.78			Mean in Log Scale			2.052
496					SD in Original Scale	8.181			SD in Log Scale			0.906
497					95% t UCL (assumes normality of ROS data)	14.65			95% Percentile Bootstrap UCL			14.82
498					95% BCA Bootstrap UCL	14.62			95% Bootstrap t UCL			15.68
499					95% H-UCL (Log ROS)	22.77						
500												

	A	B	C	D	E	F	G	H	I	J	K	L
501	**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**											
502					KM Mean (logged)	2.026					KM Geo Mean	7.584
503					KM SD (logged)	0.932					95% Critical H Value (KM-Log)	2.682
504					KM Standard Error of Mean (logged)	0.273					95% H-UCL (KM -Log)	23.43
505					KM SD (logged)	0.932					95% Critical H Value (KM-Log)	2.682
506					KM Standard Error of Mean (logged)	0.273						
507												
508	**DL/2 Statistics**											
509	**DL/2 Normal**						**DL/2 Log-Transformed**					
510					Mean in Original Scale	17.08					Mean in Log Scale	2.062
511					SD in Original Scale	25.32					SD in Log Scale	1.384
512					95% t UCL (Assumes normality)	29.06					95% H-Stat UCL	77.75
513	**DL/2 is not a recommended method, provided for comparisons and historical reasons**											
514												
515	**Nonparametric Distribution Free UCL Statistics**											
516	**Detected Data appear Normal Distributed at 5% Significance Level**											
517												
518	**Suggested UCL to Use**											
519					95% KM (t) UCL	15.18						
520												
521	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
522	Recommendations are based upon data size, data distribution, and skewness.											
523	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
524	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
525												
526												
527	**Copper**											
528												
529	**General Statistics**											
530					Total Number of Observations	14					Number of Distinct Observations	13
531											Number of Missing Observations	0
532					Minimum	880					Mean	7977
533					Maximum	24000					Median	5750
534					SD	7842					Std. Error of Mean	2096
535					Coefficient of Variation	0.983					Skewness	1.119
536												
537	**Normal GOF Test**											
538					Shapiro Wilk Test Statistic	0.821	**Shapiro Wilk GOF Test**					
539					5% Shapiro Wilk Critical Value	0.874	Data Not Normal at 5% Significance Level					
540					Lilliefors Test Statistic	0.218	**Lilliefors GOF Test**					
541					5% Lilliefors Critical Value	0.226	Data appear Normal at 5% Significance Level					
542	**Data appear Approximate Normal at 5% Significance Level**											
543												
544	**Assuming Normal Distribution**											
545	**95% Normal UCL**						**95% UCLs (Adjusted for Skewness)**					
546					95% Student's-t UCL	11689					95% Adjusted-CLT UCL (Chen-1995)	12094
547											95% Modified-t UCL (Johnson-1978)	11793
548												

	A	B	C	D	E	F	G	H	I	J	K	L
549	**Gamma GOF Test**											
550					A-D Test Statistic	0.439	**Anderson-Darling Gamma GOF Test**					
551					5% A-D Critical Value	0.759	Detected data appear Gamma Distributed at 5% Significance Level					
552					K-S Test Statistic	0.149	**Kolmogorov-Smirnov Gamma GOF Test**					
553					5% K-S Critical Value	0.235	Detected data appear Gamma Distributed at 5% Significance Level					
554	**Detected data appear Gamma Distributed at 5% Significance Level**											
555												
556	**Gamma Statistics**											
557					k hat (MLE)	1.065			k star (bias corrected MLE)			0.884
558					Theta hat (MLE)	7490			Theta star (bias corrected MLE)			9019
559					nu hat (MLE)	29.82			nu star (bias corrected)			24.77
560					MLE Mean (bias corrected)	7977			MLE Sd (bias corrected)			8482
561									Approximate Chi Square Value (0.05)			14.43
562					Adjusted Level of Significance	0.0312			Adjusted Chi Square Value			13.39
563												
564	**Assuming Gamma Distribution**											
565					95% Approximate Gamma UCL (use when n>=50))	13689			95% Adjusted Gamma UCL (use when n<50)			14750
566												
567	**Lognormal GOF Test**											
568					Shapiro Wilk Test Statistic	0.917	**Shapiro Wilk Lognormal GOF Test**					
569					5% Shapiro Wilk Critical Value	0.874	Data appear Lognormal at 5% Significance Level					
570					Lilliefors Test Statistic	0.15	**Lilliefors Lognormal GOF Test**					
571					5% Lilliefors Critical Value	0.226	Data appear Lognormal at 5% Significance Level					
572	**Data appear Lognormal at 5% Significance Level**											
573												
574	**Lognormal Statistics**											
575					Minimum of Logged Data	6.78			Mean of logged Data			8.446
576					Maximum of Logged Data	10.09			SD of logged Data			1.158
577												
578	**Assuming Lognormal Distribution**											
579					95% H-UCL	24353			90% Chebyshev (MVUE) UCL			17161
580					95% Chebyshev (MVUE) UCL	21093			97.5% Chebyshev (MVUE) UCL			26550
581					99% Chebyshev (MVUE) UCL	37270						
582												
583	**Nonparametric Distribution Free UCL Statistics**											
584	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
585												
586	**Nonparametric Distribution Free UCLs**											
587					95% CLT UCL	11424			95% Jackknife UCL			11689
588					95% Standard Bootstrap UCL	11238			95% Bootstrap-t UCL			13232
589					95% Hall's Bootstrap UCL	11438			95% Percentile Bootstrap UCL			11334
590					95% BCA Bootstrap UCL	11699						
591					90% Chebyshev(Mean, Sd) UCL	14264			95% Chebyshev(Mean, Sd) UCL			17112
592					97.5% Chebyshev(Mean, Sd) UCL	21065			99% Chebyshev(Mean, Sd) UCL			28829
593												
594	**Suggested UCL to Use**											
595					95% Student's-t UCL	11689						
596												
597	When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test											
598	When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL											
599												

	A	B	C	D	E	F	G	H	I	J	K	L
600	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
601	Recommendations are based upon data size, data distribution, and skewness.											
602	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
603	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
604												
605												
606	**Lead**											
607												
608	**General Statistics**											
609					Total Number of Observations	14			Number of Distinct Observations			13
610									Number of Missing Observations			0
611					Minimum	18			Mean			243.9
612					Maximum	1200			Median			108.5
613					SD	325.9			Std. Error of Mean			87.11
614					Coefficient of Variation	1.336			Skewness			2.21
615												
616	**Normal GOF Test**											
617					Shapiro Wilk Test Statistic	0.72			**Shapiro Wilk GOF Test**			
618					5% Shapiro Wilk Critical Value	0.874			Data Not Normal at 5% Significance Level			
619					Lilliefors Test Statistic	0.244			**Lilliefors GOF Test**			
620					5% Lilliefors Critical Value	0.226			Data Not Normal at 5% Significance Level			
621	**Data Not Normal at 5% Significance Level**											
622												
623	**Assuming Normal Distribution**											
624					**95% Normal UCL**				**95% UCLs (Adjusted for Skewness)**			
625					95% Student's-t UCL	398.2			95% Adjusted-CLT UCL (Chen-1995)			442.2
626									95% Modified-t UCL (Johnson-1978)			406.8
627												
628	**Gamma GOF Test**											
629					A-D Test Statistic	0.584			**Anderson-Darling Gamma GOF Test**			
630					5% A-D Critical Value	0.771			Detected data appear Gamma Distributed at 5% Significance Level			
631					K-S Test Statistic	0.225			**Kolmogorov-Smirnov Gamma GOF Test**			
632					5% K-S Critical Value	0.238			Detected data appear Gamma Distributed at 5% Significance Level			
633	**Detected data appear Gamma Distributed at 5% Significance Level**											
634												
635	**Gamma Statistics**											
636					k hat (MLE)	0.747			k star (bias corrected MLE)			0.635
637					Theta hat (MLE)	326.3			Theta star (bias corrected MLE)			384.2
638					nu hat (MLE)	20.93			nu star (bias corrected)			17.78
639					MLE Mean (bias corrected)	243.9			MLE Sd (bias corrected)			306.1
640									Approximate Chi Square Value (0.05)			9.231
641					Adjusted Level of Significance	0.0312			Adjusted Chi Square Value			8.424
642												
643	**Assuming Gamma Distribution**											
644					95% Approximate Gamma UCL (use when n>=50)	469.8			95% Adjusted Gamma UCL (use when n<50)			514.8
645												
646	**Lognormal GOF Test**											
647					Shapiro Wilk Test Statistic	0.925			**Shapiro Wilk Lognormal GOF Test**			
648					5% Shapiro Wilk Critical Value	0.874			Data appear Lognormal at 5% Significance Level			
649					Lilliefors Test Statistic	0.188			**Lilliefors Lognormal GOF Test**			
650					5% Lilliefors Critical Value	0.226			Data appear Lognormal at 5% Significance Level			
651	**Data appear Lognormal at 5% Significance Level**											

	A	B	C	D	E	F	G	H	I	J	K	L
652												
653						Lognormal Statistics						
654					Minimum of Logged Data	2.89				Mean of logged Data		4.696
655					Maximum of Logged Data	7.09				SD of logged Data		1.361
656												
657						Assuming Lognormal Distribution						
658					95% H-UCL	1009				90% Chebyshev (MVUE) UCL		550.3
659					95% Chebyshev (MVUE) UCL	687.3				97.5% Chebyshev (MVUE) UCL		877.6
660					99% Chebyshev (MVUE) UCL	1251						
661												
662						Nonparametric Distribution Free UCL Statistics						
663						Data appear to follow a Discernible Distribution at 5% Significance Level						
664												
665						Nonparametric Distribution Free UCLs						
666					95% CLT UCL	387.2				95% Jackknife UCL		398.2
667					95% Standard Bootstrap UCL	385.3				95% Bootstrap-t UCL		545.7
668					95% Hall's Bootstrap UCL	976.3				95% Percentile Bootstrap UCL		391.7
669					95% BCA Bootstrap UCL	448.6						
670					90% Chebyshev(Mean, Sd) UCL	505.2				95% Chebyshev(Mean, Sd) UCL		623.6
671					97.5% Chebyshev(Mean, Sd) UCL	787.9				99% Chebyshev(Mean, Sd) UCL		1111
672												
673						Suggested UCL to Use						
674					95% Adjusted Gamma UCL	514.8						
675												
676						Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.						
677						Recommendations are based upon data size, data distribution, and skewness.						
678						These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).						
679						However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.						
680												
681												
682	Manganese											
683												
684						General Statistics						
685					Total Number of Observations	14				Number of Distinct Observations		12
686										Number of Missing Observations		0
687					Minimum	120				Mean		292.9
688					Maximum	700				Median		250
689					SD	166.3				Std. Error of Mean		44.46
690					Coefficient of Variation	0.568				Skewness		1.713
691												
692						Normal GOF Test						
693					Shapiro Wilk Test Statistic	0.78				Shapiro Wilk GOF Test		
694					5% Shapiro Wilk Critical Value	0.874				Data Not Normal at 5% Significance Level		
695					Lilliefors Test Statistic	0.293				Lilliefors GOF Test		
696					5% Lilliefors Critical Value	0.226				Data Not Normal at 5% Significance Level		
697						Data Not Normal at 5% Significance Level						
698												
699						Assuming Normal Distribution						
700					95% Normal UCL					95% UCLs (Adjusted for Skewness)		
701					95% Student's-t UCL	371.6				95% Adjusted-CLT UCL (Chen-1995)		387.7
702										95% Modified-t UCL (Johnson-1978)		375
703												

	A	B	C	D	E	F	G	H	I	J	K	L
704	**Gamma GOF Test**											
705					A-D Test Statistic	0.755	**Anderson-Darling Gamma GOF Test**					
706					5% A-D Critical Value	0.739	Data Not Gamma Distributed at 5% Significance Level					
707					K-S Test Statistic	0.247	**Kolmogorov-Smirnov Gamma GOF Test**					
708					5% K-S Critical Value	0.23	Data Not Gamma Distributed at 5% Significance Level					
709	**Data Not Gamma Distributed at 5% Significance Level**											
710												
711	**Gamma Statistics**											
712					k hat (MLE)	4.345			k star (bias corrected MLE)			3.461
713					Theta hat (MLE)	67.4			Theta star (bias corrected MLE)			84.6
714					nu hat (MLE)	121.7			nu star (bias corrected)			96.92
715					MLE Mean (bias corrected)	292.9			MLE Sd (bias corrected)			157.4
716									Approximate Chi Square Value (0.05)			75.21
717					Adjusted Level of Significance	0.0312			Adjusted Chi Square Value			72.68
718												
719	**Assuming Gamma Distribution**											
720					95% Approximate Gamma UCL (use when n>=50))	377.4			95% Adjusted Gamma UCL (use when n<50)			390.5
721												
722	**Lognormal GOF Test**											
723					Shapiro Wilk Test Statistic	0.925	**Shapiro Wilk Lognormal GOF Test**					
724					5% Shapiro Wilk Critical Value	0.874	Data appear Lognormal at 5% Significance Level					
725					Lilliefors Test Statistic	0.214	**Lilliefors Lognormal GOF Test**					
726					5% Lilliefors Critical Value	0.226	Data appear Lognormal at 5% Significance Level					
727	**Data appear Lognormal at 5% Significance Level**											
728												
729	**Lognormal Statistics**											
730					Minimum of Logged Data	4.787			Mean of logged Data			5.56
731					Maximum of Logged Data	6.551			SD of logged Data			0.487
732												
733	**Assuming Lognormal Distribution**											
734					95% H-UCL	383.6			90% Chebyshev (MVUE) UCL			406
735					95% Chebyshev (MVUE) UCL	458.6			97.5% Chebyshev (MVUE) UCL			531.6
736					99% Chebyshev (MVUE) UCL	674.9						
737												
738	**Nonparametric Distribution Free UCL Statistics**											
739	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
740												
741	**Nonparametric Distribution Free UCLs**											
742					95% CLT UCL	366			95% Jackknife UCL			371.6
743					95% Standard Bootstrap UCL	363.7			95% Bootstrap-t UCL			466.1
744					95% Hall's Bootstrap UCL	838.1			95% Percentile Bootstrap UCL			371.4
745					95% BCA Bootstrap UCL	376.4						
746					90% Chebyshev(Mean, Sd) UCL	426.2			95% Chebyshev(Mean, Sd) UCL			486.6
747					97.5% Chebyshev(Mean, Sd) UCL	570.5			99% Chebyshev(Mean, Sd) UCL			735.2
748												
749	**Suggested UCL to Use**											
750					95% Student's-t UCL	371.6			or 95% Modified-t UCL			375
751					or 95% H-UCL	383.6						
752												

	A	B	C	D	E	F	G	H	I	J	K	L
753	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
754	Recommendations are based upon data size, data distribution, and skewness.											
755	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
756	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
757												
758	**ProUCL computes and outputs H-statistic based UCLs for historical reasons only.**											
759	**H-statistic often results in unstable (both high and low) values of UCL95 as shown in examples in the Technical Guide.**											
760	**It is therefore recommended to avoid the use of H-statistic based 95% UCLs.**											
761	**Use of nonparametric methods are preferred to compute UCL95 for skewed data sets which do not follow a gamma distribution.**											
762												
763												
764	**Mercury**											
765												
766	**General Statistics**											
767	Total Number of Observations					14	Number of Distinct Observations					14
768							Number of Missing Observations					0
769	Minimum					0.17	Mean					2.554
770	Maximum					14	Median					0.825
771	SD					4.475	Std. Error of Mean					1.196
772	Coefficient of Variation					1.752	Skewness					2.264
773												
774	**Normal GOF Test**											
775	Shapiro Wilk Test Statistic					0.546	**Shapiro Wilk GOF Test**					
776	5% Shapiro Wilk Critical Value					0.874	Data Not Normal at 5% Significance Level					
777	Lilliefors Test Statistic					0.406	**Lilliefors GOF Test**					
778	5% Lilliefors Critical Value					0.226	Data Not Normal at 5% Significance Level					
779	**Data Not Normal at 5% Significance Level**											
780												
781	**Assuming Normal Distribution**											
782	**95% Normal UCL**						**95% UCLs (Adjusted for Skewness)**					
783	95% Student's-t UCL					4.672	95% Adjusted-CLT UCL (Chen-1995)					5.295
784							95% Modified-t UCL (Johnson-1978)					4.793
785												
786	**Gamma GOF Test**											
787	A-D Test Statistic					1.454	**Anderson-Darling Gamma GOF Test**					
788	5% A-D Critical Value					0.781	Data Not Gamma Distributed at 5% Significance Level					
789	K-S Test Statistic					0.267	**Kolmogorov-Smirnov Gamma GOF Test**					
790	5% K-S Critical Value					0.239	Data Not Gamma Distributed at 5% Significance Level					
791	**Data Not Gamma Distributed at 5% Significance Level**											
792												
793	**Gamma Statistics**											
794	k hat (MLE)					0.635	k star (bias corrected MLE)					0.546
795	Theta hat (MLE)					4.023	Theta star (bias corrected MLE)					4.674
796	nu hat (MLE)					17.78	nu star (bias corrected)					15.3
797	MLE Mean (bias corrected)					2.554	MLE Sd (bias corrected)					3.455
798							Approximate Chi Square Value (0.05)					7.471
799	Adjusted Level of Significance					0.0312	Adjusted Chi Square Value					6.757
800												
801	**Assuming Gamma Distribution**											
802	95% Approximate Gamma UCL (use when n>=50))					5.231	95% Adjusted Gamma UCL (use when n<50)					5.784
803												

	A	B	C	D	E	F	G	H	I	J	K	L
804	**Lognormal GOF Test**											
805	Shapiro Wilk Test Statistic					0.886	**Shapiro Wilk Lognormal GOF Test**					
806	5% Shapiro Wilk Critical Value					0.874	Data appear Lognormal at 5% Significance Level					
807	Lilliefors Test Statistic					0.169	**Lilliefors Lognormal GOF Test**					
808	5% Lilliefors Critical Value					0.226	Data appear Lognormal at 5% Significance Level					
809	**Data appear Lognormal at 5% Significance Level**											
810												
811	**Lognormal Statistics**											
812	Minimum of Logged Data					-1.772	Mean of logged Data					-0.0274
813	Maximum of Logged Data					2.639	SD of logged Data					1.302
814												
815	**Assuming Lognormal Distribution**											
816	95% H-UCL					7.529	90% Chebyshev (MVUE) UCL					4.457
817	95% Chebyshev (MVUE) UCL					5.543	97.5% Chebyshev (MVUE) UCL					7.05
818	99% Chebyshev (MVUE) UCL					10.01						
819												
820	**Nonparametric Distribution Free UCL Statistics**											
821	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
822												
823	**Nonparametric Distribution Free UCLs**											
824	95% CLT UCL					4.522	95% Jackknife UCL					4.672
825	95% Standard Bootstrap UCL					4.45	95% Bootstrap-t UCL					16.85
826	95% Hall's Bootstrap UCL					16.89	95% Percentile Bootstrap UCL					4.759
827	95% BCA Bootstrap UCL					5.162						
828	90% Chebyshev(Mean, Sd) UCL					6.142	95% Chebyshev(Mean, Sd) UCL					7.768
829	97.5% Chebyshev(Mean, Sd) UCL					10.02	99% Chebyshev(Mean, Sd) UCL					14.45
830												
831	**Suggested UCL to Use**											
832	95% Chebyshev (Mean, Sd) UCL					7.768						
833												
834	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
835	Recommendations are based upon data size, data distribution, and skewness.											
836	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
837	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
838												
839	**Nickel**											
840												
841	**General Statistics**											
842	Total Number of Observations					14	Number of Distinct Observations					10
843	Number of Detects					11	Number of Non-Detects					3
844	Number of Distinct Detects					9	Number of Distinct Non-Detects					1
845	Minimum Detect					3.1	Minimum Non-Detect					2
846	Maximum Detect					22	Maximum Non-Detect					2
847	Variance Detects					36.56	Percent Non-Detects					21.43%
848	Mean Detects					10.4	SD Detects					6.047
849	Median Detects					8.4	CV Detects					0.581
850	Skewness Detects					1.191	Kurtosis Detects					0.55
851	Mean of Logged Detects					2.198	SD of Logged Detects					0.564
852												

	A	B	C	D	E	F	G	H	I	J	K	L
853	**Normal GOF Test on Detects Only**											
854					Shapiro Wilk Test Statistic	0.844	**Shapiro Wilk GOF Test**					
855					5% Shapiro Wilk Critical Value	0.85	Detected Data Not Normal at 5% Significance Level					
856					Lilliefors Test Statistic	0.241	**Lilliefors GOF Test**					
857					5% Lilliefors Critical Value	0.251	Detected Data appear Normal at 5% Significance Level					
858	**Detected Data appear Approximate Normal at 5% Significance Level**											
859												
860	**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**											
861					KM Mean	8.6			KM Standard Error of Mean			1.728
862					KM SD	6.164			95% KM (BCA) UCL			11.54
863					95% KM (t) UCL	11.66			95% KM (Percentile Bootstrap) UCL			11.55
864					95% KM (z) UCL	11.44			95% KM Bootstrap t UCL			13.26
865					90% KM Chebyshev UCL	13.78			95% KM Chebyshev UCL			16.13
866					97.5% KM Chebyshev UCL	19.39			99% KM Chebyshev UCL			25.79
867												
868	**Gamma GOF Tests on Detected Observations Only**											
869					A-D Test Statistic	0.442	**Anderson-Darling GOF Test**					
870					5% A-D Critical Value	0.733	Detected data appear Gamma Distributed at 5% Significance Level					
871					K-S Test Statistic	0.189	**Kolmogorov-Smirnov GOF**					
872					5% K-S Critical Value	0.257	Detected data appear Gamma Distributed at 5% Significance Level					
873	**Detected data appear Gamma Distributed at 5% Significance Level**											
874												
875	**Gamma Statistics on Detected Data Only**											
876					k hat (MLE)	3.638			k star (bias corrected MLE)			2.706
877					Theta hat (MLE)	2.859			Theta star (bias corrected MLE)			3.843
878					nu hat (MLE)	80.03			nu star (bias corrected)			59.54
879					Mean (detects)	10.4						
880												
881	**Gamma ROS Statistics using Imputed Non-Detects**											
882	GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs											
883	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)											
884	For such situations, GROS method may yield incorrect values of UCLs and BTVs											
885	This is especially true when the sample size is small.											
886	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates											
887					Minimum	0.01			Mean			8.243
888					Maximum	22			Median			7.15
889					SD	6.823			CV			0.828
890					k hat (MLE)	0.594			k star (bias corrected MLE)			0.514
891					Theta hat (MLE)	13.87			Theta star (bias corrected MLE)			16.02
892					nu hat (MLE)	16.64			nu star (bias corrected)			14.4
893					Adjusted Level of Significance (β)	0.0312						
894					Approximate Chi Square Value (14.40, α)	6.849			Adjusted Chi Square Value (14.40, β)			6.169
895					95% Gamma Approximate UCL (use when n>=50)	17.34			95% Gamma Adjusted UCL (use when n<50)			19.25
896												
897	**Estimates of Gamma Parameters using KM Estimates**											
898					Mean (KM)	8.6			SD (KM)			6.164
899					Variance (KM)	38			SE of Mean (KM)			1.728
900					k hat (KM)	1.946			k star (KM)			1.577
901					nu hat (KM)	54.5			nu star (KM)			44.16
902					theta hat (KM)	4.418			theta star (KM)			5.453
903					80% gamma percentile (KM)	13.23			90% gamma percentile (KM)			17.7
904					95% gamma percentile (KM)	22.03			99% gamma percentile (KM)			31.77

	A	B	C	D	E	F	G	H	I	J	K	L
905												
906						Gamma Kaplan-Meier (KM) Statistics						
907					Approximate Chi Square Value (44.16, α)	29.92			Adjusted Chi Square Value (44.16, β)			28.37
908					95% Gamma Approximate KM-UCL (use when n>=50)	12.69			95% Gamma Adjusted KM-UCL (use when n<50)			13.39
909												
910						Lognormal GOF Test on Detected Observations Only						
911					Shapiro Wilk Test Statistic	0.946			Shapiro Wilk GOF Test			
912					5% Shapiro Wilk Critical Value	0.85			Detected Data appear Lognormal at 5% Significance Level			
913					Lilliefors Test Statistic	0.153			Lilliefors GOF Test			
914					5% Lilliefors Critical Value	0.251			Detected Data appear Lognormal at 5% Significance Level			
915						Detected Data appear Lognormal at 5% Significance Level						
916												
917						Lognormal ROS Statistics Using Imputed Non-Detects						
918					Mean in Original Scale	8.69			Mean in Log Scale			1.912
919					SD in Original Scale	6.304			SD in Log Scale			0.761
920					95% t UCL (assumes normality of ROS data)	11.67			95% Percentile Bootstrap UCL			11.54
921					95% BCA Bootstrap UCL	11.51			95% Bootstrap t UCL			13.06
922					95% H-UCL (Log ROS)	15.06						
923												
924						Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution						
925					KM Mean (logged)	1.876			KM Geo Mean			6.525
926					KM SD (logged)	0.78			95% Critical H Value (KM-Log)			2.45
927					KM Standard Error of Mean (logged)	0.219			95% H-UCL (KM -Log)			15.03
928					KM SD (logged)	0.78			95% Critical H Value (KM-Log)			2.45
929					KM Standard Error of Mean (logged)	0.219						
930												
931						DL/2 Statistics						
932					DL/2 Normal				DL/2 Log-Transformed			
933					Mean in Original Scale	8.386			Mean in Log Scale			1.727
934					SD in Original Scale	6.644			SD in Log Scale			1.059
935					95% t UCL (Assumes normality)	11.53			95% H-Stat UCL			23.01
936						DL/2 is not a recommended method, provided for comparisons and historical reasons						
937												
938						Nonparametric Distribution Free UCL Statistics						
939						Detected Data appear Approximate Normal Distributed at 5% Significance Level						
940												
941						Suggested UCL to Use						
942					95% KM (t) UCL	11.66						
943												
944						When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test						
945						When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL						
946												
947						Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.						
948						Recommendations are based upon data size, data distribution, and skewness.						
949						These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).						
950						However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.						
951												
952												

	A	B	C	D	E	F	G	H	I	J	K	L
953	Selenium0823											
954												
955						General Statistics						
956					Total Number of Observations	14				Number of Distinct Observations		13
957										Number of Missing Observations		0
958					Minimum	8.3				Mean		35.24
959					Maximum	59				Median		32.5
960					SD	17.87				Std. Error of Mean		4.776
961					Coefficient of Variation	0.507				Skewness		-0.117
962												
963						Normal GOF Test						
964					Shapiro Wilk Test Statistic	0.919				Shapiro Wilk GOF Test		
965					5% Shapiro Wilk Critical Value	0.874				Data appear Normal at 5% Significance Level		
966					Lilliefors Test Statistic	0.168				Lilliefors GOF Test		
967					5% Lilliefors Critical Value	0.226				Data appear Normal at 5% Significance Level		
968						Data appear Normal at 5% Significance Level						
969												
970						Assuming Normal Distribution						
971					95% Normal UCL					95% UCLs (Adjusted for Skewness)		
972					95% Student's-t UCL	43.69				95% Adjusted-CLT UCL (Chen-1995)		42.93
973										95% Modified-t UCL (Johnson-1978)		43.67
974												
975						Gamma GOF Test						
976					A-D Test Statistic	0.528				Anderson-Darling Gamma GOF Test		
977					5% A-D Critical Value	0.742				Detected data appear Gamma Distributed at 5% Significance Level		
978					K-S Test Statistic	0.17				Kolmogorov-Smirnov Gamma GOF Test		
979					5% K-S Critical Value	0.23				Detected data appear Gamma Distributed at 5% Significance Level		
980						Detected data appear Gamma Distributed at 5% Significance Level						
981												
982						Gamma Statistics						
983					k hat (MLE)	3.242				k star (bias corrected MLE)		2.595
984					Theta hat (MLE)	10.87				Theta star (bias corrected MLE)		13.58
985					nu hat (MLE)	90.78				nu star (bias corrected)		72.66
986					MLE Mean (bias corrected)	35.24				MLE Sd (bias corrected)		21.87
987										Approximate Chi Square Value (0.05)		54.03
988					Adjusted Level of Significance	0.0312				Adjusted Chi Square Value		51.91
989												
990						Assuming Gamma Distribution						
991					95% Approximate Gamma UCL (use when n>=50))	47.38				95% Adjusted Gamma UCL (use when n<50)		49.33
992												
993						Lognormal GOF Test						
994					Shapiro Wilk Test Statistic	0.888				Shapiro Wilk Lognormal GOF Test		
995					5% Shapiro Wilk Critical Value	0.874				Data appear Lognormal at 5% Significance Level		
996					Lilliefors Test Statistic	0.165				Lilliefors Lognormal GOF Test		
997					5% Lilliefors Critical Value	0.226				Data appear Lognormal at 5% Significance Level		
998						Data appear Lognormal at 5% Significance Level						
999												
1000						Lognormal Statistics						
1001					Minimum of Logged Data	2.116				Mean of logged Data		3.4
1002					Maximum of Logged Data	4.078				SD of logged Data		0.644
1003												

	A	B	C	D	E	F	G	H	I	J	K	L
1004					Assuming Lognormal Distribution							
1005					95% H-UCL	55.31				90% Chebyshev (MVUE) UCL		55.76
1006					95% Chebyshev (MVUE) UCL	64.61				97.5% Chebyshev (MVUE) UCL		76.88
1007					99% Chebyshev (MVUE) UCL	101						
1008												
1009					Nonparametric Distribution Free UCL Statistics							
1010					Data appear to follow a Discernible Distribution at 5% Significance Level							
1011												
1012					Nonparametric Distribution Free UCLs							
1013					95% CLT UCL	43.09				95% Jackknife UCL		43.69
1014					95% Standard Bootstrap UCL	42.94				95% Bootstrap-t UCL		43.69
1015					95% Hall's Bootstrap UCL	42.41				95% Percentile Bootstrap UCL		42.5
1016					95% BCA Bootstrap UCL	42.64						
1017					90% Chebyshev(Mean, Sd) UCL	49.56				95% Chebyshev(Mean, Sd) UCL		56.06
1018					97.5% Chebyshev(Mean, Sd) UCL	65.06				99% Chebyshev(Mean, Sd) UCL		82.76
1019												
1020					Suggested UCL to Use							
1021					95% Student's-t UCL	43.69						
1022												
1023					Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.							
1024					Recommendations are based upon data size, data distribution, and skewness.							
1025					These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).							
1026					However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.							
1027												
1028					Note: For highly negatively-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be							
1029					reliable. Chen's and Johnson's methods provide adjustments for positvely skewed data sets.							
1030												
1031	Silver											
1032												
1033					General Statistics							
1034					Total Number of Observations	14				Number of Distinct Observations		11
1035					Number of Detects	13				Number of Non-Detects		1
1036					Number of Distinct Detects	11				Number of Distinct Non-Detects		1
1037					Minimum Detect	2.5				Minimum Non-Detect		2.5
1038					Maximum Detect	14				Maximum Non-Detect		2.5
1039					Variance Detects	14.27				Percent Non-Detects		7.143%
1040					Mean Detects	7.454				SD Detects		3.777
1041					Median Detects	5.9				CV Detects		0.507
1042					Skewness Detects	0.268				Kurtosis Detects		-1.49
1043					Mean of Logged Detects	1.875				SD of Logged Detects		0.555
1044												
1045					Normal GOF Test on Detects Only							
1046					Shapiro Wilk Test Statistic	0.893				Shapiro Wilk GOF Test		
1047					5% Shapiro Wilk Critical Value	0.866				Detected Data appear Normal at 5% Significance Level		
1048					Lilliefors Test Statistic	0.203				Lilliefors GOF Test		
1049					5% Lilliefors Critical Value	0.234				Detected Data appear Normal at 5% Significance Level		
1050					Detected Data appear Normal at 5% Significance Level							
1051												

	A	B	C	D	E	F	G	H	I	J	K	L
1052	**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**											
1053					KM Mean	7.1				KM Standard Error of Mean		1.036
1054					KM SD	3.723				95% KM (BCA) UCL		8.929
1055					95% KM (t) UCL	8.934				95% KM (Percentile Bootstrap) UCL		8.707
1056					95% KM (z) UCL	8.803				95% KM Bootstrap t UCL		9.096
1057					90% KM Chebyshev UCL	10.21				95% KM Chebyshev UCL		11.61
1058					97.5% KM Chebyshev UCL	13.57				99% KM Chebyshev UCL		17.4
1059												
1060	**Gamma GOF Tests on Detected Observations Only**											
1061					A-D Test Statistic	0.629	**Anderson-Darling GOF Test**					
1062					5% A-D Critical Value	0.737	Detected data appear Gamma Distributed at 5% Significance Level					
1063					K-S Test Statistic	0.236	**Kolmogorov-Smirnov GOF**					
1064					5% K-S Critical Value	0.238	Detected data appear Gamma Distributed at 5% Significance Level					
1065	**Detected data appear Gamma Distributed at 5% Significance Level**											
1066												
1067	**Gamma Statistics on Detected Data Only**											
1068					k hat (MLE)	3.908				k star (bias corrected MLE)		3.057
1069					Theta hat (MLE)	1.907				Theta star (bias corrected MLE)		2.438
1070					nu hat (MLE)	101.6				nu star (bias corrected)		79.49
1071					Mean (detects)	7.454						
1072												
1073	**Gamma ROS Statistics using Imputed Non-Detects**											
1074	GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs											
1075	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)											
1076	For such situations, GROS method may yield incorrect values of UCLs and BTVs											
1077	This is especially true when the sample size is small.											
1078	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates											
1079					Minimum	0.951				Mean		6.989
1080					Maximum	14				Median		5.6
1081					SD	4.024				CV		0.576
1082					k hat (MLE)	2.575				k star (bias corrected MLE)		2.071
1083					Theta hat (MLE)	2.714				Theta star (bias corrected MLE)		3.375
1084					nu hat (MLE)	72.1				nu star (bias corrected)		57.98
1085					Adjusted Level of Significance (β)	0.0312						
1086					Approximate Chi Square Value (57.98, α)	41.48				Adjusted Chi Square Value (57.98, β)		39.63
1087					95% Gamma Approximate UCL (use when n>=50)	9.771				95% Gamma Adjusted UCL (use when n<50)		10.23
1088												
1089	**Estimates of Gamma Parameters using KM Estimates**											
1090					Mean (KM)	7.1				SD (KM)		3.723
1091					Variance (KM)	13.86				SE of Mean (KM)		1.036
1092					k hat (KM)	3.638				k star (KM)		2.906
1093					nu hat (KM)	101.9				nu star (KM)		81.37
1094					theta hat (KM)	1.952				theta star (KM)		2.443
1095					80% gamma percentile (KM)	10.17				90% gamma percentile (KM)		12.68
1096					95% gamma percentile (KM)	15.04				99% gamma percentile (KM)		20.15
1097												
1098	**Gamma Kaplan-Meier (KM) Statistics**											
1099					Approximate Chi Square Value (81.37, α)	61.58				Adjusted Chi Square Value (81.37, β)		59.3
1100					95% Gamma Approximate KM-UCL (use when n>=50)	9.381				95% Gamma Adjusted KM-UCL (use when n<50)		9.742
1101												

	A	B	C	D	E	F	G	H	I	J	K	L
1102					Lognormal GOF Test on Detected Observations Only							
1103					Shapiro Wilk Test Statistic	0.912	Shapiro Wilk GOF Test					
1104					5% Shapiro Wilk Critical Value	0.866	Detected Data appear Lognormal at 5% Significance Level					
1105					Lilliefors Test Statistic	0.235	Lilliefors GOF Test					
1106					5% Lilliefors Critical Value	0.234	Detected Data Not Lognormal at 5% Significance Level					
1107					Detected Data appear Approximate Lognormal at 5% Significance Level							
1108												
1109					Lognormal ROS Statistics Using Imputed Non-Detects							
1110					Mean in Original Scale	7.045	Mean in Log Scale					1.78
1111					SD in Original Scale	3.939	SD in Log Scale					0.641
1112					95% t UCL (assumes normality of ROS data)	8.909	95% Percentile Bootstrap UCL					8.707
1113					95% BCA Bootstrap UCL	8.781	95% Bootstrap t UCL					9.058
1114					95% H-UCL (Log ROS)	10.9						
1115												
1116					Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution							
1117					KM Mean (logged)	1.807	KM Geo Mean					6.091
1118					KM SD (logged)	0.57	95% Critical H Value (KM-Log)					2.128
1119					KM Standard Error of Mean (logged)	0.159	95% H-UCL (KM -Log)					10.03
1120					KM SD (logged)	0.57	95% Critical H Value (KM-Log)					2.128
1121					KM Standard Error of Mean (logged)	0.159						
1122												
1123					DL/2 Statistics							
1124					DL/2 Normal		DL/2 Log-Transformed					
1125					Mean in Original Scale	7.011	Mean in Log Scale					1.757
1126					SD in Original Scale	3.99	SD in Log Scale					0.692
1127					95% t UCL (Assumes normality)	8.899	95% H-Stat UCL					11.52
1128					DL/2 is not a recommended method, provided for comparisons and historical reasons							
1129												
1130					Nonparametric Distribution Free UCL Statistics							
1131					Detected Data appear Normal Distributed at 5% Significance Level							
1132												
1133					Suggested UCL to Use							
1134					95% KM (t) UCL	8.934						
1135												
1136					Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.							
1137					Recommendations are based upon data size, data distribution, and skewness.							
1138					These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).							
1139					However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.							
1140												
1141												
1142	Zinc											
1143												
1144					General Statistics							
1145					Total Number of Observations	14	Number of Distinct Observations					14
1146							Number of Missing Observations					0
1147					Minimum	55	Mean					1277
1148					Maximum	15000	Median					210
1149					SD	3953	Std. Error of Mean					1056
1150					Coefficient of Variation	3.095	Skewness					3.732
1151												

	A	B	C	D	E	F	G	H	I	J	K	L
1152						Normal GOF Test						
1153					Shapiro Wilk Test Statistic	0.33			Shapiro Wilk GOF Test			
1154					5% Shapiro Wilk Critical Value	0.874			Data Not Normal at 5% Significance Level			
1155					Lilliefors Test Statistic	0.508			Lilliefors GOF Test			
1156					5% Lilliefors Critical Value	0.226			Data Not Normal at 5% Significance Level			
1157						Data Not Normal at 5% Significance Level						
1158												
1159						Assuming Normal Distribution						
1160					95% Normal UCL				95% UCLs (Adjusted for Skewness)			
1161					95% Student's-t UCL	3148			95% Adjusted-CLT UCL (Chen-1995)			4141
1162									95% Modified-t UCL (Johnson-1978)			3324
1163												
1164						Gamma GOF Test						
1165					A-D Test Statistic	2.54			Anderson-Darling Gamma GOF Test			
1166					5% A-D Critical Value	0.815			Data Not Gamma Distributed at 5% Significance Level			
1167					K-S Test Statistic	0.415			Kolmogorov-Smirnov Gamma GOF Test			
1168					5% K-S Critical Value	0.245			Data Not Gamma Distributed at 5% Significance Level			
1169						Data Not Gamma Distributed at 5% Significance Level						
1170												
1171						Gamma Statistics						
1172					k hat (MLE)	0.386			k star (bias corrected MLE)			0.351
1173					Theta hat (MLE)	3312			Theta star (bias corrected MLE)			3643
1174					nu hat (MLE)	10.8			nu star (bias corrected)			9.818
1175					MLE Mean (bias corrected)	1277			MLE Sd (bias corrected)			2157
1176									Approximate Chi Square Value (0.05)			3.828
1177					Adjusted Level of Significance	0.0312			Adjusted Chi Square Value			3.347
1178												
1179						Assuming Gamma Distribution						
1180					95% Approximate Gamma UCL (use when n>=50))	3276			95% Adjusted Gamma UCL (use when n<50)			3747
1181												
1182						Lognormal GOF Test						
1183					Shapiro Wilk Test Statistic	0.795			Shapiro Wilk Lognormal GOF Test			
1184					5% Shapiro Wilk Critical Value	0.874			Data Not Lognormal at 5% Significance Level			
1185					Lilliefors Test Statistic	0.233			Lilliefors Lognormal GOF Test			
1186					5% Lilliefors Critical Value	0.226			Data Not Lognormal at 5% Significance Level			
1187						Data Not Lognormal at 5% Significance Level						
1188												
1189						Lognormal Statistics						
1190					Minimum of Logged Data	4.007			Mean of logged Data			5.436
1191					Maximum of Logged Data	9.616			SD of logged Data			1.44
1192												
1193						Assuming Lognormal Distribution						
1194					95% H-UCL	2701			90% Chebyshev (MVUE) UCL			1309
1195					95% Chebyshev (MVUE) UCL	1644			97.5% Chebyshev (MVUE) UCL			2108
1196					99% Chebyshev (MVUE) UCL	3021						
1197												
1198						Nonparametric Distribution Free UCL Statistics						
1199						Data do not follow a Discernible Distribution (0.05)						
1200												

	A	B	C	D	E	F	G	H	I	J	K	L
1201	**Nonparametric Distribution Free UCLs**											
1202					95% CLT UCL	3015				95% Jackknife UCL		3148
1203					95% Standard Bootstrap UCL	2940				95% Bootstrap-t UCL		33015
1204					95% Hall's Bootstrap UCL	15944				95% Percentile Bootstrap UCL		3373
1205					95% BCA Bootstrap UCL	4408						
1206					90% Chebyshev(Mean, Sd) UCL	4446				95% Chebyshev(Mean, Sd) UCL		5882
1207					97.5% Chebyshev(Mean, Sd) UCL	7874				99% Chebyshev(Mean, Sd) UCL		11788
1208												
1209	**Suggested UCL to Use**											
1210					95% Chebyshev (Mean, Sd) UCL	5882						
1211												
1212	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
1213	Recommendations are based upon data size, data distribution, and skewness.											
1214	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
1215	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
1216												

	A	B	C	D	E	F	G	H	I	J	K	L	M
1				General Statistics on Uncensored Data									
2		Date/Time of Computation		ProUCL 5.110/18/2019 10:50:15 AM									
3		User Selected Options											
4			From File	ProUCL Input_HCW.xls									
5			Full Precision	OFF									
6													
7	From File: ProUCL Input_HCW.xls												
8													
9	General Statistics for Censored Data Set (with NDs) using Kaplan Meier Method												
10													
11	Variable		NumObs	# Missing	Num Ds	NumNDs	% NDs	Min ND	Max ND	KM Mean	KM Var	KM SD	KM CV
12		Antimony	4	0	0	4	100.00%	4.8	5	N/A	N/A	N/A	N/A
13		Arsenic	4	0	3	1	25.00%	4.8	4.8	19.88	174.7	13.22	0.665
14		Barium	4	0	4	0	0.00%	N/A	N/A	55.25	911.6	30.19	0.546
15		Beryllium	4	0	1	3	75.00%	0.48	0.5	0.685	0.126	0.355	0.518
16		Cadmium	4	0	4	0	0.00%	N/A	N/A	0.708	0.0268	0.164	0.231
17		Chromium	4	0	4	0	0.00%	N/A	N/A	18.93	326.7	18.07	0.955
18		Copper	4	0	4	0	0.00%	N/A	N/A	1001	1138564	1067	1.066
19		Lead	4	0	4	0	0.00%	N/A	N/A	21.75	88.92	9.43	0.434
20		Manganese	4	0	4	0	0.00%	N/A	N/A	362.5	58958	242.8	0.67
21		Mercury	4	0	2	2	50.00%	0.093	0.1	0.304	0.115	0.339	1.115
22		Nickel	4	0	4	0	0.00%	N/A	N/A	19.7	316	17.78	0.902
23		Selenium	4	0	3	1	25.00%	4.8	4.8	8.325	8.017	2.831	0.34
24		Silver	4	0	0	4	100.00%	2.4	2.5	N/A	N/A	N/A	N/A
25		Thallium	4	0	0	4	100.00%	4.8	5	N/A	N/A	N/A	N/A
26		Zinc	4	0	4	0	0.00%	N/A	N/A	157	9036	95.06	0.605
27													
28	General Statistics for Raw Data Sets using Detected Data Only												
29													
30	Variable		NumObs	# Missing	Minimum	Maximum	Mean	Median	Var	SD	MAD/0.675	Skewness	CV
31		Antimony	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
32		Arsenic	3	0	8.7	34	24.9	32	197.8	14.07	2.965	-1.693	0.565
33		Barium	4	0	34	100	55.25	43.5	911.6	30.19	8.154	1.856	0.546
34		Beryllium	1	0	1.3	1.3	1.3	1.3	N/A	N/A	0	N/A	N/A
35		Cadmium	4	0	0.57	0.93	0.708	0.665	0.0268	0.164	0.119	1.09	0.231
36		Chromium	4	0	8.7	46	18.93	10.5	326.7	18.07	1.705	1.984	0.955
37		Copper	4	0	64	2200	1001	870	1138564	1067	1139	0.262	1.066
38		Lead	4	0	11	33	21.75	21.5	88.92	9.43	10.38	0.13	0.434
39		Manganese	4	0	120	690	362.5	320	58958	242.8	192.7	0.922	0.67
40		Mercury	2	0	0.14	0.89	0.515	0.515	0.281	0.53	0.556	N/A	1.03
41		Nickel	4	0	6.8	46	19.7	13	316	17.78	4.596	1.833	0.902
42		Selenium	3	0	6.5	12	9.5	10	7.75	2.784	2.965	-0.782	0.293
43		Silver	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
44		Thallium	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
45		Zinc	4	0	48	270	157	155	9036	95.06	105.3	0.103	0.605
46													

	A	B	C	D	E	F	G	H	I	J	K	L	M
47	Percentiles using all Detects (Ds) and Non-Detects (NDs)												
48													
49	Variable		NumObs	# Missing	10%ile	20%ile	25%ile(Q1)	50%ile(Q2)	75%ile(Q3)	80%ile	90%ile	95%ile	99%ile
50		Antimony	4	0	4.83	4.86	4.875	4.9	4.925	4.94	4.97	4.985	4.997
51		Arsenic	4	0	5.97	7.14	7.725	20.35	32.5	32.8	33.4	33.7	33.94
52		Barium	4	0	36.4	38.8	40	43.5	58.75	67	83.5	91.75	98.35
53		Beryllium	4	0	0.48	0.48	0.48	0.49	0.7	0.82	1.06	1.18	1.276
54		Cadmium	4	0	0.579	0.588	0.593	0.665	0.78	0.81	0.87	0.9	0.924
55		Chromium	4	0	9.09	9.48	9.675	10.5	19.75	25	35.5	40.75	44.95
56		Copper	4	0	86.8	109.6	121	870	1750	1840	2020	2110	2182
57		Lead	4	0	13.1	15.2	16.25	21.5	27	28.2	30.6	31.8	32.76
58		Manganese	4	0	162	204	225	320	457.5	504	597	643.5	680.7
59		Mercury	4	0	0.0951	0.0972	0.0983	0.12	0.328	0.44	0.665	0.778	0.868
60		Nickel	4	0	8.66	10.52	11.45	13	21.25	26.2	36.1	41.05	45.01
61		Selenium	4	0	5.31	5.82	6.075	8.25	10.5	10.8	11.4	11.7	11.94
62		Silver	4	0	2.43	2.46	2.475	2.5	2.5	2.5	2.5	2.5	2.5
63		Thallium	4	0	4.83	4.86	4.875	4.95	5	5	5	5	5
64		Zinc	4	0	69.6	91.2	102	155	210	222	246	258	267.6

ATTACHMENT G-3

LEAD EVALUATION

Calculations of Blood Lead Concentrations (PbBs) and Risk in Nonresidential Areas

U.S. EPA Technical Review Workgroup for Lead

Version date 06/14/2017

Edit Red Cells

Variable	Description of Variable	Units	GSDi and PbBo from Analysis of NHANES 2009-2014	GSDi and PbBo from Analysis of NHANES 2007-2010	GSDi and PbBo from Analysis of NHANES 2004-2007	GSDi and PbBo from Analysis of NHANES III (Phases 1&2)
PbS	Soil lead concentration	µg/g or ppm	230	230	230	230
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9	0.9	0.9	0.9
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4	0.4	0.4	0.4
GSD_i	Geometric standard deviation PbB	--	1.8	1.7	1.8	2.1
PbB_0	Baseline PbB	µg/dL	0.6	0.7	1.0	1.5
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.025	0.050	0.050	0.050
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	--	--	--	--
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--	--	--	--
K_{SD}	Mass fraction of soil in dust	--	--	--	--	--
$AF_{S, D}$	Absorption fraction (same for soil and dust)	--	0.12	0.12	0.12	0.12
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/yr	90	90	90	90
$AT_{S, D}$	Averaging time (same for soil and dust)	days/yr	365	365	365	365
PbB_{adult}	PbB of adult worker, geometric mean	µg/dL	0.7	0.8	1.1	1.6
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adult workers	µg/dL	1.7	1.8	2.7	5.0
PbB_t	Target PbB level of concern (e.g., 2-8 ug/dL)	µg/dL	**5.0**	**5.0**	**5.0**	**5.0**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB exceeds target PbB, assuming lognormal distribution**	**%**	**0.0229%**	**0.0%**	**0.3%**	**5.0%**

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil

Calculations of Preliminary Remediation Goals (PRGs) for Soil in Nonresidential Areas

U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee

Version date 06/14/2017

EDIT RED CELLS

Variable	Description of Variable	Units	GSDi and PbBo from Analysis of NHANES 2009-2014	GSDi and PbBo from Analysis of NHANES 2007-2010	GSDi and PbBo from Analysis of NHANES 1999-2004	GSDi and PbBo from Analysis of NHANES III (Phases 1&2)
$PbB_{fetal,\ 0.95}$	Target PbB in fetus (e.g., 2-8 µg/dL)	µg/dL	5	5	5	5
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9	0.9	0.9	0.9
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4	0.4	0.4	0.4
GSD_i	Geometric standard deviation PbB	--	1.8	1.7	1.8	2.1
PbB_0	Baseline PbB	µg/dL	0.6	0.7	1.0	1.5
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.025	0.025	0.025	0.025
$AF_{S,\ D}$	Absorption fraction (same for soil and dust)	--	0.12	0.12	0.12	0.12
$EF_{S,\ D}$	Exposure frequency (same for soil and dust)	days/yr	90	90	90	90
$AT_{S,\ D}$	Averaging time (same for soil and dust)	days/yr	365	365	365	365
PRG in Soil for no more than 5% probability that fetal PbB exceeds target PbB		**ppm**	**5,112**	**5,478**	**3,760**	**471**

Calculations of Blood Lead Concentrations (PbBs) and Risk in Nonresidential Areas

U.S. EPA Technical Review Workgroup for Lead

Version date 06/14/2017

Edit Red Cells

Variable	Description of Variable	Units	GSDi and PbBo from Analysis of NHANES 2009-2014	GSDi and PbBo from Analysis of NHANES 2007-2010	GSDi and PbBo from Analysis of NHANES 2004-2007	GSDi and PbBo from Analysis of NHANES III (Phases 1&2)
PbS	Soil lead concentration	µg/g or ppm	230	230	230	230
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9	0.9	0.9	0.9
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4	0.4	0.4	0.4
GSD_i	Geometric standard deviation PbB	--	1.8	1.7	1.8	2.1
PbB_0	Baseline PbB	µg/dL	0.6	0.7	1.0	1.5
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.025	0.050	0.050	0.050
IR_{S+D}	Total ingestion rate of outdoor soil and indoor dust	g/day	--	--	--	--
W_S	Weighting factor; fraction of IR_{S+D} ingested as outdoor soil	--	--	--	--	--
K_{SD}	Mass fraction of soil in dust	--	--	--	--	--
$AF_{S, D}$	Absorption fraction (same for soil and dust)	--	0.12	0.12	0.12	0.12
$EF_{S, D}$	Exposure frequency (same for soil and dust)	days/yr	90	90	90	90
$AT_{S, D}$	Averaging time (same for soil and dust)	days/yr	365	365	365	365
PbB_{adult}	PbB of adult worker, geometric mean	µg/dL	0.7	0.8	1.1	1.6
$PbB_{fetal, 0.95}$	95th percentile PbB among fetuses of adult workers	µg/dL	1.7	1.8	2.7	5.0
PbB_t	Target PbB level of concern (e.g., 2-8 ug/dL)	µg/dL	**10.0**	**10.0**	**10.0**	**10.0**
$P(PbB_{fetal} > PbB_t)$	**Probability that fetal PbB exceeds target PbB, assuming lognormal distribution**	**%**	**0.0001%**	**0.0%**	**0.0%**	**0.5%**

Source: U.S. EPA (1996). Recommendations of the Technical Review Workgroup for Lead for an Interim Approach to Assessing Risks Associated with Adult Exposures to Lead in Soil

Calculations of Preliminary Remediation Goals (PRGs) for Soil in Nonresidential Areas

U.S. EPA Technical Review Workgroup for Lead, Adult Lead Committee

Version date 06/14/2017

EDIT RED CELLS

Variable	Description of Variable	Units	GSDi and PbBo from Analysis of NHANES 2009-2014	GSDi and PbBo from Analysis of NHANES 2007-2010	GSDi and PbBo from Analysis of NHANES 1999-2004	GSDi and PbBo from Analysis of NHANES III (Phases 1&2)
$PbB_{fetal,\ 0.95}$	Target PbB in fetus (e.g., 2-8 µg/dL)	µg/dL	10	10	10	10
$R_{fetal/maternal}$	Fetal/maternal PbB ratio	--	0.9	0.9	0.9	0.9
BKSF	Biokinetic Slope Factor	µg/dL per µg/day	0.4	0.4	0.4	0.4
GSD_i	Geometric standard deviation PbB	--	1.8	1.7	1.8	2.1
PbB_0	Baseline PbB	µg/dL	0.6	0.7	1.0	1.5
IR_S	Soil ingestion rate (including soil-derived indoor dust)	g/day	0.025	0.025	0.025	0.025
$AF_{S,\ D}$	Absorption fraction (same for soil and dust)	--	0.12	0.12	0.12	0.12
$EF_{S,\ D}$	Exposure frequency (same for soil and dust)	days/yr	90	90	90	90
$AT_{S,\ D}$	Averaging time (same for soil and dust)	days/yr	365	365	365	365
PRG in Soil for no more than 5% probability that fetal PbB exceeds target PbB		**ppm**	**12,251**	**13,321**	**10,900**	**6,011**

APPENDIX H

SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT

APPENDIX H

SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT VERDE CENTRAL MINE VOLUNTARY REMEDIATION PROGRAM

Near Jerome, Arizona

VRP Site Code: 508483-00

Prepared for
Freeport Minerals Corporation

April 17, 2020

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LIST OF ACRONYMS AND ABBREVIATIONS

AAC – Arizona Administrative Code

ADEQ – Arizona Department of Environmental Quality

AECOM – AECOM Technical Services, Inc.

AF – absorbed fraction

amsl – above mean sea level

AUF – area use factor

A&We – aquatic and wildlife, ephemeral

BAF – bioavailability factor

BCC – bioaccumulative chemicals of concern

bgs – below ground surface

BERA – baseline ecological risk assessment

BLM – Bureau of Land Management

BW – body weight

COPEC – contaminant of potential ecological concern

CSM – conceptual site model

CTV – central tendency value

DD – daily dose

DL – detection limit

EA – exposure area

ECOSSL – ecological soil screening level

EPC – exposure point concentration

ERA – ecological risk assessment

ERAGS – Ecological Risk Assessment Guidance for Superfund

FI – food intake

FIR – food ingestion rate

FMC – Freeport Minerals Corporation

HEAST – Health Effects Assessment Summary Tables

HI – hazard index

HHRA – human health risk assessment

HQ – hazard quotient

IRIS – Integrated Risk Information System

LANL – Los Alamos National Laboratory

LOEC – lowest observable effect concentration

LOAEL – lowest observed adverse effect level

LRL – laboratory reporting limit

MDC – maximum detected concentration

MRL – maximum reporting limit

NOAEL – no observed adverse effect level

µg/L – micrograms per liter

mg/kg – milligrams per kilogram

mg/L – milligrams per liter

ORNL – Oak Ridge National Laboratory

PAH – polynuclear aromatic hydrocarbon

RL – reporting limit

SAP – sampling and analysis plan

SCR – Site Characterization Report

SIR – soil ingestion rate

SLERA – screening level ecological risk assessment

SMDP – Scientific Management Decision Point

SRL – soil remediation level

SPLP – Synthetic Precipitation Leaching Procedure

SUF – site use factor

T&E – threatened and endangered

TRV – toxicity reference value

UCL – upper confidence limit

USEPA – United States Environmental Protection Agency

USFWS – United States Fish and Wildlife Service

VCM – Verde Central Mine

VOC – volatile organic compound

1.0 INTRODUCTION

The Freeport Minerals Corporation (FMC) has retained AECOM Technical Services, Inc. (AECOM) to perform a screening level ecological risk assessment (SLERA) for the former Verde Central Mine (VCM), located near Jerome, Arizona (Site). This SLERA is submitted as Appendix H of the Site Characterization Report (SCR) for the former VCM, under the Arizona Department of Environmental Quality (ADEQ) Voluntary Remediation Program (VRP). The results of this SLERA are summarized in Section 4.2 of the SCR.

1.1 OBJECTIVES

Physically disturbed areas are evident in association with past mining activities; however, there are no overt signs of acute or chronic toxicity (e.g., stressed or dead vegetation, absence of biota) within the VCM. Given the sparse vegetation and therefore, minimal cover and food resources, it is reasonable to assume that most biota would prefer adjacent areas with less physical disturbance. While potential for localized hazards and risk cannot be discounted from exposure to several metals such as copper within the VCM, the risks to soil communities and individual receptors are expected to be minimal. This SLERA was prepared for completeness of the documentation under the VRP to evaluate whether Site soil and Hull Canyon Wash sediment and surface water pose potential risks to ecological receptors, if present on the Site.

This assessment was conducted through the collection and evaluation of data for the Site as described in the Revised Project Work Plan (URS Corporation [URS] 2013a) and outlined in the SCR. Data obtained during the field investigation activities conducted in 2014, 2015 and 2018 were used in the SLERA.

Comprehensive ecological risk assessment guidance is not available from the state of Arizona; therefore, the SLERA is based on national level U.S. Environmental Protection Agency (USEPA) guidance. The framework for the proposed SLERA is intended to be consistent with USEPA methodology, and is based on the following key guidance documents:

- *Ecological Risk Assessment Guidance for Superfund* (ERAGS) (USEPA, 1997a). ERAGS is specific guidance establishing the fundamental tiered process for assessing ecological risk at hazardous waste sites. This SLERA focuses on the first three steps of the USEPA process.

- *Guidelines for Ecological Risk Assessment* (USEPA, 1998).This general guidance focuses on the process and theory of developing an ecological risk assessment (ERA) in the U.S.

- *The Role of Screening-Level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments (*BERA*)* (USEPA, 2001). This guidance provides clarification on sub-tiering in conducting an ERA and provides a refining step for contaminants of potential ecological concern (COPECs) as part of the Step 3 of the ERA process, using site-specific data. Only COPECs, pathways, and receptors retained from Step 3A of the SLERA would be subject to additional, baseline level risk assessment (Step 3B through Step 8).

- Memorandum - Issuance of Final Guidance: Ecological Risk Assessment and Risk Management Principles for Superfund Sites (USEPA, 1999a)

- Eco Updates:
    - Volume 1, Numbers 1 through 5 (USEPA, 1991a,b; and 1992a,b,c)
    - Volume 2, Numbers 1 through 4 (USEPA, 1994a,b,c,d)
    - Volume 3, Numbers 1 and 2 (USEPA, 1996a,b)

1.2 ECOLOGICAL RISK ASSESSMENT PROCESS

A streamlined SLERA was conducted at the site that includes an evaluation of risk (both current and anticipated future risk) for a select number of receptors, exposure pathways and media. As presented in ERAGS (USEPA, 1997a), the SLERA encompasses Steps 1 and 2 of the ERA process, complemented by a Step 3 refinement of COPECs per USEPA (2001) guidance (Step 3A). The outcome of Step 2 represents an initial refinement of COPECs based on a conservative screening level risk estimate. Following the Step 2 screening, and utilizing elements of USEPA (2001) guidance, refining COPECs in Step 3 of the ERA process enables identification of screening level risk estimates with site-specific significance. The overall SLERA process includes the following:

- **Step 1: Screening level problem formulation.** The first step of the SLERA process is consistent with USEPA guidance (1997a and 1998). The intent of Step 1 is to present the tools and sources to be used in the development of a preliminary conceptual site model (CSM). This step involves a qualitative assessment of the site to determine area, medium, and receptor inclusion or exclusion in the SLERA. Results of this evaluation provide the basis for focusing on those areas, media, and receptors appropriate for further evaluation.

- **Step 2: Initial screening level evaluation.** The second step of the SLERA corresponds to the first two steps of the eight-step ERA process defined by USEPA (1997a). The evaluation is based on the assumption of maximum exposure to site constituents and is

intended to focus the risk assessment to only those COPECs and key measurement receptors that require further site-specific evaluation in Step 3. The outcome of the Step 2 evaluation is an identification of COPECs and associated receptors with the potential for unacceptable risk, which are carried forward into Step 3 of the risk assessment process.

- **Step 3: Refinement of COPECs.** As defined in USEPA (1997a) and further detailed in USEPA (2001), the outcome of Step 3A of this SLERA represents a scientific management decision point (SMDP). In most cases, the Step 3 refined risk estimate provides the basis for defining potential site risk drivers with the overall goal of identifying and prioritizing additional data needs for a potential BERA or a remedial action decision for the site.

1.3 SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT CONTENTS

The SLERA includes the following sections while incorporating details from the SCR:

- Section 2.0, provides a site description and development of an acceptable dataset.
- Section 3.0, the problem formulation, summarizes and identifies key ecological communities, receptors, appropriate Step 2 and Step 3A assessment and measurement endpoints, and the process for determining site COPECs.
- Section 4.0, presents the sources, procedures, and assumptions for exposure and toxicity assessment parameters applied in the Step 2 and Step 3A evaluations, and includes an Exposure Characterization, which describes exposure assumptions and models used to estimate exposure and an Ecological Effects Characterization that presents an overview of the toxicity information available to derive toxicity reference values (TRVs) for each representative species or receptor group.
- Section 5.0, the risk characterization, provides the methods and process to calculate and describe risk estimates assuming Steps 2 and 3A toxicity and exposure assumptions.
- Section 6.0, the uncertainty analysis, includes a qualitative evaluation of major uncertainties and limitations associated with the risk assessment results, data, and methodology inherent to SLERAs**.**
- Section 7.0, presents a summary of the risk results and conclusions based on consideration of the Step 3A refinement of COPECs, risk characterization and uncertainty analyses.
- Section 8.0, includes the literature and regulatory sources used in the SLERA.

Tables and figures provide data and graphical representations of the information.

2.0 SITE DESCRIPTION AND THE IDENTIFICATION OF AN ACCEPTABLE DATASET

This section provides a brief description of the Site, describes the data collection process and presents how the data were evaluated for use in the SLERA.

2.1 SITE DESCRIPTION AND ECOLOGICAL SETTING

The Site is a former copper mine site located in central Arizona, approximately 0.7 miles southwest of the Town of Jerome (Figure H-1). The site is approximately 12 acres in overall size and is located on the south side of State Highway 89A. The overall project area (Figure H-2) includes a mine rock stockpile comprised of Waste Rock and Low-Grade Ore, miscellaneous mining residual materials (High Grade Ore, Tailing and Suspected Waste Concentrate from milling operations), multiple closed mine shafts/adits, and the foundation of a former mill. Approximately 6 acres of the project area are covered with waste rock material. The Site is located in Hull Canyon, a steep, rocky canyon with relatively minimal soil development and difficult access. The elevation of the project varies from approximately 5,350 feet above mean sea level (amsl) at the lowest point in Hull Canyon, to 5,520 feet amsl at the highest elevations of the remnant building foundations (URS, 2013b).

Vegetation in the project area is characteristic of the Mogollon Chaparral Biotic Community vegetation community (URS, 2013b). This vegetation community occurs across central Arizona (Mogollon Rim), western New Mexico and southern Utah and Nevada. It often dominants along the mid-elevation transition from the Mojave, Sonoran, and northern Chihuahuan deserts into mountains. It occurs on foothills, mountain slopes, and canyons in drier habitats below the Ponderosa pine (*Pinus ponderosa*) and oak woodlands. Stands are often associated with more xeric and coarse textured substrates such as limestone, basalt, or alluvium. The moderate to dense shrub canopy includes species such as shrub live oak (*Quercus turbinella*), birchleaf mountain mahogany (*Cercocarpus betuloides*), skunkbush sumac (*Rhus trilobata*), silktassels (*Garrya wrightii*), and desert ceanothus (C*eanothus greggii*).

A number of wildlife species are expected to be found in the vicinity of Hull Canyon and may include the following:

- Mammalian species include: bighorn sheep (*Ovis canadensis*), black-tailed jackrabbit (*Lepus californicus*) and coyote (*Canis latrans*), bobcat (*Lynx rufus*), rock squirrel (*Spermaphilus variegatus),* white-tailed antelope squirrel (*Ammospermophilus leucurus*), Ord's Kangaroo rat (*Dipodomys ordii*), desert woodrat (*Neotoma lepida*), bushy-tailed

woodrat (*Neotoma cinerea*), black-tailed (mule) deer (*Ococoileus hemionus*), and desert cottontail (*Sylvilagus audubonii*).

- Avian species include: lark sparrow (*Chondestes grammacus*), horned lark (*Eremophila alpestris*), sagebrush sparrow (*Artemisiospiza nevadensis*), dark-eyed junco (*Junco hyemalis*), rock wren (*Salpinctes obsoletus*), canyon wren (*Catherpes mexicanus*), western bluebird (*Sialia mexicana*), Gambel's quail (*Callipepla gambelii*), turkey vulture (*Cathartes aura*), red-tailed hawk (*Buteo jamaicensis*) and American kestrel (*Falco sparverius*).

- Reptilian species include: desert collared lizard (*Crotaphytus bicinctores*), long-nosed leopard lizard (*Gambelia wislizenii*), common side-blotched lizard (*Uta stansburiana*), sagebrush lizard (*Sceloporus graciosus*), greater short-horned lizard (*Phrynosoma hernandesi*), western whiptail (*Aspidoscelis tigris*), striped whipsnake (*Coluber taeniatus*), and western rattlesnake (*Crotalus oreganus*).

An unnamed ephemeral streambed (referred to as Hull Canyon Wash in this evaluation), exists at the base of the canyon and toe of the rock stockpile located within the Site. Flow in the wash, when present, is from southwest to northeast across the Site; flow is generally only present in response to precipitation events. The drainage in the project area is ephemeral and dry most of the year, only flowing for short durations in response to rain events. As is characteristic of arid region ephemeral drainages, during times of intense rainfall when the soil in this area becomes saturated, water runs across the surface into confined wash channels. The observed ephemeral drainage ranges in width from 8 to 12 feet and has a length of 2,257 feet (URS, 2013b).

2.2 IDENTIFICATION OF ACCEPTABLE DATASET

Target analytes and data quality objectives were established in the sampling and analysis plan (SAP) in order to collect a dataset of sufficient quality to support risk assessment. The SLERA incorporated analytical results for surface soil (0 to 4 inches below ground surface [bgs]), sediment, and surface water. Although polynuclear aromatic hydrocarbons (PAHs) were also evaluated in the SCR in surface water and sediment in the Hull Canyon Wash, there were no detections of PAHs and therefore, no exceedances of screening levels. Based on this evaluation in the SCR, only metals are evaluated in this SLERA. Synthetic precipitation leaching procedure (SPLP) metals were also evaluated in the SCR to help characterize the potential for metals leaching to groundwater at concentrations that may be harmful to human health. Groundwater is not considered a media of concern for ecological receptors at the overall site and therefore, the evaluation of SPLP results is not considered further in the SLERA.

Analytical data are presented in detail in Attachment H-1. The samples used in the SLERA are listed in Table H-1 and include:

- **Soil.** Surface soil samples (0 to 4 inches bgs) from 36 locations within the overall Site.
- **Sediment.** Sediment/soil samples from four representative locations collected along the Hull Canyon Wash adjacent to mine site area.
- **Surface Water.** Fourteen surface water samples collected from the Hull Canyon Wash following significant rain events in the same vicinity as the four sediment samples.

Anthropogenic background soil data from ten locations within the overall 12-acre site but outside of areas where mining activities occurred, were collected in 2014/2015 as part of the SCR (Figure H-2). In general, these data are intended to be used to characterize the presence of inorganic contaminants in areas not impacted by past mining activities. Background threshold values were subsequently developed and are presented in the SCR and included in Table H-2. Additional discussion of the application of background data is provided in Section 5.0.

All sample locations used in the SLERA are identified in Figures H-3 for Exposure Area (EA) 1 and Figure H-4 for EA 2, respectively.

2.3 DATA VALIDATION

Data collected for use in the SLERA are validated to provide data quality assurance. Quality assurance and quality control (QA/QC) procedures were performed on the laboratory data for each sampling event to determine the level of precision, accuracy, completeness, representativeness, and comparability of the data collected. Data verification reports completed by URS and AECOM for samples collected during the site characterization field events conducted in 2014, 2015 and 2018 are presented in Appendix E of the SCR. Further discussion of the validation processes is presented in Section 3.7 of the SCR.

Data included in the SLERA were considered acceptable at the conclusion of the data validation process.

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3.0 PROBLEM FORMULATION

The problem formulation synthesizes what is known or predicted for the site in order to develop a CSM that will guide the SLERA process (see Figure H-5). The problem formulation identifies representative receptors drawn from a larger number of ecological receptors present at the site, and develops assessment endpoints and measures of effect to evaluate ecological risk. Some receptors may be evaluated as individual populations or individuals of a species (i.e., receptor specific), while others are evaluated as ecological communities (i.e., community specific). The problem formulation includes the following:

- Ecological fate and transport pathways,
- Key habitats, exposure areas and potential receptors,
- Assessment endpoints and measures of effects,
- Conceptual site model, and
- Determination of site COPECs.

3.1 ECOLOGICAL FATE AND TRANSPORT PATHWAYS

Fate and transport pathways refer to movement and deposition of soil contaminants via release mechanisms from source areas. Potential transport pathways include wind erosion/wind-generated dusts, overland surface flow/erosion following precipitation events, vertical leaching through the soil column to underlying groundwater, and movement of impacted groundwater into surface water or other areas of expression. Although ecological exposure may occur via various release mechanisms, the contact medium or secondary source (e.g., surface water, sediment or soil) is of primary importance for assessing ecological exposure.

3.1.1 Exposure Media and Receptors

Several potential migration pathways may allow exposure of potential receptors to site-related chemicals. Exposure media and rationale for selection of representative receptors are detailed in Table H-3. On the basis of site observations and current conditions, the following media and pathways are considered potentially significant for ecological exposure:

- **Surface soil, direct/indirect contact.** This pathway is potentially complete for terrestrial receptors. Exposure assumes direct contact to surface soil (0–4 inches bgs) and indirect

exposure via ingestion of biota (i.e., terrestrial plants, terrestrial invertebrates and /or small mammals).

- **Sediment, direct/indirect contact.** The Hull Canyon Wash is ephemeral and therefore, associated sediments are typically exposed and not saturated. Sediment is thus effectively considered to be soil for the purposes of the SLERA.

- **Surface water, direct contact.** While all surface water features are ephemeral, potential use of water features by area wildlife for drinking water may occur and therefore, this pathway is potentially complete. The Hull Canyon Wash does not support an aquatic community.

3.1.2 Exposure Media and Migration Pathways Not Considered Quantitatively

Certain exposure media involved in the release and migration of metals were not quantitatively considered for ecological risk as they represent intermittent and/or localized exposures (i.e., wind-generated dust, overland surface flow) that result in limited contact relative to primary or secondary contact media. These release mechanisms, while relevant to site understanding, are therefore not specifically evaluated in the SLERA. Inhalation of dust particles by wildlife is considered a minor pathway relative to the diet; dust particles are typically trapped in the upper airways and removed via mucoscilliary action and ultimately enter the digestive tract. Further, as all COPECs at the site are metals, none are volatile and subject to inhalation in dens or enclosed space. Potential exposure via these pathways is considered negligible. Potential for vertical migration of soil contaminants to groundwater is possible although groundwater at the site is "perched" or confined and so subsequent lateral transport off site is limited and there are no known areas where groundwater is expressed at the surface (e.g., groundwater seeps) or in nearby perennial streams.

Groundwater is not a primary medium of concern for ecological evaluation since no ecological receptors are directly exposed to groundwater as it is not accessible. Based on current site understanding there is no evidence that temporary waterbodies (surface water) are influenced by groundwater or that groundwater expresses at the surface as seeps. As previously discussed, SPLP metals are evaluated in the HHRA to help characterize the potential for metals leaching to groundwater at concentrations that may be harmful to human health but are not evaluated in the SLERA since there is no complete pathway for ecological receptors.

Potentially complete and significant pathways are put into the context of applicable assessment and measurement endpoints, discussed below.

3.2 KEY HABITATS, EXPOSURE AREAS AND POTENTIAL RECEPTORS

With consideration of habitat features under current and reasonably anticipated future conditions, two primary EAs were defined for inclusion in the SLERA. The EAs were based on historical site use, current habitat conditions and environmental setting, and potential future site use. The two EAs are depicted in Figures H-3 and H-4 and include:

- EA 1 – represents the area in and around the Waste Rock Ore pile, the Low Grade Ore pile and the T-1 and T-2 tailings piles. The majority of the area is disturbed and located on steep terrain that is barren and dominated by rocky/gravel substrate with little vegetation present. Only small isolated pockets of weedy vegetation are present in waste rock and low grade ore areas. The tailings pile areas are situated on low slope terrain topographically above the Hull Canyon Wash. Ground cover is largely absent in this area with only sparse grasses and low scrub-shrub cover. The surrounding area is dominated by more developed scrub-shrub communities.

- EA 2 – represents the area in and around the high grade ore pile, suspected waste concentrate area, the T-3 tailings pile sand remnant building foundations. Most of the area in the vicinity of the former building foundations is disturbed and ruderal but with pockets of healthy plant life (grasses, scrub-shrub). Scrub-shrub communities dominate the area beyond former building footprint and surrounding area.

Hull Canyon Wash – represents the area at the toe of EA 1 and EA 2 and is also evaluated as an exposure area. The ephemeral nature of the Wash precludes the establishment of an aquatic community, and therefore this area was included in the SLERA for evaluation of terrestrial biota/receptors without regard to the boundaries of EA 1 and EA 2. The Hull Canyon Wash is characterized as upland habitat, with the bed substrate dominated by sand/gravel, with some areas of sparse grasses and isolated shrubs. The riparian corridor is dominated by scrub-shrub with some larger tress present.

Site-specific pathways and selection of representative receptors was determined based on site-specific and literature information. Table H-3 presents an analysis of receptors, exposure media and exposure pathways for the project area and the rationale for selection of each representative ecological receptor. Table H-4 presents a summary of receptors and exposure pathways. The following representative terrestrial receptors are evaluated in this SLERA:

- Soil Community (plants)

- Soil Community (invertebrates)

- Horned lark (omnivorous bird)
- Black-tailed jackrabbit (herbivorous mammal)
- Coyote (carnivorous mammal)

The wildlife receptors selected are considered representative of those feeding guilds that are expected or observed to be present at the site. Additional feeding guilds were considered for inclusion as representative receptors but were dismissed based on expected presence and frequency/duration of site use. These include herbivorous birds, invertivorous mammals and carnivorous birds. Upper trophic level receptors (carnivorous birds) may be important at large sites, especially when bioaccumulative compounds are present, which may biomagnify through the food chain. However, none of the metals at the site biomagnify, and given the relative absence of cover/vegetation at the EAs, the large home ranges relative to the EAs, and expected low population density for these receptor types, this guild was not evaluated, as site-related exposure is expected to be negligible.

Few invertivorous mammals are expected at the VCM site. Rodents expected for the area are primarily herbivorous (e.g., Ord's kangaroo rat [*Dipodomys ordii*]). While larger invertivorous mammals such as skunk and raccoons, that have moderately large home ranges (10's to 100's of hectares), may be expected to periodically visit the site, significant site presence is not expected given the absence of onsite or nearby perennial water resources, which they require, and considering the relatively large home ranges for these receptors.

Herbivorous birds are expected in the area (e.g., Gambel's quail [*Callipepla gambelii*]). However, exposure to herbivorous birds is likely to be lower than that of omnivorous or invertivorous birds because the soil to invertebrate uptake pathway is the primary driver for most metals. The horned lark consumes mainly insects/invertebrates (90% of diet) with the remainder coming from vegetation and is therefore considered adequately protective of herbivorous birds. The exception is for selenium, which may hyperaccumulate in some plant tissues resulting in higher exposure for herbivores. Potential exposure of herbivorous birds to selenium in soil will be addressed in the uncertainty analysis.

Reptiles (e.g., snakes, lizards) are expected to be present at the VCM site. Given the absence of life history and toxicity data for this class of animals, the results for other invertivorous animal classes (i.e., horned lark) may conservatively be considered an appropriate surrogate for adult reptilian receptors insofar as to provide a general understanding of the COPECs and exposure pathways that may be of concern for these receptors. Reptiles are considered within the context of

the uncertainty analysis. A review of special status species in Yavapai County was conducted as part of the evaluation and selection of representative receptors. Based on current listings of threatened and endangered federal status species (United States Fish and Wildlife Service [USFWS], 2018), and Bureau of Land Management (BLM), Arizona Bureau sensitive species (BLM, 2017), no state and/or federally listed species are expected to occur at or in association with the VCM Site. Given the disturbed nature of the Site and absence of sightings or documented presence of such species significant site presence is not likely, especially given the presence of nearby undisturbed native habitat. For reference, Attachment H-2 provides a summary listing of threatened and endangered and special status species obtained from USFWS and BLM.

3.3 ASSESSMENT ENDPOINTS AND MEASURES OF EFFECT

An assessment endpoint is an explicit expression of the environmental value to be protected (USEPA, 1997a). The measures of exposure and effect are the ecological characteristic(s) that quantify the assessment endpoint. The measures of effect for wildlife receptors are measurable changes in an attribute of an assessment endpoint, or its surrogate in response to a stressor, and is evaluated by comparing the ingested doses relative to TRVs of the receptor population under conservative (Step 2) and site-specific Step 3A assumptions. In Step 2, evaluation is based on a no observed adverse effect level (NOAEL) TRVs focusing on adverse effects on individuals. The Step 3A evaluation also considers lowest observed adverse effect level (LOAEL) TRVs that serve as a surrogate for organism population-level effects for consideration by risk managers.

Table H-5 presents the assessment endpoints and measures of effect to be considered in the SLERA. The assessment endpoints are expressed in terms of "productivity". *Productivity* is here defined as a combined measure of potential population-level endpoints, which include survival, growth and reproduction, and are evaluated through calculation of risk-based dose levels under NOAEL and/or LOAEL assumptions for wildlife, or by use of medium-specific benchmarks for community level evaluations.

A qualitative weight-of-evidence evaluation was implemented for assessment of community level receptors. Toxicity screening benchmarks for community level receptors (Table H-5) are typically limited to relatively few analytes and based on very conservative laboratory studies and not on locally relevant biota. As such, it is difficult to draw meaningful conclusions regarding potential risk to these communities based on toxicity benchmarks alone. The weight-of-evidence approach provides a means to evaluate these communities with additional site-specific considerations. To this end, the weight-of-evidence approach includes 1) a comparison to screening benchmarks, 2) qualitative field observations (e.g., percent ground cover, habitat characteristics, suitability for the community, absence of visible signs of stress), and 3) contribution from background

concentrations of metals. A weight-of-evidence approach was also implemented to evaluate terrestrial receptors that are expected to have limited exposure to the ephemeral Hull Canyon Wash.

3.4 CONCEPTUAL SITE MODEL

The ecological CSM integrates each component of the problem formulation detailed above (with consideration for analyte fate and transport pathways) to define exposure pathways for the representative species and presents them in the context of selected assessment endpoints. Figure H-5 presents the graphical CSM for the ecologically relevant exposure areas, receptors, and habitat evaluated in the SLERA. These include upland terrestrial areas and areas associated with the Hull Canyon Wash. A summary of the applicable receptors, media, and relevant pathways is provided in Table H-4.

3.5 COPEC SCREENING PROCESS

The screening of COPECs is implicit in the overall SLERA process, which serves to focus the analysis to only those analytes or chemicals that are likely to result in exposures producing unacceptable risk. To do this, site data for the initial set of chemicals of concern are compared to conservative screening concentrations protective of ecological receptors. Figure H-6 presents the site-specific COPEC selection process, consistent with USEPA guidance (USEPA, 1994e), and is largely in harmony with that presented for a HHRA. COPECs defined by this process are retained for the development of risk estimates in Steps 2 and 3A.

The initial screening process involves a comparison of site maximum concentrations to generic ecological screening levels. Multiple screening levels specific to ecological guilds are available for the site: soil invertebrates, terrestrial plants, avian wildlife, and mammalian wildlife represent the receptors to be evaluated. The COPEC selection process was conducted by comparing maximum concentrations to the lowest screening benchmark from the above four ecological guilds. Chemicals identified as potentially bioaccumulative chemicals of concern (BCC) per "Bioaccumulation Testing and Interpretation for the Purpose of Sediment Quality Assessment Status and Needs" (USEPA, 2000) were also retained as COPECs if detected. Specific screening levels for potential receptors and the hierarchy of selection for these values is presented in Table H-6.

For soil, the screening of COPECs was performed for both EAs. The screening of COPECs for sediment and surface water was based on all results collected from the Hull Canyon Wash Area, without regard to the boundaries of EA 1 or 2. As an initial step, the maximum detected concentration (MDC) or the maximum reporting limit (MRL) if not detected, the target analyte

detection frequency, and the presence or absence of screening benchmarks for each analyte were determined. Based on these parameters, target analyte concentrations were compared to screening benchmarks (Step 2) as outlined in Figure H-6 and as follows:

- Analytes without screening levels were eliminated as potential COPECs and discussed in the uncertainty analysis.
- Detected analytes that are identified as BCC are retained as COPECs.
- Detected analytes with a detection frequency less than 5 percent where the MDC exceeds the screening level and has been historically used or present on the site are evaluated qualitatively in the uncertainty analysis; detected analytes below the screening level and those without historical site use or presence were not further evaluated.
- Detected analytes with a detection frequency greater than or equal to 5 percent whose MDC exceeds screening levels are retained as COPECs; detected analytes with MDCs below the screening levels are not further evaluated.
- Detected analytes with a detection frequency greater than or equal to 5 percent that lack an applicable screening level but possess an applicable TRV are retained as COPECs; detected analytes with concentrations below the screening level and lacking a TRV were not be further evaluated.
- Non-detected analytes with a MRL in exceedance of screening levels and historical site use or presence are considered in the uncertainty section; non-detect analytes with a MRL below the screening level, and those exceeding the screening level without historical site use or presence were not further evaluated.

Those COPECs retained following the screening evaluation are evaluated in more detail which serves to focus the investigation on only those areas and media where COPECs are identified. As presented in Table H-7, retained COPECs based on this initial screen include the following for each EA:

- EA 1: antimony, arsenic, cadmium, copper, lead, manganese, mercury, nickel, selenium, silver and zinc.
- EA 2: antimony, arsenic, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium, silver and zinc.

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4.0 EXPOSURE AND TOXICITY ASSESSMENT

The SLERA, and specifically the exposure characterization and ecological effects characterization, evaluates the relationships among receptors, potential exposures, and potential effects. This approach provides the information necessary to estimate potential risks to the representative receptors under the exposure scenarios defined for the VCM Site. The exposure and effects assumptions progress from very conservative assumptions in the Step 2 assessment to more realistic assumptions in the Step 3A assessment.

4.1 EXPOSURE CHARACTERIZATION

The exposure characterization presents the assumptions and parameters used to develop estimates of exposure. Per USEPA (1997a,b) guidance, an ERA is an evaluation based on conservative assumptions and is intended to eliminate COPECs with no potential to cause risk. The Step 3A evaluation allows for refinement of COPECs identified in Step 2 (USEPA, 2001; 1997a) and allows for the identification and characterization of current and future risk using site-specific assumptions.

4.1.1 Community Exposure Assumptions

An ecological community is a group of actually or potentially interacting species living in the same area. In the context of this SLERA, community receptors are assessed as a group such as the terrestrial plant and invertebrate communities. Assessing contaminant exposure in ecological communities is based upon the integration of all exposures (via multiple uptake/exposure pathways) into a media-specific (soil, sediment or surface water) screening benchmark irrespective of any food-web modeling. For example, plant communities experience direct uptake via roots and/or foliage and benchmarks are developed based on the administered dose (to soil and/or foliage) without consideration of uptake, uptake rates, and other food-web based exposure assumptions. Aquatic plant and invertebrate communities are absent at the site and are therefore not evaluated.

Potential terrestrial soil community receptors were evaluated based on a comparison of available data to terrestrial soil screening levels for the specific type of receptor. As discussed in Section 3.0, the COPEC selection process is conducted by comparing maximum concentrations to screening benchmarks for each individual guild, thus resulting in the identification of guild-specific COPECs (e.g., terrestrial plant and soil invertebrate COPECs). Screening levels were selected based on a hierarchy of sources, giving the most robust or technically defensible sources of screening values a higher priority for use in the SLERA. For terrestrial soil communities, the following sources were considered in the evaluation:

- *Guidance for Developing Ecological Soil Screening Levels* (USEPA, 2007a) including chemical-specific interim documents and procedural updates in 2005 through 2008 (USEPA, 2005a,b,c,d,e,f; 2006; 2007b,c,d,e,f; and 2008);

- *Los Alamos National Laboratory (LANL)* *https://www.lanl..gov/environment/protection/eco-risk-assessment.php*

- Toxicological Benchmarks for Screening Contaminants of Concern for Effects to Terrestrial Plants (Efroymson, et al., 1997a);

- Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process (Efroymson, et al., 1997b); and

- Risk Assessment Information System – https://rais.ornl.gov/tools/rais_chemical_risk_guide.html

In the qualitative screening of surface water in the Hull Canyon Wash, dissolved metals are compared to aquatic and wildlife, ephemeral (A&We) values from the state of Arizona (Arizona Administrative Code [AAC], 2009). A&We is defined as "the use of an ephemeral water by animals, plants, or other organisms, excluding fish, for habitation, growth, or propagation." Ephemeral water is defined as "a surface water that has a channel that is at all times above the water table and flows only in direct response to precipitation." The A&We Acute standards apply to an unlisted tributary that is an ephemeral water and are based on acute exposure (AAC, 2009). National level Tier II Secondary Acute Values (Suter and Tsao, 1996) are used for COPECs that do not have State values. Given that the Hull Canyon Wash is dry most of the year and is not available as a resource for aquatic biota, sediment data from the Wash are compared to soil screening values in this SLERA.

4.1.2 Wildlife Exposure Assumptions

Wildlife exposure is based on food-web modeling to estimate exposure dose. The dose is modeled using exposure point concentrations (EPCs) and exposure parameters for a given representative receptor. The ingested dose equation to model exposure for a wildlife receptor is presented below. The equation is adapted from the fully expanded model used for ecological soil screening level (EcoSSL) derivation presented by USEPA (2007a) by considering other media (sediment and surface water), area use factors (AUF) and in some cases seasonal use factors (SUF) as presented in *Ecological Risk Assessment for Contaminated Soils* (Suter et al., 2000), and focusing on only the exposure term.

$$Dose\ (soil/sediment) = [(S_j \times P_s \times FIR \times Af_{js}) + \sum_{i=1}^{n} B_i \times P_i \times FIR \times AF_{ji}\ ] \times AUF \quad [1]$$

Where:

AF_{ji} = absorbed fraction of j from biota i (assumed equal to 1)
AF_{js} = absorbed fraction of j from soil/sediment (assumed equal to 1)
AUF = area use factor (Step 2=1, Step 3A=receptor and site specific)
B_i = concentration of j in biota type i, where Bi = BAFi x Sj (e.g., plants and invertebrates), BAFi = bioaccumulation factor of j from soil/sediment to food item i, on a dry weight basis (Step 2=90th percentile value, if known; Step 3A = median or average value)
Dose = ingested dose based on direct and indirect contact to soil or sediment (milligrams per kilogram per day [mg/kg/day])
FIR = food ingestion rate (kg food – dry weight/kg body weight [BW]-day) (literature value)
P_s = sediment/soil ingestion as a fraction of the diet (literature value)
P_i = proportion of biota i as part of the diet (literature value). (Step 2 = 100 percent dominant food item, Step 3A= typical species diet)
S_j = concentration of COPEC j in soil or sediment (mg/kg)

Exposure via inhalation in the absence of very high volatile organic compound (VOC) concentrations is not considered significant for non-burrowing wildlife receptors (USEPA, 2007g). Such conditions are not expected to exist at the site for even a burrowing receptor. In addition, quantitative evaluation of this pathway is not commonly conducted because additional assumptions are needed to estimate exposure levels for inhalation and the results are less certain relative to dietary exposure (USEPA, 2007g).

Dermal uptake for wildlife is considered insignificant in relation to the dose from ingestion for most wildlife species in the absence of free product (USEPA, 2007g). The ingestion of surface water from the Hull Canyon Wash (the only surface water source within the Verde Central site) is also considered an insignificant pathway because of the ephemeral nature of the Wash. Therefore, all three of these pathways are not considered in the calculation of exposure doses; these pathways are further addressed in the uncertainty discussion (Section 6).

4.1.2.1 Bioaccumulation Factors

Uptake factors or Bioaccumulation Factors (BAFs) estimate prey tissue concentrations in the absence of empirical tissue concentration data; this estimate is based on the product of the BAF and media concentration (e.g., S_j). Literature BAFs are available for terrestrial plants, terrestrial invertebrates and small mammals. The BAFs for site-specific COPECs are presented in Table H-8. Step 2 BAFs utilize 90th percentile (upper bound) value where available or in the absence of a 90th percentile value, the central tendency value (CTV, i.e., average or median) is applied. For Step 3A, CTV BAFs are used. The BAFs and hierarchy of sources for quantitatively evaluated media are summarized below.

- **Soil-to-plant BAF.** The BAFs developed by Bechtel-Jacobs (1998a) were used as the primary source and as developed/reported in USEPA guidance (USEPA 2007g).

- **Soil-to-soil invertebrate BAF.** Values or regression equations based on the BAFs developed by USEPA (2007g) were used as a primary source. For metals lacking appropriate USEPA (2007g) values, BAFs were based upon the values derived by Sample and others (1999).

- **Soil-to-small mammal BAF.** Uptake factors for soil-to-small mammals are primarily based on Sample and others. (1998). For metals lacking appropriate Sample et al. (1998) values, BAFs were based upon the values derived by USEPA (2007g).

4.1.2.2 Receptor-Specific Exposure Factors

Life history parameters and exposure factors for wildlife receptors are from USEPA sources (USEPA, 2007g; 1993) and other literature, or were calculated using the body weight allometric models in those sources. The life history parameters for wildlife receptors are presented in Table H-9 and briefly presented below. Regionally relevant life history data were preferentially selected where available.

- **Body weight.** Body weight (BW) of the measurement receptor is used to normalize exposure factors to a unit weight basis. Numerous physiological functions, including metabolism, are a function of body size. Smaller animals have higher rates of metabolism, which directly influences their ingestion rates per unit BW. Body weight values were derived from several sources including (in order of preference) USEPA documents (USEPA, 2007g; 1993; and 1999b) as well as literature sources. To provide a conservative estimate of intake rates, the lower end of the adult BW range was used to provide the normalizing factor, where applicable.

- **Food ingestion rate.** Food ingestion rate (FIR) is the total amount of food consumed per unit BW per day (kg dry weight/kg-BW-day). Ingestion rate values obtained from empirical studies are preferred (USEPA; 2007g and 1993). In the absence of empirical data, allometric relationships were used to estimate food intake (FI) (Nagy, 2001), which supplements the algorithms recommended in USEPA (1993). The equations used to develop FIRs are presented, as applicable, in Table H-9.

- **Soil ingestion rate.** The soil ingestion rate (SIR) is the product of the FIR and the fraction of soil measured or estimated in the diet. The amount of media in the diet of each measurement receptor is used to predict COPEC exposure due to incidental ingestion and were obtained from USEPA-recommended values per Beyer, et al. (1994), as cited in USEPA (1993, 1999b, and 2007g).

- **Dietary composition.** The dietary composition specifies the major dietary biota (e.g., vegetation and invertebrates) that can be measured or modeled. Empirical estimates of dietary composition were obtained from a variety of sources as shown in Table H-9.

- **Area use factors.** The AUF is the site-specific ratio of the total area of foraging or home range to the defined exposure area. Foraging areas were obtained from USEPA (1993) and other sources (see Table H-9), and applied to the site-defined exposure area(s). AUFs are presented in Table H-9 for each receptor. For the evaluation of seasonal or migratory receptors, a SUF which considers migration (regional, local and/or altitudinal) and seasonal shift in dietary preferences, can be applied to account for temporal use of food and water resources. The three representative receptors in this assessment are year-round residents; therefore, no SUF was included in the calculations. AUFs are used only in the Step 3A evaluation; 100 percent site use is assumed in Step 2 (i.e., all food and water resources are assumed to come from the specific EA).

- **Absorption factors (bioavailability).** In Step 2, 100 percent bioavailability of site COPECs is assumed for all COPECs. In Step 3A, 100 percent bioavailability is also assumed except where bioavailability data are available (i.e., lead). Bioavailability issues are discussed in the risk characterization (Section 5) and uncertainty analysis (Section 6).

4.1.2.3 Exposure Point Concentrations

EPCs are estimates of the representative exposure concentration of COPECs in a given exposure area. In Step 2, the EPC is the maximum detected concentration (MDC). In Step 3A, the 95% upper confidence limit (UCL) of the arithmetic mean for soil is used. For sediment and surface water where the sample size is limited, the MDC is used as the EPC in Step 3A as well as the data

density was not sufficient to develop a 95% UCL. Concentrations in the Hull Canyon Wash are evaluated on a sample point basis.

The following EPCs were applied for each receptor group using the data sets defined in Section 3.0:

- Step 2
    - Community Receptors – EPC represented by the MDC ; and
    - Wildlife Receptors – exposure/risk estimates developed using an EPC represented by the MDC.
- Step 3A
    - Community Receptors – EPCs represented by the 95% UCL of the mean; and
    - Wildlife Receptors – represented by 95% UCL of the mean for the defined exposure area.

The 95% UCL of the mean was calculated using ProUCL version 5.1.00 (USEPA, 2016) wherever data density (i.e., n≥10) and ECOPC detection (n≥5) were sufficient to compute the 95% UCL of the mean; otherwise, the MDC was applied. The lower of the 95% UCL of the mean and MDC was used in those instances where the distribution of the data skews the 95% UCL of the mean above the MDC. Defaulting to the MDC in the Step 3A risk estimates is discussed in the uncertainty section. All Step 2 and Step 3A EPCs for soil and surface water are presented in Table H-10. Attachment H-3 provides ProUCL inputs/outputs and descriptive statistics for each EA.

4.2 ECOLOGICAL EFFECTS CHARACTERIZATION

The ecological effects characterization evaluates available toxicity and other effects information to correlate the exposure to adverse effects. TRVs that correlate a specified effect to a given chemical concentration are used to characterize potential ecological effects. Stressor-response (that is, effects) data used to evaluate ecological risks resulting from chemical exposure was obtained from literature-derived single-chemical toxicity data.

TRVs are developed separately for birds and mammals; that is, no extrapolation across taxonomic classes (e.g., mammalian toxicity data will not be extrapolated to birds or vice-versa) was conducted because of the associated uncertainties (USEPA, 2007g). Tables H-11 and H-12 present a summary of avian and mammalian TRVs, respectively. COPECs without available toxicity data are discussed in the uncertainty analysis (Section 6).

4.2.1 Community Toxicity Assumptions

The "community" receptors (terrestrial plants, terrestrial invertebrates, terrestrial receptors in the Hull Canyon Wash) are evaluated using media-based screening concentrations or benchmarks derived from literature sources. In Step 2, the screening concentrations are compared to the media MDC, while in the Step 3A evaluation, the 95% UCL of the mean is used, if it can be calculated. The approach for each defined community-level receptor is presented below.

- **Terrestrial Vegetation.** In Step 2, soil benchmarks protective of terrestrial plants are from EcoSSLs (USEPA, 2005a,b,c,d,e,f; 2006; 2007b,c,d,e,f; and 2008) and in the absence of EcoSSLs, from Efroymson and others (1997a) or Alloway (1990). In Step 3A, LOAEL-based benchmarks from LANL (2017) protective of terrestrial plants are compared with EPCs.

- **Soil Invertebrates.** In Step 2, soil benchmarks protective of soil invertebrates are from EcoSSLs (USEPA, 2005a,b,c,d,e,f; 2006; 2007b,c,d,e f; and 2008) and, in the absence of EcoSSLs, from Efroymson and others (1997b) or Alloway (1990). In Step 3A, LOAEL-based benchmarks from LANL (2017) protective of soil invertebrates are compared with EPCs.

- **Terrestrial Receptors Using the Hull Canyon Wash.** A&We acute values from the state of Arizona (AAC, 2009) and in the absence of these values, National Level Tier II Secondary Acute Values (Suter and Tsao, 1996).

4.2.2 Wildlife Toxicity Assumptions

For wildlife receptors, two TRVs were developed based on ingested dose and dose based toxicological effect endpoint(s) (survival, reproduction, and growth):

- A TRV based on chronic NOAEL-based TRV applied in the Step 2 and Step 3A screening; and

- A TRV based on chronic LOAEL-based TRV applied in the Step 3A refinement of COPECs only.

Using both the NOAEL TRV and LOAEL TRV in the Step 3A evaluations provides a range of hazard quotients (HQs) representing the range between no observed effect (applicable to individual organisms) and an observed effect level (applicable to organism population). All TRVs were from recognized literature sources (in order of preference below):

- EPA EcoSSLs (USEPA, 2005a,b,c,d,e,f; 2006; 2007b,c,d,e,f; and 2008);
- Sample and others (1996); and
- EPA (BAH,2012), and others.

Because the USEPA EcoSSL-based TRVs (USEPA, 2005a,b,c,d,e,f; 2006; 2007b,c,d,e,f; and 2008) include the most detailed and quantitative data evaluation, these values and the underlying datasets were used as the first choice for TRV selection. The TRVs obtained from other listed sources were developed based on consideration of a broad dataset and a range of endpoints, but the data evaluation was less comprehensive and less rigorous than that of the EcoSSLs. It is important to note that TRVs from all sources were developed to provide conservative screening levels that can be used generically across a wide range of sites and conditions, and may include toxicity endpoints of uncertain biological relevance. More specific and detailed analysis of the underlying toxicity data may be undertaken to refine TRVs if refinement of risk estimates is warranted.

Animal study results underlying Health Effects Assessment Summary Tables (HEAST) (USEPA, 1997b) and Integrated Risk Information System (IRIS) (USEPA, 2012) databases were consulted for those COPECs lacking TRV data in the primary or secondary sources. Since no threatened or endangered species were identified in the area of the site based on a review of potential site species (USFWS, 2018) and web-based inquiry of the Arizona Bureau of Land Management (BLM) Sensitive Species (BLM, 2017), using a NOAEL-based value exclusively for the Step 3A evaluation (USEPA, 1997b) is not appropriate.

In developing TRVs for use in the SLERA, it is important to recognize that the intent of an ERA is to protect communities or populations of ecological receptors (USEPA, 1997b and 1999b). TRVs are primarily based on laboratory toxicity studies and the results are extrapolated to potential impacts to communities or populations. Therefore, it is critical that the specific measures of effect, or the endpoints measured in a study, be biologically relevant. For example, a measure of a biochemical response to a toxicant may or may not result in an organism-level effect and therefore, biochemical response endpoints are not considered as an appropriate basis for TRV selection. For the purposes of the SLERA, a biologically relevant endpoint is considered to be an effect that results in the potential for impacts on populations or communities of organisms. The EcoSSL guidance (USEPA, 2007a) defines the endpoints considered for NOAEL TRV development as growth, reproduction, and mortality, and a wide range of endpoints are included within each of these categories. In some cases, the actual biological relevance of the specific study endpoints that are included in these categories (e.g., organ weight changes or general body weight changes) is

uncertain and may or may not have biological relevance. While this level of conservatism may be appropriate for the general screening purposes intended for the EcoSSLs, and is retained in the EcoSSL-based NOAEL TRVs included herein, it may not be appropriate as the basis for LOAEL TRVs in a site-specific ERA. Thus, the underlying summaries of toxicity data provided in the EcoSSL documents were reviewed and the relevance of the endpoints measured was considered in the context of the complete EcoSSL dataset and of other available TRVs to support selection of LOAEL TRVs.

Specifically, when the EcoSSL NOAEL TRV was based on a bounded NOAEL from a single study (i.e., the same study included a LOAEL for that endpoint), the LOAEL from that study was selected as the LOAEL TRV. Results from the same study are preferred as they are most likely to prevent selected toxicity values being affected by study design elements and test species variations. Bounded NOAELs and LOAELs from the same study were available for arsenic, lead and selenium for mammals, and for lead and silver for birds. When the recommended NOAEL-based TRV was unbounded or was a geometric mean of a range of NOAEL values, the LOAEL results for reproduction, growth, and survival that were greater than the NOAEL-based TRV were considered. In these cases, the LOAEL TRV was generally selected as the lowest LOAEL for a biologically relevant endpoint that was above the selected NOAEL. For TRVs developed from non-EcoSSL sources, the doses reported by the listed sources were converted, as needed, to chronic NOAEL and LOAEL and/or adjusted for study duration by using uncertainty factors from USEPA (1997a) as presented in Tables H-11 and H-12.

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5.0 RISK CHARACTERIZATION

Risk characterization is the estimation and description of risk based on the exposure and toxicity assessment and also considers the uncertainties associated with the estimation and description of risk (USEPA, 1998; 1997a,b). This SLERA presents two risk estimates:

- **Step 2.** Exposure and HQ estimate developed using conservative assumptions regarding exposure and toxicity.
- **Step 3A.** Exposure and HQ estimate developed using refined exposure assumptions per USEPA (1997b, 2001). This step was applied to any COPEC (and receptor) where ecological risk could not be excluded in Step 2.

The outcome of Step 3A represents a SMDP in which ecological risk conclusions are used to guide risk management decisions.

5.1 RISK ESTIMATION AND DESCRIPTION

Risk estimation uses quantitative methods to evaluate the potential for risk, which are presented as Step 2 HQs and Step 3A HQs. For each tier, risk estimates are derived for each combination of assessment endpoint and measure of effect for each exposure medium and EPCs developed in the previous sections. At Step 3A, the risk description considers the quantitative risk estimates and, along with other evidence such as habitat and vegetation quality and potentially affected receptor groups, serves to identify preliminary risk drivers for consideration as a SMDP.

The HQ is an important line of evidence for risk estimation and description when sufficient exposure and toxicity data exist. An HQ≤1 indicates that a given COPEC-receptor combination may be excluded from further consideration (i.e., potential risk is not likely). If HQ>1, the potential for a hazard or risk cannot be excluded. However, the magnitude of the HQ is not a measure of the magnitude of a potential hazard and is not comparable across assessment endpoints (i.e., an HQ=10 for one receptor is not necessarily "worse" than an HQ=5 for another), as the underlying dose-response relationship is not linear nor comparable between species.

As indicated in the following subsections, HQs are unitless ratios calculated by dividing the receptor's estimated exposure by a comparable toxicity benchmark or TRV expressed in the same units of measure. Due to the inherent uncertainties in uptake, toxicity, and exposure terms included in the calculation, the level of mathematical precision of a dose-based HQ is only considered reliable to one significant digit. Providing additional significant digits (e.g., to the nearest tenth, HQ=5.6) compounds this uncertainty and overstates the level of confidence in the HQ. HQs (dose-

based and media concentration-based) less than 1 are presented to one significant digit, and all HQs equal to or greater than 1 are presented to the nearest whole number. For medium-specific concentration-based HQs (determined by comparison of an EPC to an applicable benchmark or screening level), while a rounded HQ is presented, the potential for risk is contingent upon whether a given site concentration is above, equal to, or below the corresponding benchmark or screening level: a COPEC with an EPC greater than or equal to the benchmark or screening level is retained as a COPEC.

5.1.1 Community Receptors (Plants, Invertebrates and Terrestrial Receptor Use of Wash)

For community receptors, potential risk is estimated by a direct comparison of measured concentrations of COPECs in soil/sediment or surface water to their respective screening level or benchmark TRVs. These comparisons apply to terrestrial plants and invertebrates exposed to soil and terrestrial receptors exposed to surface water in the Hull Canyon Wash using the following relationship:

$$HQ = \frac{EPC}{TRV\ or\ Benchmark}$$

EPC = measured medium-specific concentration (MDC or 95% UCL) expressed in like terms to that of the TRV mg/kg or micrograms per liter (µg/L).

TRV/Benchmark = media-based toxicity reference value or benchmark in matching units to that of the EPC.

5.1.2 Ingested Dose Based Receptors (Birds and Mammals)

For birds and mammals, the risk estimate is based on a HQ defined as the ingested dose divided by the appropriate TRV, both on a body weight normalized basis:

$$HQ = \frac{DD}{TRV}$$

DD = estimated dietary dose expressed in like terms to that of the TRV (i.e., mg/kg $_{BW}$-day).

TRV = toxicity reference value in matching units to that of DD.

A cumulative hazard index (HI) is not calculated for ecological receptors (USEPA, 1997a).

Food web biotransfer from contaminated media to biota is based on assumptions that generally result in conservative estimates of exposure dose. Table H-13 summarizes the specific differences

in exposure assumptions used for Step 2 and for the Step 3A refinement and indicates where the site-specific and receptor-specific exposure and toxicity values are implemented in the overall process. Risk estimates are based on the following:

- For the Step 2 evaluation, the dose and TRV are based on the most conservative assumptions including NOAEL-based toxicity values, predators feeding only on the most dominant dietary food item from the most impacted location (MDC). Uptake factors (BAFs) are based on the upper end of observed distributions (90th percentile, where available). Risk estimates developed in Step 2 were not considered as a SMDP but rather, were used to identify COPECs to be carried forward into Step 3A.

- The Step 3A evaluation applies exposure assumptions intended to more closely reflect actual or expected site-specific use and exposure by defined receptors (i.e., typical diet, area use considerations, and central tendency estimates for biota uptake and exposure concentrations) and also includes not only NOAEL-based toxicity values, but LOAEL-based toxicity values that provide more realistic estimates of risk.

The HQ is not a predictor of risk, but rather is a "binary" index (i.e., screened out versus screened in for subsequent analysis) used to eliminate potential risk and to identify chemicals-receptors for which additional evaluation may be required (EPA, 1997a; Allard and others, 2009). The HQ is interpreted as follows:

- Step 2 or Step 3A, NOAEL HQ <1 - indicates that a given COPEC-receptor combination may be eliminated from further consideration as potential for risk from the given constituent is not likely.

- Step 2 HQ≥1 - indicates the potential for risk cannot be excluded and indicates that conservative data and assumptions are insufficient to conclude that risks are absent. Additional refinement may be warranted to limit the uncertainty.

- Step 3A, LOAEL HQ>1 – indicates the potential for risk cannot be excluded and additional refinement may be warranted to limit the uncertainty.

The outcome of Step 3A is a SMDP that can serve as the basis for risk management decisions.

5.2 STEP 2 RISK RESULTS

This section summarizes the risk characterization results for the selected assessment endpoints under the Step 2 screening-level exposure and toxicity scenarios for Exposure Areas 1 and 2 and

the four sample locations along the Hull Canyon Wash. The Step 3A evaluation results are discussed in Section 5.3.

5.2.1 Soil Evaluation

Tables H-14 and H-15 show the Step 2 risk characterization for terrestrial plants (protect terrestrial plant community [productivity] by limiting adverse effects from exposure to site-related COPECs) and soil invertebrates (protect terrestrial invertebrate community [productivity] by limiting adverse effects from exposure to site-related COPECs), respectively. The evaluation compares soil benchmarks protective of terrestrial communities to the soil MDC for each COPEC. Results for Step 2 include the following for terrestrial plants and soil invertebrates.

- **Terrestrial Plants.** The potential for risk cannot be excluded for the following COPECs that exceed applicable screening benchmarks, listed by exposure area:
    - EA 1 – antimony, arsenic, copper, lead, manganese, mercury, selenium and zinc
    - EA 2 – antimony, arsenic, cadmium, copper, lead, manganese, mercury, selenium and zinc
- **Soil Invertebrates.** The potential for risk cannot be excluded for the following COPECs by exposure area:
    - EA 1 – arsenic, copper, manganese, mercury, selenium and zinc
    - EA 2 – arsenic, copper, manganese, mercury, selenium and zinc

These exceedances are evaluated further in the Step 3A evaluation.

5.2.2 Sediment Evaluation

Table H-16 shows the Step 2 risk characterization for terrestrial receptors that may come in contact with sediment at the four sample locations (plus one duplicate sample, SC-HCW-S-5) in the Hull Canyon Wash. As previously discussed, soil benchmarks rather than sediment benchmarks are used in this evaluation because of the ephemeral nature of the Hull Canyon Wash and the lack of aquatic biota in the vicinity of the Wash. The concentration at each sample location is also compared to the MDC in the background dataset and only concentrations that exceed both the screening level and background are retained as final COPECs in sediment. Results for Step 2 include the following for terrestrial receptor exposure to soil/sediment in the Wash:

- **Terrestrial Receptors Exposed to Soil/Sediment in the Wash.** The potential for risk cannot be excluded for the following COPECs that exceed applicable soil screening benchmarks and/or background, listed by sample location:
    - SC-HCW-S-1 – none
    - SC-HCW-S-2 – copper and selenium
    - SC-HCW-S-3 – chromium and nickel
    - SC-HCW-S-4 – copper and selenium
    - SC-HCW-S-5 – copper, mercury and selenium

The results from this sediment evaluation are compared to the following surface water results since surface water samples were collected in the vicinity of the four sediment/soil sample locations.

5.2.3 Surface Water Evaluation

As part of the site characterization process, metals were compared to A&We Acute Standards (AAC, 2009) and the results are presented in the SCR. A subset of these results are presented in Table H-17, focusing on the twelve remaining COPECs. Dissolved concentrations in surface water at each of the four sample locations in the ephemeral Hull Canyon Wash were compared to the A&We Acute standards (AAC, 2009). As stated in the SCR, A&We Acute standards apply to an unlisted tributary that is an ephemeral water and are based on acute exposure (AAC, 2009). AAC defines ephemeral water as "a surface water that has a channel that is at all times above the water table and flows only in direct response to precipitation."

All of the COPECs analyzed in site surface water, with the exception of silver, were detected above the laboratory reporting limit (LRL) in at least one sample. For arsenic, mercury and selenium, the A&We Acute standards are established as constant values. For cadmium, copper, lead, nickel, silver and zinc, the A&We Acute standards are established as variables that depend on the hardness (expressed as mg/L of CaCO3). The footnotes of Appendix A of AAC R18-11 indicate that for the A&We Acute standards, hardness is intended to be measured in effluent rather than in the receiving water body from a sample taken at the same time that the sample for the metal is collected. Because there is no "effluent" entering the wash, the samples to be analyzed for hardness were collected from the receiving water, i.e., from Hull Canyon Wash. Hardness concentrations ranged from 220 to 370 mg/L as CaCO3 in the filtered surface water samples. Based on this hardness range, a lower and upper bound of the A&We Acute standard is provided for cadmium, copper, lead, nickel, silver, and zinc. There are no A&We Acute water quality standards established for antimony and manganese.

Dissolved copper was found to exceed the upper bound A&We Acute standard (0.080 mg/L, based on hardness of 370 mg/L as CaCO3) in two samples; HCW-4-W (0.081 mg/L on October 2, 2014) and HCW-2-W (0.087 mg/L on May 20, 2015). Hardness was not measured in the HCW-4-W sample; therefore, this is considered a provisional exceedance. In further evaluating the October 2, 2014 sampling event, sample location HCW-4-W is the second-most up-stream of the four sample locations, near the south end of the site, but downstream of the Suspected Waste Concentrate area, the High-Grade Ore pile, and the former building foundation. The next downstream sample, HCW-3-W, had a dissolved copper concentration of 0.013 mg/L based on the same flow event; therefore, its concluded that the reach of the (provisional) surface water exceedance in dissolved copper concentration was limited to an area upstream of SC-HCW-3. This reach is about 1,400 feet long, and is not known to provide unique habitat, nor is its length likely to be significant in light of the expansive surrounding landscape. In addition, an exceedance of the A&We Acute standard was not observed for dissolved copper at HCW-4-W during the December 2014 or the May 2015 sampling event. Therefore this dissolved copper concentration does not present a significant ecological risk.

It is noted that the dissolved copper concentration at HCW-2-W exceeds the A&We Acute standard; however, given the variation in dissolved copper concentrations observed for the three samples collected at HCW-4-W, and the typical absence of water at HCW-2-W, it is difficult to draw a conclusion regarding ecological risk based on a single sample collected at this location. Both of these sample locations also had relatively high copper concentrations in the collocated sediment/soil samples. Given that the overall area has high copper concentrations in soil, intermittent increases in copper concentrations in the Hull Canyon Wash is likely to occur. As previously discussed, there is no evidence of aquatic biota in this ephemeral wash; therefore, the potential ecological risks associated with exposure to copper concentrations in surface water is minimal even for terrestrial receptors that may consume water from the Wash when there is actually water present.

5.2.4 Wildlife Evaluation

Step 2 risk results are presented in Table H-18 for terrestrial wildlife. The Step 2 screening-level evaluation is based on highly conservative assumptions: lifelong and year-round exposure to the maximum concentration in the exposure area, NOAEL-based TRVs, and preferential feeding on the most contaminated food item. The estimated dose and resulting HQ are presented for each receptor. All COPECs with Step 2 HQs greater than or equal to 1 were retained for further evaluation in Step 3A.

5.2.4.1 Omnivorous/Insectivorous Receptors

Omnivorous/insectivorous receptors (Table H-18) were evaluated in Step 2 based on ingested dose via incidental ingestion of surface soil (0 to 4 inches bgs) and biological uptake via prey/forage obtained from terrestrial sources using the exposure assumptions described in Section 4.0. The horned lark was selected as the representative receptor for the protection of omnivorous (and insectivorous) wildlife consumers from adverse effects on growth, survival, and reproduction from exposure to site-related COPECs:

EA 1

- **Horned Lark.** Step 2 HQs are greater than or equal to 1 for the following eight COPECs: arsenic (HQ=4), cadmium (HQ=5), copper (HQ=1,615), lead (HQ=6), mercury (HQ=2), selenium (HQ=21), silver (HQ=29), and zinc (HQ=3).

EA 2

- **Horned Lark.** Step 2 HQs are greater than or equal to 1 for the following eight COPECs: arsenic (8), cadmium (HQ=30), copper (HQ=1,762), lead (HQ=34), mercury (HQ=10), selenium (HQ=17), silver (HQ=21), and zinc (HQ=7).

5.2.4.2 Herbivorous Receptors

Herbivorous receptors (Table H-18) were evaluated based on ingested dose via incidental ingestion of surface soil (0 to 4 inches bgs) and biological uptake via forage obtained from terrestrial sources using the exposure assumptions described in Section 4.0. The black-tailed jackrabbit was selected as a representative receptor for the following assessment endpoints: protect small herbivorous wildlife consumers from adverse effects on growth, survival, and reproduction from exposure to site-related COPECs:

EA 1

- **Black-tailed jackrabbit.** Step 2 HQs are greater than or equal to 1 for three COPECs: arsenic (HQ=13), copper (HQ=5), and selenium (HQ=21).

EA 2

- **Black-tailed jackrabbit.** Step 2 HQs are greater than or equal to 1 for four COPECs: antimony (HQ=2), arsenic (HQ=23), copper (HQ=5) and selenium (HQ=16).

5.2.4.3 Carnivorous Receptors

Carnivorous receptors (Table H-18) were evaluated based on ingested dose via incidental ingestion of surface soil (0 to 4 inches bgs) and biological uptake via prey/forage obtained from terrestrial sources using the exposure assumptions described in Section 4.0. The coyote was selected as a representative receptor for the following assessment endpoint: protect carnivorous wildlife consumers from adverse effects on growth, survival, and reproduction from exposure to site-related COPECs:

EA 1

- **Coyote.** Step 2 HQs are greater than or equal to 1 for two COPECs: copper (HQ=8) and selenium (HQ=3).

EA 2

- **Coyote.** Step 2 HQs are greater than or equal to 1 for three COPECs: antimony (HQ=2), copper (HQ=9) and selenium (HQ=2).

5.3 STEP 3A RISK RESULTS

In the Step 3A evaluation, COPECs and receptors for which possible risk was indicated in Step 2 are further evaluated based on site-specific modifying factors and LOAEL- and NOAEL-based toxicity data. Step 3A refinements include:

- **95% UCLs of the mean as estimates of EPCs.** For soil and surface water data with adequate sample size, the 95% UCL of the mean is used as the EPC. The EPC defaults to the MDC if too few samples are available (as is the case for sediment) to calculate a reliable 95% UCL or if the 95% UCL is skewed higher than the MDC due to small sample size.

- **Receptor-specific exposure.** Applies site-specific exposure assumptions for birds and mammals based on typical diet, foraging range, and seasonal area use.

- **Bioavailability.** For lead, bioavailability data are available and were applied to exposure estimates.

- **Background.** Metals with Step 3A HQs > 1 were also compared to background values. Background data and selected values are presented in Table H-2.

Bioavailability is defined as the fraction of contaminant dissolved in the gut that enters the blood stream and is distributed systemically to target organs in an organism. In the absence of bioavailability data, bioaccessibility data can be considered as a conservative surrogate for bioavailability. Bioaccessibility is defined as the fraction of contaminant mobilized into digestive tract fluid from ingested soil and food (Kaufman et al. 2007) and does not take into account assimilation and distribution via the bloodstream. A lead-specific bioaccessibility factor for birds and mammals per Kaufman and others (2007) was considered. The study developed models simulating gastric conditions of birds and mammals to estimate the proportion of lead mobilized into gastric fluid from soil, invertebrates and plants. The average bioaccessibility factors for lead reported in Kaufman and others (2007) applied in Step 3A were:

- Mammals – soil (66 percent), plants (50 percent) and soil invertebrates (77 percent)
- Birds – soil (53 percent) and soil invertebrates (73 percent)

5.3.1 Soil Evaluation

The evaluation of terrestrial plants and invertebrates compares vegetation and soil/leaf litter invertebrate benchmarks, respectively, to area 95% UCL soil concentrations.

5.3.1.1 Plants

Table H-14 shows the Step 3A risk characterization for terrestrial plants based on a comparison of site 95% UCLs to LOAEL-based LANL soil benchmarks (2017) protective of terrestrial plants as well as a comparison to background.

- **Plants.** The potential for risk cannot be excluded for the following COPECs by exposure area:
    - EA 1 – arsenic (HQ=2), copper (HQ=10), and selenium (HQ=13)
    - EA 2 – arsenic (HQ=3), copper (HQ=24), selenium (HQ=6) and zinc (HQ=7)

Although all of the applied benchmarks are considered conservative, the potential for risk from exposure to these COPECs cannot be discounted. Additional discussion of the potential for risk to plants is provided in the uncertainty analysis (Section 6).

5.3.1.2 Invertebrates

Table H-15 shows the Step 3A risk characterization for terrestrial invertebrates based on a comparison of site 95% UCLs to soil benchmarks protective of terrestrial invertebrates as well as background.

- **Invertebrates.** The potential for risk cannot be excluded for the following COPECs by exposure area:
    - EA 1 – arsenic (HQ=2), copper (HQ=10) and mercury (HQ=3)
    - EA 2 – arsenic (HQ=5), copper (HQ=22), mercury (HQ=16), selenium (HQ=1) and zinc (HQ=6)

Although all of the applied benchmarks are considered conservative, the potential for risk from exposure to these COPECs cannot be discounted. Additional discussion of the potential for risk to terrestrial invertebrates is provided in the uncertainty analysis (Section 6).

5.3.2 Soil/Sediment and Surface Water Evaluation

For Hull Canyon Wash, when considering all soil/sediment and surface water data available for the ephemeral wash, calculation of a 95% UCL of the mean is not feasible due to a small dataset. Therefore, as shown in Table H-16 for soil/sediment and Table H-17 for surface water, all metals that were equal to or exceeded the screening values in the Step 2 comparison to the MDC resulting in a potential risk concern cannot be discounted in Step 3A as well.

5.3.3 Wildlife Evaluation

Step 3A HQ results were calculated where HQs≥1 were noted. Step 3A results for wildlife are presented in Table H-19 for the three representative terrestrial receptors .

5.3.3.1 Omnivorous/Insectivorous Receptors

Step 3A HQs were calculated for terrestrial-feeding omnivorous or insectivorous wildlife (Table 5-7) that may be present at the site. The following COPECs show Step 3A LOAEL- and NOAEL-based HQ risk equal to or in excess of unity for the representative receptor horned lark:

EA 1

- LOAEL-based HQs are greater than 1 for the following three COPECs: copper (HQ=44), selenium (HQ=10) and zinc (HQ=2). NOAEL-based HQs are greater than 1 for the following six COPECs: cadmium (HQ=2), copper (HQ=131), lead (HQ=2), selenium (HQ=12), silver (HQ=2) and zinc (HQ=2).

EA 2

- LOAEL HQs are greater than 1 for the following six COPECs: cadmium (HQ=9), copper (HQ=102), lead (HQ=6), mercury(HQ=3), selenium(HQ=10) and zinc (HQ=4). NOAEL-based HQs are greater than 1 for the following eight COPECs: arsenic (HQ=2), cadmium

(HQ=15), copper (HQ=301), lead (HQ=12), mercury (HQ=6), selenium (HQ=13), silver (HQ=2) and zinc (HQ=5).

The potential for risk cannot be discounted for omnivorous (or insectivorous) wildlife for the COPECs listed above. Further discussion of Step 3A risk estimates is provided in the uncertainty analysis (Section 6.4.3).

5.3.3.2 Herbivorous Receptors

Step 3A HQs were calculated for terrestrial-feeding herbivorous wildlife (Table H-19) that may be present in the site. The following COPECs show Step 3A LOAEL-and NOAEL-based HQs in excess of unity for the representative receptor black-tailed jackrabbit:

EA 1

- There are no LOAEL HQs greater than 1. NOAEL-based HQs are greater than 1 for the following COPEC: selenium (HQ=2).

EA 2

- There are no Step 3A LOAEL- or NOAEL-based HQs greater than 1.

5.3.3.3 Carnivorous Receptors

Step 3A HQs were calculated for terrestrial-feeding carnivorous wildlife (Table H-19) that may be present at the site. There are no Step 3A LOAEL-and NOAEL-based HQs in excess of unity for the coyote, the representative receptor.

Further discussion of Step 3A risk estimates is provided in the uncertainty analysis (Section 6.4.3).

5.3.3.4 Comparison to Background

Consideration of naturally occurring background levels for inorganics is an integral part of the risk characterization process and is in accordance with USEPA guidance, Role of Background in the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Cleanup Program (USEPA, 2002b) and Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites (USEPA, 2002a). The presence of naturally occurring concentrations for most metals implies that a greater or smaller part of the reported risk can be due to naturally occurring concentrations, to which the local biota are adapted. Background concentrations were evaluated and finalized in the SCR. The range of background concentrations and 95% UCL background concentrations are presented in Table H-2.

Focusing on the LOAEL-based Step 3A results for birds and mammals, only three metals in EA 1 (copper, selenium and zinc) and six metals in EA 2 (cadmium, copper, lead, mercury, selenium and zinc) had Step 3A HQs > 1, suggesting a need for further analysis and a comparison to background. As presented in Table H-2, soil background concentrations for the above COPECs were well below their respective EPCs (Table H-10) in each EA. Based on this comparison, background concentrations of the remaining COPECs do not appear to account for the elevated concentrations found in the two EAs.

6.0 UNCERTAINTY ASSESSMENT

Risk assessment is constrained by uncertainty (lack of knowledge) regarding data, exposure, toxicity, and risk issues. Although risk assessment follows a structured approach, professional judgment and assumptions or estimates based on limited available information are inherent parts of the risk assessment process. The uncertainty analysis provides a description of the nature of the uncertainties encountered in developing risk estimates and is an integral part of the ERA process (USEPA, 1997a). Uncertainties built into the estimation of exposures and ultimately risks may result in overestimates or underestimates of the actual risk.

Risk assessment is designed to apply conservative assumptions to avoid missing potential risk. Resulting risk estimates are inherently conservative, and it is important to keep this in mind when interpreting the results of a risk assessment. There are two general categories of uncertainty:

- **Common uncertainties** – applicable to ERAs in general in relation to data quality, COPEC selection processes, generic exposure assumptions, development and use of EPCs, and applicability of toxicity values; and

- **Site-specific uncertainties** – applicable to site-specific concerns in relation to ecological conditions, site and species specific exposures, area use factors, data availability, and other considerations.

Uncertainties associated with these ERA components account for the majority of potential limitations in a risk assessment. Key sources of common and site-specific uncertainty and the potential impact on this ERA are presented below.

6.1 DATA QUALITY

Limitations may exist with respect to the type, quantity, and quality of available data that may lead to uncertainties in estimating the overall risk posed by a site. These limitations are the product of both the collection of data and the ability to strictly evaluate the data according to EPA guidelines. Also, reporting limits differ among similar datasets. This factor alone does not invalidate the data nor imply that the data are unusable for risk assessment. Measurement variability among reporting limits may introduce uncertainty into the estimate of potential risk associated with low concentrations of chemicals at the sites.

6.1.1 Accuracy of Analytical Measurements

Laboratory analysis of environmental samples is subject to a number of technical difficulties, and values reported by the laboratory may not always be accurate. The magnitude of analytical error

is usually small compared to other sources of uncertainty, although the relative uncertainty increases for results that are near the detection limit. For non-detected results at a given location, where no detections were measured, the method reporting limit is considered in the dataset used for risk assessment. Constituents detected below the sample reporting limit but above the method detection limit (DL) (i.e., J-flagged data) lack sufficient precision in the reported concentration and are thus estimated concentrations. These data were included in the risk analysis as recommended by USEPA (1989) guidance. Although there are not many J-flagged data, inclusion of these data in the risk assessment provides additional robustness to the overall dataset. Except in instances where statistical estimates of exposure concentrations are based in large part or solely on these data, little overall effect on statistical estimates, and consequently risk estimates, is expected.

6.1.2 **Elevated RLs**

Laboratory MRLs are relevant in data sets containing censored (non-detect) values. Especially if the reporting limits (RLs) are elevated due to analytical or matrix interferences the presence of censored data can skew the statistical evaluation and hide true exposure. In the extreme case where most or all of the analytical results are non-detected yet elevated above screening or evaluation levels the uncertainty can become very high. In some cases, RLs were elevated as a result of sample dilution, resulting in elevated RLs and, in some instances, RLs were estimated (J-flagged) detected results.

More specifically, several analytes were not detected in any of the collected samples. These analytes may not have been detected because they truly are not present, or because the DL was not low enough to detect their presence. The DL is the lowest concentration that must be present in a sample to be detected at a 99 percent confidence level. To ascertain the importance of the lack of detected concentrations on assessing risk from these chemicals, the RL for all non-detected chemicals were compared to available screening criteria in Table H-7

For the majority of chemicals that were not detected in any sample, the RLs were less than the screening level. The uncertainty associated with the lack of actual detected concentrations is not important in these cases because the RL is the maximum limit of each unknown concentration. However, some analytes had a MRL that exceeded their corresponding screening level in surface soil and surface water. These analytes were identified as ND COPECs in Table H-7 and are discussed further below. All other sample results in soil were either detected and evaluated in the SLERA or were reported as a non-detected result with reporting limits below the screening criteria.

Thallium was identified as a ND COPEC (never detected with maximum reporting limits exceeding the ecological screening level) in soil at EA1 and EA2, and antimony and thallium were identified as ND COPECs in Hull Canyon Wash sediment/soil. In all instances, the minimum reporting limit also exceeded the screening level indicating that the laboratory was unable to achieve reporting limits at or below screening levels). Because the reporting limit exceeds the screening level, these chemicals could be present at concentrations that identify them as COPECs based on screening level comparison, and it is possible that hazards to these metals were underestimated. However, while the magnitude of impact on the overall risk assessment is uncertain, concentrations of these metals in background samples were also not detected at similar levels indicating that the effects on risk conclusions is likely negligible.

Surface water screening levels for antimony and manganese are not available to compare with the RL. Typically, in these cases, risk may be underestimated. Because surface water screening levels are not available for these two metals, it is unknown whether these two metals may occur on site at concentrations below reporting limits, but still at concentrations that may pose risk. Additionally, the lack of a screening level likely indicates that toxicity information has not been developed due to a limited concern for these metals. As a result, it is not possible to determine a benchmark at which these chemicals may pose risk. However, as stated above, the lack of toxicity information indicates that any contribution to risk by these two metals in surface water is likely negligible. A review of the analytical data indicated that the reported RLs for these metals were in the normal range for the laboratory, and there were no apparent issues with the analytical methodology. It is likely that these two metals would not be considered risk drivers, and exclusion of them would not affect the overall risk evaluation for a given receptor.

6.1.3 Limited Data Set for the Hull Canyon Wash

Risk results were based on the assessment of four soil/sediment and surface water sample locations along the length of the Hull Canyon Wash. The apparent absence of aquatic biota introduces high uncertainty for any pathway which assumes biological transfer (uptake) from surface water to biota and ultimately to wildlife. Based on the ephemeral nature of Hull Canyon Wash, the presence of surface water is limited and only occurs following significant rain events. Therefore, water concentrations are likely to vary considerably depending on the time of collection throughout the year and from year to year, and on the volume of water that may be present and the period of time for which water is present. Given the small number of sample locations (n=4) and the limited number of temporal samples at each location, a 95% UCL was not calculated and results for the four sample locations were therefore conservatively based on the point specific maximum result for each sample location. Using the MDC derived from one or two surface water sample events to

represent concentrations in the Hull Canyon Wash may under- or over-estimate potential exposure to wildlife.

6.2 ECOLOGICAL EFFECTS AND TOXICITY

Uncertainties associated with ecological effects and toxicity may result in an over- or under-estimate of the effects that a particular COPEC may have on a given receptor.

In general, most toxicity benchmark values are derived from high dosing regimen lab studies of the adverse effects of a single constituent. However, exposures to ecological receptors usually involve multiple constituents, where additive, synergistic, or antagonistic interactions could occur. Data generally are not adequate to permit any quantitative adjustment in toxicity values or risk calculations based on inter-chemical interactions. In accordance with USEPA ecological risk guidance (USEPA, 1997a,b), effects from different compounds are generally not considered additive (i.e., a HI is not calculated, except in certain cases where the additive effect is recognized). Classifying risk as low or high and/or applying the concept of additivity to develop a HI is inappropriate because of varying dose-response relationships and mechanisms of action (Allard and others, 2009). While use of an HI may be appropriate for certain chemicals known to act additively (e.g., polychlorinated biphenyls) developing a HI based on chronic toxicity data in the absence of well understood mechanisms of action and dose-response is uncertain. Consideration of additive effects may result in overestimated or underestimated risks if, in fact, additive or antagonistic effects are present for the mixture of COPECs.

Applicable screening levels or other relevant toxicity values are lacking in generally accepted data sources and regulations for some of the analytes. The absence of toxicity information may underestimate risk, particularly if observed concentrations are high.

6.2.1 Individual vs. Population Based Endpoints

Adverse effects on individuals do not necessarily imply adverse effects at the population or community level. In general, the goal of an ERA is to protect and maintain viable communities and populations, and not to protect each individual in that population (except in the case of threatened and endangered species). This ERA focuses on individual level risk and the extrapolation of individual risk estimates to the local population is an uncertainty for consideration in interpreting results. A common population endpoint, which unfortunately is very difficult to operationally define, is a population level EC20 (i.e., the concentration or dose that results in an adverse effect on 20 percent of the population). However, almost all toxicity reference values for dose-based evaluations are based on individual-level adverse effects. Risk estimates based on individual risk (as represented by individual level effects, the NOAEL and LOAEL estimates) are

used in the ERA. For Step 3A, both the NOAEL HQ and LOAEL HQ were developed to present a range of potential hazards for a given receptor. This range is presented, along with the geometric mean of the NOAEL and LOAEL HQs, in Attachment H-4.

Non-listed threatened and endangered (T&E) species should be considered on a population basis. In general, a "population" can be defined as the minimum viable population size for a species in an area. For example, the minimum viable population size for mice is typically considered to be around 500 reproducing individuals to maintain population stability (Lehmkuhl, 1984; Thomas, 1990; and Reed and others, 2003), but more may be needed to maintain genetic variability (Reed and others, 2003). The area for a minimum viable population therefore may be considerably larger than the exposure areas under consideration. A true population based endpoint should consider the EC20 or similar effect level at this scale, to place the potential impact from the site into perspective. The area of the site in the context of the minimum viable population area has not been evaluated, but for wide ranging species such as a coyote or hawk, the entire site is smaller than the home range of a single animal, suggesting that the risk estimates on an individual level may not be representative of the unacceptable adverse risk to the population.

6.2.2 Surface Water Toxicity

6.2.2.1 No Step 3A Specific Values

The same surface water screening levels are used in both the Step 2 and Step 3A risk evaluations. The screening levels are A&We acute standards that are water quality criteria protective of the most sensitive receptors. A&We acute standards are designed to protect the "use of an ephemeral water by animals, plants or other organisms, excluding fish, for habitation, growth or propagation" (AAC, 2009). While appropriate in Step 2, the absence of more appropriate screening values representative of the actual biota and ecological conditions expected at the Site results in an uncertainty. Therefore, exceedances reported in Table H-17 are uncertain and likely overestimate potential exposure and risk.

6.2.3 Terrestrial Plant Toxicity

6.2.3.1 No Step 3A Specific Values

Screening levels are from literature sources of varying quality and in most cases are based on the most sensitive endpoint. At best these benchmark levels can be indicative of a potential threshold of effects for the species and conditions under which they were derived. It is for that reason that additional lines of evidence (e.g. background conditions, site conditions, and observations) are typically required and often given equal or added weight to the benchmarks themselves. So while the two sets of screening levels are appropriate for the purposes of screening, the absence of screening values representative of the actual biota expected or likely to be present under ecological

conditions present at the site represents an uncertainty. The risks as reported are therefore, highly uncertain with potentially large overestimates of true risk to terrestrial plants.

6.2.3.2 Sources of Screening Values

Soil benchmarks protective of terrestrial plants are from EcoSSLs (USEPA, 2005a,b,c,d,e,f; 2006; 2007b,c,d,e,f; and 2008) or in the absence of EcoSSLs, selected from Efroymson and others (1997a) and Alloway (1990). The USEPA values are considered less uncertain than the Oak Ridge National Laboratory (ORNL) (Efroymson and others 1997a) antimony and mercury values or the Alloway (1990) total chromium value, as they consider a wider range of data, including more recent data, and have a more rigorous data quality evaluation. USEPA plant values are based on the geometric mean of the "acceptable" studies. The ORNL values (lowest observed effect concentrations [LOECs] at the 20 percent effect level) are based on the most sensitive test found in the literature. These benchmarks are considered conservative and appropriate for screening (Efroymson et al., 1997a). The ORNL values are highly uncertain and in many cases the plant screening values are below typical soil background values for metals (Efroymson et al., 1997a).

The following COPECs have screening benchmarks with moderate to high uncertainty

- Eco-SSL based screening values - moderate uncertainty associated with the risk estimate: arsenic, lead, manganese, and selenium.
- ORNL-based screening values - high uncertainty associated with the risk estimate: antimony and mercury.
- Alloway-based screening value – high uncertainty associated with the risk estimate: total chromium.

In Step 3A, LANL (2017) ecological screening levels (ESLs) are used as benchmarks in the evaluation. The low effect ESL, comparable to a LOEL, was specifically used.

6.2.4 **Terrestrial Invertebrate Toxicity**

6.2.4.1 Sources of Screening Values

Invertebrate screening levels for the Step 2 and Step 3A evaluations are based on conservative endpoints. For invertebrates, most values are based on earthworm studies that used soluble chemical forms (readily bioavailable). While appropriate for the purposes of screening, the absence of screening values representative of the actual biota expected or likely to be present under ecological conditions present in VCM soil represents an uncertainty. The risks as reported for Step 2 and Step 3A are therefore highly uncertain.

Soil benchmarks protective of terrestrial invertebrates were obtained from EcoSSLs (USEPA, 2005a,b,c,d,e,f; 2006; 2007b,c,d,e,f; and 2008) and, in the absence of EcoSSLs, ORNL-based values for antimony and mercury from Efroymson and others (1997b) and the total chromium value from Alloway (1990). For the ORNL values, invertebrate benchmarks were derived in the same manner as that described above for plants and are considered conservative levels appropriate for screening purposes (Efroymson and others, 1997b).

The following COPECs have screening benchmarks with moderate to high uncertainty:

- Eco-SSL based screening values - moderate uncertainty associated with the risk estimate: manganese.
- ORNL-based screening values - high uncertainty associated with the risk estimate: arsenic and mercury.
- Alloway-based screening value – high uncertainty associated with the risk estimate: total chromium

In Step 3A, LANL (2017) ecological screening levels (ESLs) are used as benchmarks in the evaluation. The low effect ESL, comparable to a LOEL, was specifically used.

6.2.4.2 Earthworms as Surrogates for Arthropods

Terrestrial invertebrate screening benchmarks (and BAFs) are based largely on earthworm studies. Invertebrate screening levels are the same for Step 2 and Step 3A evaluations and are based on conservative endpoints. For invertebrates, most values are based on earthworm studies that used soluble chemical forms (readily bioavailable). While appropriate in Step 2 for the purposes of screening, the absence of screening values representative of the actual biota expected or likely to be present under ecological conditions at the Site represents an uncertainty. The risks as reported are therefore highly uncertain with potentially large overestimates of true risk to soil invertebrates.

For wildlife exposures, use of earthworm-based uptake factors likely overestimates potential uptake and exposure to receptors that may feed on litter invertebrates (e.g., insectivorous or omnivorous birds and mammals), as earthworms represent a maximally exposed community that is continually in contact with soil. Given taxonomic and ecological uncertainties for earthworms and arthropods (e.g., flies, moths, beetles) that would typically comprise an insectivore or more generally an invertivore diet, the applicability of these uptake data (BAFs) to terrestrial arthropods is uncertain, likely overestimating exposure and risk estimates for insectivorous receptors.

6.2.5 **Wildlife Toxicity**

6.2.5.1 Sources and Extrapolations

Extrapolation between toxicological endpoints (e.g., NOAEL and LOAEL) and/or study duration endpoints (e.g., chronic, subchronic) adds uncertainty to the resulting risk estimates. For example, extrapolation of subchronic duration endpoints (e.g., subchronic LOAEL) to chronic duration endpoints (e.g., chronic NOAEL) for laboratory test species introduces uncertainty into the determination of potential impacts, as the distribution of exposure and effect within these bounds is not known. There is higher confidence in toxicological values derived from studies where the full distribution of exposure and effect is bounded (i.e., chronic NOAEL bounded by a chronic LOAEL) as defined in the study design.

Uncertainty also remains with respect to interspecific sensitivity, as laboratory/test species may differ from target species with respect to absorption, metabolism, distribution, and excretion of chemical constituents. Relative sensitivity has sometimes been addressed by applying additional interspecific uncertainty factors (i.e., to convert test species TRVs to target species TRVs using allometric body weight adjustments or taxonomic uncertainty factors) (Sample and others, 1996; Sample and Arenal, 1999). Currently available quantitative models to extrapolate toxicity data from test species to target species are based solely on acute toxicity data and are insufficient to estimate relative sensitivity for chronic exposures (Allard and others, 2009). Therefore, at present there is generally insufficient scientific data to define quantitative interspecific relationships for chronic exposure and such adjustment is not recommended (USEPA, 2007g). The absence of data regarding interspecific sensitivity and the use of modifying (uncertainty) factors to adjust toxicity (e.g., LOAEL) and duration (e.g., chronic) endpoints results in uncertainty in the toxicity data applied and may result in an over- or underestimation of risk.

Reptiles (e.g., snakes, lizards) are expected to be present at the VCM site. Given the paucity of life history information and toxicity data for this class of animals, the results for other invertivorous animal classes (i.e., horned lark) may conservatively be considered an appropriate surrogate for adult reptilian receptors insofar as to provide a general understanding of the COPECs and exposure pathways that may be of concern. While reptiles consume a variety of prey (typically a combination of invertebrates, birds, small mammals) invertebrate ingestion is likely to drive exposure based on the site-specific analytes. However, applying risk estimates derived for the lark to reptiles is highly uncertain due to differences in chemical sensitivity, mechanism of action, and other factors that define the differences in TRVs across vertebrate classes. Therefore, use of surrogate animal classes may over- or underestimate potential hazards to amphibians and reptiles.

6.2.5.2 COPECs Lacking TRVs

Bird TRVs are not available for antimony. Therefore, the potential for risk to birds cannot be evaluated for antimony. Antimony may require further consideration in subsequent studies.

6.3 EXPOSURE CHARACTERIZATION

Uncertainties associated with the exposure assessment include a number of parameters that may affect the qualitative and quantitative estimates of exposure. The key parameters specific to this SLERA and risk assessments in general are provided below.

6.3.1 Selection of Receptors

Knowledge about site-specific dietary composition, exposure pathways, and spatial and temporal constraints on exposure for the selected receptors may be incomplete. Moreover, the actual dietary composition of an organism will vary daily and seasonally. The intake (ingestion) rates for food, water and incidental soil used to estimate exposure of wildlife were derived from literature reports of typical intake rates, body weights, dietary compositions, consumption rates, and metabolic rates in receptors at other locations or from measurements of laboratory-raised organisms. These values are not necessarily representative for site-specific intake rates of ecological receptors.

Use of a single surrogate species to represent a number of species may introduce uncertainty because of interspecies variability in exposure or sensitivity to a COPEC. Risks to wildlife were assessed for a small subset of the species likely to be present at the VCM Site. Although wildlife receptors selected represent a range of taxonomic groups and life history types, these species may not represent the full range of exposures and sensitivities present. The species selected may be either more or less exposed or sensitive to constituents than typical species located within the area. However, the species selected for evaluation are considered typical and representative for ecological risk evaluation in this region.

It was assumed that wildlife exposures were continuous and that receptor home ranges were located entirely or at least in part within the VCM boundary (i.e., the entire dietary intake was assumed to be from the Site). In the case of resident small-home-range receptors (e.g., horned lark), these assumptions are likely to be fairly realistic. In regards to exposures occurring within the Site, these assumptions tend to overestimate exposures for receptors that have large home ranges and that may not be exposed at the Site most of the time. However, potential exposure to contaminants or other stressors outside of the VCM boundary is not considered in this analysis; contribution to total exposure to a receptor from outside the Site is an uncertainty.

6.3.2 Use of UCLs and Development of EPCs

In all exposure calculations, the desired input parameter is the true mean concentration (or the 95% UCL of the sample average, to be conservative) of a compound within a given medium over the area where exposure may occur. Use of the UCL of the mean as an EPC is intended to provide a conservative estimate of average site concentrations, in order to provide a high probability (95%) that the true mean concentration is lower than the calculated sample average. It is likely that use of the UCL concentration may result in moderate overestimate of risk (95% probability that the true mean is lower than the UCL), particularly when sample locations are biased to include impacted areas within an exposure area. However, in some instances, calculating an estimated mean concentration is not possible or not wholly applicable as a result of data that are dynamic due to temporal fluctuation (e.g., surface water concentrations). Use of the MDC in these instances for a defined time period is a conservative approach and is likely to overestimate exposure based on water intake, as average exposures are more likely.

Use of a single large exposure area is appropriate for large-ranging receptors (e.g., the coyote) because contact is expected to occur over a wide area. Division of the site into smaller subunit exposure areas (i.e., Exposure Area 1 and 2) could potentially obscure the overall (actual) ecological risk for these wide-ranging receptors. Evaluating small- to moderate-ranging wildlife receptors on a site-wide basis could invite the possibility of overlooking potentially significant risk to these receptors in localized areas. Because of this, small- to moderate-ranging wildlife receptors are evaluated on an exposure area basis rather than a site-wide basis.

The Hull Canyon Wash is dry for most of the year. Therefore, the primary substrate present in the Wash is essentially soil. Therefore, aquatic biota (i.e., a benthic community) and aquatic-oriented birds and mammals are absent and were not considered as viable receptors for the VCM Site.

The calculations of the 95% UCLs were performed for surface soil (0-4 inches bgs) at each exposure area assuming a single sample population; that is, considering the various potential source types sampled within each exposure area belong to the same population or statistical distribution (i.e., Exposure Area 1 - low grade ore, tailings, and waste rock; and Exposure Area 2 - high grade ore, waste concentrate, tailings, and surface soil). It is acknowledged that considering the data on a by-source basis or through other EPC calculation approaches (e.g., area-weighted average or weighted 95% UCLs of the mean) may yield a more notionally robust EPC at sites where multiple sources are present and/or where there was a desire or need to characterize each source material separately. However, the sampling strategy used to obtain data (i.e., judgmental sampling, focused in high concentration areas) is considered highly conservative (i.e., more protective to the environment and public health) and unlikely to lead to an underestimation of

EPCs and resulting hazard quotients. The uncertainty associated with the EPCs used underestimating potential hazards is therefore low.

To verify that combining various source types is appropriate for 95% UCL calculation, the analytical results for metals of concern in each exposure area were reviewed graphically using normal quantile plots (Q-Q plots) and by evaluation of statistical distributions (see Appendix D of the SCR). Combining data from truly different populations usually results in a non-parametric statistical determination because multiple modes are present in the distribution. However, the results do not show evidence of a bi- or multi-modal distribution, but rather, follow a parametric distribution (normal, gamma, or lognormal) for all but two data sets (cadmium and zinc at Exposure Area 2). For these analytes, the non-parametric assumption is explained by the relatively high number of non-detected cadmium concentrations and the presence of an elevated zinc concentration value, which skewed these distributions.

Although some minor breaks or gaps were observed in the data points displayed on the Q-Q plots for some analytes (e.g., arsenic at Exposure Area 1 and Exposure Area 2) that may suggest potentially separate populations, the data are distributed parametrically (normal and gamma distributions, respectively), which were confirmed by statistical goodness-of-fit tests. Review of by-source results for arsenic indicate that concentrations for the various source types are intermixed with each other (i.e., when concentrations are arranged from lowest to highest concentration irrespective of source type) and no one particular source type is dominant at the high-end or the low-end of the detected concentrations. For metals with parametric distributions, none of the data points for any metals fall outside of the upper or lower confidence bands (i.e., dotted lines displayed on Q-Q plots presented in Appendix D of the SCR), which indicates a high degree of confidence that all data points closely fit the straight line (with constant slope), and thus, the combined data sets are representative of a single data population and calculation of 95% UCLs by combining material types is appropriate for this site.

6.3.3 Chemical Form and Bioavailability/Bioaccessibility

Toxicity depends on how much of the chemical in its environmental matrix is accessible to the organisms and how much of the accessible fraction is eventually absorbed from the gastrointestinal tract into the body. The actual extent of absorption from ingested media (e.g., soil, sediment, surface water, and food) is usually not known and may vary widely depending on the chemical and physical form of the chemical and specifics of uptake kinetics for various receptors. NOAEL TRVs are based on ingested doses believed to be safe, based on tests in a laboratory setting using more or less artificial means of administration and forms of the chemical. In contrast, LOAEL TRVs are based on ingested doses at which adverse effects may be observed. The relative

availability of a chemical in its environmental matrix may be very different from the form underlying the TRV. If the absorption of a compound from a given medium is different (usually lower) than occurred in the laboratory study, then the hazard estimate will be biased. In this SLERA, estimates of wildlife exposure assumed a relative bioavailability of 100 percent for all compounds in all media. Assuming bioavailability of 100 percent overestimates the potential exposure to receptors.

For lead, bioaccessibility factors (used as a surrogate for bioavailability), were implemented for birds and mammals. Use of these values reduces the uncertainty in the resulting exposure estimates.

The chemical species present is generally not evaluated as total metals are typically evaluated. However, speciation can be useful to determine the chemical form present at a given site to provide added context to the relevance of the toxicity data used to assess potential hazards. For example, the various chemical forms and valence states of selenium exhibit different fate and transport, bioavailability and toxicity characteristics. The dominant selenium species include:

- **Inorganic selenium forms.** Typically includes selenite (Se +4) and selenate (Se +6) that are dominant in aqueous media (sediment and water). Other inorganic forms may predominate in soil/sediment, especially low toxicity and low bioavailability zero valent selenium.

- **Organic selenium.** Includes selenocyanate, selenomethionine, and selenomethylcysteine that are produced by biological processes. Dominate in biological systems but may also be present in surrounding media. Volatile methylselenides would not be expected in soil or sediment.

Oxidized selenium (Se +4 and Se +6) is more relevant to the water column than in sediment or soil, where reduced organic selenium is likely the more important form. In general, toxicity data used for TRV development are based on highly soluble and bioavailable forms and therefore are likely to result in overestimate of exposure relative to the generally stable chemical forms found under field conditions.

6.3.3.1 Use of Calculated BAFs

Literature-derived uptake factors are for a variety of organisms and conditions and typically do not consider that only a finite mass of each chemical is available for the receptors. Lack of data specific to local diets increases uncertainty in the exposure and resulting risk estimate. BAFs are estimates of the potential uptake from media to food items (e.g., soil to invertebrates). Often, the

BAF is derived by determining the geometric mean of values reported in studies (EPA, 1999b). Part of the difficulty and, hence, the uncertainty, is the selection and appropriateness of data to include in the BAF calculation. For some inorganics, applicable BAF values are not available and so default values were applied: a default of 1 (i.e., tissue concentration equivalent to media concentration), used for soil to terrestrial invertebrate uptake pathway. For soil to small mammal uptake pathways, the arithmetic mean of available metals data was applied to derive a central tendency value and 90th percentile BAF as default. The use of default values introduces uncertainty and may over- or underestimate actual uptake and resulting pathway specific exposure.

6.3.4 Minor Exposure Pathways

Dermal exposures of wildlife to soil and surface water is not easily quantifiable and is considered to be insignificant relative to dietary exposures due to the protection that wildlife coat/feathers offer which limits direct dermal contact. Inhalation of dust particles by wildlife is also considered a minor pathway relative to the diet; dust particles are typically trapped in the upper airways and removed via mucoscilliary action and ultimately enter the digestive tract. Further, as the COPECs at VCM are metals, none are volatile and subject to inhalation in dens or enclosed space. Exposure to subsurface soil by burrowing mammals is typically driven by direct contact only, as dietary resources are not typically obtained from the subsurface. In addition, shallow subsurface soil concentrations would be expected to be similar to those observed in surface soil given the nature of the source material present at the site. Potential exposure via the above pathways is considered negligible and uncertainty is low. In addition, terrestrial plants that grow in the footprint of the ephemeral Hull Canyon Wash may be intermittently exposed via root contact with surface water. Solution-based phytotoxicity benchmark concentrations are available (Efroymson et al., 1997a). However, the majority of exposure is expected via dissolved constituents in soil moisture (soil exposure) and so plant uptake via surface water is considered a minor pathway. Potential exposure to surface water by terrestrial plants is considered negligible and the uncertainty is low.

Although the surface water ingestion pathway for wildlife is potentially quantifiable (USEPA, 1993), this minor pathway was not included in the risk evaluation because the contribution to the overall risk estimate from water ingestion particularly from an ephemeral wash is generally trivial relative to the ingested dose via incidental ingestion of soil and diet, and contributes little to overall risk. Based on maximum surface water concentrations from a perennial waterbody, with few exceptions the dose from water ingestion of metals contributes less than 1 percent of the combined total dose from other exposure pathways. This negligible contribution from water to overall dose is typical for these chemical classes and leads to a risk estimate unaffected by the water pathway. In practice, many drinking water sources not related to the Verde Central site are also available and used by wide-ranging animals. Therefore, estimating risk based

on an assumed reliance of mobile animals on only one impacted site-related location such as the ephemeral Hull Canyon Wash for water resources is likely to overestimate risk.

6.3.5 Habitat Quality

As previously stated in Section 2, habitat in the former mine operating areas of the site is generally of limited use for wildlife, as better habitat is present in relatively undisturbed areas surrounding the formerly active mining areas of the site. This is particularly true for EA 1 that is predominantly waste rock piles with little or no vegetation or cover. As previously discussed in Section 2, the overall site certainly can support a diversity of small mammals and birds, and provide resources for larger wildlife species as well. However, the ruderal nature of formerly active mining areas is likely to limit resource use in these areas, especially with consideration of the presence of relatively undisturbed/recovered portions of the site and other undisturbed areas located off-site. The likelihood of exclusive site use by wildlife populations is also low given current habitat conditions are unlikely to provide the resources or spatial/biological diversity to support entire populations of organisms.

6.4 RISK CHARACTERIZATION

Uncertainties associated with the risk characterization include a number of factors that may affect the qualitative and quantitative estimates of risk.

6.4.1 Area Use Factors

The AUF is the site-specific ratio of the defined exposure area to the total area of foraging or home range of the receptor. Foraging areas obtained from USEPA (1993) and other literature sources were applied to the site-defined exposure area. The average estimates of the home range were applied in Step 2 as presented in Table H-9. Two types of use factors are typically considered in a SLERA: an AUF based on home range of given receptor; and a seasonal use factor based on the seasonal use which considers migration and/or seasonal shift in dietary preferences.

Use of average estimate generally reduces uncertainty and the potential for overestimating site use (e.g., if applying the minimum home range). In reality, given variability in regional and habitat-specific home ranges for a given species, and the extent of other attractive (native, undisturbed) habitat nearby, the selected home ranges may over-estimate potential exposure and risk for receptors with large home ranges and over- or under-estimate potential exposure and risk to small home range receptor. Existence of attractive habitat nearby is likely to result in a reduced presence in disturbed areas for mobile receptors, with a consequent overestimation of risk. This is particularly a factor for Exposure Area 1 where most of the area is covered with waste rock with minimal vegetation and associated habitat.

6.4.2 **Interpreting HQs**

The HQ is not a predictor of risk but rather is a "binary" index (i.e., screened out versus screened in for subsequent analysis) used to eliminate potential risk and to identify chemicals-receptors for which additional evaluation may be required (USEPA, 1997a; Allard and others, 2009). The HQ is interpreted as follows:

- Step 2 or Step 3A, NOAEL HQ <1 – indicates that a given COPEC-receptor combination may be eliminated from further consideration as potential for risk from the given constituent is not likely.

- Step 2 HQ≥1 – indicates the potential for risk cannot be excluded and indicates that conservative data and assumptions are insufficient to conclude that risks are absent. Additional refinement may be warranted to limit the uncertainty.

- Step 3A, NOAEL- or LOAEL-based HQ ≥1 – indicates the potential for risk cannot be excluded and additional refinement may be warranted to limit the uncertainty.

The magnitude of the HQ is not comparable across or within AEs (i.e., an HQ of 10 for one receptor is not necessarily "worse" than a HQ of 5 for another), as the underlying dose-response relationship may not be linear or comparable between representative species (Allard et al., 2009).

6.4.2.1 NOAEL/LOAEL TRV Extrapolation

Extrapolation between toxicological endpoints (e.g., NOAEL and LOAEL) and/or study duration endpoints (e.g., chronic, subchronic) adds uncertainty to the resulting risk estimates. For example, use of uncertainty factors to extrapolate subchronic duration endpoints (e.g., subchronic LOAEL) to chronic duration endpoints (e.g., chronic NOAEL) for laboratory test species introduces uncertainty into the determination of potential adverse effects, as the distribution of exposure and effect within these bounds is not known. There is higher confidence in toxicological values derived from studies where the full distribution of exposure and effect are bounded (i.e., chronic NOAEL bounded by a chronic LOAEL) as defined in the study design. The use of uncertainty factors to adjust toxicity (e.g., LOAEL) and duration (e.g., chronic) endpoints results in uncertainty in the toxicity data applied and may result in an over- or underestimation of risk.

6.4.2.2 LOAEL- and NOAEL-based HQs

Adverse effects to individuals do not necessarily imply adverse effects at the population or community level. TRVs, upon which the potential for adverse effects are assessed, are typically based on studies of relatively small sample size and limited species and so conferring population or community level effects based on such data is uncertain. TRVs for dose-based evaluations are

based on individual-level adverse effects. Risk estimates based on individual risk as represented by Step 2 NOAEL-based HQs and Step 3A LOAEL-based HQs and NOAEL-based HQs) may therefore overestimate risk at the population or community level. The population and community levels are relevant endpoints for evaluation of ecological receptors that are not listed, threatened or endangered.

6.4.3 Risk Characterization Results

The risk results are presented below with consideration of receptors-specific characteristics and the uncertainties described above.

6.4.3.1 Omnivorous/Insectivorous Receptors

The horned lark (the representative omnivorous/insectivorous receptor) had the following Step 3A risk results:

- LOAEL-based HQs equal to or exceeding unity for copper (HQ=44), selenium (HQ=10) and zinc (HQ=2) at EA 1, and cadmium (HQ=9), copper (HQ=102), lead (HQ=6), mercury (HQ=3), selenium (HQ=10) and zinc (HQ=4) at EA 2.

- NOAEL-based HQs equal to or exceeding unity for cadmium (HQ=2), copper (HQ=131), lead (Q=2), selenium (HQ=12), silver (HQ=2) and zinc (HQ=2) at EA 1, and arsenic (HQ=2), cadmium (HQ=15), copper (HQ=301), lead (HQ=12), mercury (HQ=6), selenium (HQ=13) and silver (HQ=2), zinc (HQ=5) at EA 2.

The potential for risk to omnivorous birds that may be present at VCM is likely overestimated by an unknown amount as larks are not expected to remain in this marginal open habitat for an extended period of time; this represents a significant uncertainty. Assuming a seasonal use factor of 100 percent (no migration or emigration) is considered conservative and is likely to overestimate risk for birds when considering seasonal movement due to emigration to other biological niches. Uptake factors used to model uptake into terrestrial invertebrates were developed mostly from earthworm data, a maximally exposed community. While uptake data for litter invertebrates such as arthropods are not readily available, consideration of such data would likely provide a more realistic estimate of exposure to omnivorous birds.

The concentrations of COPECs in soil that are consumed incidentally along with the dietary items are included in the daily dose used to estimate risk. For the lark, a default assumption of 2.9 percent incidental soil ingestion was applied and was based on the American robin as reported in Whitford (2009). Use of this value is considered conservative because this value was applied irrespective of consideration of feeding strategy, nesting habits, grooming and other factors that may influence

incidental soil intake for bird species observed or expected at the site. The assumption that the diet and incidental soil ingestion rate based on the American robin (a ground forager that probes soil for earthworms) is likely to overestimate risk for birds like the lark that glean invertebrates from the ground surface, or other invertivores that glean insects from foliage, and otherwise have a somewhat attenuated or limited direct contact with soil relative to the robin. Use of the 2.9 percent soil proportion is considered conservative for this receptor and therefore exposure via this pathway is likely overestimated.

With the exception of selenium the invertivorous diet drives exposure and HQs for the horned lark (Attachment H-4). The expected exposure and HQs for herbivorous birds would be lower for all metals except selenium, which is known to hyperaccumulate in some plant tissues (Galeas and others, 2006) and therefore, the evaluation of the lark underestimates the HQ for herbivores from selenium. For example, using the lark exposure parameters and assuming that the lark consumes 100 percent vegetation at EA1 results in a selenium LOAEL HQ=18, whereas assuming the typical lark diet the LOAEL HQ=10. Similarly, at EA2 the resulting LOAEL HQ=20, versus the LOAEL HQ=10 assuming a typical diet. For all other metals identified as COPECs, evaluation of the lark is considered fully protective of herbivorous birds.

Because toxicity data are not available to evaluate reptiles the results presented above for the lark, a sensitive receptor that has a similar diet of invertebrates, may be used as a surrogate.

6.4.3.2 Herbivorous Receptors

For moderate home range herbivorous receptors such as the black-tailed jackrabbit, risk is not expected as all LOAEL-based HQs were below unity and the only NOAEL-based HQ greater than 1 was for selenium (HQ=2). The assumption that the jackrabbit spends all or most of their time within a given exposure area likely overestimates risk, as the relatively low vegetative cover (particularly in Exposure Area 1) and spatial density likely requires these and similar receptors to forage over wider areas.

6.4.3.3 Large Home Range Carnivorous Receptors

For large home range carnivorous receptors such as the coyote, risk is not expected as all LOAEL- and NOAEL-based HQs were below unity. The uncertainty in the results is low as area use by these receptors likely overestimates risk particularly since suitable habitat for prey animals is likely more available in nearby areas and their large home foraging range relative to the size of the Site and population dynamics indicates that that potential hazards to populations of these types of receptors is not likely. Risk for these receptors is not expected.

6.4.3.4 Plant and Invertebrate Communities

For terrestrial plants, potential risks cannot be ruled out for arsenic (HQ=2), copper (HQ=10), and selenium (HQ=13) in EA 1 and arsenic (HQ=3), copper (HQ=24), selenium (HQ=6), and zinc (HQ=7) in EA 2. For soil invertebrates, potential risks cannot be ruled out for arsenic (HQ=2), copper (HQ=10), and mercury (HQ=3) in EA 1 and arsenic (HQ=5), copper (HQ=22), mercury (HQ=16), selenium (HQ=1) and zinc (HQ=6) in EA 2. Toxicity values used for the terrestrial vegetation and soil invertebrate evaluations in Step 2 were screening levels provided by USEPA, ORNL and Alloway. Screening values from these sources are considered conservative, as most of them are no effect or threshold levels derived from laboratory studies. For plants and invertebrates, toxicity endpoints from these studies are based on sensitive seedling growth and germination, and earthworm growth and survival, respectively, and typically use highly soluble chemical forms. The relevance of the screening levels to site-specific vegetation/invertebrates under site-specific soil conditions and the actual constituent form for each metal is subject to high uncertainty. Reported exceedance of these conservative screening levels may overestimate the potential for risks to these communities.

6.4.3.5 Surface Water and Sediment (Soil)

In Hull Canyon Wash, for surface water, only copper was identified as a COPEC at one sample location based on a comparison of individual sample concentrations to acute water criteria protective of aquatic life (A&We) (AAC, 2009). Calculation of a 95%UCL at each sample location was not possible due to the small dataset. Comparing individual sample concentrations with acute water criteria is conservative and likely overestimates the potential for risk because it does not account for temporal changes or central tendency concentrations.

One sediment sample was collected at each of the four sample locations. As previously discussed, samples were considered soil rather than sediment because of the ephemeral nature of the Wash and therefore, the four samples were compared to soil benchmark values and background rather than sediment benchmark values. Copper and selenium were identified as primary COPECs at SC-HCW-S-2 and SC-HCW-4. Chromium and nickel were identified as COPECs in SC-HCW-S-3 only. Comparing individual sample concentrations with conservative soil benchmarks likely overestimates the potential for risk because it does not account for receptor-specific input factors or central tendency concentrations.

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7.0 CONCLUSIONS AND RECOMMENDATIONS

Risk characterization and associated uncertainties result in the following risk conclusions after the completion of the Step 3A risk evaluation at the VCM site.

The SLERA evaluated seven assessment endpoints and associated representative receptors and addressed exposures to soil, surface water, and food. Two habitat types were evaluated:

- **Terrestrial Exposure Area.** Two areas were evaluated separately: the waste rock and low grade ore area (EA 1) and the high grade ore/suspected waste concentrate and building foundation area (EA 2).
- **Ephemeral Hull Canyon Wash.** Ephemeral wash that is not in contact with groundwater and flows only in response to precipitation events.

The following sections provide conclusions regarding risk results developed for this SLERA. Uncertainties associated with the reported risk results, as presented in Section 6.0, are considered in presentation of these results. Table H-20 presents a summary of risk results for all representative receptors and media evaluated.

7.1 TERRESTRIAL AREAS

Evaluation of terrestrial areas included assessment of terrestrial exposures for wildlife and soil communities (plants and invertebrates) to soil. For wildlife, direct contact with soil and uptake via biota (diet) were evaluated. Soil communities (including plants and invertebrates) were evaluated based on uptake from soil. Results for each are summarized below.

7.1.1 Wildlife and Soil Communities

Table H-20 summarizes reported soil community level and wildlife risk for both exposure areas. The SLERA concludes that ecological risk for small home range wildlife receptors (represented by the horned lark) and terrestrial plants and soil invertebrates cannot be excluded for some COPECs. Risk to medium home range receptors (represented by the black-tailed jackrabbit) and wide-ranging receptors (represented by the coyote) potentially exposed to soil and food items is not expected.

7.1.1.1 Plants and Invertebrates

Risks to soil communities are possible from exposure to three COPECs (arsenic, copper and selenium) for terrestrial plants and three COPECs (arsenic, copper and mercury) for soil invertebrates in EA 1, and four COPECS (arsenic, copper, selenium and zinc) for terrestrial plants

and five COPECs (arsenic, copper, mercury, selenium and zinc) for soil invertebrates in EA 2. However, results are based on a screening evaluation using conservative benchmarks derived from USEPA, ORNL, Alloway and LANL sources. For plants and invertebrates, toxicity endpoints from the USEPA and ORNL studies are based on sensitive seedling growth and germination, and earthworm growth and survival, respectively, and typically use highly soluble chemical forms. The relevance of the screening levels for site-specific vegetation/invertebrates under site-specific soil conditions and constituent form is subject to high uncertainty.

Although physically disturbed areas are evident in association with past mining activities in both EA1 and EA2, no overt signs of acute or chronic toxicity (e.g., stressed or dead vegetation, absence of biota) have been noted. Risk results based on the Step 2/3A benchmark screen for both plant and invertebrate communities are highly uncertain because they are based on individual species of plants and invertebrates (not populations or communities) and therefore should not be used to infer actual or expected risks for communities of organisms.

In summary, risk results based on the Step 2/Step 3A screen for both plants and invertebrates are highly uncertain and are unlikely to reflect actual risks that may be present at the Site, especially given the notable differences in test versus local species and extrapolation of individual toxicity tests to entire communities. Consideration of additional lines of evidence including soil background conditions and community structure/ site observations indicate the ruderal conditions present are primarily due to physical rather than chemical stressors. While potential for localized hazards and risk cannot be discounted from exposure to the above COPECs, the risks to soil communities as a whole are expected to be minimal.

7.1.1.2 Wildlife

Ecological risk for small ranging wildlife receptors with home foraging ranges that imply 100 percent site exposure cannot be excluded. More specifically, risks to omnivorous (insectivorous) receptors as represented by the horned lark are possible from exposure to the following COPECs with

LOAEL- or NOAEL-based HQs greater than or equal to 1:

- Arsenic – Exposure Area 2 (NOAEL HQ=2)
- Cadmium – Exposure Area 1 (NOAEL HQ=2), Exposure Area 2 (LOAEL HQ=9, NOAEL HQ=15)

- Copper – Exposure Area 1 (LOAEL HQ=44, NOAEL HQ=131), Exposure Area 2 (LOAEL HQ=102, NOAEL HQ=301)
- Lead – Exposure Area 1 (NOAEL HQ=2), Exposure Area 2 (LOAEL HQ=6, NOAEL HQ=12)
- Mercury – Exposure Area 2 (LOAEL HQ=3, NOAEL HQ=6)
- Selenium – Exposure Area 1 (LOAEL HQ=10, NOAEL HQ=12), Exposure Area 2 (LOAEL HQ=10, NOAEL HQ=13)
- Silver – Exposure Area 1 (NOAEL HQ=2), Exposure Area 2 (NOAEL HQ=2)
- Zinc – Exposure Area 1 (LOAEL HQ=2, NOAEL HQ=2), Exposure Area 2 (LOAEL HQ=4, NOAEL HQ=5)

HQs for all remaining COPECs are driven by invertebrate ingestion by the horned lark. Invertebrates account for more than 90 percent of the total ingested dose for all metals except selenium (75 percent invertebrates, 18 percent plants and 7 percent soil) and zinc (88 percent invertebrates, 2 percent plants and 10 percent soil).

Key uncertainties regarding wildlife risk results indicate that risk is generally overestimated. In particular, the assumption that most receptors spend all of their time in a specific area likely overestimates risk, especially for receptors with moderate home or feeding ranges such as the horned lark, as the relatively low vegetative cover within physically disturbed/recovering areas of the Site (for example, the waste piles) and attractiveness of adjacent areas within and outside of each EA would likely lead these receptors to forage over wider areas. Although all terrestrial wildlife evaluated are year-round residents, wildlife receptors such as the horned lark may migrate locally due to seasonal factors (e.g., food availability, thermal cover) resulting in wider home ranges and/or altered diets, which may vary from year to year. For omnivorous receptors that rely on invertebrates for most of their diet, reported risk is likely overestimated, as uptake factors used to model invertebrate (food) concentrations are based on earthworm models; use of earthworm-based uptake factors where earthworms are not expected to be the primary food source is likely to overestimate potential risk. Although herbivorous birds are addressed indirectly through evaluation of the lark, which is generally a more sensitive feeding guild, exposure to selenium for herbivorous or omnivorous birds where vegetation is the dominant portion of the diet, may be underestimated given that the soil to plant pathway typically accounts for the majority of ingested dose from selenium.

Because toxicity data are not available to evaluate reptiles the results presented above for the horned lark, may be used as a surrogate.

Although the potential for unacceptable risks from exposure to six COPECs cannot be excluded for small ranging wildlife receptors such as the horned lark, a number of uncertainties result in a likely overestimate of the potential risks. These uncertainties coupled with the general lack of habitat at EA1 and the availability of nearby (offsite) higher quality habitat, suggest that the likelihood of small ranging wildlife receptors being maximally exposed to COPECs within EA 1 or EA 2 is unlikely.

7.2 EPHEMERAL WASH

Aquatic exposures to surface water in the Hull Canyon Wash was evaluated by comparing sample concentrations to screening levels that are designed to protect aquatic organisms and wildlife in ephemeral waterbodies (AAC, 2009). Only two samples exceeded screening levels at two locations: HCW-2-W (copper) and HCW-4-W (copper). The exceedance for the HCW-4-W sample was not repeated in a separate sample at the same location two months later.

Sediment (or more realistically, soil) samples were also collected at the four sample locations within the Wash. These samples were compared to soil benchmarks on a sample by sample basis because of the ephemeral nature of the Wash and the lack of sediment-related biota in the area of the Wash. Copper and selenium concentrations exceeded their respective soil benchmarks and background concentrations in two samples and chromium and nickel exceeded their respective benchmarks in one other sample. With the exception of copper, none of the other three COPECs were considered a concern in the associated surface water samples. In addition, soil screening benchmarks are highly conservative resulting in a high level of uncertainty as previously discussed.

Although concentrations of several metals slightly exceed conservative screening benchmarks in both surface water (copper only) and sediment/soil (copper, selenium, chromium and nickel) in the Hull Canyon Wash, there is no evidence that metals from nearby mining operations have migrated into the Wash via overland flow.

7.3 USE OF THE SLERA

The SLERA evaluated available Site data to provide estimates for potential adverse risk to ecological receptors from exposure to soil and water. On the basis of a Step 3A refinement of COPEC evaluation of existing data, risk cannot be excluded for small home range terrestrial wildlife represented by the horned lark and to a lesser extent, the terrestrial plant and invertebrate

communities. As indicated in Sections 1 and 5, the outcome of Step 3A represents a SMDP where the SLERA outcome is considered in the context of the need for additional evaluation (e.g., further data collection, refinement of exposure assumptions, conduct of a Step 3B BERA) and/or remedial action. To that end, the results from this SLERA may be used to inform risk management decisions in subsequent steps of the "project lifecycle" for the Site.

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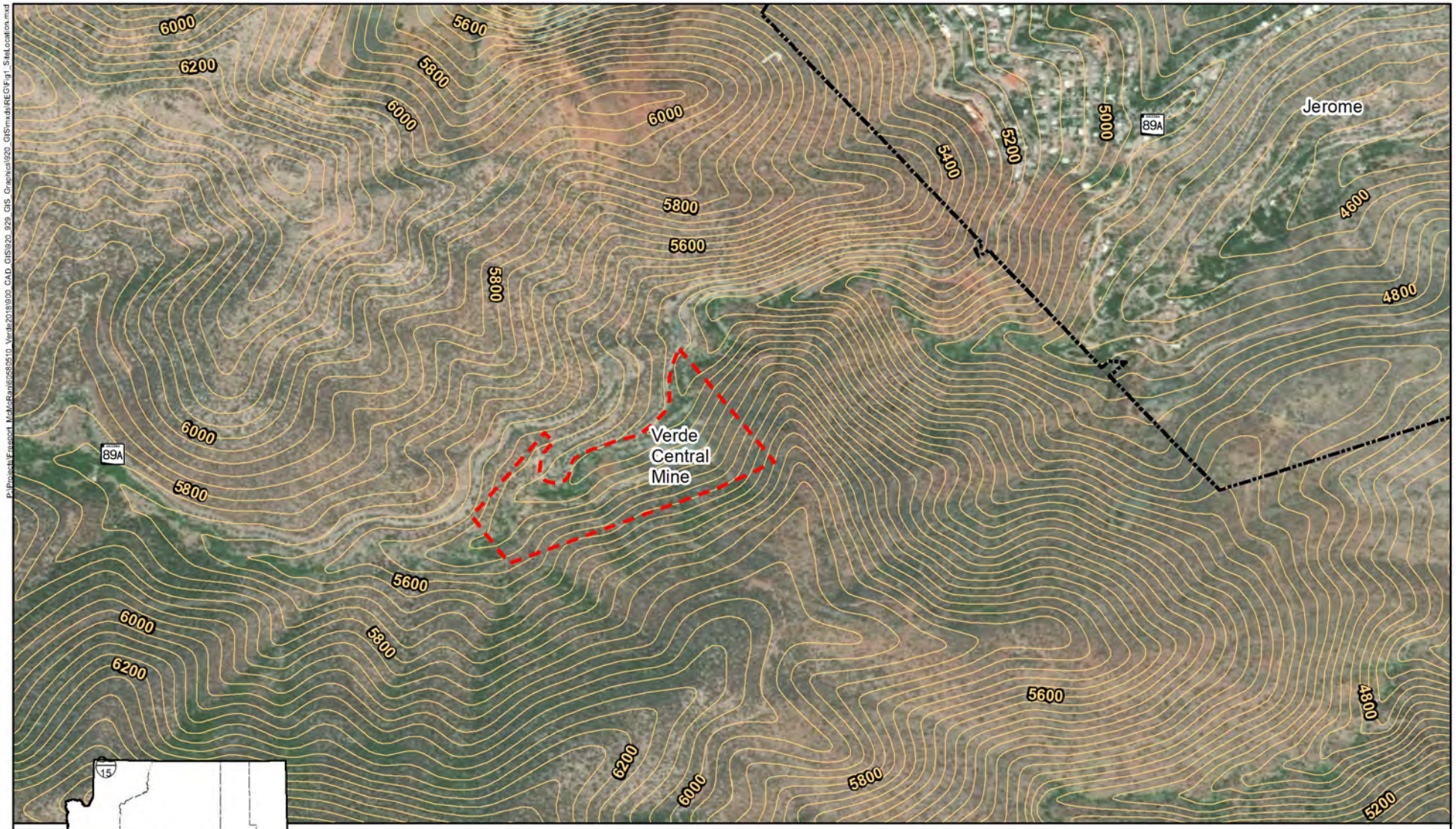
FIGURES



LEGEND

- Verde Central Mine Site
- Town Boundary
- USGS Elevation Contour

Base Map: ALRIS 2016
Project Area: URS 2007
Elevation Contours: U.S. Geologic Survey DEM
Imagery: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

0 500 1,000
Feet

Figure H – 1

Site Location Map

Freeport Minerals Corporation

Updated Site Characterization Report
Verde Central Mine, Near Jerome, Arizona

AECOM

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LEGEND

Mine Features

- Verde Central Voluntary Remediation Site
- Closed Mine Shaft or Adit
- Project Exposure Areas
- Approximate Extent of Waste Rock Stockpile
- Approximate Extent of Low-Grade Ore Rock Stockpile
- Mill Building Foundation
- Tailing[1]
- Waste Concentrate[1]
- High Grade Ore[1]
- USGS Elevation Contour

[1] The extent of tailing, waste concentrate, and high grade ore shown above was estimated during planning stages or the project.

Sample Type

- Background Soil

General Features

- Ephemeral Stream Bed

N

0 100 200
Feet

Hydrology and Mine Features: URS 2008
Elevation Contours: U.S.Geological Survey DEM
Imagery: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure H - 2

Project Area and Background Sample Locations

Freeport Minerals Corporation
Updated Site Characterization Report
Verde Central Mine, Near Jerome, Arizona

AECOM

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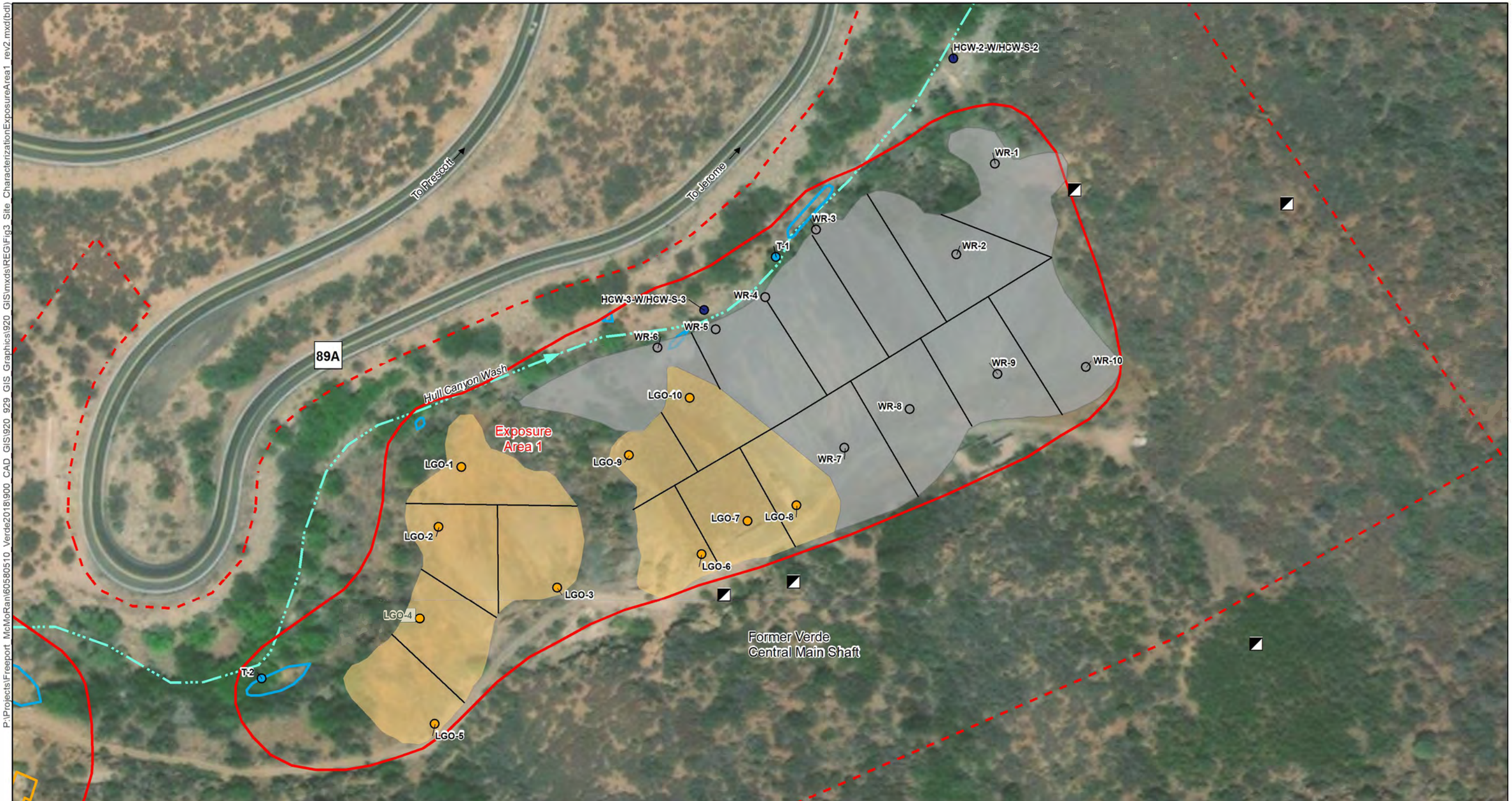

LEGEND

- Verde Central Mine Site
- Project Exposure Areas
- Closed Mine Shaft or Adit
- Approximate Extent of Waste Rock Stockpile
- Approximate Extent of Low-Grade Ore Rock Stockpile
- Mill Building Foundation
- Tailing[1]

Sample Type

- Low Grade Ore Stockpile
- Tailing Stockpile
- Waste Rock Stockpile
- Hull Canyon Wash

General Features

- Ephemeral Stream Bed

N

0 50 100
Feet
1 inch = 100 feet

[1] The extent of tailing shown above was estimated during planning stages of the project. Some sample locations were modified to coincide with tailing observed at the time of the sampling.

Source:
Hydrology and Mine Features: URS 2008
Imagery: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure H - 3

Site Characterization Sample Locations Exposure Area 1

Freeport Minerals Corporation
Updated Site Characterization Report
Verde Central Mine, Near Jerome, Arizona

AECOM

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LEGEND

- Verde Central Mine Site
- Project Exposure Areas

SampleType

- High Grade Ore Stockpile
- Hull Canyon Wash
- Tailing Stockpile
- Waste Concentrate Stockpile
- Soil

- Mill Building Foundation
- Tailing[1]
- Ephemeral Stream Bed

N

0 50 100

Feet

1 inch = 100 feet

[1]The extent of tailing shown above was estimated during planning stages of the project.
Some sample locations were modified to coincide with tailing observed at the time of the sampling.

Figure H - 4

Site Characterization Sample Locations Exposure Area 2

Freeport Minerals Corporation
Updated Site Characterization Report
Verde Central Mine, Near Jerome, Arizona

AECOM

Figure H-5
Ecological Conceptual Site Model

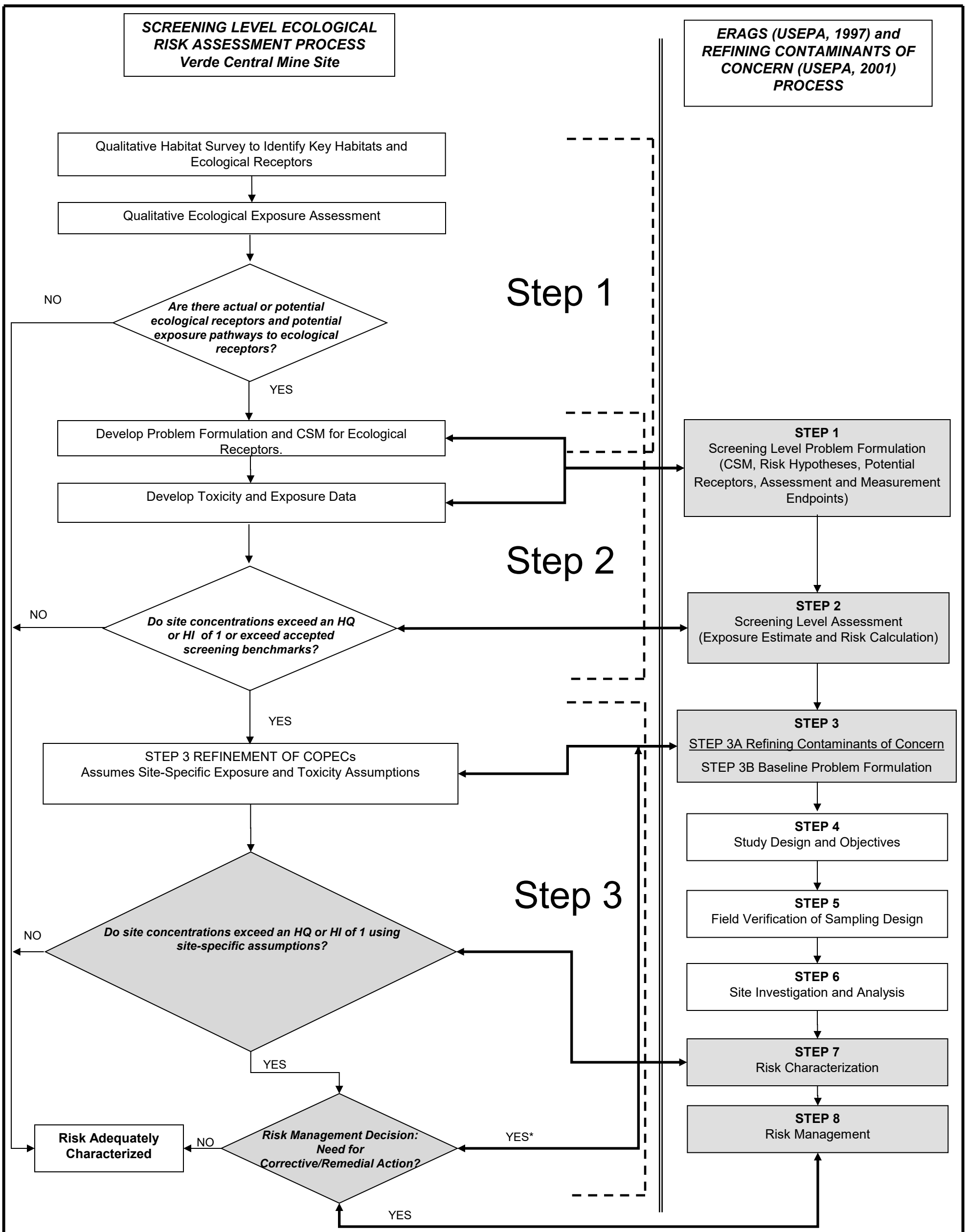
Primary Source	Primary Release Mechanism	Secondary Source	Secondary Release Mechanism	Exposure Medium	Terrestrial Plants	Soil Invertebrates	Omnivorous and Insectivorous Wildlife (Horned Lark)	Herbivorous Wildlife (Black-tailed Jackrabbit)	Carnivorous Wildlife (Coyote)	Biota Exposed to Ephemeral Wash*
Exposed Rock, Tailings, and Mill Waste Resulting from Historic Mining and Milling Operations		Waste Rock/Soil		Waste Rock/Soil	DC	Ing, DC	Ing	Ing	Ing	--
	Bioaccumulation		Bioaccumulation	Plants/Animals	--	Ing	Ing	Ing	Ing	--
	Wind Erosion	Dust		Fugitive Dust	--	--	Inh	Inh	Inh	--
			Deposition							
	Surface Runoff	Soil		Soil	DC	Ing, DC	Ing	Ing	Ing	--
		Ephemeral Wash Sediment/Soil		Ephemeral Wash Sediment/Soil	--	--	--	--	--	Ing, DC
		Ephemeral Wash Surface Water		Ephemeral Wash Surface Water	--	--	--	--	--	Ing, DC
	Infiltration (i.e., leaching)	Subsurface Soil		Subsurface Soil	--	--	--	--	--	--
		Groundwater		Groundwater						

Notes:

	Potentially Complete Pathway
--	Insignificant or Incomplete Pathway

DC = direct contact route of exposure
Ing = ingestion route of exposure
Inh = inhalation route of exposure

*Biota exposed to Ephemeral Wash includes animals, plants, or other organisms, excluding fish, for habitation, growth, or propagation. Ephemeral water is defined as “a surface water that has a channel that is at all times above the water table and flows only in direct response to precipitation.”



Notes:

- Dark arrow represents points of correspondence between USEPA guidance and tiered approach

- Scientific Management Decision Point

*Risk Management decision indicating additional data needs

Terms:
COPEC = Chemical of Potential Ecological Concern
CSM = Conceptual Site Model
ERAGS = Ecological Risk Assessment Guidance for Superfund
HQ = Hazard Quotient
HI = Hazard Index
ERA = Ecological Risk Assessment

Shaded boxes indicate USEPA steps applied in the ERA

References:

USEPA, 1997. Ecological Risk Assessment Guidance for Superfund (ERAGS): Process for Designing and Conducting Ecological Risk Assessments, Interim Final. Environmental Response Team, U.S. Environmental Protection Agency. Edison, NJ

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Ecological Risk Assessment Verde Central Mine Site, near Jerome, Arizona	Ecological Risk Assessment Process	
DATE: December 2017	R:PROJECTS\Verde Central Mine\ERA_2018\Fgures	FIGURE H-6

TABLES

Table H-1
Sample Locations used in the Screening Level Ecological Risk Assessment

Sample Description	Number of Original Samples	Sample Identification	Number of Duplicate Samples	Duplicate Sample Identification
Background Soil	10	SC-B-1 through SC-B-10	1	SC-B-11 (dup of SC-B-5)
Exposure Area 1				
Waste Rock	10	SC-WR-1 through SC-WR-10	1	SC-WR-11 (dup of SC-WR-7)
Low Grade Ore	10	SC-LGO-1 through SC-LGO-10	1	SC-LGO-11 (dup of SC-LGO-8)
Tailings	2	SC-T-1 and SC-T-2	0	NA
Exposure Area 2				
High Grade Ore	1	SC-HGO-1	0	NA
Suspected Waste Concentrate	2	SC-SWC-1 and SC-SWC-2	0	NA
Suspected Waste Concentrate (2018)	1	SC-SWC-3	1	SC-SWC-3MS (dup of SC-SWC-3)
Tailings	1	SC-T-3	0	NA
Tailings (2018)	2	SC-T-4 and SC-T-5	1	SC-T5-D (dup of SC-T-5)
Building Area (2018)	7	SC-SS-1 through SC-SS-7	0	NA
Hull Canyon Wash				
Sediment/Soil	4	SC-HCW-S-1 through SC-HCW-S-4	1	SC-HCW-S-5 (dup of SC-HCW-S-4)
Surface Water	13	HCW-1-W*, HCW-2-W, HCW-3-W* and HCW-4-W*	1	SC-HCW-5-Filter/Unfilt (dup of SC-HCW-4-Filter/Unfilt)

* Multiple rounds of data

Table H-2
Summary of Background Concentrations

Analyte	CAS Number	Number of Samples	Number of Detections	Minimum Background Concentration (mg/kg)	Maximum Background Concentration (mg/kg)	Mean Background Concentration (mg/kg)	Standard Deviation (mg/kg)	95% UCL Background Concentration (mg/kg)
Antimony	7440-36-0	11	0	<4.9	<5.0	NA	NA	<5.0
Arsenic	7440-38-2	11	11	5	36	21.09	9.71	24.71
Barium	7440-39-3	11	11	33	180	96.45	46.96	111.3
Beryllium	7440-41-7	11	7	0.56	0.84	0.625	0.129	0.695
Cadmium	7440-43-9	11	9	0.86	6.5	2.71	4.773	3.518
Chromium	7440-47-3	11	11	2.4	14	9.509	3.065	11.21
Copper	7440-50-8	11	11	25	590	264.6	218.9	348.5
Lead	7439-92-1	11	10	5.3	94	44.68	34.27	59.43
Manganese	7439-96-5	11	11	88	2,800	817.1	947.6	1,036
Mercury	7439-97-6	11	5	0.11	0.28	0.131	0.0651	0.159
Nickel	7440-02-0	11	10	4.9	9.4	7.23	2.185	8.35
Selenium	7782-49-2	11	7	5.2	9.3	6.391	1.519	7.23
Silver	7440-22-4	11	0	<2.4	<2.5	NA	NA	<2.5
Thallium	7440-28-0	11	0	<4.8	<5.0	NA	NA	<5.0
Zinc	7440-66-6	11	11	47	320	152	89.83	178.3

Notes:
Values preceded by "<" indicate a non-detect result - the result presented is the method reporting limit.
Background datasets (inputs), descriptive statistics and UCLs generated by EPA ProUCL v5.1 are presented in Appendix D of the SCR.

For analytes with less than 100 percent detection, the Kaplan-Meier (KM) mean and KM standard deviation is shown, which consider detected and non-detected concentrations.

CAS = Chemical Abstract Service
mg/kg = milligrams per kilogram
UCL = upper confidence limit (on the arithmetic mean)
NA = not applicable

Table H-3
Rationale for the Selection of Representative Species and Exposure Pathways

Community or Receptor Guild[1]	Key Species Noted in Field Surveys or Expected to be Found in the Area	Exposure Media	Pathway Evaluated? [2]	Rationale [3]	Representative Species
Hull Canyon Wash					
Aquatic Community	None. Dry ephemeral Wash most of the year	Surface water	No	As the Hull canyon wash is ephemeral, an established aquatic community is not present or expected.	None
Terrestrial Biota	Terrestrial biota (plants, invertebrates and wildlife) that are present or occasionally visit the Wash area, particularly when there is water present in this ephemeral water feature.	Surface water	Yes	Concentrations of metals in surface water intermittently present in the wash were compared to A&We (aqueous and wildlife, ephemeral) acute standards (AAC, 2009).	Terrestrial biota
Terrestrial Habitat					
Terrestrial Plant Community	Expected species include Ponderosa pine (*Pinus ponderosa*), shrub live oak (*Quercus turbinella*), birchleaf mountain mahogany (*Cercocarpus betuloides*), skunkbush sumac (*Rhus trilobata*), silktassels (*Garrya wrightii*), and desert ceanothus (*Ceanothus greggii*).	Soil	Yes	Exposure Area 1 is located on steep terrain and is dominated by rocky/gravel substrate with very little vegetation present, with only small pockets of weedy vegetation present in waste rock and low grade ore areas. The tailings areas are situated on low sloping/flat terrain amidst scrub-shrub communities. Exposure Area 2 in association with the former building footprint is disturbed and dominated by sparse coverage of stress-tolerant, opportunistic weeds and grasses. Scrub-shrub communities dominate that area beyond former building footprint. Hull Canyon Wash bed consists of sparsely distributed grasses with some low shrubs. The riparian corridor is dominated by scrub-shrub with some larger tress present. The terrestrial plant community evaluation consist of a weight of evidence assessment considering uptake/exposure from upland soil in these areas. Although vegetation is sparse in association with Exposure Area 1, this area is conservatively retained for evaluation.	Terrestrial Plant Community [4]
Terrestrial Invertebrate Community	Expected invertebrates include ants, grasshoppers, beetles, flies, bees, wasps, butterflies, moths, spiders etc. Earthworms may be present although soil conditions (waste rock, limited moisture) may prohibit their survival at least in surface soil.	Soil	Yes	As described for terrestrial plants, some areas of the site have limited or absent vegetative cover and therefore resources for invertebrates (humic matter, vegetation) may be limited in some areas. Nonetheless, soil invertebrates are likely generally present in upland soils and may represent a food source for higher trophic level animals. This community was evaluated qualitatively.	Terrestrial Invertebrate Community [4]
Terrestrial Omnivorous/ Insectivorous Birds and Mammals	Expected to be present but not observed: horned lark (*Eremophila alpestris*), lark sparrow (*Chondestes grammacus*), sagebrush sparrow (*Artemisiospiza nevadensis*), dark-eyed junco (*Junco hyemalis*), rock wren (*Salpinctes obsoletus*), canyon wren (*Catherpes mexicanus*), western bluebird (*Sialia mexicana*), Gambel's quail (*Callipepla gambelii*).	Soil, Biota, Surface Water	Yes	The horned lark serves as a surrogate for other omnivorous/insectivorous birds and mammals in the area. However, site use by insectivores is likely somewhat low due to limited forage opportunities in the more disturbed/waste rock sections of the site where food resources and vegetative cover are limited. Surface water ingestion from the Hull Canyon Wash was not considered as water presence is ephemeral and therefore not a significant water resource. The evaluation assumed food ingestion and incidental soil ingestion.	Horned Lark

Table H-3
Rationale for the Selection of Representative Species and Exposure Pathways

Community or Receptor Guild[1]	Key Species Noted in Field Surveys or Expected to be Found in the Area	Exposure Media	Pathway Evaluated? [2]	Rationale [3]	Representative Species
Terrestrial Herbivorous Mammals and Birds	Expected to be present but not observed: black-tailed jackrabbit (*Lepus californicus*), rock squirrel (*Spermaphilus variegatus*), white-tailed antelope squirrel (*Ammospermophilus leucurus*), Ord's Kangaroo rat (*Dipodomys ordii*), desert woodrat (*Neotoma lepida*), busy-tailed woodrat (*Neotoma cinerea*), black-tailed (mule) deer (*Odocoileus hemionus*), and desert cottontail (*Sylvilagus audubonii*).	Soil, Biota	Yes	The black-tailed jackrabbit is likely to be a common species in the area; however, site use is likely somewhat low due to limited forage opportunities in the more disturbed waste rock sections of the site. The black-tailed jackrabbit was selected to represent herbivorous mammals and birds as it is ubiquitous in the region and habitat is expected on site. Surface water ingestion from the Hull Canyon Wash was not considered as water presence is ephemeral and therefore not a significant water resource. The evaluation assumed food ingestion and incidental soil ingestion.	Black-tailed jackrabbit
Terrestrial Carnivorous Mammals and Birds	Expected to be present but not observed: coyote (*Canis latrans*) and bobcat (*Lynx rufus*).	Soil, Biota, Surface Water	Yes	A number of predators may live or hunt in the vicinity of site including the coyote. The coyote was selected to represent terrestrial carnivorous mammals and birds as it is likely found in the area. Surface water ingestion from the Hull Canyon Wash was not considered as water presence is ephemeral and therefore not a significant water resource. The evaluation assumed food ingestion and incidental soil ingestion.	Coyote

Notes:

[1] Guilds limited to those identified in preliminary desktop site survey for locally/regionally relevant wildlife.

[2] Refers to whether a given pathway is included for evaluation in the ERA.

[3] Rationale provided is based on narrative and observations criteria presented in personal communications with field staff and desktop review of site resources.

[4] A weight-of-evidence evaluation will be applied for these receptors using applicable criteria where available, available site data, and qualitative considerations (e.g., site observations) to assess potential risk.

Table H-4
Summary of Representative Species and Exposure Pathways

Media		Exposure Areas 1 and 2 [1]		Area Surface Water	
		Surface Soil		Surface Water	Sediment/Soil [2]
Representative Receptor	**Biota Ingestion**	**Uptake and Direct Contact [4]**	**Incidental Ingestion**	**Uptake and Direct Contact [4]**	**Uptake and Direct Contact [4]**
Aquatic Receptors [3]					
Terrestrial biota that occasionally use ephemeral water in the Wash				o	o
Terrestrial Receptors					
Terrestrial Plant Community		x [5]			x [5]
Terrestrial Invertebrate Community		x [5]			x [5]
Horned Lark	x	x	x		
Black-tailed Jackrabbit	x	x	x		
Coyote	x	x	x		

Notes:

[1] Exposure pathways are defined assuming the whole of the site is suitable ecological habitat.

[2] Surface water is ephemeral in the Hull Canyon wash. Ephemeral water is defined as "a surface water that has a channel that is at all times above the water table and flows only in direct response to precipitation" (AAC, 2009). Associated sediments are thus effectively considered soil.

[3] Aquatic and benthic communities are not present in the ephemeral Hull Canyon Wash.

[4] For the purposes of the ecological risk assessment, only "direct contact" with media is applicable to community level receptors. Wildlife receptors are assessed based on uptake via biota from applicable media, and incidental ingestion of soil as indicated.

[5] Evaluation of terrestrial communities is based on a comparison to generic screening levels coupled with a weight of evidence evaluation to assess potential risk.

x = Primary exposure route addressed quantitatively in the ecological risk assessment.
o = Primary exposure route addressed qualitatively in the ecological risk assessment.
Blank cells indicate that receptor is not evaluated for given exposure area/media.

Reference:

Arizona Administrative Code (AAC). 2009. Title 18, Environmental Quality. Chapter 11, Department of Environmental Quality – Water Quality Standards. January 31.

Table H-5
Assessment and Measurement Endpoints

Assessment Endpoint (What is being protected?)	Risk Questions	Representative Receptor	Assessment Measure (What is being measured to assess environmental effects?)	Measurement Endpoint (How are the measurements related to assessment?)
Terrestrial Biota that Use Surface Water from the Hull Canyon Wash	Are terrestrial biota that use water from the Wash subject to significant toxicity from surface water?	Terrestrial biota community	Comparison of surface water concentrations from the Hull Canyon Wash to A&We Acute Standards (AAC, 2009).	**Step 2 Screening Level Only** Comparison of MDC at each sample location to applicable screening levels protective of wildlife.
Terrestrial Plant Survival	Are terrestrial upland plants subject to significant toxicity from soil/sediment?	Upland Plant Species	Comparison of site soil/sediment concentrations to soil-based screening levels for plants	**Step 2 Screening Level** Comparison of MDC to screening levels. **Step 3A Refined Screening Level** Individual and central tendency (95UCL and/or arithmetic average) sample concentrations comparison to secondary screening levels combined with weight-of-evidence site-specific evaluation. Weight of evidence evaluation based on sample concentrations compared to soil screening benchmark and qualitative considerations (e.g., exposure, site observations).
Terrestrial Invertebrate Survival	Are soil invertebrates subject to significant toxicity from soil?	Upland Invertebrate Species	Comparison of site soil concentrations to soil screening levels for invertebrates	**Step 2 Screening Level** Comparison of MDC to screening levels. **Step 3A Refined Screening Level** Individual and central tendency (95UCL and/or arithmetic average) sample concentrations comparison to secondary screening levels combined with weight-of-evidence site-specific evaluation. Weight of evidence evaluation based on sample concentrations compared to soil screening benchmark and qualitative considerations (e.g., exposure, site observations).
Terrestrial Omnivorous/Insectivorous Wildlife Population Productivity	Is the productivity[1] of this guild preserved?	Secondary Consumers: Horned lark	Estimated toxicity from site soil and biota	**Step 2 Screening Level Assessment/Step 3A Refinement of COPEC** Acceptable[1] ingested dose based on appropriate Step 2/3A modeled uptake of COPEC from soil/sediment to receptor, biota to receptor, and on appropriate TRV and exposure point concentration.
Terrestrial Herbivorous Wildlife Population Productivity	Is the productivity[1] of this guild preserved?	Primary Consumers: Black-tailed jackrabbit	Estimated toxicity from site soil and biota	**Step 2 Screening Level Assessment/Step 3A Refinement of COPEC** Acceptable[1] ingested dose based on appropriate Step 2/3A modeled uptake of COPEC from soil/sediment to receptor, biota to receptor, and on appropriate TRV and exposure point concentration.
Terrestrial Carnivorous Wildlife Population Productivity	Is the productivity[1] of this guild preserved?	Tertiary Consumers: Coyote	Estimated toxicity from site soil and biota	**Step 2 Screening Level Assessment/Step 3A Refinement of COPEC** Acceptable[1] ingested dose based on appropriate Step 2/3A modeled uptake of COPEC from soil/sediment to receptor, biota to receptor, and on appropriate TRV and exposure point concentration.

Table H-5
Assessment and Measurement Endpoints

Assessment Endpoint (What is being protected?)	Risk Questions	Representative Receptor	Assessment Measure (What is being measured to assess environmental effects?)	Measurement Endpoint (How are the measurements related to assessment?)

Notes:
[1] In general, if less than a population-level EC20 is observed, the productivity is considered preserved if the EC20 is a chronic value that includes long-term exposure and sublethal effects (e.g., reproduction). Population-level endpoints are difficult to measure directly and are evaluated via surrogate values.

95UCL = 95 percent upper confidence limit (of the arithmetic mean).
COPEC = contaminant of potential ecological concern.
MDC = maximum detected concentration.
TRV = toxicity reference value

Table H-6
Screening Levels and Benchmarks

Analyte	CAS Number	Bioaccumulative Metals (BCC)	Soil Benchmark[a] (mg/kg)	Receptor/Basis	Source	A&We Acute Water Quality Standards (mg/L)	Source
Antimony	7440-36-0		0.27	Mammal/EcoSSL	EPA, 2005a	NA	AAC, 2009
Arsenic	7440-38-2	x	18	Plant/EcoSSL	EPA, 2005b	0.44 D	AAC, 2009
Barium	7440-39-3		330	Invertebrate/EcoSSL	EPA, 2005c	NA	AAC, 2009
Beryllium	7440-41-7		21	Mammal/EcoSSL	EPA, 2005d	NA	AAC, 2009
Cadmium	7440-43-9	x	0.36	Mammal/EcoSSL	EPA, 2005e	0.081 H	AAC, 2009
Chromium[b]	7440-47-3		26	Bird/EcoSSL	EPA, 2008	5.58 H	AAC, 2009
Copper	7440-50-8	x	28	Bird/EcoSSL	EPA, 2007b	0.08 H	AAC, 2009
Lead	7439-92-1	x	11	Bird/EcoSSL	EPA, 2005f	0.547 H	AAC, 2009
Manganese	7439-96-5		220	Plant/EcoSSL	EPA, 2007c	NA	AAC, 2009
Mercury	7439-97-6	x	0.3	Plant/LOEC	Efroymson et al., 1997a	0.005 D	AAC, 2009
Nickel	7440-02-0	x	38	Plant/EcoSSL	EPA, 2007d	12.578 H	AAC, 2009
Selenium	7782-49-2	x	0.52	Plant/EcoSSL	EPA, 2007e	0.033 T	AAC, 2009
Silver	7440-22-4	x	4.2	Bird/EcoSSL	EPA, 2006	0.031 H	AAC, 2009
Thallium	7440-28-0		1	Plant/LOEC	Efroymson et al., 1997a	NA	AAC, 2009
Zinc	7440-66-6	x	46	Mammal/EcoSSL	EPA, 2007f	3.369 H	AAC, 2009

Notes:

[a] Hierarchy for selection of terrestrial screening benchmarks for soil:
-Lowest EcoSSL for terrestrial plants, invertebrates, birds, or mammals (EPA, 2005a,b,c,d,e,f, 2006, 2007a,b,c,d,e,f, 2008)
-LOEC (lowest observed effect concentration) values for terrestrial plants from Efroymson et al. (1997a)

[b] For total chromium, the more conservative value between Chromium III and Chromium VI was selected.

[c] State of Arizona Acute Water Quality Standards (AAC, 2009).

Bioaccumulative chemicals of concern (BCC) are also considered in the screening process (USEPA, 2000)
D = dissolved

EcoSSL = ecological soil screening level

EPA = Environmental Protection Agency

H = hardness dependent; adjusted screening level based on site-specific hardness of 370 mg/L as Calcium Carbonate.

LOEC = lowest observed effect concentration
mg/kg = milligrams per kilogram

mg/L = milligrams per liter

NA= not available

T = total

References:

Arizona Administrative Code (AAC). 2009. Title 18, Environmental Quality. Chapter 11, Department of Environmental Quality – Water Quality Standards. January 31.

Efroymson, R, M. Will, G. Suter II, and A. Wooten. 1997. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. ES/ER/TM-85/R3.
http://www.esd.ornl.gov/programs/ecorisk/benchmark_reports.html

United States Environmental Protection Agency (EPA), (2005). Guidance for Developing Ecological Soil Screening Levels. Office of Emergency and Remedial Response. Washington D.C. November 2003, Revised February 2005. Specific Interim Finals:

EPA. 2005. Ecological Soil Screening Levels for Arsenic Interim Final, OSWER Directive 9285.7-62. March.
EPA. 2005. Ecological Soil Screening Levels for Cadmium Interim Final, OSWER Directive 9285.7-65. March.
EPA. 2007. Ecological Soil Screening Levels for Copper Interim Final, OSWER Directive 9285.7-68. Revised February.
EPA. 2005. Ecological Soil Screening Levels for Lead Interim Final, OSWER Directive 9285.7-70. March.
EPA. 2007. Ecological Soil Screening Levels for Manganese Interim Final, OSWER Directive 9285.7-71. April.
EPA. 2007. Ecological Soil Screening Levels for Nickel Interim Final, OSWER Directive 9285.7-76. March.
EPA. 2007. Ecological Soil Screening Levels for Selenium Interim Final, OSWER Directive 9285.7-72. July.
EPA. 2006. Ecological Soil Screening Levels for Silver Interim Final, OSWER Directive 9285.7-77. September.
EPA. 2007. Ecological Soil Screening Levels for Zinc Interim Final, OSWER Directive 9285.7-73. June.

Table H-7
Chemicals of Potential Ecological Concern (COPECs) in Surface Soil

Analyte	CAS Number	Soil Screening Level or Benchmark (mg/kg)	Exposure Area 1		Exposure Area 2	
			MDC (mg/kg)	COPEC	MDC (mg/kg)	COPEC
Soil (0- 4 inches bgs)						
Antimony	7440-36-0	0.27	7.2	x	42	x
Arsenic	7440-38-2	18	250	x	450	x
Barium	7440-39-3	330	64	--	290	--
Beryllium	7440-41-7	21	<0.5	--	<0.5	--
Cadmium	7440-43-9	0.36	6.8	x	65	x
Chromium	7440-47-3	26	14	--	31	x
Copper	7440-50-8	28	22,000	x	24,000	x
Lead	7439-92-1	11	140	x	1,200	x
Manganese	7439-96-5	220	2,400	x	700	x
Mercury	7439-97-6	0.3	2.7	x	14	x
Nickel	7440-02-0	38	14	BCC	22	BCC
Selenium	7782-49-2	0.52	77	x	59	x
Silver	7440-22-4	4.2	20	x	14	x
Thallium	7440-28-0	1	<5	--	<5	--
Zinc	7440-66-6	46	1,800	x	15,000	x

Notes:
BCC = bioaccumulative chemical compound. Retained as a COPEC on the basis: COPEC - Detected and BCC.
bgs = below ground surface
COPEC = contaminant of potential ecological concern
MDC = maximum detected concentration
mg/kg = milligram per kilogram
SL = screening level or benchmark
x= COPEC - MDC>SL
-- = Not a COPEC

References:

Efroymson, R, M. Will, G. Suter II, and A. Wooten. 1997. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. ES/ER/TM-85/R3.
http://www.esd.ornl.gov/programs/ecorisk/benchmark_reports.html

United States Environmental Protection Agency (EPA), (2005). Guidance for Developing Ecological Soil Screening Levels. Office of Emergency and Remedial Response. Washington D.C. November 2003, Revised February 2005. Specific Interim Finals:

EPA. 2005. Ecological Soil Screening Levels for Arsenic Interim Final, OSWER Directive 9285.7-62. March.
EPA. 2005. Ecological Soil Screening Levels for Cadmium Interim Final, OSWER Directive 9285.7-65. March.
EPA. 2007. Ecological Soil Screening Levels for Copper Interim Final, OSWER Directive 9285.7-68. Revised February.
EPA. 2005. Ecological Soil Screening Levels for Lead Interim Final, OSWER Directive 9285.7-70. March.
EPA. 2007. Ecological Soil Screening Levels for Manganese Interim Final, OSWER Directive 9285.7-71. April.
EPA. 2007. Ecological Soil Screening Levels for Nickel Interim Final, OSWER Directive 9285.7-76. March.
EPA. 2007. Ecological Soil Screening Levels for Selenium Interim Final, OSWER Directive 9285.7-72. July.
EPA. 2006. Ecological Soil Screening Levels for Silver Interim Final, OSWER Directive 9285.7-77. September.
EPA. 2007. Ecological Soil Screening Levels for Zinc Interim Final, OSWER Directive 9285.7-73. June.

Table H-8
Chemical-Specific Uptake Factors

Analyte	CAS	Soil/Sediment-to-Plant (mg/kg tissue dwt)/(mg/kg soil/sed dwt)			Soil-to-Soil Invertebrate (mg/kg tissue dwt)/(mg/kg soil dwt)			Soil-to-Small Mammal (mg/kg tissue dwt)/(mg/kg soil/sed dwt)		
		BAFplant[1]	90th Percentile[1] BAFplant	Comment/ Reference	BAFinv[1]	90th Percentile[1] BAFinv.	Comment/ Reference	BAFmam	90th Percentile[1] BAFmam.	Comment/ Reference
Inorganics (6010B/6020)										
Antimony	7440-36-0	ln(Cp)=0.938*Ln(Cs)-3.233	NA	USEPA (2007)	[invert] = [soil], or 1	NA	USEPA (2007)	Cm=0.001*50*Cd	NA	USEPA (2007)
Arsenic	7440-38-2	0.038	1.103	Bechtel-Jacobs (1998)	ln(Ce)= -1.421 + 0.706 ln(Cs)	NA	USEPA (2007)	ln(Cm)=0.8188*Ln(Cs)-4.8471	NA	Sample et al. (1998)
Cadmium	7440-43-9	ln(Cp)=0.546*Ln(Cs)-0.475	NA	Bechtel-Jacobs (1998)	ln(Ce)= 2.114 + 0.795 ln(Cs)	NA	USEPA (2007)	ln(Cm)=0.4723*Ln(Cs)-1.2571	NA	Sample et al. (1998)
Chromium, total	7440-47-3	0.041	0.0829	Bechtel-Jacobs (1998)	0.31	3.16	USEPA (2007)	ln(Cm)=0.7338*Ln(Cs)-1.4599	NA	Sample et al. (1998)
Copper	7440-50-8	ln(Cp)=0.394*Ln(Cs)+0.668	NA	Bechtel-Jacobs (1998)	0.515	1.53	USEPA (2007)	ln(Cm)=0.1444*Ln(Cs)+2.042	NA	Sample et al. (1998)
Lead	7439-92-1	ln(Cp)=0.561*Ln(Cs)-1.328	NA	Bechtel-Jacobs (1998)	ln(Ce)= -0.218 + 0.807 ln(Cs)	NA	USEPA (2007)	ln(Cm)=0.4422*Ln(Cs)+0.0761	NA	Sample et al. (1998)
Manganese	7439-96-5	0.079	0.234	Bechtel-Jacobs (1998)	ln(Ce)= -0.809 + 0.682 ln(Cs)	NA	USEPA (2007)	0.0205	0.06	Sample et al. (1998)
Mercury (method 7471A/7470A)	7439-97-6	ln(Cp)=0.544*Ln(Cs)-0.996	NA	Bechtel-Jacobs (1998)	ln(Ce)= -0.684 + 0.118 ln(Cs)	NA	Sample et al. (1999)	0.0543	0.19	Sample et al. (1998)
Nickel	7440-02-0	ln(Cp)=0.784*Ln(Cs)-2.223	NA	Bechtel-Jacobs (1998)	1	NA	Default= mean of metals	ln(Cm)=0.4658*Ln(Cs)-0.2462	NA	Sample et al. (1998)
Selenium	7782-49-2	ln(Cp)=1.104*Ln(Cs)-0.677	NA	Bechtel-Jacobs (1998)	ln(Ce)= -0.075 + 0.733 ln(Cs)	NA	USEPA (2007)	ln(Cm)=0.3764*Ln(Cs)-0.4158	NA	Sample et al. (1998)
Silver	7440-22-4	0.014	0.0367	Bechtel-Jacobs (1998)	2.045	15.34	USEPA (2007)	0.004	0.50	Sample et al. (1998)
Zinc	7440-66-6	ln(Cp)=0.554*Ln(Cs)+1.575	NA	Bechtel-Jacobs (1998)	ln(Ce)= 4.449 + 0.328 ln(Cs)	NA	USEPA (2007)	ln(Cm)=0.0706*Ln(Cs)+4.3632	NA	Sample et al. (1998)

Notes:

[1]The central tendency value is represented by the median, unless otherwise noted. The median value is used for Step 3A (refinement of COPEC) and 90th percentile values, where available, are used for the Step 2 screening level assessment.

NA = value not available

dwt = dry weight basis

References:

Bechtel-Jacobs Company LLC., 1998a. *Empirical Models for the Uptake of Inorganic Chemicals by Plants.* Bechtel-Jacobs Company LLC, Oak Ridge, Tennessee. BJC/OR-133. Bechtel-Jacobs Company LLC.

Sample, B.E., Beauchamp, J.J., Efroymson, R.A., Suter II, G.W., 1999. "Literature-derived Bioaccumulation Models for Earthworms: Development and Validation." *Environmental Toxicology and Chemistry* , vol. 18: 2110-2120.

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USEPA, 2007. *Ecological Soil Screening Level Guidance. Attachment 4-1 Exposure Factors and Bioaccumulation Models for Derivation of Wildlife Eco-SSLs.* Washington D.C.: Office of Emergency and Remedial Response. Revised: April, 2007.

Table H-9
Life History Parameters for Representative Wildlife Receptors

Receptor	Exposure Factors: Body Weight: Mean (kg)	Body Weight: Notes	Body Weight: Reference	Ingestion Rate Food (Dry Weight): Mean (kg/kgbw-d)	Ingestion Rate: Notes	Ingestion Rate: Reference	Feeding Habits and Foraging Range: Biotic Dietary Items (fraction of diet): Terrestrial Plants	Biotic Dietary Items: Soil Invertebrates	Biotic Dietary Items: Mammals	Biotic Dietary Items: Notes	Biotic Dietary Items: Major Food Items	Biotic Dietary Items: Reference	Abiotic Media Ingestion (fraction of diet): Soil	Abiotic Media Ingestion: Sediment	Abiotic Media Ingestion: Notes	Abiotic Media Ingestion: Reference	Foraging Range: Range (Hectares)	Foraging Range: Notes	Foraging Range: Reference	Area Use Factor: AUF Exposure Area 1	AUF Exposure Area 2	SUF (unitless)	Final AUF Exposure Area 1	Final AUF Exposure Area 2	Notes
Bird Receptors																									
Horned lark	0.030	mean body weight of male and female adult horned larks	Beason, 1995	0.21	allometric estimation for 'omnivorous birds' normalized to body weight	Nagy, 2001	0.1	0.9	--	average for year (four seasons) for western United States	diet includes insects and possibly worms in spring/summer, higher percentage of seeds in fall/winter	Beason, 1995	0.029	--	assumes similar soil intake as American robin, where 20% of invertebrate intake from earthworms	Whitford, 2009	0.28	Average home range in Colorado short grass prairie	Dinkins et al., 2003	1	1	1	1.00	1.00	Exposure Area 1 (6.37 acres or 2.58 hectares) and Exposure Area 2 (2.07 acres or 0.84 hectares) exceeds home range - AUF=1. SUF assumes site use 12 months of the year with no local/ regional migration to other areas.
Mammalian Receptors																									
Black-tailed Jackrabbit	2.3	mean of males and females in Montana	Montana Field Guide, 2018	0.048	allometric estimation for 'herbivorous mammals' normalized to body weight	Nagy, 2001	1	--	--	--	grasses and forbs in spring and summer, and buds, bark, and leaves of woody plants in fall and winter	Montana Field Guide, 2018	0.020	--	assumed comparable to white-footed mouse	adapted from Beyer et al., 1994	16	range in Idaho	Montana Field Guide, 2018	0.161	0.053	1	0.16	0.05	Exposure Area 1 (6.37 acres or 2.58 hectares) and Exposure Area 2 (2.07 acres or 0.84 hectares) are both less than home range. SUF assumes site use 12 months of the year with no local/ regional migration to other areas.
Coyote	12	females from Minnesota Windberg et al. 1997	Windberg et al., 1997; Berg and Chesness, 1978	0.032	allometric estimation for 'carnivorous mammals' normalized to body weight	Nagy, 2001	0.025	0.025	0.95	estimated from two studies in California; intake from birds combined with mammals for purposes of risk estimation	rodents, mammals, birds, fruit, and plant material	Cypher et al. 1996; in Cal/EPA Web site 2007	0.028	--	assumed comparable to red fox	adapted from Beyer et al., 1994	1570	average range for male and female in Arizona	Bounds et al., 1997 in Cal/EPA Web site 2007	0.00164	0.0005	1	0.0016	0.0005	Exposure Area 1 (6.37 acres or 2.58 hectares) and Exposure Area 2 (2.07 acres or 0.84 hectares) are both less than home range. SUF assumes site use 12 months of the year with no local/ regional migration to other areas.

Notes:
The seasonal use factor (SUF) considers local and/or regional seasonal migration by receptors.
The Final AUF is the mathematical product of the AUF and SUF. If AUF, SUF or Final AUF > 1 then set equal to 1 (i.e., 100 % site use)
-- = not applicable

References:

Beason, Robert C. 1995. Horned Lark (*Eremophila alpestris*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/195
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Table H-10
Exposure Point Concentrations (EPCs) for Exposure Areas 1 and 2

COPEC	CAS No.	Exposure Area 1			Exposure Area 2		
		Step 2 MDC	Step 3A EPC	Step 3A EPC Basis	Step 2 MDC	Step 3A EPC	Step 3A EPC Basis
Surface Soil (mg/kg) - 0 to 4 inches bgs							
Antimony	7440-36-0	7.2	5.34	95% UCL	42	23.42	95% UCL
Arsenic	7440-38-2	250	143.2	95% UCL	450	315	95% UCL
Cadmium	7440-43-9	6.8	1.8	95% UCL	65	26.11	95% UCL
Chromium	7440-47-3	--	--	--	31	15.18	95% UCL
Copper	7440-50-8	22,000	5,077	95% UCL	24,000	11,689	95% UCL
Lead	7439-92-1	140	50.63	95% UCL	1,200	514.8	95% UCL
Manganese	7439-96-5	2,400	842.2	95% UCL	700	371.6	95% UCL
Mercury	7439-97-6	2.7	1.34	95% UCL	14	7.77	95% UCL
Nickel	7440-02-0	14	4.52	95% UCL	22	11.66	95% UCL
Selenium	7782-49-2	77	40.33	95% UCL	59	43.69	95% UCL
Silver	7440-22-4	20	7.84	95% UCL	14	8.93	95% UCL
Zinc	7440-66-6	1,800	416.6	95% UCL	15,000	5,882	95% UCL

Notes:
-- = Not a chemical of potential ecological concern for a given exposure area
bgs = below ground surface
COPEC = contaminant of potential ecological concern
MDC = maximum detected concentration
EPC = exposure point concentration. Represented as the 95% upper confidence level of the arithmetic mean (95% UCL).
mg/kg = milligram per kilogram
UCL = upper confidence limit

Table H-11
Toxicity Reference Values for Avian Receptors

Analyte	CAS No.	Toxicologic Endpoint	Endpoint Basis	Secondary Endpoint Basis	Test Species	Dose[1] (mg/kg-BW/d)	Eco-SSL TRV Basis - NOAEL	Secondary Dose[1] (mg/kg-BW/d)	Eco-SSL TRV Basis - LOAEL	UF[2]		TRV_{NOAEL}[2] (mg/kg-BW/d)	TRV_{LOAEL}[3] (mg/kg-BW/d)	Comments and Source[5]
Antimony	7440-36-0	NA	NA		NA	NA		NA		NA		NA	NA	
Arsenic	7440-38-2	Reproduction and Growth	C NOAEL	C LOAEL	na-use direct[4]	2.24	Lowest (Unbounded) NOAEL	4.5	geometric mean of LOAELs (n=3, growth endpoint)	1	1	2.24	4.5	USEPA (2005b)
Cadmium	7440-43-9	Reproduction and Growth	C NOAEL	C LOAEL	na-use direct[4]	1.47	geometric mean	2.4	Lowest bounded LOAEL above Eco-SSL NOAEL	1	1	1.47	2.4	USEPA (2005c); BAH (2012)
Chromium[6]	7440-47-3	Reproduction and Growth	C NOAEL	C LOAEL	na-use direct[4]	2.66	geometric mean	5.0	Lowest LOAEL above Eco-SSL NOAEL	1	1	2.66	5.0	USEPA (2008). Note that the lowest LOAEL value reported in USEPA 2008 (2.78 mg/kg-d) was based on an undefined intake rate. The body weight and food intake as reported in Sample et al, 1996 was applied to derive a LOAEL of 5.0 mg/kg-d.
Copper	7440-50-8	Reproduction and Growth	C NOAEL	C LOAEL	na-use direct[4]	4.05	highest NOAEL value lower than the lowest bound LOAEL	12.1	Bounded LOAEL value from NOAEL study (and lower than the geometric mean of LOAELs (36.3 mg/kd/day); lowest LOAEL for reproduction endpoint	1	1	4.05	12.1	USEPA (2007b)
Lead	7439-92-1	Reproduction, Growth, Survival	C NOAEL	C LOAEL	na-use direct[4]	1.63	highest bounded NOAEL below the lowest bounded LOAEL	3.26	Bounded to NOAEL	1	1	1.63	3.26	USEPA (2005d); BAH (2012)
Manganese	7439-96-5	Reproduction, Growth, Survival	C NOAEL	C LOAEL	na-use direct[4]	179	geometric mean	376.6	geometric mean of LOAELs (n=3, growth endpoint)	1	1	179	376.6	USEPA (2007c)
Mercury (7470A)	7439-97-6	Reproduction	C NOAEL	C LOAEL	Japanese quail	0.45		0.9		1	1	0.45	0.9	Sample et al. (1996)
Nickel	7440-02-0	Reproduction, Growth, Survival	C NOAEL	C LOAEL	na-use direct[4]	6.71	geometric mean	18.6	geometric mean of LOAELs (for growth and reproduction endpoints, and below survival endpoints)	1	1	6.71	18.6	USEPA (2007d)
Selenium	7782-49-2	Reproduction, Growth, Survival	C NOAEL	C LOAEL	na-use direct[4]	0.29	highest NOAEL value lower than the lowest bounded LOAEL	0.37	Lowest Bounded LOAEL above Eco-SSL NOAEL	1	1	0.29	0.37	USEPA (2007e)
Silver	7440-22-4	Reproduction, Growth, Survival	C NOAEL	C LOAEL	na-use direct[4]	2.02	Lowest LOAEL divided by 10	20.2	Lowest LOAEL above Eco-SSL NOAEL	1	1	2.02	20.2	USEPA (2006). Selected LOAEL is the paired LOAEL from study on which NOAEL is based.
Zinc	7440-66-6	Reproduction, Growth, Survival	C NOAEL	C LOAEL	na-use direct[4]	66.1	geometric mean	79.3	Lowest bounded LOAEL above Eco-SSL NOAEL	1	1	66.1	79.3	USEPA (2007f)

Notes:

[1] Dose values are the reported dose (converted to mg/kg-day, as appropriate) as cited in the listed source without the application of any uncertainty factor(s). Secondary dose refers to the corresponding LOAEL-based value observed in the same study.

[2] An uncertainty factor (UF) was used to extrapolate exposure duration and toxicologic endpoint to a chronic NOAEL-based TRV value. This was accomplished by dividing the reported dose by the recommended uncertainty factor.
A second UF, if present, was applied to the secondary dose.

[3] For analytes without a study-derived LOAEL, no extrapolation/adjustment was done to estimate a LOAEL from a given NOAEL due to the added level of uncertainty. For these compounds, the NOAEL will be used in both Step 2 and Step 3 analyses.

[4] Multiple species were used in development of the TRV. Toxicologic or intertaxon extrapolation not applicable.

[5] The source refers to the document (or internet site, as appropriate) from which the endpoint and dose were cited. For complete references refer to the listed source.

[6] Values presented are for total chromium

LOAEL - Lowest Observed Adverse Effects Level
NA - Not Applicable or No Data Available
NOAEL - No Observed Adverse Effects Level
TRV - toxicity reference value
Note that the NOEL endpoint is assumed equivalent to the NOAEL, where indicated.
The toxicity values presented are consistent with the general approach presented in Eco-SSL guidance (USEPA, 2007a). All values, receptors, and COPECs are interim.
TRVs for the full COPC list and all applicable receptors will be presented at the time of the risk assessment.
For toxicological endpoint basis: C = chronic, SC = subchronic, A = acute

Table H-11
Toxicity Reference Values for Avian Receptors

References:

BAH 2012. Derivation of Mammalian and Avian Dose-Based Toxicity Reference Values and Soil Screening Levels for Selected Chemicals. Prepared by Booz/Allen/Hamilton for U.S EPA, Region 8. December

Sample, B.E., Opresko, D.M., and Suter II, G.W. 1996. Toxicological Benchmarks for Wildlife: 1996 Revision. ES/ER/TM-86/R3. Risk Assessment Program, Health Sciences Research Division, Oak Ridge National Laboratory.

USEPA. 1997. EPA Region 10 Supplemental Ecological Risk Assessment Guidance for Superfund. June 1997

USEPA. 1999. *Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities (Volume Three)* . EPA 530-D-99-001A. Washington D.C.: United States Environmental Protection Agency, Office of Solid Waste, August 1999.

USEPA 2005a. Guidance for Developing Ecological Soil Screening Levels. Office of Emergency and Remedial Response. Washington D.C. November 2003, Revised February 2005.

USEPA. 2005b. Ecological Soil Screening Levels for Arsenic Interim Final, OSWER Directive 9285.7-62. U.S. Environmental Protection Agency Office of Solid Waste and Emergency Response. March 2005

USEPA. 2005c. Ecological Soil Screening Levels for Cadmium Interim Final, OSWER Directive 9285.7-65. U.S. Environmental Protection Agency Office of Solid Waste and Emergency Response. March 2005

USEPA. 2005d. Ecological Soil Screening Levels for Lead Interim Final, OSWER Directive 9285.7-70. U.S. Environmental Protection Agency Office of Solid Waste and Emergency Response. March 2005.

USEPA. 2006. Ecological Soil Screening Levels for Silver Interim Final, OSWER Directive 99285.7-77. U.S. Environmental Protection Agency Office of Solid Waste and Emergency Response. September 2006

USEPA. 2007a. Guidance for Developing Ecological Soil Screening Levels. OSWER Directive 9285.7-55. Office of Emergency and Remedial Response. Washington D.C. Revised April 2007.

USEPA 2007b. Ecological Soil Screening Levels for Copper Interim Final, OSWER Directive 9285.7-68. U.S. Environmental Protection Agency Office of Solid Waste and Emergency Response. Issued July 2006, Revised February 2007.

USEPA. 2007c. Ecological Soil Screening Levels for Manganese Interim Final, OSWER Directive 9285.7-71. U.S. Environmental Protection Agency Office of Solid Waste and Emergency Response. April 2007

USEPA 2007d. Ecological Soil Screening Levels for Nickel Interim Final, OSWER Directive 9285.7-76. U.S. Environmental Protection Agency Office of Solid Waste and Emergency Response. March 2007

USEPA. 2007e. Ecological Soil Screening Levels for Selenium Interim Final, OSWER Directive 99285.7-72. U.S. Environmental Protection Agency Office of Solid Waste and Emergency Response. July 2007

USEPA 2007f. Ecological Soil Screening Levels for Zinc Interim Final, OSWER Directive 9285.7-73. U.S. Environmental Protection Agency Office of Solid Waste and Emergency Response. June 2007

USEPA. 2008. Ecological Soil Screening Levels for Chromium Interim Final, OSWER Directive 9285.7- 66. U.S. Environmental Protection Agency Office of Solid Waste and Emergency Response. April 2008

Table H-12
Toxicity Reference Values for Mammalian Receptors

Analyte	CAS No.	Toxicologic Endpoint	Endpoint Basis	Secondary Endpoint Basis	Test Species	Dose[1] (mg/kg-BW/d)	Eco-SSL TRV Basis - NOAEL	Secondary Dose[1] (mg/kg-BW/d)	Eco-SSL TRV Basis - LOAEL	UF[2]		TRV_{NOAEL}[2] (mg/kg-BW/d)	TRV_{LOAEL}[3] (mg/kg-BW/d)	Comments and Source[8]
Antimony	7440-36-0	Reproduction, Growth, Survival	C NOAEL	C LOAEL	na-use direct [4]	0.059	highest bounded NOAEL lower than the lowest bounded LOAEL	0.59	Bounded to NOAEL (lowest bounded LOAEL)	1	1	0.059	0.59	USEPA (2005b)
Arsenic	7440-38-2	Reproduction, Growth, Survival	C NOAEL	C LOAEL	na-use direct [4]	1.04	Bounded and below lowest (unbounded) LOAEL	1.66	Bounded to NOAEL (lowest bounded LOAEL)	1	1	1.04	1.66	USEPA (2005c)
Cadmium	7440-43-9	Reproduction, Growth, Survival	C NOAEL	C LOAEL	na-use direct [4]	0.77	Bounded and below lowest (unbounded) LOAEL	2.64	Lowest LOAEL	1	1	0.77	2.64	USEPA (2005d)
Chromium, total	7440-47-3	Reproduction, Growth, Survival	C NOAEL	C LOAEL	na-use direct [4]	2.4	geometric mean	9.6	Lowest LOAEL for reproduction or growth endpoint	1	1	2.4	9.6	USEPA (2008)
Copper	7440-50-8	Reproduction, Growth, Survival	C NOAEL	C LOAEL	na-use direct [4]	5.6	highest NOAEL lower than the lowest LOAEL	15.5	Bounded to NOAEL	1	1	5.6	15.5	USEPA (2007b)
Lead	7439-92-1	Reproduction, Growth, Survival	C NOAEL	C LOAEL	na-use direct [4]	4.7	highest bounded NOAEL below the lowest bounded LOAEL	8.9	Bounded to NOAEL	1	1	4.7	8.9	USEPA (2005e)
Manganese	7439-96-5	Reproduction, Growth, Survival	C NOAEL	C LOAEL	na-use direct [4]	51.5	geometric mean	71.0	Lowest LOAEL for reproduction endpoint	1	1	51.5	71	USEPA (2007c)
Mercury (7470A)	7439-97-6	Reproduction	C NOAEL	NA	mink	1.0		NA		1	NA	1.0	5.05	Sample et al. (1996)
Nickel	7440-02-0	Reproduction, Growth, Survival	C NOAEL	C LOAEL	na-use direct 4	1.7	highest bounded NOAEL below the lowest bounded LOAEL	3.4	Bounded to NOAEL	1	1	1.7	3.4	USEPA (2007d)
Selenium	7782-49-2	Reproduction, Growth, Survival	C NOAEL	C LOAEL	na-use direct [4]	0.143	highest NOAEL value lower than the lowest LOAEL	0.215	Bounded to NOAEL	1	1	0.143	0.215	USEPA (2007e), BAH (2012)
Silver	7440-22-4	Reproduction, Growth, Survival	C LOAEL	NA	na-use direct [4]	6.02	Lowest LOAEL divided by 10	60.2	Lowest LOAEL	1	1	6.02	60.2	USEPA 2006
Zinc	7440-66-6	Reproduction, Growth, Survival	C NOAEL	C LOAEL	na-use direct [4]	75.4	geometric mean	81.1	Lowest LOAEL for reproduction endpoint	1	1	75.4	81.1	USEPA (2007f)

Notes:

[1] Dose values are the reported dose (converted to mg/kg-day, as appropriate) as cited in the listed source without the application of any uncertainty factor(s). Secondary dose refers to the corresponding LOAEL-based value observed in the same study.

[2] An uncertainty factor (UF) was used to extrapolate exposure duration and toxicologic endpoint to a chronic NOAEL-based TRV value. This was accomplished by dividing the reported dose by the recommended uncertainty factor. A second UF, if present, was applied to the secondary dose.

[3] For analytes without a study-derived LOAEL, no extrapolation/adjustment was done to estimate a LOAEL from a given NOAEL due to the added level of uncertainty. For these compounds, the NOAEL will be used in both Step 2 and Step 3 analyses.

[4] Multiple species used in development of the TRV. Toxicologic/duration endpoint extrapolation not applicable.

[5] Dose cited on Integrated Risk Information System (IRIS) web site: (IRIS, 2005) http://www.epa.gov/iris/ September 20, 2005, 12:00 PM MDT.

[6] The source refers to the document (or internet site, as appropriate) from which the endpoint and dose were cited. For complete references refer to the listed source.

Note that the no observed effect level (NOEL) endpoint is assumed equivalent to the NOAEL, where indicated.
The toxicity values presented are consistent with the general approach presented in Eco-SSL guidance (USEPA, 2007a). All values, receptors, and COPECs are interim. TRVs for the full COPEC list and all applicable receptors will be presented at the time of the risk assessment.
LOAEL - Lowest Observed Adverse Effects Level
NA - Not Applicable or No Data Available
NOAEL - No Observed Adverse Effects Level
TRV - toxicity reference value
For toxicological endpoint basis: C = chronic, SC = subchronic, A = acute

Table H-12
Toxicity Reference Values for Mammalian Receptors

References:

BAH 2012. Derivation of Mammalian and Avian Dose-Based Toxicity Reference Values and Soil Screening Levels for Selected Chemicals. Prepared by Booz/Allen/Hamilton for U.S. EPA, Region 8. December

Sample, B.E., D.M. Opresko and G.W. Suter II, 1996. T*oxicological Benchmarks for Wildlife: 1996 Revision* . ES/ER/TM-86/R3. Risk Assessment Program, Health Sciences Research Division, Oak Ridge National Laboratory

USEPA 1997. EPA Region 10 Supplemental Ecological Risk Assessment Guidance for Superfund. June 1997

USEPA 1999. Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities (Volume Three). EPA 530-D-99-001A. Washington D.C.: United States Environmental Protection Agency, Office of Solid Waste. August 1999

USEPA 2005a. Guidance for Developing Ecological Soil Screening Levels. Office of Emergency and Remedial Response. Washington D.C. November 2003, Revised February 2005.

USEPA 2005b. Ecological Soil Screening Levels for Antimony Interim Final, OSWER Directive 9285.7-61. U.S. Environmental Protection Agency Office of Solid Waste and Emergency Response. February 2005

USEPA 2005c. Ecological Soil Screening Levels for Arsenic Interim Final, OSWER Directive 9285.7-62. U.S. Environmental Protection Agency Office of Solid Waste and Emergency Response. March 2005

USEPA 2005d. Ecological Soil Screening Levels for Cadmium Interim Final, OSWER Directive 9285.7-65. U.S. Environmental Protection Agency Office of Solid Waste and Emergency Response. March 2005

USEPA 2005e. Ecological Soil Screening Levels for Lead Interim Final, OSWER Directive 9285.7-70. U.S. Environmental Protection Agency Office of Solid Waste and Emergency Response. March 2005.

USEPA 2006. Ecological Soil Screening Levels for Silver Interim Final, OSWER Directive 99285.7-77. U.S. Environmental Protection Agency Office of Solid Waste and Emergency Response. September 2006

USEPA 2007a. Guidance for Developing Ecological Soil Screening Levels. OSWER Directive 9285.7-55. Office of Emergency and Remedial Response. Washington D.C. Revised April 2007.

USEPA 2007b. Ecological Soil Screening Levels for Copper Interim Final, OSWER Directive 9285.7-68. U.S. Environmental Protection Agency Office of Solid Waste and Emergency Response. Issued July 2006, Revised February 2007.

USEPA 2007c. Ecological Soil Screening Levels for Manganese Interim Final, OSWER Directive 9285.7-71. U.S. Environmental Protection Agency Office of Solid Waste and Emergency Response. April 2007

USEPA 2007d. Ecological Soil Screening Levels for Nickel Interim Final, OSWER Directive 9285.7-76. U.S. Environmental Protection Agency Office of Solid Waste and Emergency Response. March 2007

USEPA 2007e. Ecological Soil Screening Levels for Selenium Interim Final, OSWER Directive 99285.7-72. U.S. Environmental Protection Agency Office of Solid Waste and Emergency Response. July 2007

USEPA 2007f. Ecological Soil Screening Levels for Zinc Interim Final, OSWER Directive 9285.7-73. U.S. Environmental Protection Agency Office of Solid Waste and Emergency Response. June 2007

USEPA 2008. Ecological Soil Screening Levels for Chromium Interim Final, OSWER Directive 9285.7- 66. U.S. Environmental Protection Agency Office of Solid Waste and Emergency Response. April 2008

Table H-13
Screening Level Ecological Risk Assessment Assumptions

Parameter	Step 2 Screening Level Assessment[1]	Step 3A Refinement of ECOPC[1]
Exposure		
Area Use Factors	100 Percent	Species-specific, per site observations and estimates for future land use, as appropriate.
Bioavailability	100 Percent	Assumed 100 percent in the absence of quantitative data (lead only). Specific site and COPEC bioavailability data is discussed qualitatively.
Life History	Per Receptor Exposure Parameters	Per Receptor Exposure Parameters
Dietary Composition	100% of diet consists of most dominant food item[1]	Species-specific typical dietary composition, as listed in Receptor Exposure Parameters
Body Weight	Minimum of available data	Mean of available data
Intake Rate	Maximum measured or estimated value	Mean of measured or estimated value
Dietary BCF factors	Literature data, per Receptor Exposure Parameters. The 90th percentile (upper bound) value is used where available.	Literature data, the central tendency value is used.
Exposure Point Concentrations		
Media Concentration	Maximum Detected Concentration (MDC) for exposure area.	Central tendency value of exposure area concentrations (i.e., 95% upper confidence limit, UCL)
Exposure Depth Interval (soil)	0-0.33 feet (0-4 inches) below ground surface	0-0.33 feet (0-4 inches) below ground surface
Toxicity Values		
Toxicity Reference Value (TRV)	Chronic NOAEL	Chronic LOAEL (surrogate for EC20 population level effect)

Table H-13
Screening Level Ecological Risk Assessment Assumptions

Notes:

[1] Assumptions presented are based on the guidelines set forth in United States Environmental Protection Agency (USEPA) guidance (USEPA 1997 and 2001) and Department of Navy guidance (DON 1999 and 2003).

[2] Most dominant food item assumes 100% of diet composed of the dominant food item allowing for the bounding of risk for the feeding guild.

COPEC = chemical of potential ecological concern
EC20 = 20 percent effect concentration
LOAEL = lowest observable adverse effect level
NOAEL = no observable adverse effect level

References:

DON. 2003. Ecological Risk Assessment Process. http://web.ead.anl.gov/ecorisk/process/pdf/index.cfm. Last modified: 02/28/2003.

DON. 1999. Navy Policy for Conducting Ecological Risk Assessments. Letter from A. A. Granuzzo, Chief of Naval Operations, to Commander, Naval Facilities Engineering Command. Ser. N453E/9U595355.Access: http://web.ead.anl.gov/ecorisk/process/pdf/index.cfm. Washington. 5 April.

USEPA 1997. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments, Interim Final. Environmental Response Team, USEPA. Edison, NJ.

USEPA 2001. The Role of Screening-Level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments. ECO Update. Office of Solid Waste and Emergency Response, USEPA. EPA 540/F-01/014. June.

Table H-14
Terrestrial Vegetation Risk Evaluation

COPEC	CAS Number	Maximum Detected Concentration (mg/kg)	Plant Screening Benchmark (mg/kg)	Source	Step 2 Risk Possible?	Soil EPC (95%UCL)	LOAEL-Based Plant Screening Benchmark (mg/kg)	Source	95% UCL Background (mg/kg)	Is EPC > Benchmark and/or Background?	Step 3A HQ (unitless)	Proportion of Risk due to Background	Step 3A Risk Characterization. Is there potential ecological risk?
Exposure Area 1													
Antimony	7440-36-0	7.2	5	ORNL	YES	5.34	58	LANL	<5.0	NO	0.1	NA	No. EPC<SB
Arsenic	7440-38-2	250	18	EcoSSL	YES	143.2	91	LANL	24.7	YES	2	17%	Yes. EPC>SB and Background
Cadmium	7440-43-9	6.8	32	EcoSSL	NO	1.80	--	--	3.52	NO	--	--	No. MDC<SB
Copper	7440-50-8	22,000	70	EcoSSL	YES	5077	490	LANL	348.5	YES	10	7%	Yes. EPC>SB and Background
Lead	7439-92-1	140	120	EcoSSL	YES	50.63	570	LANL	59.43	NO	0.1	>100%	No. EPC<SB and Background
Manganese	7439-96-5	2,400	220	EcoSSL	YES	842.2	1100	LANL	1036	NO	0.8	>100%	No. EPC<SB and Background
Mercury	7439-97-6	2.7	0.3	ORNL	YES	1.34	64	LANL	0.16	NO	0.02	12%	No. EPC<SB
Nickel	7440-02-0	14	38	EcoSSL	NO	4.52	--	--	8.35	NO	--	--	No. MDC<SB
Selenium	7782-49-2	77	0.52	EcoSSL	YES	40.33	3	LANL	7.23	YES	13	18%	Yes. EPC>SB and Background
Silver	7440-22-4	20	560	EcoSSL	NO	7.84	--	--	<2.5	NO	--	--	No. MDC<SB
Zinc	7440-66-6	1,800	160	EcoSSL	YES	416.6	810	LANL	178.3	NO	0.5	43%	No. EPC<SB
Exposure Area 2													
Antimony	7440-36-0	42	5	ORNL	YES	23.4	58	LANL	<5.0	NO	0.4	NA	No. EPC<SB
Arsenic	7440-38-2	450	18	EcoSSL	YES	315	91	LANL	24.7	YES	3	8%	Yes. EPC>SB and Background
Cadmium	7440-43-9	65	32	EcoSSL	YES	26.11	160	LANL	3.52	NO	0.2	13%	No. EPC<SB
Chromium, total	7440-47-3	31	75	Alloway 1990	NO	15.2	--	--	11.21	NO	--	--	No. MDC<SB
Copper	7440-50-8	24000	70	EcoSSL	YES	11,689	490	LANL	348.5	YES	24	3%	Yes. EPC>SB and Background
Lead	7439-92-1	1200	120	EcoSSL	YES	514.8	570	LANL	59.43	NO	0.9	12%	No. EPC<SB
Manganese	7439-96-5	700	220	EcoSSL	YES	371.6	1100	LANL	1036	NO	0.3	>100%	No. EPC<SB and Background
Mercury	7439-97-6	14	0.3	ORNL	YES	7.77	64	LANL	0.16	NO	0.1	2%	No. EPC<SB
Nickel	7440-02-0	22	38	EcoSSL	NO	11.7	--	--	8.35	NO	--	--	No. MDC<SB
Selenium	7782-49-2	59	0.52	EcoSSL	YES	43.7	3	LANL	7.23	YES	6	17%	Yes. EPC>SB and Background
Silver	7440-22-4	14	560	EcoSSL	NO	8.9	--	--	<2.5	NO	--	--	No. MDC<SB
Zinc	7440-66-6	15000	160	EcoSSL	YES	5,882	810	LANL	178.3	YES	7	3%	Yes. EPC>SB and Background

Notes:
The analytes shown were identified as COPECs based on initial screening.
Shaded cells indicate a HQ>1.
-- = not applicable - no Step 2 exceedances
CAS = Chemical Abstract Service
COPEC = chemical of potential ecological concern
EcoSSL = Ecological Soil Screening Levels
EPC = exposure point concentration

Table H-14
Terrestrial Vegetation Risk Evaluation

HQ = hazard quotient
LANL = Los Alamos National Laboratory
MDC = maximum detected concentration. Used as EPC where insufficient samples for statistical analysis exist, or where the calculation was not needed.
NA = not applicable
mg/kg = milligrams per kilogram
ORNL = Oak Ridge National Laboratory
SB = screening benchmark
UCL = upper confidence limit of the mean

References:

Alloway, B.J. 1990. Heavy Metals in Soils. John Wiley and Sons, Inc. New York. ISBN 0470215984

Efroymson, R, M. Will, G. Suter II, and A. Wooten. 1997. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. ES/ER/TM-85/R3.
http://www.esd.ornl.gov/programs/ecorisk/benchmark_reports.html

Los Alamos National Laboratory (LANL). 2017. ECORISK Database Release 4.1. September. https://www.lanl.gov/environment/protection/eco-risk-assessment.php

United States Environmental Protection Agency (EPA), (2005). Guidance for Developing Ecological Soil Screening Levels. Office of Emergency and Remedial Response. Washington D.C. November 2003, Revised February 2005. Specific Interim Finals:

EPA. 2005. Ecological Soil Screening Levels for Arsenic Interim Final, OSWER Directive 9285.7-62. March.
EPA. 2005. Ecological Soil Screening Levels for Cadmium Interim Final, OSWER Directive 9285.7-65. March.
EPA. 2007. Ecological Soil Screening Levels for Copper Interim Final, OSWER Directive 9285.7-68. Revised February.
EPA. 2005. Ecological Soil Screening Levels for Lead Interim Final, OSWER Directive 9285.7-70. March.
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EPA. 2007. Ecological Soil Screening Levels for Nickel Interim Final, OSWER Directive 9285.7-76. March.
EPA. 2007. Ecological Soil Screening Levels for Selenium Interim Final, OSWER Directive 9285.7-72. July.
EPA. 2006. Ecological Soil Screening Levels for Silver Interim Final, OSWER Directive 9285.7-77. September.
EPA. 2007. Ecological Soil Screening Levels for Zinc Interim Final, OSWER Directive 9285.7-73. June.

Table H-15
Soil Invertebrates Risk Evaluation

COPEC	CAS Number	Maximum Detected Concentration (mg/kg)	Soil Invertebrate Screening Benchmark (mg/kg)	Source	Step 2 Risk Possible?	Soil EPC (95%UCL, mg/kg)	LOAEL-Based Invertebrate Screening Benchmark (mg/kg)	Source	95% UCL Background (mg/kg)	Is EPC > Benchmark and/or Background?	Step 3A HQ (unitless)	Proportion of Risk due to Background	Step 3A Risk Characterization. Is there potential ecological risk?
Exposure Area 1													
Antimony	7440-36-0	7.2	78	ORNL	NO	5.34	--	--	<5.0	NO	--	--	No. MDC < SB
Arsenic	7440-38-2	250	60	EcoSSL	YES	143.2	68	LANL	24.7	YES	2	17%	Yes. EPC>SB and Background
Cadmium	7440-43-9	6.8	140	EcoSSL	NO	1.80	--	--	3.52	NO	--	--	No. MDC < SB
Copper	7440-50-8	22,000	80	EcoSSL	YES	5077	530	LANL	348.5	YES	10	7%	Yes. EPC>SB and Background
Lead	7439-92-1	140	1700	EcoSSL	NO	50.63	--	--	59.43	NO	--	--	No. MDC < SB
Manganese	7439-96-5	2,400	450	EcoSSL	YES	842.2	4500	LANL	1036	NO	0.2	>100%	No. EPC<SB and Background
Mercury	7439-97-6	2.7	0.1	ORNL	YES	1.34	0.5	LANL	0.17	NO	3	12%	No. EPC<SB
Nickel	7440-02-0	14	280	EcoSSL	NO	4.52	--	--	10.19	NO	--	--	No. MDC < SB
Selenium	7782-49-2	77	4.1	EcoSSL	YES	40.33	41	LANL	7.23	YES	1	18%	No. EPC<SB
Silver	7440-22-4	20	NA	--	NA	7.84	NA	LANL	NA	--	--	--	SB and background not available
Zinc	7440-66-6	1,800	120	EcoSSL	YES	416.6	930	LANL	178.3	NO	0.4	43%	No. EPC<SB
Exposure Area 2													
Antimony	7440-36-0	42	78	ORNL	NO	23.4	--	--	<5.0	NO	--	--	No. MDC < SB
Arsenic	7440-38-2	450	60	EcoSSL	YES	315	68	LANL	24.7	YES	5	8%	Yes. EPC>SB and Background
Cadmium	7440-43-9	65	140	EcoSSL	NO	26.11	--	--	3.52	NO	--	--	No. MDC < SB
Chromium, total	7440-47-3	31	57	Alloway	NO	15.2	--	--	11.21	NO	--	--	No. MDC < SB
Copper	7440-50-8	24000	80	EcoSSL	YES	11,689	530	LANL	348.5	YES	22	3%	Yes. EPC>SB and Background
Lead	7439-92-1	1200	1700	EcoSSL	NO	514.8	--	--	59.43	NO	--	--	No. MDC < SB
Manganese	7439-96-5	700	450	EcoSSL	YES	371.6	4500	LANL	1036	NO	0.1	>100%	No. EPC<SB and Background
Mercury	7439-97-6	14	0.1	ORNL	YES	7.77	0.5	LANL	0.17	NO	16	2%	No. EPC>SB
Nickel	7440-02-0	22	280	EcoSSL	NO	11.7	--	--	10.19	NO	--	--	No. MDC < SB
Selenium	7782-49-2	59	4.1	EcoSSL	YES	43.7	41	LANL	7.23	YES	1	17%	Yes. EPC>SB and Background
Silver	7440-22-4	14	NA	--	NA	8.9	NA	LANL	NA	--	--	--	SB and background not available
Zinc	7440-66-6	15000	120	EcoSSL	YES	5,882	930	LANL	178.3	YES	6	3%	Yes. EPC>SB and Background

Notes:
The analytes shown were identified as ECOPCs based on initial screening.
Shaded cells indicate HQ>1.
-- = not applicable
CAS = Chemical Abstract Service
COPEC = chemical of potential ecological concern
EcoSSL = Ecological Soil Screening Levels

EPC = exposure point concentration
HQ = hazard quotient
LANL = Los Alamos National Laboratory
MDC = maximum detected concentration. Used as EPC where insufficient samples for statistical analysis exist, or where the calculation was not needed.
mg/kg = milligrams per kilogram
NA = not available
ORNL = Oak Ridge National Laboratory
SB = screening benchmark
UCL = upper confidence limit of the mean

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EPA. 2007. Ecological Soil Screening Levels for Selenium Interim Final, OSWER Directive 9285.7-72. July.

EPA. 2006. Ecological Soil Screening Levels for Silver Interim Final, OSWER Directive 9285.7-77. September.

EPA. 2007. Ecological Soil Screening Levels for Zinc Interim Final, OSWER Directive 9285.7-73. June.

Table H-16
Sediment/Soil Risk Evaluation in Hull Canyon Wash

COPEC	CAS No.	units	Soil Benchmark[a] (mg/kg)	Background Range (mg/kg)		Background 95 UCL (mg/kg)	SC-HCW-S-1	SC-HCW-S-2	SC-HCW-S-3	SC-HCW-S-4	SC-HCW-S-5 (DUP of S-4)
Antimony	7440-36-0	mg/kg	0.27	<4.9	<5.0	<5.0	<5.0	<4.8	<4.9	<4.9	<5.0
Arsenic	7440-38-2	mg/kg	18	5	36	26.4	<4.8	34	8.7	31	32
Cadmium	7440-43-9	mg/kg	0.36	0.86	6.5	3.98	0.73	0.93	0.6	<0.48	0.57
Chromium	7440-47-3	mg/kg	26	2.4	14	11.18	10	11	46	8	8.7
Copper	7440-50-8	mg/kg	28	25	590	384.3	64	2,200	140	910	1,600
Lead	7439-92-1	mg/kg	11	5.3	94	64.42	11	18	25	33	33
Manganese	7439-96-5	mg/kg	220	88	2800	1769	120	690	380	240	260
Mercury	7439-97-6	mg/kg	0.3	0.11	0.28	0.159	<0.10	0.14	<0.093	0.17	0.89
Nickel	7440-02-0	mg/kg	38	4.9	9.4	8.35	13	13	46	6.8	6.4
Selenium	7782-49-2	mg/kg	0.52	5.2	9.3	7.29	<4.8	10	6.5	9.8	12
Silver	7440-22-4	mg/kg	4.2	<2.4	<2.5	<2.5	<2.4	<2.5	<2.5	<2.4	<2.5
Zinc	7440-66-6	mg/kg	46	47	320	201.1	48	270	190	88	120

Notes:
Shaded cells indicate sample concentration is greater than soil benchmark or background
Values preceded by "<" indicate a non-detected concentration. Value listed in the method reporting limit.
See Table H-7 for identification of COPECs for overall area

[a] Hierarchy for selection of terrestrial screening benchmarks for soil:
-Lowest EcoSSL for terrestrial plants, invertebrates, birds, or mammals (EPA, 2005a,b,c,d,e,f, 2006, 2007a,b,c,d,e,f, 2008)
-LOEC (lowest observed effect concentration) values for terrestrial plants from Efroymson et al. (1997a)

CAS = Chemical Abstract Service
COPEC = chemical of potential ecological concern
MDC = maximum detected concentration
mg/kg = milligram per kilogram

Table H-17
Surface Water Risk Evaluation in Hull Canyon Wash

Sample Location	Sample Type	Date	Antimony (mg/L)	Arsenic (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Copper (mg/L)	Lead (mg/L)	Manganese (mg/L)	Mercury (mg/L)	Nickel (mg/L)	Selenium (mg/L)	Silver (mg/L)	Zinc (mg/L)	Hardness*	pH [2]
13 Priority Pollutant Metals Plus Barium, Manganese, Calcium and Magnesium by EPA Methods 200.7, 200.8, and 245.1 (mg/L)																
HCW-1-W	Total Recoverable	9/16/2014	<0.0030	<0.0030	<0.0010	<0.010	0.012	<0.015	0.015	<0.00020	<0.010	<0.0020	<0.010	**0.078**	390	7.30
	Dissolved	9/16/2014	<0.0030 H6	<0.0030 H6	<0.0010 H6	<0.010 H6	<0.010 H6	<0.015 H6	<0.010 H6	0.00028 H6	<0.010 H6	<0.0020 H6	<0.010 H6	<0.050 H6	320	-
	Total Recoverable ***	10/2/2014	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	7.32
	Total Recoverable	12/4/2014	<0.0030	<0.0030	<0.0010	<0.010	<0.010	<0.015	<0.010	<0.00020	<0.010	<0.0020	<0.010	<0.050	340	8.36
	Dissolved	12/4/2014	<0.0030 H6	<0.0030 H6	<0.0010 H6	<0.010 H6	<0.010 H6	<0.015 H6	<0.010 H6	<0.00020 H6	<0.010 H6	0.0023 H6	<0.010 H6 L5	<0.050 H6	350	-
	Total Recoverable	5/20/2015	<0.0030	<0.0030	<0.0010	<0.010	<0.010	<0.015	<0.010	<0.00020	<0.010	<0.0020	<0.010	<0.050	220	8.33
	Dissolved	5/20/2015	<0.0030	<0.0030	<0.0010	<0.010	<0.010	<0.015	<0.010	<0.00020	<0.010	<0.0020	<0.010	<0.050	220	8.33
HCW-2-W	Total Recoverable	5/20/2015	<0.0030	0.0059	<0.0010	<0.010	0.1	<0.015	<0.010	<0.00020	<0.010	0.0093	<0.010	<0.050	350	8.59
	Dissolved	5/20/2015	<0.0030	0.0074	<0.0010	<0.010	**0.087**	<0.015	<0.010	<0.00020	<0.010	0.011	<0.010	<0.050	370	8.59
HCW-3-W	Total Recoverable	9/16/2014	<0.0030	0.011	<0.0010	0.014	0.065	0.05	0.28	<0.00020	0.012	<0.0020	<0.010	0.65	76	7.87
	Total Recoverable	10/2/2014	<0.0030	0.0031	<0.0010	<0.010	0.058	0.022	0.17	<0.00020	<0.010	<0.0020	<0.010	0.11	NA	7.36
	Dissolved	10/2/2014	<0.0030 H6	<0.0030 H6	<0.0010 H6	<0.010 H6 B1	0.013 H6	<0.015 H6	0.018 H6	<0.00020 H6	<0.010 H6	<0.0020 H6	<0.010 H6	<0.050 H6	NA	-
	Dissolved****	12/4/2014	<0.030 H6	<0.030 H6	<0.010 H6	<0.10 H6	<0.10 H6	<0.15 H6	<0.10 H6	<0.00020 H6	<0.10 H6	<0.020 H6	<0.10 H6	<0.50 H6	<13	-
	Total Recoverable	5/20/2015	<0.0030	<0.0030	<0.0010	<0.010	0.044	<0.015	0.025	<0.00020	<0.010	0.0047	<0.010	<0.050	340	7.88
HCW-4-W	Total Recoverable	9/16/2014	0.0035	0.03	0.0015	0.014	1.3	0.12	0.53	0.00068	<0.010	0.0054	<0.010	0.4	110	6.98
	Total Recoverable	10/2/2014	0.0035	0.027	<0.0010	0.011	0.87	0.09	0.4	0.00044	<0.010	0.005	<0.010	0.27	NA	7.33
	Dissolved	10/2/2014	<0.0030 H6	<0.0030 H6	<0.0010 H6	<0.010 H6 B1	**0.081** H6	<0.015 H6	<0.010 H6	<0.00020 H6	<0.010 H6	0.0020 H6	<0.010 H6	<0.050 H6	NA	-
	Total Recoverable	12/4/2014	<0.0030	<0.0030	<0.0010	<0.010	0.075	<0.015	0.066	<0.00020	<0.010	0.0042	<0.010 L5	<0.050	330	6.83
	Dissolved	12/4/2014	<0.0030 H6	<0.0030 H6	<0.0010 H6	<0.010 H6	0.044 H6	<0.015 H6	0.026 H6	<0.00020 H6	<0.010 H6	0.0039 H6	<0.010 H6	<0.050 H6	360	-
	Total Recoverable	5/20/2015	<0.0030	<0.0030	<0.0010	<0.010	0.034	<0.015	<0.010	<0.00020	<0.010	<0.0020	<0.010	<0.050	330	8.11
	Dissolved	5/20/2015	<0.0030	<0.0030	<0.0010	<0.010	0.03	<0.015	<0.010	<0.00020	<0.010	0.002	<0.010	<0.050	330	8.11
HCW-5-W (Dup of HCW-4-W)	Total Recoverable	5/20/2015	<0.0030	<0.0030	<0.0010	<0.010	0.033	<0.015	<0.010	<0.00020	<0.010	<0.0020	<0.010	<0.050	330	8.11
	Dissolved	5/20/2015	<0.0030	<0.0030	<0.0010	<0.010	0.029	<0.015	<0.010	<0.00020	<0.010	<0.0020	<0.010	<0.050	330	8.11
A&We Acute[1] (mg/L)	Standard		NE	0.44 D	Table 6	Table 4** / 0.034 D	Table 12	Table 15	NE	0.005 D	Table 18	0.033 T	Table 19	Table 21	NE	6.5 - 9.0
	Hardness 220 mg/L as $CaCO_3$		-	-	0.049	3.65**	0.049	0.318	-	-	8.102	-	0.012	2.169	-	-
	Hardness 370 mg/L as CaCO3		-	-	0.081	5.58**	0.08	0.547	-	-	12.578	-	0.031	3.369	-	-

Notes:
Only dissolved samples are compared to A&We Acute Standards, with exception of selenium, which is compared to total recoverable concentrations. Total recoverable results for other metals are presented for reference only.
EPA = Environmental Protection Agency
A&We = aqueous and wildlife, ephemeral
mg/L = milligrams per liter
T = Total recoverable
D = dissolved
NA = Not analyzed
NE = Not established
NS = Not sampled

Table H-17
Surface Water Risk Evaluation in Hull Canyon Wash

[1] = Standard represents dissolved concentration that is dependent on the concentration of hardness (expressed as mg/L CaCO3) in the effluent water, per Arizona Administrative Code (AAC) R18-11 Appendix A (Numeric Water Quality Standards) effective January 31, 2009. There is no effluent stream to sample at this site, therefore the hardness values and chemical results are based on samples collected from Hull Canyon Wash. Table numbers reference tables presenting standards as a function of hardness in Arizona Administrative Code (AAC) R18-11 Appendix A (Numeric Water Quality Standards) effective January 31, 2009. Values shown for upper (370 mg/L as CaCO3) and lower (220 mg/L as CaCO3) bounds of measured hardness (as CaCO3) in filtered surface water samples.

[2] = pH measurements conducted in field.
* = Total Hardness as Calcium Carbonate ($CaCO_3$) by calculation via Method SM2340B (mg/L)
** = A&We Acute Standard reported for Chromium III (trivalent) per AACR18-11 Table 4. Because chromium species were not analyzed, the hexavelent chromium standard (0.034 mg/L) was also applied.
*** The 10/2/14 sample from location SC-HCW-1 only had enough water for a pH reading.
**** The 12/4/14 sample from location SC-HCW-3 had a note on COC of "filter + analyze if possible" due to low sample recovery from the stream sampler. This sample result is considered anomalous due to the non-detected concentration of hardness.
Bold = Indicates analyte detected above the minimum laboratory reporting limit (LRL)
H6, B1, L5 - See laboratory reports, Definitions/Glossary section, for QC qualifiers
= LRL equals or exceeds A&We Acute Standard
= Result equals or exceeds A&We Acute Standard

Table H-18
Step 2 Risk Estimate Results for Birds and Mammals

COPEC	CAS NO.	MDC (mg/kg)	Horned Lark	Black-tailed Jackrabbit	Coyote
			Step 2 HQ (unitless)	Step 2 HQ (unitless)	Step 2 HQ (unitless)
Exposure Area 1					
Antimony	7440-36-0	7.2	NA	0.3	0.4
Arsenic	7440-38-2	250	4	13	0.5
Cadmium	7440-43-9	6.8	5	0.1	0.1
Copper	7440-50-8	22,000	1615	5	8
Lead	7439-92-1	140	6	0.1	0.1
Manganese	7439-96-5	2,400	0.2	0.6	0.1
Mercury	7439-97-6	2.7	2	0.0	0.0
Nickel	7440-02-0	14	0.4	0.0	0.1
Selenium	7782-49-2	77	21	21	3
Silver	7440-22-4	20	29	0.0	0.1
Zinc	7440-66-6	1,800	3	0.1	0.1
Exposure Area 2					
Antimony	7440-36-0	42	NA	2	2
Arsenic	7440-38-2	450	8	23	0.8
Cadmium	7440-43-9	65	30	0.5	0.4
Chromium	7440-47-3	31	7	0.1	0.1
Copper	7440-50-8	24,000	1762	5	9
Lead	7439-92-1	1,200	34	0.4	0.4
Manganese	7439-96-5	700	0.1	0.2	0.0
Mercury	7439-97-6	14	10	0.1	0.1
Nickel	7440-02-0	22	0.7	0.0	0.1
Selenium	7782-49-2	59	17	16	2
Silver	7440-22-4	14	21	0.0	0.1
Zinc	7440-66-6	15,000	7	0.50	0.3

Notes:
Shaded cells indicate a HQ>1.
CAS = Chemical Abstract Service
COPEC = chemical of potential ecological concern
HQ = hazard quotient
MDC = maximum detected concentration
mg/kg = milligrams per kilogram
NA = Not Available - COPEC lacks appropriate TRV to calculate HQ

Table H-19
Step 3A Risk Estimate Results for Birds and Mammals

COPEC	CAS Number	EPC (mg/kg)	Omnivorous/ Insectivorous Receptor		Herbivorous Receptor		Carnivorous Receptor	
			Horned Lark		Black-tailed Jackrabbit		Coyote	
			Step 3A NOAEL HQ (unitless)	Step 3A LOAEL HQ (unitless)	Step 3A NOAEL HQ (unitless)	Step 3A LOAEL HQ (unitless)	Step 3A NOAEL HQ (unitless)	Step 3A LOAEL HQ (unitless)
Exposure Area 1								
Arsenic	7440-38-2	143.2	1	0.6	0.1	0.0	--	--
Cadmium	7440-43-9	1.8	2	1	--	--	--	--
Copper	7440-50-8	5077	131	44	0.2	0.1	0.0	0.0
Lead	7439-92-1	50.6	2	0.9	--	--	--	--
Mercury	7439-97-6	1.3	1	0.5	--	--	--	--
Selenium	7782-49-2	40.3	12	10	2	1	0.0	0.0
Silver	7440-22-4	7.8	2	0.2	--	--	--	--
Zinc	7440-66-6	416.6	2	2	--	--	--	--
Exposure Area 2								
Antimony	7440-36-0	23.4	NA	NA	0.1	0.0	0.0	0.0
Arsenic	7440-38-2	315	2	1	0.0	0.0	--	--
Cadmium	7440-43-9	26.11	15	9	--	--	--	--
Chromium	7440-47-3	15.2	0.4	0.2	--	--		
Copper	7440-50-8	11,689	301	102	0.1	0.1	0.0	0.0
Lead	7439-92-1	515	12	6	--	--	--	--
Mercury	7439-97-6	7.8	6	3	--	--	--	--
Selenium	7782-49-2	43.7	13	10	0.6	0.4	0.0	0.0
Silver	7440-22-4	8.9	2	0.2	--	--	--	--
Zinc	7440-66-6	5,882	5	4	--	--	--	--

Notes:
Shaded cells indicate a HQ>1.
CAS = Chemical Abstract Service
-- = Analyte passed Tier I evaluation; i.e., (HQ<1) for given receptor - not applicable
COPEC = chemical of potential ecological concern
HQ = hazard quotient
mg/kg = milligrams per kilogram
NA = COPEC lacks appropriate TRV to calculate risk.

Table H-20
Summary of Ecological Risk for the Verde Central Mine Site

Terrestrial Receptor	Exposure Medium	Step 3A Risk Estimates		Step 2 Risk Estimates	
	Media	Exposure Area 1	Exposure Area 2	Hull Canyon Wash - Surface Water	Hull Canyon Wash - Sediment/Soil
Horned Lark (omnivore)	Surface soil and biota	LOAEL-based HQs: copper (HQ=44), selenium (HQ=10) and zinc (HQ=2).	LOAEL-based HQs: cadmium (HQ=9), copper (HQ=102), lead (HQ=6), mercury (HQ=3), selenium (HQ=10) and zinc (HQ=4)	--	--
Black-tailed Jackrabbit (herbivore)	Surface soil and biota	No risk expected	No risk expected	--	--
Coyote (carnivore)	Surface soil and biota	No risk expected	No risk expected	--	--
Terrestrial Plant Community	Surface soil	Arsenic (HQ= 2), copper HQ=10) and selenium (HQ=13).	Arsenic (HQ=3), copper (HQ=24), selenium (HQ=6) and zinc (HQ=7).	--	--
Soil Invertebrate Community	Surface soil	Arsenic (HQ=2), copper (HQ=10) and mercury (HQ=3).	Arsenic (HQ=5), copper (HQ=22), mercury (HQ=16), selenium (HQ=1), zinc (HQ=6).	--	--
Terrestrial Biota	Surface water	--	--	Copper (two samples at two locations)	--
Terrestrial Biota	Sediment/Soil	--	--	--	Copper and Selenium (two sample locations), cadmium and nickel (one sample location)

Notes:
-- = not applicable
HQ = hazard quotient
LOAEL = lowest observed adverse effect level

ATTACHMENT H-1

ANALYTICAL DATA USED IN THE SLERA

Table H-1A
Summary of Soil Sample Results Used in the SLERA

ANALYTE	CAS NUMBER	UNITS	Matrix	Background SC-B-1 7/23/2014 0 - 0.33 ft	Background SC-B-10 7/24/2014 0 - 0.33 ft	Background SC-B-11 7/23/2014 0 - 0.33 ft	Background SC-B-2 7/22/2014 0 - 0.33 ft	Background SC-B-3 7/22/2014 0 - 0.33 ft	Background SC-B-4 7/22/2014 0 - 0.33 ft	Background SC-B-5 7/23/2014 0 - 0.33 ft	Background SC-B-6 7/23/2014 0 - 0.33 ft	Background SC-B-7 7/24/2014 0 - 0.33 ft	Background SC-B-8 7/22/2014 0 - 0.33 ft	Background SC-B-9 7/22/2014 0 - 0.33 ft	Exposure Area 1 SC-LGO-1 7/24/2014 0 - 0.33 ft	Exposure Area 1 SC-LGO-10 7/24/2014 0 - 0.33 ft	Exposure Area 1 SC-LGO-11 7/24/2014 0 - 0.33 ft
Antimony	7440-36-0	mg/Kg	SO	<4.9	<5	<5	<4.9	<4.9	<5	<4.9	<5	<4.9	<4.9	<4.9	5.3	6	7.2
Arsenic	7440-38-2	mg/Kg	SO	14	21	36	5	19	25	31	23	33	13	12	240	200	140
Barium	7440-39-3	mg/Kg	SO	100	73	180	33	130	39	160	110	100	78	58	24	45	38
Beryllium	7440-41-7	mg/Kg	SO	<0.49	0.73	0.75	<0.49	0.77	<0.49	0.67	0.84	0.64	<0.48	0.56	<0.48	<0.49	<0.49
Cadmium	7440-43-9	mg/Kg	SO	1	2	6.5	<0.49	0.86	2.4	5.9	4.3	5	0.87	<0.49	<0.48	<0.49	0.79
Chromium	7440-47-3	mg/Kg	SO	8.9	14	11	2.4	10	10	9.8	12	11	9.4	6.1	<1.9	<2	12
Copper	7440-50-8	mg/Kg	SO	79	150	590	29	98	270	510	380	590	190	25	4100	480	4500
Lead	7439-92-1	mg/Kg	SO	83	20	94	<4.9	8.3	50	85	42	83	16	5.3	59	60	140
Manganese	7439-96-5	mg/Kg	SO	330	330	2800	88	690	230	2500	910	770	170	170	300	260	600
Mercury	7439-97-6	mg/Kg	SO	0.12	<0.089	0.24	<0.088	<0.1	<0.097	0.16	0.11	0.28	<0.094	<0.092	0.49	0.31	2.3
Nickel	7440-02-0	mg/Kg	SO	6.9	8.6	9.4	<2	8.3	4.9	8.4	8.8	8.4	8.7	5.1	<1.9	2.1	11
Selenium	7782-49-2	mg/Kg	SO	5.2	7.8	7.7	<4.9	7.3	<4.9	6.5	7.3	9.3	<4.8	<4.9	77	38	46
Silver	7440-22-4	mg/Kg	SO	<2.4	<2.4	<2.5	<2.5	<2.5	<2.5	<2.4	<2.4	<2.5	<2.4	<2.4	14	3.4	10
Thallium	7440-28-0	mg/Kg	SO	<4.9	<4.9	<490	<4.9	<4.9	<4.9	<480	<4.9	<5	<4.8	<4.9	<240	<4.9	<4.9
Zinc	7440-66-6	mg/Kg	SO	110	120	320	47	140	160	290	130	220	64	71	180	110	300
Antimony	7440-36-0	mg/L	SPLP														
Arsenic	7440-38-2	mg/L	SPLP														
Barium	7440-39-3	mg/L	SPLP														
Beryllium	7440-41-7	mg/L	SPLP														
Cadmium	7440-43-9	mg/L	SPLP														
Chromium	7440-47-3	mg/L	SPLP														
Copper	7440-50-8	mg/L	SPLP														
Lead	7439-92-1	mg/L	SPLP														
Manganese	7439-96-5	mg/L	SPLP														
Mercury	7439-97-6	mg/L	SPLP														
Nickel	7440-02-0	mg/L	SPLP														
Selenium	7782-49-2	mg/L	SPLP														
Silver	7440-22-4	mg/L	SPLP														
Thallium	7440-28-0	mg/L	SPLP														
Zinc	7440-66-6	mg/L	SPLP														

Notes:
CAS = Chemical Abstract Service
ft = feet
HHRA = Human Health Risk Assessment
mg/kg = milligram per kilogram
mg/L = milligrams per liter
SO = soil
SPLP = Synthetic Precipitation Leaching Procedure

Table H-1A
Summary of Soil Sample Results Used in the SLERA

ANALYTE	CAS NUMBER	UNITS	Matrix	Exposure Area 1 SC-LGO-2 7/24/2014 0 - 0.33 ft	Exposure Area 1 SC-LGO-3 7/24/2014 0 - 0.33 ft	Exposure Area 1 SC-LGO-4 7/24/2014 0 - 0.33 ft	Exposure Area 1 SC-LGO-5 7/24/2014 0 - 0.33 ft	Exposure Area 1 SC-LGO-6 7/24/2014 0 - 0.33 ft	Exposure Area 1 SC-LGO-7 7/24/2014 0 - 0.33 ft	Exposure Area 1 SC-LGO-8 7/24/2014 0 - 0.33 ft	Exposure Area 1 SC-LGO-9 7/24/2014 0 - 0.33 ft	Exposure Area 1 SC-T-1 7/23/2014 0 - 0.33 ft	Exposure Area 1 SC-T-2 7/23/2014 0 - 0.33 ft	Exposure Area 1 SC-WR-1 7/22/2014 0 - 0.33 ft	Exposure Area 1 SC-WR-10 7/24/2014 0 - 0.33 ft	Exposure Area 1 SC-WR-11 7/24/2014 0 - 0.33 ft	Exposure Area 1 SC-WR-2 7/23/2014 0 - 0.33 ft
Antimony	7440-36-0	mg/Kg	SO	<5	<4.9	<5	<4.9	<4.9	6.6	7.1	<4.9	<5	<4.9	<5	<4.9	<5	<4.8
Arsenic	7440-38-2	mg/Kg	SO	94	250	36	140	180	250	140	120	180	120	100	69	33	27
Barium	7440-39-3	mg/Kg	SO	64	22	51	25	16	13	39	21	13	6.7	13	50	39	7.6
Beryllium	7440-41-7	mg/Kg	SO	<0.49	<0.5	<0.49	<0.49	<0.49	<0.5	<0.49	<0.5	<0.48	<0.5	<0.48	<0.5	<0.48	<0.5
Cadmium	7440-43-9	mg/Kg	SO	<0.49	<0.5	<0.49	<0.49	<0.49	<0.5	0.58	<0.5	<0.48	<0.5	0.77	1.1	6.8	<0.5
Chromium	7440-47-3	mg/Kg	SO	5.5	<2	6.3	<1.9	<2	<2	14	<2	2.5	<2	<1.9	<2	<1.9	<2
Copper	7440-50-8	mg/Kg	SO	4500	22000	1300	1300	4300	3900	6000	2900	1300	680	3600	2500	3000	650
Lead	7439-92-1	mg/Kg	SO	45	68	22	40	46	68	130	40	15	18	16	12	48	5.7
Manganese	7439-96-5	mg/Kg	SO	230	380	230	1000	330	340	480	400	220	150	620	1100	2400	390
Mercury	7439-97-6	mg/Kg	SO	0.25	1.1	0.14	2.7	0.65	0.78	1.5	1	0.46	0.26	0.42	1.4	2.1	0.14
Nickel	7440-02-0	mg/Kg	SO	3.9	2.2	4.3	<1.9	<2	<2	14	<2	<1.9	<2	<1.9	2.3	5.8	<2
Selenium	7782-49-2	mg/Kg	SO	33	61	16	34	69	58	45	44	21	30	18	20	19	11
Silver	7440-22-4	mg/Kg	SO	5.2	16	<2.4	4.8	11	20	8.7	8.4	4.7	4.9	3	3.5	<2.4	<2.5
Thallium	7440-28-0	mg/Kg	SO	<4.9	<5	<4.9	<240	<4.9	<5	<4.9	<5	<4.8	<5	<4.8	<5	<4.8	<5
Zinc	7440-66-6	mg/Kg	SO	120	310	86	350	180	250	280	190	110	57	220	270	1800	120
Antimony	7440-36-0	mg/L	SPLP									<0.015	<0.015				
Arsenic	7440-38-2	mg/L	SPLP									0.54	<0.5				
Barium	7440-39-3	mg/L	SPLP									<10	<10				
Beryllium	7440-41-7	mg/L	SPLP									<0.25	<0.25				
Cadmium	7440-43-9	mg/L	SPLP									<0.25	<0.25				
Chromium	7440-47-3	mg/L	SPLP									<0.5	<0.5				
Copper	7440-50-8	mg/L	SPLP									2.2	<0.5				
Lead	7439-92-1	mg/L	SPLP									<0.5	<0.5				
Manganese	7439-96-5	mg/L	SPLP									<0.5	<0.5				
Mercury	7439-97-6	mg/L	SPLP									0.0009	<0.0005				
Nickel	7440-02-0	mg/L	SPLP									<0.5	<0.5				
Selenium	7782-49-2	mg/L	SPLP									<0.005	<0.005				
Silver	7440-22-4	mg/L	SPLP									<0.25	<0.25				
Thallium	7440-28-0	mg/L	SPLP									<0.005	<0.005				
Zinc	7440-66-6	mg/L	SPLP									<2	<2				

Notes:
CAS = Chemical Abstract Service
ft = feet
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mg/kg = milligram per kilogram
mg/L = milligrams per liter
SO = soil
SPLP = Synthetic Precipitation Leaching Procedure

Table H-1A
Summary of Soil Sample Results Used in the SLERA

ANALYTE	CAS NUMBER	UNITS	Matrix	Exposure Area 1 SC-WR-3 7/23/2014 0 - 0.33 ft	Exposure Area 1 SC-WR-4 7/23/2014 0 - 0.33 ft	Exposure Area 1 SC-WR-5 7/23/2014 0 - 0.33 ft	Exposure Area 1 SC-WR-6 7/23/2014 0 - 0.33 ft	Exposure Area 1 SC-WR-7 7/24/2014 0 - 0.33 ft	Exposure Area 1 SC-WR-8 7/24/2014 0 - 0.33 ft	Exposure Area 1 SC-WR-9 7/24/2014 0 - 0.33 ft	Exposure Area 2 SC-HGO-1 7/25/2014 0 - 0.33 ft	Exposure Area 2 SC-SS-1 7/11/2018 0 - 0.33 ft	Exposure Area 2 SC-SS-2 7/11/2018 0 - 0.33 ft	Exposure Area 2 SC-SS-3 7/11/2018 0 - 0.33 ft	Exposure Area 2 SC-SS-4 7/11/2018 0 - 0.33 ft	Exposure Area 2 SC-SS-5 7/11/2018 0 - 0.33 ft	Exposure Area 2 SC-SS-6 7/11/2018 0 - 0.33 ft
Antimony	7440-36-0	mg/Kg	SO	<5	<4.9	<4.9	<4.9	<5	<4.8	<4.8	5.3	<4.9	<5	6.8	24	19	<5
Arsenic	7440-38-2	mg/Kg	SO	24	120	51	19	34	19	120	410	110	31	330	430	250	400
Barium	7440-39-3	mg/Kg	SO	33	20	21	27	40	41	15	6.7	58	93	140	<99	270	<5
Beryllium	7440-41-7	mg/Kg	SO	<0.49	<0.49	<0.49	<0.49	<0.49	<0.49	<0.49	<0.5	<0.49	<0.5	<0.49	<0.5	<0.49	<0.5
Cadmium	7440-43-9	mg/Kg	SO	1.3	0.75	1.3	<0.49	4.5	1.9	1.7	<0.5	0.91	<0.5	1.5	0.67	2	<0.5
Chromium	7440-47-3	mg/Kg	SO	6.3	6.5	<2	<2	2	<2	<2	<200	8.7	13	14	30	9.4	<2
Copper	7440-50-8	mg/Kg	SO	460	2400	2000	240	5000	320	1800	4600	6000	1200	10000	5500	20000	2000
Lead	7439-92-1	mg/Kg	SO	9.7	13	22	7.9	56	18	14	41	42	32	240	160	570	21
Manganese	7439-96-5	mg/Kg	SO	1200	1200	570	250	1200	880	670	260	610	250	140	240	250	360
Mercury	7439-97-6	mg/Kg	SO	0.33	0.6	0.49	0.71	1.9	2.2	1.9	2	0.46	0.17	14	0.55	12	0.42
Nickel	7440-02-0	mg/Kg	SO	3.1	3.7	<2	<2	7.2	<2	<2	<2	8.8	7.4	6.9	21	6.9	<2
Selenium	7782-49-2	mg/Kg	SO	14	17	12	5.4	19	10	17	51	19	8.3	58	51	45	33
Silver	7440-22-4	mg/Kg	SO	<2.5	<2.4	<2.5	<2.5	<2.5	<2.4	<2.4	11	4.2	<2.5	14	9.9	11	3.7
Thallium	7440-28-0	mg/Kg	SO	<4.9	<4.9	<4.9	<4.9	<4.9	<4.9	<4.9	<500	<4.9	<5	<4.9	<5	<4.9	<5
Zinc	7440-66-6	mg/Kg	SO	320	260	290	140	1200	570	470	140	260	55	280	83	430	160
Antimony	7440-36-0	mg/L	SPLP								<0.015						
Arsenic	7440-38-2	mg/L	SPLP								<0.5						
Barium	7440-39-3	mg/L	SPLP								<10						
Beryllium	7440-41-7	mg/L	SPLP								<0.25			<0.25		<0.25	
Cadmium	7440-43-9	mg/L	SPLP								<0.25						
Chromium	7440-47-3	mg/L	SPLP								<0.5						
Copper	7440-50-8	mg/L	SPLP								4.4			1.2		<0.5	
Lead	7439-92-1	mg/L	SPLP								<0.5						
Manganese	7439-96-5	mg/L	SPLP								<0.5						
Mercury	7439-97-6	mg/L	SPLP								<0.0005			<0.0005		<0.0005	
Nickel	7440-02-0	mg/L	SPLP								<0.5						
Selenium	7782-49-2	mg/L	SPLP								<0.005						
Silver	7440-22-4	mg/L	SPLP								<0.25			<0.25		<0.25	
Thallium	7440-28-0	mg/L	SPLP								<0.005						
Zinc	7440-66-6	mg/L	SPLP								<2			<2		<2	

Notes:
CAS = Chemical Abstract Service
ft = feet
HHRA = Human Health Risk Assessment
mg/kg = milligram per kilogram
mg/L = milligrams per liter
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Table H-1A
Summary of Soil Sample Results Used in the SLERA

ANALYTE	CAS NUMBER	UNITS	Matrix	Exposure Area 2 SC-SS-7 7/11/2018 0 - 0.33 ft	Exposure Area 2 SC-SWC-1 7/25/2014 0 - 0.33 ft	Exposure Area 2 SC-SWC-2 7/25/2014 0 - 0.33 ft	Exposure Area 2 SC-SWC-3 7/11/2018 0 - 0.33 ft	Exposure Area 2 SC-SWC-3-MS 7/11/2018 0 - 0.33 ft	Exposure Area 2 SC-T-3 7/23/2014 0 - 0.33 ft	Exposure Area 2 SC-T4 7/11/2018 0 - 0.33 ft	Exposure Area 2 SC-T5 7/11/2018 0 - 0.33 ft	Exposure Area 2 SC-TS-D 7/11/2018 0 - 0.33 ft
Antimony	7440-36-0	mg/Kg	SO	36	42	42	23	9.5	<5	<4.9	<4.9	<5
Arsenic	7440-38-2	mg/Kg	SO	88	110	300	86	68	100	130	59	68
Barium	7440-39-3	mg/Kg	SO	74	12	26	120	99	<4.9	21	76	74
Beryllium	7440-41-7	mg/Kg	SO	<0.49	<0.49	<0.5	<0.5	<0.49	<0.49	<0.49	<0.49	<0.5
Cadmium	7440-43-9	mg/Kg	SO	1.3	65	2.2	1.2	1.4	<0.49	<0.49	<0.49	<0.5
Chromium	7440-47-3	mg/Kg	SO	21	<2	2.7	16	11	<2	5.3	16	16
Copper	7440-50-8	mg/Kg	SO	8700	24000	20000	6500	5500	1000	880	1000	1300
Lead	7439-92-1	mg/Kg	SO	450	1200	310	240	210	18	34	54	57
Manganese	7439-96-5	mg/Kg	SO	250	700	310	210	190	170	120	180	230
Mercury	7439-97-6	mg/Kg	SO	0.31	1.5	1.3	1.1	1.1	0.38	1.2	0.37	0.35
Nickel	7440-02-0	mg/Kg	SO	12	22	5.9	12	9	<2	3.1	8	8.4
Selenium	7782-49-2	mg/Kg	SO	12	54	59	17	31	32	27	12	13
Silver	7440-22-4	mg/Kg	SO	5.3	10	11	3.6	2.6	4.8	5.9	<2.5	2.5
Thallium	7440-28-0	mg/Kg	SO	<4.9	<98	<5	<5	<4.9	<4.9	<4.9	<4.9	<5
Zinc	7440-66-6	mg/Kg	SO	390	15000	480	370	400	67	65	72	83
Antimony	7440-36-0	mg/L	SPLP		<0.015	<0.015			<0.015			
Arsenic	7440-38-2	mg/L	SPLP		<0.015	<0.015			<0.5			
Barium	7440-39-3	mg/L	SPLP		<10	<10			<10			
Beryllium	7440-41-7	mg/L	SPLP	<0.5	<0.25	<0.25			<0.25			
Cadmium	7440-43-9	mg/L	SPLP		<0.25	<0.25			<0.25			
Chromium	7440-47-3	mg/L	SPLP		<0.5	<0.5			<0.5			
Copper	7440-50-8	mg/L	SPLP	<0.5	3.5	34			1.5			
Lead	7439-92-1	mg/L	SPLP		<0.5	<0.5			<0.5			
Manganese	7439-96-5	mg/L	SPLP		<0.5	1.1			<0.5			
Mercury	7439-97-6	mg/L	SPLP	<0.0005	<0.0005	<0.0005			<0.0005			
Nickel	7440-02-0	mg/L	SPLP		<0.5	<0.5			<0.5			
Selenium	7782-49-2	mg/L	SPLP		0.0057	0.01			0.012			
Silver	7440-22-4	mg/L	SPLP	<0.25	<0.25	<0.25			<0.25			
Thallium	7440-28-0	mg/L	SPLP		<0.005	<0.005			<0.005			
Zinc	7440-66-6	mg/L	SPLP	<2	4.2	<2			<2			

Notes:
CAS = Chemical Abstract Service
ft = feet
HHRA = Human Health Risk Assessment
mg/kg = milligram per kilogram
mg/L = milligrams per liter
SO = soil
SPLP = Synthetic Precipitation Leaching Procedure

Table H-1B
Summary of Sediment Sample Results Used in the SLERA

ANALYTE	CAS NUMBER	UNITS	Matrix	Hull Canyon Wash SC-HCW-S-1 7/23/2014 0 - 0.33 ft	Hull Canyon Wash SC-HCW-S-2 7/23/2014 0 - 0.33 ft	Hull Canyon Wash SC-HCW-S-3 7/23/2014 0 - 0.33 ft	Hull Canyon Wash SC-HCW-S-4 7/25/2014 0 - 0.33 ft	Hull Canyon Wash SC-HCW-S-5 7/25/2014 0 - 0.33 ft
Antimony	7440-36-0	mg/Kg	SO	<5	<4.8	<4.9	<4.9	<5
Arsenic	7440-38-2	mg/Kg	SO	<4.8	34	8.7	31	32
Barium	7440-39-3	mg/Kg	SO	42	45	100	32	34
Beryllium	7440-41-7	mg/Kg	SO	<0.48	<0.5	1.3	<0.48	<0.49
Cadmium	7440-43-9	mg/Kg	SO	0.73	0.93	0.6	<0.48	0.57
Chromium	7440-47-3	mg/Kg	SO	10	11	46	8	8.7
Copper	7440-50-8	mg/Kg	SO	64	2200	140	910	1600
Lead	7439-92-1	mg/Kg	SO	11	18	25	33	33
Manganese	7439-96-5	mg/Kg	SO	120	690	380	240	260
Mercury	7439-97-6	mg/Kg	SO	<0.1	0.14	<0.093	0.17	0.89
Nickel	7440-02-0	mg/Kg	SO	13	13	46	6.8	6.4
Selenium	7782-49-2	mg/Kg	SO	<4.8	10	6.5	9.8	12
Silver	7440-22-4	mg/Kg	SO	<2.4	<2.5	<2.5	<2.4	<2.5
Thallium	7440-28-0	mg/Kg	SO	<4.8	<5	<5	<4.8	<4.9
Zinc	7440-66-6	mg/Kg	SO	48	270	190	88	120
Antimony	7440-36-0	mg/L	SPLP	<0.015	<0.015	<0.015	<0.015	<0.015
Arsenic	7440-38-2	mg/L	SPLP	<0.015	<0.5	<0.015	<0.5	0.023
Barium	7440-39-3	mg/L	SPLP	<10	<10	<10	<10	<10
Beryllium	7440-41-7	mg/L	SPLP	<0.25	<0.25	<0.25	<0.25	<0.25
Cadmium	7440-43-9	mg/L	SPLP	<0.25	<0.25	<0.25	<0.25	<0.25
Chromium	7440-47-3	mg/L	SPLP	<0.5	<0.5	<0.5	<0.5	<0.5
Copper	7440-50-8	mg/L	SPLP	<0.5	3.7	<0.5	1.1	0.98
Lead	7439-92-1	mg/L	SPLP	<0.5	<0.5	<0.5	<0.5	<0.5
Manganese	7439-96-5	mg/L	SPLP	<0.5	<0.5	<0.5	<0.5	<0.5
Mercury	7439-97-6	mg/L	SPLP	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Nickel	7440-02-0	mg/L	SPLP	<0.5	<0.5	<0.5	<0.5	<0.5
Selenium	7782-49-2	mg/L	SPLP	<0.005	<0.005	<0.005	<0.005	<0.005
Silver	7440-22-4	mg/L	SPLP	<0.25	<0.25	<0.25	<0.25	<0.25
Thallium	7440-28-0	mg/L	SPLP	<0.005	<0.005	<0.005	<0.005	<0.005
Zinc	7440-66-6	mg/L	SPLP	<2	<2	<2	<2	<2

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mg/L = milligrams per liter
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Table H-1C
Summary of Surface Water Sample Results Used in the SLERA

ANALYTE	CAS NUMBER	UNITS	Hull Canyon Wash HCW-1-W 12/4/2014	Hull Canyon Wash HCW-1-W 9/16/2014	Hull Canyon Wash HCW-3-W 10/2/2014	Hull Canyon Wash HCW-3-W 12/4/2014	Hull Canyon Wash HCW-3-W 9/16/2014	Hull Canyon Wash HCW-4-W 10/2/2014	Hull Canyon Wash HCW-4-W 12/4/2014	Hull Canyon Wash HCW-4-W 9/16/2014	Hull Canyon Wash SC-HCW-1-FILTER-20150520 5/20/2015
Antimony	7440-36-0	mg/L	<0.003	<0.003	<0.003		<0.003	0.0035	<0.003	0.0035	
Antimony, Dissolved	7440-36-0	mg/L	<0.003	<0.003	<0.003	<0.03		<0.003	<0.003		<0.003
Arsenic	7440-38-2	mg/L	<0.003	<0.003	0.0031		0.011	0.027	<0.003	0.03	
Arsenic, Dissolved	7440-38-2	mg/L	<0.003	<0.003	<0.003	<0.03		<0.003	<0.003		<0.003
Barium	7440-39-3	mg/L	0.012	0.022	0.028		0.063	0.099	0.024	0.13	
Barium, Dissolved	7440-39-3	mg/L	0.013	0.013	<0.01	<0.1		0.015	0.027		<0.01
Beryllium	7440-41-7	mg/L	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001	<0.001	
Beryllium, Dissolved	7440-41-7	mg/L	<0.001	<0.001	<0.001	<0.01		<0.001	<0.001		<0.001
Cadmium	7440-43-9	mg/L	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001	0.0015	
Cadmium, Dissolved	7440-43-9	mg/L	<0.001	<0.001	<0.001	<0.01		<0.001	<0.001		<0.001
Calcium	7440-70-2	mg/L	71						74		
Calcium, Dissolved	7440-70-2	mg/L	74			<20			80		37
Chromium	7440-47-3	mg/L	<0.01	<0.01	<0.01		0.014	0.011	<0.01	0.014	
Chromium, Dissolved	7440-47-3	mg/L	<0.01	<0.01	<0.01	<0.1		<0.01	<0.01		<0.01
Copper	7440-50-8	mg/L	<0.01	0.012	0.058		0.065	0.87	0.075	1.3	
Copper, Dissolved	7440-50-8	mg/L	<0.01	<0.01	0.013	<0.1		0.081	0.044		<0.01
Mercury	7439-97-6	mg/L	<0.0002	<0.0002	<0.0002		<0.0002	0.00044	<0.0002	0.00068	
Mercury, Dissolved	7439-97-6	mg/L	<0.0002	0.00028	<0.0002	<0.0002		<0.0002	<0.0002		<0.0002
Lead	7439-92-1	mg/L	<0.015	<0.015	0.022		0.05	0.09	<0.015	0.12	
Lead, Dissolved	7439-92-1	mg/L	<0.015	<0.015	<0.015	<0.15		<0.015	<0.015		<0.015
Magnesium	7439-95-4	mg/L	39						36		
Magnesium, Dissolved	7439-95-4	mg/L	41			<20			38		30
Manganese	7439-96-5	mg/L	<0.01	0.015	0.17		0.28	0.4	0.066	0.53	
Manganese, Dissolved	7439-96-5	mg/L	<0.01	<0.01	0.018	<0.1		<0.01	0.026		<0.01
Nickel	7440-02-0	mg/L	<0.01	<0.01	<0.01		0.012	<0.01	<0.01	<0.01	
Nickel, Dissolved	7440-02-0	mg/L	<0.01	<0.01	<0.01	<0.1		<0.01	<0.01		<0.01
Selenium	7782-49-2	mg/L	<0.002	<0.002	<0.002		<0.002	0.005	0.0042	0.0054	
Selenium, Dissolved	7782-49-2	mg/L	0.0023	<0.002	<0.002	<0.02		0.002	0.0039		<0.002
Silver	7440-22-4	mg/L	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	
Silver, Dissolved	7440-22-4	mg/L	<0.01	<0.01	<0.01	<0.1		<0.01	<0.01		<0.01
Thallium	7440-28-0	mg/L	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001	<0.001	
Thallium, Dissolved	7440-28-0	mg/L	<0.001	<0.001	<0.001	<0.01		<0.001	<0.001		<0.001
Zinc	7440-66-6	mg/L	<0.05	0.078	0.11		0.65	0.27	<0.05	0.4	
Zinc, Dissolved	7440-66-6	mg/L	<0.05	<0.05	<0.05	<0.5		<0.05	<0.05		<0.05

Notes:
CAS = Chemical Abstract Service
HHRA = Human Health Risk Assessment
mg/L = milligrams per liter
SPLP = Synthetic Precipitation Leaching Procedure

Table H-1C
Summary of Surface Water Sample Results Used in the SLERA

ANALYTE	CAS NUMBER	UNITS	Hull Canyon Wash SC-HCW-1-UNFILT-20150520 5/20/2015	Hull Canyon Wash SC-HCW-2-FILTER-20150520 5/20/2015	Hull Canyon Wash SC-HCW-2-UNFILT-20150520 5/20/2015	Hull Canyon Wash SC-HCW-3-UNFILT-20150520 5/20/2015	Hull Canyon Wash SC-HCW-4-FILTER-20150520 5/20/2015	Hull Canyon Wash SC-HCW-4-UNFILT-20150520 5/20/2015	Hull Canyon Wash SC-HCW-5-FILTER-20150520 5/20/2015	Hull Canyon Wash SC-HCW-5-UNFILT-20150520 5/20/2015
Antimony	7440-36-0	mg/L	<0.003		<0.003	<0.003		<0.003		<0.003
Antimony, Dissolved	7440-36-0	mg/L		<0.003			<0.003		<0.003	
Arsenic	7440-38-2	mg/L	<0.003		0.0059	<0.003		<0.003		<0.003
Arsenic, Dissolved	7440-38-2	mg/L		0.0074			<0.003		<0.003	
Barium	7440-39-3	mg/L	<0.01		0.016	0.018		0.021		0.021
Barium, Dissolved	7440-39-3	mg/L		0.016			0.02		0.02	
Beryllium	7440-41-7	mg/L	<0.001		<0.001	<0.001		<0.001		<0.001
Beryllium, Dissolved	7440-41-7	mg/L		<0.001			<0.001		<0.001	
Cadmium	7440-43-9	mg/L	<0.001		<0.001	<0.001		<0.001		<0.001
Cadmium, Dissolved	7440-43-9	mg/L		<0.001			<0.001		<0.001	
Calcium	7440-70-2	mg/L	38		76	89		65		64
Calcium, Dissolved	7440-70-2	mg/L		81			66		65	
Chromium	7440-47-3	mg/L	<0.01		<0.01	<0.01		<0.01		<0.01
Chromium, Dissolved	7440-47-3	mg/L		<0.01			<0.01		<0.01	
Copper	7440-50-8	mg/L	<0.01		0.1	0.044		0.034		0.033
Copper, Dissolved	7440-50-8	mg/L		0.087			0.03		0.029	
Mercury	7439-97-6	mg/L	<0.0002		<0.0002	<0.0002		<0.0002		<0.0002
Mercury, Dissolved	7439-97-6	mg/L		<0.0002			<0.0002		<0.0002	
Lead	7439-92-1	mg/L	<0.015		<0.015	<0.015		<0.015		<0.015
Lead, Dissolved	7439-92-1	mg/L		<0.015			<0.015		<0.015	
Magnesium	7439-95-4	mg/L	31		38	29		41		41
Magnesium, Dissolved	7439-95-4	mg/L		41			41		41	
Manganese	7439-96-5	mg/L	<0.01		<0.01	0.025		<0.01		<0.01
Manganese, Dissolved	7439-96-5	mg/L		<0.01			<0.01		<0.01	
Nickel	7440-02-0	mg/L	<0.01		<0.01	<0.01		<0.01		<0.01
Nickel, Dissolved	7440-02-0	mg/L		<0.01			<0.01		<0.01	
Selenium	7782-49-2	mg/L	<0.002		0.0093	0.0047		<0.002		<0.002
Selenium, Dissolved	7782-49-2	mg/L		0.011			0.002		<0.002	
Silver	7440-22-4	mg/L	<0.01		<0.01	<0.01		<0.01		<0.01
Silver, Dissolved	7440-22-4	mg/L		<0.01			<0.01		<0.01	
Thallium	7440-28-0	mg/L	<0.001		<0.001	<0.001		<0.001		<0.001
Thallium, Dissolved	7440-28-0	mg/L		<0.001			<0.001		<0.001	
Zinc	7440-66-6	mg/L	<0.05		<0.05	<0.05		<0.05		<0.05
Zinc, Dissolved	7440-66-6	mg/L		<0.05			<0.05		<0.05	

Notes:
CAS = Chemical Abstract Service
HHRA = Human Health Risk Assessment
mg/L = milligrams per liter
SPLP = Synthetic Precipitation Leaching Procedure

ATTACHMENT H-2

SPECIAL STATUS SPECIES IN YAVAPAI COUNTY, ARIZONA

Attachment H-2
Special-Status Species in Yavapai County, Arizona

Common Name	Scientific Name	Federal Status	Arizona BLM Status*	Comments
Plants				
Arizona cliffrose	*Purshia subintegra*	Endangered		Only found in white tertiary limestone lakebed deposits.
Clifton rock daisy	*Perityle ambrosiifolia*		SS	Found in narrow range, cliff faces of Gila conglomerate.
Invertebrates				
Monarch butterfly	*Danaus plexippus plexippus*		SS	Found in open fields and meadows with milkweed.
Sonoran talussnail	*Sonorella magdalenensis*		SS	Habitat - Talus slopes
Fish				
Desert pupfish	*Cyprinodon macularius*	Endangered		The ephemeral Hull Canyon Wash, the only nearby water source, does not have fish
Desert sucker	*Catostomus clarki*		SS	The ephemeral Hull Canyon Wash, the only nearby water source, does not have fish
Gila chub	*Gila intermedia*	Endangered		The ephemeral Hull Canyon Wash, the only nearby water source, does not have fish
Gila topminnow	*Poeciliopsis occidentalis occidentalis*	Endangered		The ephemeral Hull Canyon Wash, the only nearby water source, does not have fish
Little Colorado sucker	*Catostomus sp.*		SS	The ephemeral Hull Canyon Wash, the only nearby water source, does not have fish
Loach minnow	*Tiaroga cobitis*	Endangered		The ephemeral Hull Canyon Wash, the only nearby water source, does not have fish
Lonfin dace	*Agosta chrysogaster*		SS	The ephemeral Hull Canyon Wash, the only nearby water source, does not have fish
Razorback sucker	*Xurauchen texanus*	Endangered		The ephemeral Hull Canyon Wash, the only nearby water source, does not have fish
Roundtail chub	*Gila robusta*		SS	The ephemeral Hull Canyon Wash, the only nearby water source, does not have fish
Sonora sucker	*Catostomus insignis*		SS	The ephemeral Hull Canyon Wash, the only nearby water source, does not have fish
Speckled dace	*Rhinichthys osculus*		SS	The ephemeral Hull Canyon Wash, the only nearby water source, does not have fish
Spikedace	*Meda fulgida*	Endangered		The ephemeral Hull Canyon Wash, the only nearby water source, does not have fish
Woundfin	*Plagopterus argentissimus*	Endangered		The ephemeral Hull Canyon Wash, the only nearby water source, does not have fish
Amphibians				
Arizona toad	*Bufo microscaphus*		SS	Habitat - Mid-elevation riparian areas or wetlands.
Chiricahua leopard frog	*Lithobates chiricahuensis*	Threatened		Need permanent water source for reproduction.
Reptiles				
Narrow-headed gartersnake	*Thamnophis rufipunctatus*	Threatened		Classified as a semi-aquatic snake.
Northern mexican gartersnake	*Thamnophis eques megalops*	Threatened		Found in both lotic and lentic habitats, forages along banks of waterbodies.
Sonoran desert tortoise	*Gopherus morafkai*		SS	Habitat - Creosote bush scrub habitat.
Birds				
American perigrine falcon	*Falco peregrinus anatum*	Recovery	SS	Habitat includes cliffs but nest near water.
Bald eagle	*Haliaeetus leucocephalus*	Recovery	SS	Habitat usually near water where there is abundance of fish.
Cactus ferruginous pygmy owl	*Glaucidium brasilianum cactorum*		SS	Dense Sonoran scrub washes.
California condor	*Gymnogyps californianus*	Endangered		Preferred habitat includes rocky forested areas including canyons, gorges and mountains.
Le Conte's thrasher	*Toxostoma lecontei*		SS	Habitat: remote creosote scrub
Mexican spotted owl	*Strix occidentalis lucida*	Threatened		Canyon and montane forested habitats.
Pinyon jay	*Gymnorhinus cyanocephalus*		SS	Healthy pinyon pine and juniper forests between lowland scrub and upper slopes.
Southwestern willow flycatcher	*Empidonax traillii extimus*	Endangered		Lowland riparian habitat.
Western burrowing owl	*Athene cunicularia hypugaea*		SS	Typically grasslands or undeveloped valley bottoms but can be found in desert conditions.
Western yellow-billed cuckoo	*Coccyzus americanus*	Threatened		Wooded habitat with dense cover and water nearby.
Mammals				
Black-footed ferret	*Mustela nigripes*	Threatened		Habitat- lives in prairie dog colonies in grasslands or shrublands.
Lesser long-nosed bat	*Leptonycteris curasoae yerbabuenae*	Recovery	SS	Desert scrub habitat.

* Bureau of Land Management, Arizona -Bureau Sensitive Species List (February 2017), focusing on results from Gila District Office

Based on habitat, receptors that are more likely to be found in the vicinity of the Verde Central Mine Site

Key:
BLM - Bureau of Land Management
SS - Arizona BLM Sensitive Species

ATTACHMENT H-3

EPA PROUCL INPUTS AND OUTPUTS

	A	B	C	D	E	F	G	H	I	J	K	L	M
1				General Statistics on Uncensored Data									
2			Date/Time of Computation	ProUCL 5.110/17/2019 3:03:46 PM									
3			User Selected Options										
4			From File	ProUCL Input 3_EA1_rev083019.xls									
5			Full Precision	OFF									
6													
7	From File: ProUCL Input 3_EA1_rev083019.xls												
8													
9	General Statistics for Censored Data Set (with NDs) using Kaplan Meier Method												
10													
11	Variable		NumObs	# Missing	Num Ds	NumNDs	% NDs	Min ND	Max ND	KM Mean	KM Var	KM SD	KM CV
12	Antimony		22	0	4	18	81.82%	4.8	5	5.068	0.414	0.643	0.127
13	Arsenic		22	0	22	0	0.00%	N/A	N/A	115.1	5868	76.61	0.665
14	Barium		22	0	22	0	0.00%	N/A	N/A	27.6	244.5	15.64	0.566
15	Cadmium		22	0	9	13	59.09%	0.48	0.5	1.03	1.763	1.328	1.29
16	Chromium		22	0	7	15	68.18%	1.9	2	3.255	8.148	2.854	0.877
17	Copper		22	0	22	0	0.00%	N/A	N/A	3260	20431643	4520	1.386
18	Lead		22	0	22	0	0.00%	N/A	N/A	36.15	973.9	31.21	0.863
19	Manganese		22	0	22	0	0.00%	N/A	N/A	623.6	269719	519.3	0.833
20	Mercury		22	0	22	0	0.00%	N/A	N/A	0.942	0.629	0.793	0.842
21	Nickel		22	0	9	13	59.09%	1.9	2	3.068	7.237	2.69	0.877
22	Selenium		22	0	22	0	0.00%	N/A	N/A	30.47	425.6	20.63	0.677
23	Silver		22	0	13	9	40.91%	2.4	2.5	5.932	25.01	5.001	0.843
24	Zinc		22	0	22	0	0.00%	N/A	N/A	304.7	127341	356.8	1.171
25													
26	General Statistics for Raw Data Sets using Detected Data Only												
27													
28	Variable		NumObs	# Missing	Minimum	Maximum	Mean	Median	Var	SD	MAD/0.675	Skewness	CV
29	Antimony		4	0	5.3	7.2	6.275	6.3	0.663	0.814	0.89	-0.151	0.13
30	Arsenic		22	0	19	250	115.1	120	5868	76.61	95.63	0.398	0.665
31	Barium		22	0	6.7	64	27.6	23	244.5	15.64	14.83	0.714	0.566
32	Cadmium		9	0	0.75	6.8	1.823	1.3	3.649	1.91	0.756	2.746	1.048
33	Chromium		7	0	2	14	6.157	6.3	15.46	3.932	1.186	1.387	0.639
34	Copper		22	0	240	22000	3260	2200	20431643	4520	2409	3.658	1.386
35	Lead		22	0	5.7	140	36.15	22	973.9	31.21	22.54	1.858	0.863
36	Manganese		22	0	150	2400	623.6	395	269719	519.3	259.5	2.113	0.833
37	Mercury		22	0	0.14	2.7	0.942	0.625	0.629	0.793	0.549	1.025	0.842
38	Nickel		9	0	2.1	14	4.756	3.7	14.48	3.805	2.076	2.182	0.8
39	Selenium		22	0	5.4	77	30.47	20.5	425.6	20.63	14.83	0.943	0.677
40	Silver		13	0	3	20	8.377	5.2	30.03	5.48	3.262	0.987	0.654
41	Zinc		22	0	57	1800	304.7	235	127341	356.8	133.4	3.807	1.171

	A	B	C	D	E	F	G	H	I	J	K	L	M
42													
43	Percentiles using all Detects (Ds) and Non-Detects (NDs)												
44													
45	Variable		NumObs	# Missing	10%ile	20%ile	25%ile(Q1)	50%ile(Q2)	75%ile(Q3)	80%ile	90%ile	95%ile	99%ile
46		Antimony	22	0	4.81	4.9	4.9	4.9	5	5	5.93	6.57	7.074
47		Arsenic	22	0	24.3	34.4	39.75	120	170	180	236	249.5	250
48		Barium	22	0	13	13.4	15.25	23	39.75	40.8	49.5	50.95	61.27
49		Cadmium	22	0	0.49	0.49	0.49	0.5	1.023	1.26	1.66	1.89	5.771
50		Chromium	22	0	1.91	2	2	2	2.375	4.9	6.3	6.49	12.43
51		Copper	22	0	462	656	835	2200	4050	4260	4950	5950	18640
52		Lead	22	0	9.93	13.2	14.25	22	53.5	58.4	67.2	68	124.9
53		Manganese	22	0	230	252	270	395	827.5	976	1190	1200	2148
54		Mercury	22	0	0.251	0.314	0.353	0.625	1.325	1.8	2.19	2.295	2.616
55		Nickel	22	0	1.9	2	2	2	2.9	3.58	4.26	7.055	12.57
56		Selenium	22	0	11.1	14.4	16.25	20.5	42.5	45.6	60.7	68.6	75.32
57		Silver	22	0	2.4	2.5	2.5	3.45	7.6	9.68	13.7	15.9	19.16
58		Zinc	22	0	110	120	125	235	307.5	318	458	565	1542

	A	B	C	D	E	F	G	H	I	J	K	L
1	**UCL Statistics for Data Sets with Non-Detects**											
2												
3	User Selected Options											
4	Date/Time of Computation			ProUCL 5.110/17/2019 3:06:06 PM								
5	From File			ProUCL Input 3_EA1_rev083019.xls								
6	Full Precision			OFF								
7	Confidence Coefficient			95%								
8	Number of Bootstrap Operations			2000								
9												
10	**Antimony**											
11												
12	**General Statistics**											
13	Total Number of Observations					22	Number of Distinct Observations					7
14	Number of Detects					4	Number of Non-Detects					18
15	Number of Distinct Detects					4	Number of Distinct Non-Detects					3
16	Minimum Detect					5.3	Minimum Non-Detect					4.8
17	Maximum Detect					7.2	Maximum Non-Detect					5
18	Variance Detects					0.663	Percent Non-Detects					81.82%
19	Mean Detects					6.275	SD Detects					0.814
20	Median Detects					6.3	CV Detects					0.13
21	Skewness Detects					-0.151	Kurtosis Detects					-0.949
22	Mean of Logged Detects					1.83	SD of Logged Detects					0.131
23												
24	**Normal GOF Test on Detects Only**											
25	Shapiro Wilk Test Statistic					0.995	**Shapiro Wilk GOF Test**					
26	5% Shapiro Wilk Critical Value					0.748	Detected Data appear Normal at 5% Significance Level					
27	Lilliefors Test Statistic					0.155	**Lilliefors GOF Test**					
28	5% Lilliefors Critical Value					0.375	Detected Data appear Normal at 5% Significance Level					
29	**Detected Data appear Normal at 5% Significance Level**											
30												
31	**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**											
32	KM Mean					5.068	KM Standard Error of Mean					0.158
33	KM SD					0.643	95% KM (BCA) UCL					N/A
34	95% KM (t) UCL					5.341	95% KM (Percentile Bootstrap) UCL					N/A
35	95% KM (z) UCL					5.329	95% KM Bootstrap t UCL					N/A
36	90% KM Chebyshev UCL					5.543	95% KM Chebyshev UCL					5.759
37	97.5% KM Chebyshev UCL					6.057	99% KM Chebyshev UCL					6.644
38												
39	**Gamma GOF Tests on Detected Observations Only**											
40	A-D Test Statistic					0.203	**Anderson-Darling GOF Test**					
41	5% A-D Critical Value					0.656	Detected data appear Gamma Distributed at 5% Significance Level					
42	K-S Test Statistic					0.187	**Kolmogorov-Smirnov GOF**					
43	5% K-S Critical Value					0.394	Detected data appear Gamma Distributed at 5% Significance Level					
44	**Detected data appear Gamma Distributed at 5% Significance Level**											
45												
46	**Gamma Statistics on Detected Data Only**											
47	k hat (MLE)					78.06	k star (bias corrected MLE)					19.68
48	Theta hat (MLE)					0.0804	Theta star (bias corrected MLE)					0.319
49	nu hat (MLE)					624.5	nu star (bias corrected)					157.4
50	Mean (detects)					6.275						
51												

	A	B	C	D	E	F	G	H	I	J	K	L
52	**Gamma ROS Statistics using Imputed Non-Detects**											
53	GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs											
54	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)											
55	For such situations, GROS method may yield incorrect values of UCLs and BTVs											
56	This is especially true when the sample size is small.											
57	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates											
58					Minimum	0.01				Mean		3.097
59					Maximum	7.2				Median		2.859
60					SD	1.962				CV		0.633
61					k hat (MLE)	1.367				k star (bias corrected MLE)		1.211
62					Theta hat (MLE)	2.265				Theta star (bias corrected MLE)		2.558
63					nu hat (MLE)	60.15				nu star (bias corrected)		53.28
64					Adjusted Level of Significance (β)	0.0386						
65					Approximate Chi Square Value (53.28, α)	37.51				Adjusted Chi Square Value (53.28, β)		36.52
66					95% Gamma Approximate UCL (use when n>=50)	4.399				95% Gamma Adjusted UCL (use when n<50)		N/A
67												
68	**Estimates of Gamma Parameters using KM Estimates**											
69					Mean (KM)	5.068				SD (KM)		0.643
70					Variance (KM)	0.414				SE of Mean (KM)		0.158
71					k hat (KM)	62.05				k star (KM)		53.62
72					nu hat (KM)	2730				nu star (KM)		2359
73					theta hat (KM)	0.0817				theta star (KM)		0.0945
74					80% gamma percentile (KM)	5.64				90% gamma percentile (KM)		5.973
75					95% gamma percentile (KM)	6.258				99% gamma percentile (KM)		6.816
76												
77	**Gamma Kaplan-Meier (KM) Statistics**											
78					Approximate Chi Square Value (N/A, α)	2247				Adjusted Chi Square Value (N/A, β)		2239
79					95% Gamma Approximate KM-UCL (use when n>=50)	5.32				95% Gamma Adjusted KM-UCL (use when n<50)		5.34
80												
81	**Lognormal GOF Test on Detected Observations Only**											
82					Shapiro Wilk Test Statistic	0.99				**Shapiro Wilk GOF Test**		
83					5% Shapiro Wilk Critical Value	0.748				Detected Data appear Lognormal at 5% Significance Level		
84					Lilliefors Test Statistic	0.168				**Lilliefors GOF Test**		
85					5% Lilliefors Critical Value	0.375				Detected Data appear Lognormal at 5% Significance Level		
86	**Detected Data appear Lognormal at 5% Significance Level**											
87												
88	**Lognormal ROS Statistics Using Imputed Non-Detects**											
89					Mean in Original Scale	3.831				Mean in Log Scale		1.285
90					SD in Original Scale	1.4				SD in Log Scale		0.344
91					95% t UCL (assumes normality of ROS data)	4.345				95% Percentile Bootstrap UCL		4.319
92					95% BCA Bootstrap UCL	4.402				95% Bootstrap t UCL		4.481
93					95% H-UCL (Log ROS)	4.413						
94												
95	**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**											
96					KM Mean (logged)	1.616				KM Geo Mean		5.034
97					KM SD (logged)	0.112				95% Critical H Value (KM-Log)		1.73
98					KM Standard Error of Mean (logged)	0.0276				95% H-UCL (KM -Log)		5.284
99					KM SD (logged)	0.112				95% Critical H Value (KM-Log)		1.73
100					KM Standard Error of Mean (logged)	0.0276						
101												

	A	B	C	D	E	F	G	H	I	J	K	L
102	DL/2 Statistics											
103	DL/2 Normal						DL/2 Log-Transformed					
104					Mean in Original Scale	3.152				Mean in Log Scale		1.069
105					SD in Original Scale	1.538				SD in Log Scale		0.371
106					95% t UCL (Assumes normality)	3.717				95% H-Stat UCL		3.634
107	DL/2 is not a recommended method, provided for comparisons and historical reasons											
108												
109	Nonparametric Distribution Free UCL Statistics											
110	Detected Data appear Normal Distributed at 5% Significance Level											
111												
112	Suggested UCL to Use											
113					95% KM (t) UCL	5.341						
114												
115	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
116	Recommendations are based upon data size, data distribution, and skewness.											
117	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
118	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
119												
120												
121	Arsenic											
122												
123	General Statistics											
124					Total Number of Observations	22				Number of Distinct Observations		15
125										Number of Missing Observations		0
126					Minimum	19				Mean		115.1
127					Maximum	250				Median		120
128					SD	76.61				Std. Error of Mean		16.33
129					Coefficient of Variation	0.665				Skewness		0.398
130												
131	Normal GOF Test											
132					Shapiro Wilk Test Statistic	0.92	Shapiro Wilk GOF Test					
133					5% Shapiro Wilk Critical Value	0.911	Data appear Normal at 5% Significance Level					
134					Lilliefors Test Statistic	0.122	Lilliefors GOF Test					
135					5% Lilliefors Critical Value	0.184	Data appear Normal at 5% Significance Level					
136	Data appear Normal at 5% Significance Level											
137												
138	Assuming Normal Distribution											
139	95% Normal UCL						95% UCLs (Adjusted for Skewness)					
140					95% Student's-t UCL	143.2				95% Adjusted-CLT UCL (Chen-1995)		143.5
141										95% Modified-t UCL (Johnson-1978)		143.5
142												
143	Gamma GOF Test											
144					A-D Test Statistic	0.587	Anderson-Darling Gamma GOF Test					
145					5% A-D Critical Value	0.757	Detected data appear Gamma Distributed at 5% Significance Level					
146					K-S Test Statistic	0.164	Kolmogorov-Smirnov Gamma GOF Test					
147					5% K-S Critical Value	0.188	Detected data appear Gamma Distributed at 5% Significance Level					
148	Detected data appear Gamma Distributed at 5% Significance Level											
149												

	A	B	C	D	E	F	G	H	I	J	K	L
150						Gamma Statistics						
151					k hat (MLE)	1.872					k star (bias corrected MLE)	1.647
152					Theta hat (MLE)	61.51					Theta star (bias corrected MLE)	69.91
153					nu hat (MLE)	82.36					nu star (bias corrected)	72.46
154					MLE Mean (bias corrected)	115.1					MLE Sd (bias corrected)	89.72
155											Approximate Chi Square Value (0.05)	53.86
156					Adjusted Level of Significance	0.0386					Adjusted Chi Square Value	52.67
157												
158						Assuming Gamma Distribution						
159					95% Approximate Gamma UCL (use when n>=50))	154.9					95% Adjusted Gamma UCL (use when n<50)	158.4
160												
161						Lognormal GOF Test						
162					Shapiro Wilk Test Statistic	0.9					Shapiro Wilk Lognormal GOF Test	
163					5% Shapiro Wilk Critical Value	0.911					Data Not Lognormal at 5% Significance Level	
164					Lilliefors Test Statistic	0.195					Lilliefors Lognormal GOF Test	
165					5% Lilliefors Critical Value	0.184					Data Not Lognormal at 5% Significance Level	
166						Data Not Lognormal at 5% Significance Level						
167												
168						Lognormal Statistics						
169					Minimum of Logged Data	2.944					Mean of logged Data	4.456
170					Maximum of Logged Data	5.521					SD of logged Data	0.861
171												
172						Assuming Lognormal Distribution						
173					95% H-UCL	195.7					90% Chebyshev (MVUE) UCL	195.9
174					95% Chebyshev (MVUE) UCL	229.4					97.5% Chebyshev (MVUE) UCL	275.8
175					99% Chebyshev (MVUE) UCL	367.1						
176												
177						Nonparametric Distribution Free UCL Statistics						
178						Data appear to follow a Discernible Distribution at 5% Significance Level						
179												
180						Nonparametric Distribution Free UCLs						
181					95% CLT UCL	142					95% Jackknife UCL	143.2
182					95% Standard Bootstrap UCL	141.7					95% Bootstrap-t UCL	145.7
183					95% Hall's Bootstrap UCL	144					95% Percentile Bootstrap UCL	141
184					95% BCA Bootstrap UCL	142.4						
185					90% Chebyshev(Mean, Sd) UCL	164.1					95% Chebyshev(Mean, Sd) UCL	186.3
186					97.5% Chebyshev(Mean, Sd) UCL	217.1					99% Chebyshev(Mean, Sd) UCL	277.6
187												
188						Suggested UCL to Use						
189					95% Student's-t UCL	143.2						
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												

	A	B	C	D	E	F	G	H	I	J	K	L
197	**Barium**											
198												
199						**General Statistics**						
200					Total Number of Observations	22				Number of Distinct Observations		19
201										Number of Missing Observations		0
202					Minimum	6.7				Mean		27.6
203					Maximum	64				Median		23
204					SD	15.64				Std. Error of Mean		3.334
205					Coefficient of Variation	0.566				Skewness		0.714
206												
207						**Normal GOF Test**						
208					Shapiro Wilk Test Statistic	0.933				**Shapiro Wilk GOF Test**		
209					5% Shapiro Wilk Critical Value	0.911				Data appear Normal at 5% Significance Level		
210					Lilliefors Test Statistic	0.157				**Lilliefors GOF Test**		
211					5% Lilliefors Critical Value	0.184				Data appear Normal at 5% Significance Level		
212						**Data appear Normal at 5% Significance Level**						
213												
214						**Assuming Normal Distribution**						
215					**95% Normal UCL**					**95% UCLs (Adjusted for Skewness)**		
216					95% Student's-t UCL	33.34				95% Adjusted-CLT UCL (Chen-1995)		33.63
217										95% Modified-t UCL (Johnson-1978)		33.43
218												
219						**Gamma GOF Test**						
220					A-D Test Statistic	0.267				**Anderson-Darling Gamma GOF Test**		
221					5% A-D Critical Value	0.749				Detected data appear Gamma Distributed at 5% Significance Level		
222					K-S Test Statistic	0.117				**Kolmogorov-Smirnov Gamma GOF Test**		
223					5% K-S Critical Value	0.187				Detected data appear Gamma Distributed at 5% Significance Level		
224						**Detected data appear Gamma Distributed at 5% Significance Level**						
225												
226						**Gamma Statistics**						
227					k hat (MLE)	3.171				k star (bias corrected MLE)		2.769
228					Theta hat (MLE)	8.705				Theta star (bias corrected MLE)		9.969
229					nu hat (MLE)	139.5				nu star (bias corrected)		121.8
230					MLE Mean (bias corrected)	27.6				MLE Sd (bias corrected)		16.59
231										Approximate Chi Square Value (0.05)		97.35
232					Adjusted Level of Significance	0.0386				Adjusted Chi Square Value		95.71
233												
234						**Assuming Gamma Distribution**						
235					95% Approximate Gamma UCL (use when n>=50))	34.55				95% Adjusted Gamma UCL (use when n<50)		35.14
236												
237						**Lognormal GOF Test**						
238					Shapiro Wilk Test Statistic	0.966				**Shapiro Wilk Lognormal GOF Test**		
239					5% Shapiro Wilk Critical Value	0.911				Data appear Lognormal at 5% Significance Level		
240					Lilliefors Test Statistic	0.116				**Lilliefors Lognormal GOF Test**		
241					5% Lilliefors Critical Value	0.184				Data appear Lognormal at 5% Significance Level		
242						**Data appear Lognormal at 5% Significance Level**						
243												
244						**Lognormal Statistics**						
245					Minimum of Logged Data	1.902				Mean of logged Data		3.152
246					Maximum of Logged Data	4.159				SD of logged Data		0.613
247												

	A	B	C	D	E	F	G	H	I	J	K	L
248	Assuming Lognormal Distribution											
249					95% H-UCL	37.41				90% Chebyshev (MVUE) UCL		39.51
250					95% Chebyshev (MVUE) UCL	44.75				97.5% Chebyshev (MVUE) UCL		52.02
251					99% Chebyshev (MVUE) UCL	66.3						
252												
253	Nonparametric Distribution Free UCL Statistics											
254	Data appear to follow a Discernible Distribution at 5% Significance Level											
255												
256	Nonparametric Distribution Free UCLs											
257					95% CLT UCL	33.09				95% Jackknife UCL		33.34
258					95% Standard Bootstrap UCL	32.84				95% Bootstrap-t UCL		33.76
259					95% Hall's Bootstrap UCL	33.64				95% Percentile Bootstrap UCL		32.77
260					95% BCA Bootstrap UCL	33.32						
261					90% Chebyshev(Mean, Sd) UCL	37.61				95% Chebyshev(Mean, Sd) UCL		42.14
262					97.5% Chebyshev(Mean, Sd) UCL	48.43				99% Chebyshev(Mean, Sd) UCL		60.78
263												
264	Suggested UCL to Use											
265					95% Student's-t UCL	33.34						
266												
267	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
268	Recommendations are based upon data size, data distribution, and skewness.											
269	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
270	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
271												
272	Cadmium											
273												
274	General Statistics											
275					Total Number of Observations	22				Number of Distinct Observations		11
276					Number of Detects	9				Number of Non-Detects		13
277					Number of Distinct Detects	8				Number of Distinct Non-Detects		3
278					Minimum Detect	0.75				Minimum Non-Detect		0.48
279					Maximum Detect	6.8				Maximum Non-Detect		0.5
280					Variance Detects	3.649				Percent Non-Detects		59.09%
281					Mean Detects	1.823				SD Detects		1.91
282					Median Detects	1.3				CV Detects		1.048
283					Skewness Detects	2.746				Kurtosis Detects		7.854
284					Mean of Logged Detects	0.325				SD of Logged Detects		0.687
285												
286	Normal GOF Test on Detects Only											
287					Shapiro Wilk Test Statistic	0.584				Shapiro Wilk GOF Test		
288					5% Shapiro Wilk Critical Value	0.829				Detected Data Not Normal at 5% Significance Level		
289					Lilliefors Test Statistic	0.373				Lilliefors GOF Test		
290					5% Lilliefors Critical Value	0.274				Detected Data Not Normal at 5% Significance Level		
291	Detected Data Not Normal at 5% Significance Level											
292												
293	Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs											
294					KM Mean	1.03				KM Standard Error of Mean		0.3
295					KM SD	1.328				95% KM (BCA) UCL		1.577
296					95% KM (t) UCL	1.546				95% KM (Percentile Bootstrap) UCL		1.568
297					95% KM (z) UCL	1.523				95% KM Bootstrap t UCL		2.496
298					90% KM Chebyshev UCL	1.93				95% KM Chebyshev UCL		2.338
299					97.5% KM Chebyshev UCL	2.905				99% KM Chebyshev UCL		4.017

	A	B	C	D	E	F	G	H	I	J	K	L
300												
301	**Gamma GOF Tests on Detected Observations Only**											
302					A-D Test Statistic	0.98	**Anderson-Darling GOF Test**					
303					5% A-D Critical Value	0.73	Detected Data Not Gamma Distributed at 5% Significance Level					
304					K-S Test Statistic	0.272	**Kolmogorov-Smirnov GOF**					
305					5% K-S Critical Value	0.283	Detected data appear Gamma Distributed at 5% Significance Level					
306	**Detected data follow Appr. Gamma Distribution at 5% Significance Level**											
307												
308	**Gamma Statistics on Detected Data Only**											
309					k hat (MLE)	1.964	k star (bias corrected MLE)					1.383
310					Theta hat (MLE)	0.928	Theta star (bias corrected MLE)					1.318
311					nu hat (MLE)	35.35	nu star (bias corrected)					24.9
312					Mean (detects)	1.823						
313												
314	**Gamma ROS Statistics using Imputed Non-Detects**											
315	GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs											
316	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)											
317	For such situations, GROS method may yield incorrect values of UCLs and BTVs											
318	This is especially true when the sample size is small.											
319	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates											
320					Minimum	0.01	Mean					0.752
321					Maximum	6.8	Median					0.01
322					SD	1.491	CV					1.983
323					k hat (MLE)	0.299	k star (bias corrected MLE)					0.289
324					Theta hat (MLE)	2.51	Theta star (bias corrected MLE)					2.602
325					nu hat (MLE)	13.18	nu star (bias corrected)					12.71
326					Adjusted Level of Significance (β)	0.0386						
327					Approximate Chi Square Value (12.71, α)	5.701	Adjusted Chi Square Value (12.71, β)					5.353
328					95% Gamma Approximate UCL (use when n>=50)	1.677	95% Gamma Adjusted UCL (use when n<50)					1.786
329												
330	**Estimates of Gamma Parameters using KM Estimates**											
331					Mean (KM)	1.03	SD (KM)					1.328
332					Variance (KM)	1.763	SE of Mean (KM)					0.3
333					k hat (KM)	0.601	k star (KM)					0.55
334					nu hat (KM)	26.45	nu star (KM)					24.18
335					theta hat (KM)	1.712	theta star (KM)					1.873
336					80% gamma percentile (KM)	1.696	90% gamma percentile (KM)					2.73
337					95% gamma percentile (KM)	3.824	99% gamma percentile (KM)					6.489
338												
339	**Gamma Kaplan-Meier (KM) Statistics**											
340					Approximate Chi Square Value (24.18, α)	13.99	Adjusted Chi Square Value (24.18, β)					13.41
341					95% Gamma Approximate KM-UCL (use when n>=50)	1.78	95% Gamma Adjusted KM-UCL (use when n<50)					1.857
342												
343	**Lognormal GOF Test on Detected Observations Only**											
344					Shapiro Wilk Test Statistic	0.82	**Shapiro Wilk GOF Test**					
345					5% Shapiro Wilk Critical Value	0.829	Detected Data Not Lognormal at 5% Significance Level					
346					Lilliefors Test Statistic	0.211	**Lilliefors GOF Test**					
347					5% Lilliefors Critical Value	0.274	Detected Data appear Lognormal at 5% Significance Level					
348	**Detected Data appear Approximate Lognormal at 5% Significance Level**											
349												

	A	B	C	D	E	F	G	H	I	J	K	L
350	**Lognormal ROS Statistics Using Imputed Non-Detects**											
351					Mean in Original Scale	0.865					Mean in Log Scale	-0.913
352					SD in Original Scale	1.436					SD in Log Scale	1.234
353				95% t UCL (assumes normality of ROS data)		1.392					95% Percentile Bootstrap UCL	1.417
354					95% BCA Bootstrap UCL	1.751					95% Bootstrap t UCL	2.163
355					95% H-UCL (Log ROS)	1.888						
356												
357	**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**											
358					KM Mean (logged)	-0.301					KM Geo Mean	0.74
359					KM SD (logged)	0.665					95% Critical H Value (KM-Log)	2.164
360					KM Standard Error of Mean (logged)	0.15					95% H-UCL (KM -Log)	1.264
361					KM SD (logged)	0.665					95% Critical H Value (KM-Log)	2.164
362					KM Standard Error of Mean (logged)	0.15						
363												
364	**DL/2 Statistics**											
365				**DL/2 Normal**						**DL/2 Log-Transformed**		
366					Mean in Original Scale	0.891					Mean in Log Scale	-0.695
367					SD in Original Scale	1.421					SD in Log Scale	0.967
368					95% t UCL (Assumes normality)	1.413					95% H-Stat UCL	1.36
369	**DL/2 is not a recommended method, provided for comparisons and historical reasons**											
370												
371	**Nonparametric Distribution Free UCL Statistics**											
372	**Detected Data appear Approximate Gamma Distributed at 5% Significance Level**											
373												
374	**Suggested UCL to Use**											
375					95% KM Adjusted Gamma UCL	1.857					95% GROS Adjusted Gamma UCL	1.786
376												
377	When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test											
378	When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL											
379												
380	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
381	Recommendations are based upon data size, data distribution, and skewness.											
382	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
383	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
384												
385	**Chromium**											
386												
387	**General Statistics**											
388					Total Number of Observations	22					Number of Distinct Observations	7
389					Number of Detects	7					Number of Non-Detects	15
390					Number of Distinct Detects	6					Number of Distinct Non-Detects	2
391					Minimum Detect	2					Minimum Non-Detect	1.9
392					Maximum Detect	14					Maximum Non-Detect	2
393					Variance Detects	15.46					Percent Non-Detects	68.18%
394					Mean Detects	6.157					SD Detects	3.932
395					Median Detects	6.3					CV Detects	0.639
396					Skewness Detects	1.387					Kurtosis Detects	2.921
397					Mean of Logged Detects	1.644					SD of Logged Detects	0.653
398												

	A	B	C	D	E	F	G	H	I	J	K	L
399	**Normal GOF Test on Detects Only**											
400					Shapiro Wilk Test Statistic	0.836	**Shapiro Wilk GOF Test**					
401					5% Shapiro Wilk Critical Value	0.803	Detected Data appear Normal at 5% Significance Level					
402					Lilliefors Test Statistic	0.322	**Lilliefors GOF Test**					
403					5% Lilliefors Critical Value	0.304	Detected Data Not Normal at 5% Significance Level					
404	**Detected Data appear Approximate Normal at 5% Significance Level**											
405												
406	**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**											
407					KM Mean	3.255	KM Standard Error of Mean					0.657
408					KM SD	2.854	95% KM (BCA) UCL					4.532
409					95% KM (t) UCL	4.386	95% KM (Percentile Bootstrap) UCL					4.364
410					95% KM (z) UCL	4.336	95% KM Bootstrap t UCL					4.876
411					90% KM Chebyshev UCL	5.227	95% KM Chebyshev UCL					6.12
412					97.5% KM Chebyshev UCL	7.36	99% KM Chebyshev UCL					9.795
413												
414	**Gamma GOF Tests on Detected Observations Only**											
415					A-D Test Statistic	0.466	**Anderson-Darling GOF Test**					
416					5% A-D Critical Value	0.712	Detected data appear Gamma Distributed at 5% Significance Level					
417					K-S Test Statistic	0.244	**Kolmogorov-Smirnov GOF**					
418					5% K-S Critical Value	0.314	Detected data appear Gamma Distributed at 5% Significance Level					
419	**Detected data appear Gamma Distributed at 5% Significance Level**											
420												
421	**Gamma Statistics on Detected Data Only**											
422					k hat (MLE)	3.032	k star (bias corrected MLE)					1.828
423					Theta hat (MLE)	2.031	Theta star (bias corrected MLE)					3.369
424					nu hat (MLE)	42.45	nu star (bias corrected)					25.59
425					Mean (detects)	6.157						
426												
427	**Gamma ROS Statistics using Imputed Non-Detects**											
428	GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs											
429	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)											
430	For such situations, GROS method may yield incorrect values of UCLs and BTVs											
431	This is especially true when the sample size is small.											
432	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates											
433					Minimum	0.01	Mean					1.979
434					Maximum	14	Median					0.01
435					SD	3.599	CV					1.819
436					k hat (MLE)	0.229	k star (bias corrected MLE)					0.228
437					Theta hat (MLE)	8.64	Theta star (bias corrected MLE)					8.676
438					nu hat (MLE)	10.08	nu star (bias corrected)					10.04
439					Adjusted Level of Significance (β)	0.0386						
440					Approximate Chi Square Value (10.04, α)	3.965	Adjusted Chi Square Value (10.04, β)					3.684
441					95% Gamma Approximate UCL (use when n>=50)	5.01	95% Gamma Adjusted UCL (use when n<50)					5.393
442												
443	**Estimates of Gamma Parameters using KM Estimates**											
444					Mean (KM)	3.255	SD (KM)					2.854
445					Variance (KM)	8.148	SE of Mean (KM)					0.657
446					k hat (KM)	1.3	k star (KM)					1.153
447					nu hat (KM)	57.2	nu star (KM)					50.73
448					theta hat (KM)	2.504	theta star (KM)					2.823
449					80% gamma percentile (KM)	5.173	90% gamma percentile (KM)					7.235
450					95% gamma percentile (KM)	9.275	99% gamma percentile (KM)					13.96

	A	B	C	D	E	F	G	H	I	J	K	L
451												
452						Gamma Kaplan-Meier (KM) Statistics						
453					Approximate Chi Square Value (50.73, α)	35.38			Adjusted Chi Square Value (50.73, β)			34.42
454					95% Gamma Approximate KM-UCL (use when n>=50)	4.667			95% Gamma Adjusted KM-UCL (use when n<50)			4.797
455												
456						Lognormal GOF Test on Detected Observations Only						
457					Shapiro Wilk Test Statistic	0.905			Shapiro Wilk GOF Test			
458					5% Shapiro Wilk Critical Value	0.803			Detected Data appear Lognormal at 5% Significance Level			
459					Lilliefors Test Statistic	0.252			Lilliefors GOF Test			
460					5% Lilliefors Critical Value	0.304			Detected Data appear Lognormal at 5% Significance Level			
461						Detected Data appear Lognormal at 5% Significance Level						
462												
463						Lognormal ROS Statistics Using Imputed Non-Detects						
464					Mean in Original Scale	2.447			Mean in Log Scale			0.109
465					SD in Original Scale	3.364			SD in Log Scale			1.313
466					95% t UCL (assumes normality of ROS data)	3.681			95% Percentile Bootstrap UCL			3.722
467					95% BCA Bootstrap UCL	4.091			95% Bootstrap t UCL			4.331
468					95% H-UCL (Log ROS)	6.318						
469												
470						Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution						
471					KM Mean (logged)	0.961			KM Geo Mean			2.613
472					KM SD (logged)	0.578			95% Critical H Value (KM-Log)			2.072
473					KM Standard Error of Mean (logged)	0.133			95% H-UCL (KM -Log)			4.011
474					KM SD (logged)	0.578			95% Critical H Value (KM-Log)			2.072
475					KM Standard Error of Mean (logged)	0.133						
476												
477						DL/2 Statistics						
478					DL/2 Normal				DL/2 Log-Transformed			
479					Mean in Original Scale	2.634			Mean in Log Scale			0.516
480					SD in Original Scale	3.238			SD in Log Scale			0.862
481					95% t UCL (Assumes normality)	3.822			95% H-Stat UCL			3.817
482						DL/2 is not a recommended method, provided for comparisons and historical reasons						
483												
484						Nonparametric Distribution Free UCL Statistics						
485						Detected Data appear Approximate Normal Distributed at 5% Significance Level						
486												
487						Suggested UCL to Use						
488					95% KM (t) UCL	4.386						
489												
490						When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test						
491						When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL						
492												
493						Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.						
494						Recommendations are based upon data size, data distribution, and skewness.						
495						These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).						
496						However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.						
497												
498												

	A	B	C	D	E	F	G	H	I	J	K	L
499	Copper											
500												
501						General Statistics						
502					Total Number of Observations	22				Number of Distinct Observations		20
503										Number of Missing Observations		0
504					Minimum	240				Mean		3260
505					Maximum	22000				Median		2200
506					SD	4520				Std. Error of Mean		963.7
507					Coefficient of Variation	1.386				Skewness		3.658
508												
509						Normal GOF Test						
510					Shapiro Wilk Test Statistic	0.565				Shapiro Wilk GOF Test		
511					5% Shapiro Wilk Critical Value	0.911				Data Not Normal at 5% Significance Level		
512					Lilliefors Test Statistic	0.259				Lilliefors GOF Test		
513					5% Lilliefors Critical Value	0.184				Data Not Normal at 5% Significance Level		
514						Data Not Normal at 5% Significance Level						
515												
516						Assuming Normal Distribution						
517					95% Normal UCL					95% UCLs (Adjusted for Skewness)		
518					95% Student's-t UCL	4919				95% Adjusted-CLT UCL (Chen-1995)		5649
519										95% Modified-t UCL (Johnson-1978)		5044
520												
521						Gamma GOF Test						
522					A-D Test Statistic	0.48				Anderson-Darling Gamma GOF Test		
523					5% A-D Critical Value	0.77				Detected data appear Gamma Distributed at 5% Significance Level		
524					K-S Test Statistic	0.125				Kolmogorov-Smirnov Gamma GOF Test		
525					5% K-S Critical Value	0.191				Detected data appear Gamma Distributed at 5% Significance Level		
526						Detected data appear Gamma Distributed at 5% Significance Level						
527												
528						Gamma Statistics						
529					k hat (MLE)	1.017				k star (bias corrected MLE)		0.909
530					Theta hat (MLE)	3206				Theta star (bias corrected MLE)		3588
531					nu hat (MLE)	44.75				nu star (bias corrected)		39.98
532					MLE Mean (bias corrected)	3260				MLE Sd (bias corrected)		3421
533										Approximate Chi Square Value (0.05)		26.49
534					Adjusted Level of Significance	0.0386				Adjusted Chi Square Value		25.67
535												
536						Assuming Gamma Distribution						
537					95% Approximate Gamma UCL (use when n>=50)	4920				95% Adjusted Gamma UCL (use when n<50)		5077
538												
539						Lognormal GOF Test						
540					Shapiro Wilk Test Statistic	0.966				Shapiro Wilk Lognormal GOF Test		
541					5% Shapiro Wilk Critical Value	0.911				Data appear Lognormal at 5% Significance Level		
542					Lilliefors Test Statistic	0.102				Lilliefors Lognormal GOF Test		
543					5% Lilliefors Critical Value	0.184				Data appear Lognormal at 5% Significance Level		
544						Data appear Lognormal at 5% Significance Level						
545												
546						Lognormal Statistics						
547					Minimum of Logged Data	5.481				Mean of logged Data		7.523
548					Maximum of Logged Data	9.999				SD of logged Data		1.102
549												

	A	B	C	D	E	F	G	H	I	J	K	L
550	**Assuming Lognormal Distribution**											
551					95% H-UCL	6536				90% Chebyshev (MVUE) UCL		5886
552					95% Chebyshev (MVUE) UCL	7077				97.5% Chebyshev (MVUE) UCL		8730
553					99% Chebyshev (MVUE) UCL	11976						
554												
555	**Nonparametric Distribution Free UCL Statistics**											
556	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
557												
558	**Nonparametric Distribution Free UCLs**											
559					95% CLT UCL	4846				95% Jackknife UCL		4919
560					95% Standard Bootstrap UCL	4775				95% Bootstrap-t UCL		6883
561					95% Hall's Bootstrap UCL	11160				95% Percentile Bootstrap UCL		4947
562					95% BCA Bootstrap UCL	6208						
563					90% Chebyshev(Mean, Sd) UCL	6152				95% Chebyshev(Mean, Sd) UCL		7461
564					97.5% Chebyshev(Mean, Sd) UCL	9279				99% Chebyshev(Mean, Sd) UCL		12849
565												
566	**Suggested UCL to Use**											
567					95% Adjusted Gamma UCL	5077						
568												
569	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
570	Recommendations are based upon data size, data distribution, and skewness.											
571	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
572	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
573												
574												
575	**Lead**											
576												
577	**General Statistics**											
578					Total Number of Observations	22				Number of Distinct Observations		18
579										Number of Missing Observations		0
580					Minimum	5.7				Mean		36.15
581					Maximum	140				Median		22
582					SD	31.21				Std. Error of Mean		6.653
583					Coefficient of Variation	0.863				Skewness		1.858
584												
585	**Normal GOF Test**											
586					Shapiro Wilk Test Statistic	0.805				**Shapiro Wilk GOF Test**		
587					5% Shapiro Wilk Critical Value	0.911				Data Not Normal at 5% Significance Level		
588					Lilliefors Test Statistic	0.22				**Lilliefors GOF Test**		
589					5% Lilliefors Critical Value	0.184				Data Not Normal at 5% Significance Level		
590	**Data Not Normal at 5% Significance Level**											
591												
592	**Assuming Normal Distribution**											
593					**95% Normal UCL**					**95% UCLs (Adjusted for Skewness)**		
594					95% Student's-t UCL	47.6				95% Adjusted-CLT UCL (Chen-1995)		49.91
595										95% Modified-t UCL (Johnson-1978)		48.04
596												
597	**Gamma GOF Test**											
598					A-D Test Statistic	0.55				**Anderson-Darling Gamma GOF Test**		
599					5% A-D Critical Value	0.758				Detected data appear Gamma Distributed at 5% Significance Level		
600					K-S Test Statistic	0.174				**Kolmogorov-Smirnov Gamma GOF Test**		
601					5% K-S Critical Value	0.188				Detected data appear Gamma Distributed at 5% Significance Level		

	A	B	C	D	E	F	G	H	I	J	K	L
602	**Detected data appear Gamma Distributed at 5% Significance Level**											
603												
604	**Gamma Statistics**											
605					k hat (MLE)	1.691			k star (bias corrected MLE)			1.491
606					Theta hat (MLE)	21.38			Theta star (bias corrected MLE)			24.25
607					nu hat (MLE)	74.41			nu star (bias corrected)			65.6
608					MLE Mean (bias corrected)	36.15			MLE Sd (bias corrected)			29.61
609									Approximate Chi Square Value (0.05)			47.96
610					Adjusted Level of Significance	0.0386			Adjusted Chi Square Value			46.83
611												
612	**Assuming Gamma Distribution**											
613					95% Approximate Gamma UCL (use when n>=50)	49.44			95% Adjusted Gamma UCL (use when n<50)			50.63
614												
615	**Lognormal GOF Test**											
616					Shapiro Wilk Test Statistic	0.963			**Shapiro Wilk Lognormal GOF Test**			
617					5% Shapiro Wilk Critical Value	0.911			Data appear Lognormal at 5% Significance Level			
618					Lilliefors Test Statistic	0.149			**Lilliefors Lognormal GOF Test**			
619					5% Lilliefors Critical Value	0.184			Data appear Lognormal at 5% Significance Level			
620	**Data appear Lognormal at 5% Significance Level**											
621												
622	**Lognormal Statistics**											
623					Minimum of Logged Data	1.74			Mean of logged Data			3.264
624					Maximum of Logged Data	4.942			SD of logged Data			0.836
625												
626	**Assuming Lognormal Distribution**											
627					95% H-UCL	57.06			90% Chebyshev (MVUE) UCL			57.58
628					95% Chebyshev (MVUE) UCL	67.21			97.5% Chebyshev (MVUE) UCL			80.58
629					99% Chebyshev (MVUE) UCL	106.8						
630												
631	**Nonparametric Distribution Free UCL Statistics**											
632	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
633												
634	**Nonparametric Distribution Free UCLs**											
635					95% CLT UCL	47.09			95% Jackknife UCL			47.6
636					95% Standard Bootstrap UCL	47			95% Bootstrap-t UCL			52.24
637					95% Hall's Bootstrap UCL	57.15			95% Percentile Bootstrap UCL			47.55
638					95% BCA Bootstrap UCL	49.47						
639					90% Chebyshev(Mean, Sd) UCL	56.11			95% Chebyshev(Mean, Sd) UCL			65.15
640					97.5% Chebyshev(Mean, Sd) UCL	77.7			99% Chebyshev(Mean, Sd) UCL			102.3
641												
642	**Suggested UCL to Use**											
643					95% Adjusted Gamma UCL	50.63						
644												
645	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
646	Recommendations are based upon data size, data distribution, and skewness.											
647	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
648	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
649												
650												

	A	B	C	D	E	F	G	H	I	J	K	L
651	**Manganese**											
652												
653						**General Statistics**						
654					Total Number of Observations	22				Number of Distinct Observations		20
655										Number of Missing Observations		0
656					Minimum	150				Mean		623.6
657					Maximum	2400				Median		395
658					SD	519.3				Std. Error of Mean		110.7
659					Coefficient of Variation	0.833				Skewness		2.113
660												
661						**Normal GOF Test**						
662					Shapiro Wilk Test Statistic	0.771				**Shapiro Wilk GOF Test**		
663					5% Shapiro Wilk Critical Value	0.911				Data Not Normal at 5% Significance Level		
664					Lilliefors Test Statistic	0.212				**Lilliefors GOF Test**		
665					5% Lilliefors Critical Value	0.184				Data Not Normal at 5% Significance Level		
666						**Data Not Normal at 5% Significance Level**						
667												
668						**Assuming Normal Distribution**						
669					**95% Normal UCL**					**95% UCLs (Adjusted for Skewness)**		
670					95% Student's-t UCL	814.2				95% Adjusted-CLT UCL (Chen-1995)		859.1
671										95% Modified-t UCL (Johnson-1978)		822.5
672												
673						**Gamma GOF Test**						
674					A-D Test Statistic	0.636				**Anderson-Darling Gamma GOF Test**		
675					5% A-D Critical Value	0.755				Detected data appear Gamma Distributed at 5% Significance Level		
676					K-S Test Statistic	0.186				**Kolmogorov-Smirnov Gamma GOF Test**		
677					5% K-S Critical Value	0.188				Detected data appear Gamma Distributed at 5% Significance Level		
678						**Detected data appear Gamma Distributed at 5% Significance Level**						
679												
680						**Gamma Statistics**						
681					k hat (MLE)	2.096				k star (bias corrected MLE)		1.841
682					Theta hat (MLE)	297.5				Theta star (bias corrected MLE)		338.8
683					nu hat (MLE)	92.23				nu star (bias corrected)		80.98
684					MLE Mean (bias corrected)	623.6				MLE Sd (bias corrected)		459.7
685										Approximate Chi Square Value (0.05)		61.25
686					Adjusted Level of Significance	0.0386				Adjusted Chi Square Value		59.97
687												
688						**Assuming Gamma Distribution**						
689					95% Approximate Gamma UCL (use when n>=50)	824.6				95% Adjusted Gamma UCL (use when n<50)		842.2
690												
691						**Lognormal GOF Test**						
692					Shapiro Wilk Test Statistic	0.959				**Shapiro Wilk Lognormal GOF Test**		
693					5% Shapiro Wilk Critical Value	0.911				Data appear Lognormal at 5% Significance Level		
694					Lilliefors Test Statistic	0.149				**Lilliefors Lognormal GOF Test**		
695					5% Lilliefors Critical Value	0.184				Data appear Lognormal at 5% Significance Level		
696						**Data appear Lognormal at 5% Significance Level**						
697												
698						**Lognormal Statistics**						
699					Minimum of Logged Data	5.011				Mean of logged Data		6.178
700					Maximum of Logged Data	7.783				SD of logged Data		0.71
701												

	A	B	C	D	E	F	G	H	I	J	K	L
702	**Assuming Lognormal Distribution**											
703					95% H-UCL	874			90% Chebyshev (MVUE) UCL			909.6
704					95% Chebyshev (MVUE) UCL	1044			97.5% Chebyshev (MVUE) UCL			1232
705					99% Chebyshev (MVUE) UCL	1600						
706												
707	**Nonparametric Distribution Free UCL Statistics**											
708	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
709												
710	**Nonparametric Distribution Free UCLs**											
711					95% CLT UCL	805.8			95% Jackknife UCL			814.2
712					95% Standard Bootstrap UCL	807			95% Bootstrap-t UCL			902.4
713					95% Hall's Bootstrap UCL	1007			95% Percentile Bootstrap UCL			823.6
714					95% BCA Bootstrap UCL	866.8						
715					90% Chebyshev(Mean, Sd) UCL	955.8			95% Chebyshev(Mean, Sd) UCL			1106
716					97.5% Chebyshev(Mean, Sd) UCL	1315			99% Chebyshev(Mean, Sd) UCL			1725
717												
718	**Suggested UCL to Use**											
719					95% Adjusted Gamma UCL	842.2						
720												
721	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
722	Recommendations are based upon data size, data distribution, and skewness.											
723	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
724	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
725												
726												
727	**Mercury**											
728												
729	**General Statistics**											
730					Total Number of Observations	22			Number of Distinct Observations			20
731									Number of Missing Observations			0
732					Minimum	0.14			Mean			0.942
733					Maximum	2.7			Median			0.625
734					SD	0.793			Std. Error of Mean			0.169
735					Coefficient of Variation	0.842			Skewness			1.025
736												
737	**Normal GOF Test**											
738					Shapiro Wilk Test Statistic	0.843			**Shapiro Wilk GOF Test**			
739					5% Shapiro Wilk Critical Value	0.911			Data Not Normal at 5% Significance Level			
740					Lilliefors Test Statistic	0.217			**Lilliefors GOF Test**			
741					5% Lilliefors Critical Value	0.184			Data Not Normal at 5% Significance Level			
742	**Data Not Normal at 5% Significance Level**											
743												
744	**Assuming Normal Distribution**											
745					**95% Normal UCL**				**95% UCLs (Adjusted for Skewness)**			
746					95% Student's-t UCL	1.233			95% Adjusted-CLT UCL (Chen-1995)			1.26
747									95% Modified-t UCL (Johnson-1978)			1.239
748												
749	**Gamma GOF Test**											
750					A-D Test Statistic	0.492			**Anderson-Darling Gamma GOF Test**			
751					5% A-D Critical Value	0.758			Detected data appear Gamma Distributed at 5% Significance Level			
752					K-S Test Statistic	0.13			**Kolmogorov-Smirnov Gamma GOF Test**			
753					5% K-S Critical Value	0.188			Detected data appear Gamma Distributed at 5% Significance Level			

	A	B	C	D	E	F	G	H	I	J	K	L
754	**Detected data appear Gamma Distributed at 5% Significance Level**											
755												
756	**Gamma Statistics**											
757					k hat (MLE)	1.554			k star (bias corrected MLE)			1.372
758					Theta hat (MLE)	0.606			Theta star (bias corrected MLE)			0.687
759					nu hat (MLE)	68.38			nu star (bias corrected)			60.39
760					MLE Mean (bias corrected)	0.942			MLE Sd (bias corrected)			0.804
761									Approximate Chi Square Value (0.05)			43.52
762					Adjusted Level of Significance	0.0386			Adjusted Chi Square Value			42.45
763												
764	**Assuming Gamma Distribution**											
765				95% Approximate Gamma UCL (use when n>=50)		1.308			95% Adjusted Gamma UCL (use when n<50)			1.34
766												
767	**Lognormal GOF Test**											
768					Shapiro Wilk Test Statistic	0.958			**Shapiro Wilk Lognormal GOF Test**			
769					5% Shapiro Wilk Critical Value	0.911			Data appear Lognormal at 5% Significance Level			
770					Lilliefors Test Statistic	0.109			**Lilliefors Lognormal GOF Test**			
771					5% Lilliefors Critical Value	0.184			Data appear Lognormal at 5% Significance Level			
772	**Data appear Lognormal at 5% Significance Level**											
773												
774	**Lognormal Statistics**											
775					Minimum of Logged Data	-1.966			Mean of logged Data			-0.414
776					Maximum of Logged Data	0.993			SD of logged Data			0.891
777												
778	**Assuming Lognormal Distribution**											
779					95% H-UCL	1.578			90% Chebyshev (MVUE) UCL			1.564
780					95% Chebyshev (MVUE) UCL	1.838			97.5% Chebyshev (MVUE) UCL			2.218
781					99% Chebyshev (MVUE) UCL	2.965						
782												
783	**Nonparametric Distribution Free UCL Statistics**											
784	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
785												
786	**Nonparametric Distribution Free UCLs**											
787					95% CLT UCL	1.22			95% Jackknife UCL			1.233
788					95% Standard Bootstrap UCL	1.213			95% Bootstrap-t UCL			1.294
789					95% Hall's Bootstrap UCL	1.242			95% Percentile Bootstrap UCL			1.211
790					95% BCA Bootstrap UCL	1.25						
791					90% Chebyshev(Mean, Sd) UCL	1.45			95% Chebyshev(Mean, Sd) UCL			1.679
792					97.5% Chebyshev(Mean, Sd) UCL	1.998			99% Chebyshev(Mean, Sd) UCL			2.625
793												
794	**Suggested UCL to Use**											
795					95% Adjusted Gamma UCL	1.34						
796												
797	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
798	Recommendations are based upon data size, data distribution, and skewness.											
799	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
800	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
801												

	A	B	C	D	E	F	G	H	I	J	K	L
802	Nickel											
803												
804	General Statistics											
805					Total Number of Observations	22				Number of Distinct Observations		11
806					Number of Detects	9				Number of Non-Detects		13
807					Number of Distinct Detects	9				Number of Distinct Non-Detects		2
808					Minimum Detect	2.1				Minimum Non-Detect		1.9
809					Maximum Detect	14				Maximum Non-Detect		2
810					Variance Detects	14.48				Percent Non-Detects		59.09%
811					Mean Detects	4.756				SD Detects		3.805
812					Median Detects	3.7				CV Detects		0.8
813					Skewness Detects	2.182				Kurtosis Detects		4.98
814					Mean of Logged Detects	1.36				SD of Logged Detects		0.619
815												
816	Normal GOF Test on Detects Only											
817					Shapiro Wilk Test Statistic	0.715	Shapiro Wilk GOF Test					
818					5% Shapiro Wilk Critical Value	0.829	Detected Data Not Normal at 5% Significance Level					
819					Lilliefors Test Statistic	0.325	Lilliefors GOF Test					
820					5% Lilliefors Critical Value	0.274	Detected Data Not Normal at 5% Significance Level					
821	Detected Data Not Normal at 5% Significance Level											
822												
823	Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs											
824					KM Mean	3.068				KM Standard Error of Mean		0.608
825					KM SD	2.69				95% KM (BCA) UCL		4.177
826					95% KM (t) UCL	4.115				95% KM (Percentile Bootstrap) UCL		4.195
827					95% KM (z) UCL	4.069				95% KM Bootstrap t UCL		6.08
828					90% KM Chebyshev UCL	4.893				95% KM Chebyshev UCL		5.72
829					97.5% KM Chebyshev UCL	6.867				99% KM Chebyshev UCL		9.121
830												
831	Gamma GOF Tests on Detected Observations Only											
832					A-D Test Statistic	0.645	Anderson-Darling GOF Test					
833					5% A-D Critical Value	0.728	Detected data appear Gamma Distributed at 5% Significance Level					
834					K-S Test Statistic	0.259	Kolmogorov-Smirnov GOF					
835					5% K-S Critical Value	0.282	Detected data appear Gamma Distributed at 5% Significance Level					
836	Detected data appear Gamma Distributed at 5% Significance Level											
837												
838	Gamma Statistics on Detected Data Only											
839					k hat (MLE)	2.658				k star (bias corrected MLE)		1.846
840					Theta hat (MLE)	1.789				Theta star (bias corrected MLE)		2.576
841					nu hat (MLE)	47.84				nu star (bias corrected)		33.22
842					Mean (detects)	4.756						
843												
844	Gamma ROS Statistics using Imputed Non-Detects											
845	GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs											
846	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)											
847	For such situations, GROS method may yield incorrect values of UCLs and BTVs											
848	This is especially true when the sample size is small.											
849	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates											
850					Minimum	0.01				Mean		1.951
851					Maximum	14				Median		0.01
852					SD	3.35				CV		1.717
853					k hat (MLE)	0.251				k star (bias corrected MLE)		0.247

	A	B	C	D	E	F	G	H	I	J	K	L
854					Theta hat (MLE)	7.788					Theta star (bias corrected MLE)	7.91
855					nu hat (MLE)	11.03					nu star (bias corrected)	10.86
856					Adjusted Level of Significance (β)	0.0386						
857					Approximate Chi Square Value (10.86, α)	4.483					Adjusted Chi Square Value (10.86, β)	4.181
858					95% Gamma Approximate UCL (use when n>=50)	4.725					95% Gamma Adjusted UCL (use when n<50)	5.067
859												
860					**Estimates of Gamma Parameters using KM Estimates**							
861					Mean (KM)	3.068					SD (KM)	2.69
862					Variance (KM)	7.237					SE of Mean (KM)	0.608
863					k hat (KM)	1.301					k star (KM)	1.154
864					nu hat (KM)	57.24					nu star (KM)	50.76
865					theta hat (KM)	2.359					theta star (KM)	2.659
866					80% gamma percentile (KM)	4.876					90% gamma percentile (KM)	6.82
867					95% gamma percentile (KM)	8.742					99% gamma percentile (KM)	13.16
868												
869					**Gamma Kaplan-Meier (KM) Statistics**							
870					Approximate Chi Square Value (50.76, α)	35.4					Adjusted Chi Square Value (50.76, β)	34.45
871					95% Gamma Approximate KM-UCL (use when n>=50)	4.399					95% Gamma Adjusted KM-UCL (use when n<50)	4.522
872												
873					**Lognormal GOF Test on Detected Observations Only**							
874					Shapiro Wilk Test Statistic	0.885			**Shapiro Wilk GOF Test**			
875					5% Shapiro Wilk Critical Value	0.829			Detected Data appear Lognormal at 5% Significance Level			
876					Lilliefors Test Statistic	0.214			**Lilliefors GOF Test**			
877					5% Lilliefors Critical Value	0.274			Detected Data appear Lognormal at 5% Significance Level			
878					**Detected Data appear Lognormal at 5% Significance Level**							
879												
880					**Lognormal ROS Statistics Using Imputed Non-Detects**							
881					Mean in Original Scale	2.327					Mean in Log Scale	0.192
882					SD in Original Scale	3.142					SD in Log Scale	1.176
883					95% t UCL (assumes normality of ROS data)	3.479					95% Percentile Bootstrap UCL	3.434
884					95% BCA Bootstrap UCL	3.858					95% Bootstrap t UCL	4.608
885					95% H-UCL (Log ROS)	5.004						
886												
887					**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**							
888					KM Mean (logged)	0.935					KM Geo Mean	2.548
889					KM SD (logged)	0.514					95% Critical H Value (KM-Log)	2.01
890					KM Standard Error of Mean (logged)	0.116					95% H-UCL (KM -Log)	3.642
891					KM SD (logged)	0.514					95% Critical H Value (KM-Log)	2.01
892					KM Standard Error of Mean (logged)	0.116						
893												
894					**DL/2 Statistics**							
895					**DL/2 Normal**				**DL/2 Log-Transformed**			
896					Mean in Original Scale	2.527					Mean in Log Scale	0.547
897					SD in Original Scale	3.02					SD in Log Scale	0.791
898					95% t UCL (Assumes normality)	3.635					95% H-Stat UCL	3.518
899					**DL/2 is not a recommended method, provided for comparisons and historical reasons**							
900												
901					**Nonparametric Distribution Free UCL Statistics**							
902					**Detected Data appear Gamma Distributed at 5% Significance Level**							
903												

	A	B	C	D	E	F	G	H	I	J	K	L
904						**Suggested UCL to Use**						
905					95% KM Adjusted Gamma UCL	4.522				95% GROS Adjusted Gamma UCL		5.067
906												
907					Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.							
908					Recommendations are based upon data size, data distribution, and skewness.							
909					These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).							
910					However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.							
911												
912												
913	**Selenium**											
914												
915						**General Statistics**						
916					Total Number of Observations	22				Number of Distinct Observations		21
917										Number of Missing Observations		0
918					Minimum	5.4				Mean		30.47
919					Maximum	77				Median		20.5
920					SD	20.63				Std. Error of Mean		4.398
921					Coefficient of Variation	0.677				Skewness		0.943
922												
923						**Normal GOF Test**						
924					Shapiro Wilk Test Statistic	0.888				**Shapiro Wilk GOF Test**		
925					5% Shapiro Wilk Critical Value	0.911				Data Not Normal at 5% Significance Level		
926					Lilliefors Test Statistic	0.222				**Lilliefors GOF Test**		
927					5% Lilliefors Critical Value	0.184				Data Not Normal at 5% Significance Level		
928						**Data Not Normal at 5% Significance Level**						
929												
930						**Assuming Normal Distribution**						
931					**95% Normal UCL**					**95% UCLs (Adjusted for Skewness)**		
932					95% Student's-t UCL	38.04				95% Adjusted-CLT UCL (Chen-1995)		38.65
933										95% Modified-t UCL (Johnson-1978)		38.19
934												
935						**Gamma GOF Test**						
936					A-D Test Statistic	0.414				**Anderson-Darling Gamma GOF Test**		
937					5% A-D Critical Value	0.754				Detected data appear Gamma Distributed at 5% Significance Level		
938					K-S Test Statistic	0.17				**Kolmogorov-Smirnov Gamma GOF Test**		
939					5% K-S Critical Value	0.187				Detected data appear Gamma Distributed at 5% Significance Level		
940						**Detected data appear Gamma Distributed at 5% Significance Level**						
941												
942						**Gamma Statistics**						
943					k hat (MLE)	2.388				k star (bias corrected MLE)		2.093
944					Theta hat (MLE)	12.76				Theta star (bias corrected MLE)		14.56
945					nu hat (MLE)	105.1				nu star (bias corrected)		92.09
946					MLE Mean (bias corrected)	30.47				MLE Sd (bias corrected)		21.06
947										Approximate Chi Square Value (0.05)		70.96
948					Adjusted Level of Significance	0.0386				Adjusted Chi Square Value		69.58
949												
950						**Assuming Gamma Distribution**						
951					95% Approximate Gamma UCL (use when n>=50)	39.55				95% Adjusted Gamma UCL (use when n<50)		40.33
952												

	A	B	C	D	E	F	G	H	I	J	K	L
953						Lognormal GOF Test						
954					Shapiro Wilk Test Statistic	0.97	Shapiro Wilk Lognormal GOF Test					
955					5% Shapiro Wilk Critical Value	0.911	Data appear Lognormal at 5% Significance Level					
956					Lilliefors Test Statistic	0.129	Lilliefors Lognormal GOF Test					
957					5% Lilliefors Critical Value	0.184	Data appear Lognormal at 5% Significance Level					
958					Data appear Lognormal at 5% Significance Level							
959												
960					Lognormal Statistics							
961					Minimum of Logged Data	1.686				Mean of logged Data		3.193
962					Maximum of Logged Data	4.344				SD of logged Data		0.702
963												
964					Assuming Lognormal Distribution							
965					95% H-UCL	43.71				90% Chebyshev (MVUE) UCL		45.55
966					95% Chebyshev (MVUE) UCL	52.26				97.5% Chebyshev (MVUE) UCL		61.56
967					99% Chebyshev (MVUE) UCL	79.83						
968												
969					Nonparametric Distribution Free UCL Statistics							
970					Data appear to follow a Discernible Distribution at 5% Significance Level							
971												
972					Nonparametric Distribution Free UCLs							
973					95% CLT UCL	37.71				95% Jackknife UCL		38.04
974					95% Standard Bootstrap UCL	37.8				95% Bootstrap-t UCL		39.7
975					95% Hall's Bootstrap UCL	38.44				95% Percentile Bootstrap UCL		37.7
976					95% BCA Bootstrap UCL	38.09						
977					90% Chebyshev(Mean, Sd) UCL	43.67				95% Chebyshev(Mean, Sd) UCL		49.64
978					97.5% Chebyshev(Mean, Sd) UCL	57.94				99% Chebyshev(Mean, Sd) UCL		74.23
979												
980					Suggested UCL to Use							
981					95% Adjusted Gamma UCL	40.33						
982												
983					Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.							
984					Recommendations are based upon data size, data distribution, and skewness.							
985					These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).							
986					However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.							
987												
988	Silver											
989												
990					General Statistics							
991					Total Number of Observations	22				Number of Distinct Observations		15
992					Number of Detects	13				Number of Non-Detects		9
993					Number of Distinct Detects	13				Number of Distinct Non-Detects		2
994					Minimum Detect	3				Minimum Non-Detect		2.4
995					Maximum Detect	20				Maximum Non-Detect		2.5
996					Variance Detects	30.03				Percent Non-Detects		40.91%
997					Mean Detects	8.377				SD Detects		5.48
998					Median Detects	5.2				CV Detects		0.654
999					Skewness Detects	0.987				Kurtosis Detects		-0.0592
1000					Mean of Logged Detects	1.936				SD of Logged Detects		0.637
1001												

	A	B	C	D	E	F	G	H	I	J	K	L
1002	**Normal GOF Test on Detects Only**											
1003					Shapiro Wilk Test Statistic	0.866	**Shapiro Wilk GOF Test**					
1004					5% Shapiro Wilk Critical Value	0.866	Detected Data appear Normal at 5% Significance Level					
1005					Lilliefors Test Statistic	0.257	**Lilliefors GOF Test**					
1006					5% Lilliefors Critical Value	0.234	Detected Data Not Normal at 5% Significance Level					
1007	**Detected Data appear Approximate Normal at 5% Significance Level**											
1008												
1009	**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**											
1010					KM Mean	5.932	KM Standard Error of Mean					1.11
1011					KM SD	5.001	95% KM (BCA) UCL					7.768
1012					95% KM (t) UCL	7.842	95% KM (Percentile Bootstrap) UCL					7.877
1013					95% KM (z) UCL	7.757	95% KM Bootstrap t UCL					8.665
1014					90% KM Chebyshev UCL	9.261	95% KM Chebyshev UCL					10.77
1015					97.5% KM Chebyshev UCL	12.86	99% KM Chebyshev UCL					16.97
1016												
1017	**Gamma GOF Tests on Detected Observations Only**											
1018					A-D Test Statistic	0.527	**Anderson-Darling GOF Test**					
1019					5% A-D Critical Value	0.74	Detected data appear Gamma Distributed at 5% Significance Level					
1020					K-S Test Statistic	0.241	**Kolmogorov-Smirnov GOF**					
1021					5% K-S Critical Value	0.238	Detected Data Not Gamma Distributed at 5% Significance Level					
1022	**Detected data follow Appr. Gamma Distribution at 5% Significance Level**											
1023												
1024	**Gamma Statistics on Detected Data Only**											
1025					k hat (MLE)	2.791	k star (bias corrected MLE)					2.199
1026					Theta hat (MLE)	3.001	Theta star (bias corrected MLE)					3.81
1027					nu hat (MLE)	72.58	nu star (bias corrected)					57.16
1028					Mean (detects)	8.377						
1029												
1030	**Gamma ROS Statistics using Imputed Non-Detects**											
1031	GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs											
1032	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)											
1033	For such situations, GROS method may yield incorrect values of UCLs and BTVs											
1034	This is especially true when the sample size is small.											
1035	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates											
1036					Minimum	0.01	Mean					4.961
1037					Maximum	20	Median					3.45
1038					SD	5.9	CV					1.189
1039					k hat (MLE)	0.31	k star (bias corrected MLE)					0.298
1040					Theta hat (MLE)	16.01	Theta star (bias corrected MLE)					16.65
1041					nu hat (MLE)	13.63	nu star (bias corrected)					13.11
1042					Adjusted Level of Significance (β)	0.0386						
1043					Approximate Chi Square Value (13.11, α)	5.965	Adjusted Chi Square Value (13.11, β)					5.607
1044					95% Gamma Approximate UCL (use when n>=50)	10.9	95% Gamma Adjusted UCL (use when n<50)					11.6
1045												
1046	**Estimates of Gamma Parameters using KM Estimates**											
1047					Mean (KM)	5.932	SD (KM)					5.001
1048					Variance (KM)	25.01	SE of Mean (KM)					1.11
1049					k hat (KM)	1.407	k star (KM)					1.245
1050					nu hat (KM)	61.9	nu star (KM)					54.79
1051					theta hat (KM)	4.217	theta star (KM)					4.764
1052					80% gamma percentile (KM)	9.358	90% gamma percentile (KM)					12.94
1053					95% gamma percentile (KM)	16.46	99% gamma percentile (KM)					24.51

	A	B	C	D	E	F	G	H	I	J	K	L
1054												
1055						Gamma Kaplan-Meier (KM) Statistics						
1056					Approximate Chi Square Value (54.79, α)	38.78				Adjusted Chi Square Value (54.79, β)		37.77
1057					95% Gamma Approximate KM-UCL (use when n>=50)	8.381				95% Gamma Adjusted KM-UCL (use when n<50)		8.604
1058												
1059						Lognormal GOF Test on Detected Observations Only						
1060					Shapiro Wilk Test Statistic	0.924				Shapiro Wilk GOF Test		
1061					5% Shapiro Wilk Critical Value	0.866				Detected Data appear Lognormal at 5% Significance Level		
1062					Lilliefors Test Statistic	0.212				Lilliefors GOF Test		
1063					5% Lilliefors Critical Value	0.234				Detected Data appear Lognormal at 5% Significance Level		
1064						Detected Data appear Lognormal at 5% Significance Level						
1065												
1066						Lognormal ROS Statistics Using Imputed Non-Detects						
1067					Mean in Original Scale	5.524				Mean in Log Scale		1.25
1068					SD in Original Scale	5.44				SD in Log Scale		1.007
1069					95% t UCL (assumes normality of ROS data)	7.52				95% Percentile Bootstrap UCL		7.578
1070					95% BCA Bootstrap UCL	7.75				95% Bootstrap t UCL		8.23
1071					95% H-UCL (Log ROS)	10.26						
1072												
1073						Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution						
1074					KM Mean (logged)	1.502				KM Geo Mean		4.491
1075					KM SD (logged)	0.702				95% Critical H Value (KM-Log)		2.205
1076					KM Standard Error of Mean (logged)	0.156				95% H-UCL (KM -Log)		8.056
1077					KM SD (logged)	0.702				95% Critical H Value (KM-Log)		2.205
1078					KM Standard Error of Mean (logged)	0.156						
1079												
1080						DL/2 Statistics						
1081					DL/2 Normal					DL/2 Log-Transformed		
1082					Mean in Original Scale	5.452				Mean in Log Scale		1.228
1083					SD in Original Scale	5.486				SD in Log Scale		0.995
1084					95% t UCL (Assumes normality)	7.465				95% H-Stat UCL		9.802
1085						DL/2 is not a recommended method, provided for comparisons and historical reasons						
1086												
1087						Nonparametric Distribution Free UCL Statistics						
1088						Detected Data appear Approximate Normal Distributed at 5% Significance Level						
1089												
1090						Suggested UCL to Use						
1091					95% KM (t) UCL	7.842						
1092												
1093						When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test						
1094						When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL						
1095												
1096						Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.						
1097						Recommendations are based upon data size, data distribution, and skewness.						
1098						These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).						
1099						However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.						
1100												
1101												

	A	B	C	D	E	F	G	H	I	J	K	L
1102	Zinc											
1103												
1104						General Statistics						
1105					Total Number of Observations	22				Number of Distinct Observations		19
1106										Number of Missing Observations		0
1107					Minimum	57				Mean		304.7
1108					Maximum	1800				Median		235
1109					SD	356.8				Std. Error of Mean		76.08
1110					Coefficient of Variation	1.171				Skewness		3.807
1111												
1112						Normal GOF Test						
1113					Shapiro Wilk Test Statistic	0.535				Shapiro Wilk GOF Test		
1114					5% Shapiro Wilk Critical Value	0.911				Data Not Normal at 5% Significance Level		
1115					Lilliefors Test Statistic	0.313				Lilliefors GOF Test		
1116					5% Lilliefors Critical Value	0.184				Data Not Normal at 5% Significance Level		
1117						Data Not Normal at 5% Significance Level						
1118												
1119						Assuming Normal Distribution						
1120					95% Normal UCL					95% UCLs (Adjusted for Skewness)		
1121					95% Student's-t UCL	435.6				95% Adjusted-CLT UCL (Chen-1995)		495.8
1122										95% Modified-t UCL (Johnson-1978)		445.9
1123												
1124						Gamma GOF Test						
1125					A-D Test Statistic	0.954				Anderson-Darling Gamma GOF Test		
1126					5% A-D Critical Value	0.758				Data Not Gamma Distributed at 5% Significance Level		
1127					K-S Test Statistic	0.194				Kolmogorov-Smirnov Gamma GOF Test		
1128					5% K-S Critical Value	0.188				Data Not Gamma Distributed at 5% Significance Level		
1129						Data Not Gamma Distributed at 5% Significance Level						
1130												
1131						Gamma Statistics						
1132					k hat (MLE)	1.726				k star (bias corrected MLE)		1.521
1133					Theta hat (MLE)	176.5				Theta star (bias corrected MLE)		200.4
1134					nu hat (MLE)	75.93				nu star (bias corrected)		66.91
1135					MLE Mean (bias corrected)	304.7				MLE Sd (bias corrected)		247.1
1136										Approximate Chi Square Value (0.05)		49.09
1137					Adjusted Level of Significance	0.0386				Adjusted Chi Square Value		47.95
1138												
1139						Assuming Gamma Distribution						
1140					95% Approximate Gamma UCL (use when n>=50))	415.3				95% Adjusted Gamma UCL (use when n<50)		425.2
1141												
1142						Lognormal GOF Test						
1143					Shapiro Wilk Test Statistic	0.948				Shapiro Wilk Lognormal GOF Test		
1144					5% Shapiro Wilk Critical Value	0.911				Data appear Lognormal at 5% Significance Level		
1145					Lilliefors Test Statistic	0.131				Lilliefors Lognormal GOF Test		
1146					5% Lilliefors Critical Value	0.184				Data appear Lognormal at 5% Significance Level		
1147						Data appear Lognormal at 5% Significance Level						
1148												
1149						Lognormal Statistics						
1150					Minimum of Logged Data	4.043				Mean of logged Data		5.402
1151					Maximum of Logged Data	7.496				SD of logged Data		0.735
1152												

	A	B	C	D	E	F	G	H	I	J	K	L
1153					Assuming Lognormal Distribution							
1154					95% H-UCL	416.6				90% Chebyshev (MVUE) UCL		431.3
1155				95% Chebyshev (MVUE) UCL		497				97.5% Chebyshev (MVUE) UCL		588.1
1156				99% Chebyshev (MVUE) UCL		767.2						
1157												
1158					Nonparametric Distribution Free UCL Statistics							
1159					Data appear to follow a Discernible Distribution at 5% Significance Level							
1160												
1161					Nonparametric Distribution Free UCLs							
1162					95% CLT UCL	429.8				95% Jackknife UCL		435.6
1163				95% Standard Bootstrap UCL		427.1				95% Bootstrap-t UCL		651.9
1164				95% Hall's Bootstrap UCL		938.9				95% Percentile Bootstrap UCL		446.8
1165				95% BCA Bootstrap UCL		526.7						
1166				90% Chebyshev(Mean, Sd) UCL		532.9				95% Chebyshev(Mean, Sd) UCL		636.3
1167				97.5% Chebyshev(Mean, Sd) UCL		779.8				99% Chebyshev(Mean, Sd) UCL		1062
1168												
1169					Suggested UCL to Use							
1170					95% H-UCL	416.6						
1171												
1172					Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.							
1173					Recommendations are based upon data size, data distribution, and skewness.							
1174					These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).							
1175					However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.							
1176												
1177					ProUCL computes and outputs H-statistic based UCLs for historical reasons only.							
1178					H-statistic often results in unstable (both high and low) values of UCL95 as shown in examples in the Technical Guide.							
1179					It is therefore recommended to avoid the use of H-statistic based 95% UCLs.							
1180					Use of nonparametric methods are preferred to compute UCL95 for skewed data sets which do not follow a gamma distribution.							
1181												

	A	B	C	D	E	F	G	H	I	J	K	L	M
1				General Statistics on Uncensored Data									
2			Date/Time of Computation	ProUCL 5.110/17/2019 3:08:45 PM									
3			User Selected Options										
4			From File	ProUCL Input 3_EA2_rev083019.xls									
5			Full Precision	OFF									
6													
7	From File: ProUCL Input 3_EA2_rev083019.xls												
8													
9	General Statistics for Censored Data Set (with NDs) using Kaplan Meier Method												
10													
11	Variable		NumObs	# Missing	Num Ds	NumNDs	% NDs	Min ND	Max ND	KM Mean	KM Var	KM SD	KM CV
12	Antimony		14	0	8	6	42.86%	4.9	5	16.25	200.8	14.17	0.872
13	Arsenic		14	0	14	0	0.00%	N/A	N/A	203.1	20684	143.8	0.708
14	Barium		14	0	11	3	21.43%	4.9	99	67.44	5022	70.87	1.051
15	Cadmium		14	0	8	6	42.86%	0.49	0.5	5.566	272.1	16.49	2.964
16	Chromium		14	0	10	4	28.57%	2	200	10.93	67.4	8.21	0.751
17	Copper		14	0	14	0	0.00%	N/A	N/A	7977	61489776	7842	0.983
18	Lead		14	0	14	0	0.00%	N/A	N/A	243.9	106225	325.9	1.336
19	Manganese		14	0	14	0	0.00%	N/A	N/A	292.9	27668	166.3	0.568
20	Mercury		14	0	14	0	0.00%	N/A	N/A	2.554	20.03	4.475	1.752
21	Nickel		14	0	11	3	21.43%	2	2	8.6	38	6.164	0.717
22	Selenium0823		14	0	14	0	0.00%	N/A	N/A	35.24	319.4	17.87	0.507
23	Silver		14	0	13	1	7.14%	2.5	2.5	7.1	13.86	3.723	0.524
24	Zinc		14	0	14	0	0.00%	N/A	N/A	1277	15623230	3953	3.095
25													
26	General Statistics for Raw Data Sets using Detected Data Only												
27													
28	Variable		NumObs	# Missing	Minimum	Maximum	Mean	Median	Var	SD	MAD/0.675	Skewness	CV
29	Antimony		8	0	5.3	42	24.76	23.5	208.4	14.44	21.65	-0.108	0.583
30	Arsenic		14	0	31	430	203.1	120	20684	143.8	104.5	0.527	0.708
31	Barium		11	0	6.7	270	81.52	74	5837	76.4	71.16	1.588	0.937
32	Cadmium		8	0	0.67	65	9.373	1.45	505.5	22.48	0.808	2.826	2.399
33	Chromium		10	0	2.7	30	13.61	13.5	62.79	7.924	6.597	0.773	0.582
34	Copper		14	0	880	24000	7977	5750	61489776	7842	6449	1.119	0.983
35	Lead		14	0	18	1200	243.9	108.5	106225	325.9	131.9	2.21	1.336
36	Manganese		14	0	120	700	292.9	250	27668	166.3	74.13	1.713	0.568
37	Mercury		14	0	0.17	14	2.554	0.825	20.03	4.475	0.689	2.264	1.752
38	Nickel		11	0	3.1	22	10.4	8.4	36.56	6.047	3.706	1.191	0.581
39	Selenium0823		14	0	8.3	59	35.24	32.5	319.4	17.87	27.43	-0.117	0.507
40	Silver		13	0	2.5	14	7.454	5.9	14.27	3.777	5.041	0.268	0.507
41	Zinc		14	0	55	15000	1277	210	15623230	3953	213.5	3.732	3.095
42													

	A	B	C	D	E	F	G	H	I	J	K	L	M
43	Percentiles using all Detects (Ds) and Non-Detects (NDs)												
44													
45	Variable		NumObs	# Missing	10%ile	20%ile	25%ile(Q1)	50%ile(Q2)	75%ile(Q3)	80%ile	90%ile	95%ile	99%ile
46		Antimony	14	0	4.9	4.96	5	6.05	23.75	28.8	40.2	42	42
47		Arsenic	14	0	73.4	87.2	91	120	322.5	358	407	417	427.4
48		Barium	14	0	5.51	9.88	14.25	66	97.5	107.4	134	185.5	253.1
49		Cadmium	14	0	0.49	0.496	0.5	0.79	1.475	1.7	2.14	24.18	56.84
50		Chromium	14	0	2	2.42	3.35	11.2	16	18	27.3	89.5	177.9
51		Copper	14	0	1060	1260	1475	5750	9675	14000	20000	21400	23480
52		Lead	14	0	24.3	33.2	35.75	108.5	292.5	366	534	790.5	1118
53		Manganese	14	0	149	194	215	250	297.5	330	535	641.5	688.3
54		Mercury	14	0	0.328	0.376	0.39	0.825	1.45	1.7	9	12.7	13.74
55		Nickel	14	0	2	2.66	3.8	7.15	11.2	12	18.3	21.35	21.87
56		Selenium0823	14	0	12.3	16.6	21	32.5	51	52.2	56.8	58.35	58.87
57		Silver	14	0	2.83	3.66	3.825	5.6	10.75	11	11	12.05	13.61
58		Zinc	14	0	65.6	70	74.75	210	397.5	412	465	5562	13112

	A	B	C	D	E	F	G	H	I	J	K	L
1	**UCL Statistics for Data Sets with Non-Detects**											
2												
3	User Selected Options											
4	Date/Time of Computation			ProUCL 5.110/17/2019 3:10:47 PM								
5	From File			ProUCL Input 3_EA2_rev083019.xls								
6	Full Precision			OFF								
7	Confidence Coefficient			95%								
8	Number of Bootstrap Operations			2000								
9												
10	**Antimony**											
11												
12	**General Statistics**											
13	Total Number of Observations					14	Number of Distinct Observations					9
14	Number of Detects					8	Number of Non-Detects					6
15	Number of Distinct Detects					7	Number of Distinct Non-Detects					2
16	Minimum Detect					5.3	Minimum Non-Detect					4.9
17	Maximum Detect					42	Maximum Non-Detect					5
18	Variance Detects					208.4	Percent Non-Detects					42.86%
19	Mean Detects					24.76	SD Detects					14.44
20	Median Detects					23.5	CV Detects					0.583
21	Skewness Detects					-0.108	Kurtosis Detects					-1.417
22	Mean of Logged Detects					2.988	SD of Logged Detects					0.795
23												
24	**Normal GOF Test on Detects Only**											
25	Shapiro Wilk Test Statistic					0.907	**Shapiro Wilk GOF Test**					
26	5% Shapiro Wilk Critical Value					0.818	Detected Data appear Normal at 5% Significance Level					
27	Lilliefors Test Statistic					0.157	**Lilliefors GOF Test**					
28	5% Lilliefors Critical Value					0.283	Detected Data appear Normal at 5% Significance Level					
29	**Detected Data appear Normal at 5% Significance Level**											
30												
31	**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**											
32	KM Mean					16.25	KM Standard Error of Mean					4.049
33	KM SD					14.17	95% KM (BCA) UCL					23.31
34	95% KM (t) UCL					23.42	95% KM (Percentile Bootstrap) UCL					22.8
35	95% KM (z) UCL					22.91	95% KM Bootstrap t UCL					24.2
36	90% KM Chebyshev UCL					28.4	95% KM Chebyshev UCL					33.9
37	97.5% KM Chebyshev UCL					41.54	99% KM Chebyshev UCL					56.54
38												
39	**Gamma GOF Tests on Detected Observations Only**											
40	A-D Test Statistic					0.465	**Anderson-Darling GOF Test**					
41	5% A-D Critical Value					0.723	Detected data appear Gamma Distributed at 5% Significance Level					
42	K-S Test Statistic					0.181	**Kolmogorov-Smirnov GOF**					
43	5% K-S Critical Value					0.297	Detected data appear Gamma Distributed at 5% Significance Level					
44	**Detected data appear Gamma Distributed at 5% Significance Level**											
45												
46	**Gamma Statistics on Detected Data Only**											
47	k hat (MLE)					2.409	k star (bias corrected MLE)					1.589
48	Theta hat (MLE)					10.28	Theta star (bias corrected MLE)					15.58
49	nu hat (MLE)					38.55	nu star (bias corrected)					25.43
50	Mean (detects)					24.76						
51												

	A	B	C	D	E	F	G	H	I	J	K	L
52	**Gamma ROS Statistics using Imputed Non-Detects**											
53	GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs											
54	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)											
55	For such situations, GROS method may yield incorrect values of UCLs and BTVs											
56	This is especially true when the sample size is small.											
57	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates											
58					Minimum	0.01				Mean		14.44
59					Maximum	42				Median		6.05
60					SD	16.3				CV		1.128
61					k hat (MLE)	0.314				k star (bias corrected MLE)		0.295
62					Theta hat (MLE)	45.96				Theta star (bias corrected MLE)		49.04
63					nu hat (MLE)	8.798				nu star (bias corrected)		8.246
64					Adjusted Level of Significance (β)	0.0312						
65					Approximate Chi Square Value (8.25, α)	2.878				Adjusted Chi Square Value (8.25, β)		2.474
66					95% Gamma Approximate UCL (use when n>=50)	41.37				95% Gamma Adjusted UCL (use when n<50)		48.13
67												
68	**Estimates of Gamma Parameters using KM Estimates**											
69					Mean (KM)	16.25				SD (KM)		14.17
70					Variance (KM)	200.8				SE of Mean (KM)		4.049
71					k hat (KM)	1.315				k star (KM)		1.081
72					nu hat (KM)	36.82				nu star (KM)		30.26
73					theta hat (KM)	12.36				theta star (KM)		15.04
74					80% gamma percentile (KM)	25.98				90% gamma percentile (KM)		36.71
75					95% gamma percentile (KM)	47.37				99% gamma percentile (KM)		71.98
76												
77	**Gamma Kaplan-Meier (KM) Statistics**											
78					Approximate Chi Square Value (30.26, α)	18.7				Adjusted Chi Square Value (30.26, β)		17.5
79					95% Gamma Approximate KM-UCL (use when n>=50)	26.3				95% Gamma Adjusted KM-UCL (use when n<50)		28.1
80												
81	**Lognormal GOF Test on Detected Observations Only**											
82					Shapiro Wilk Test Statistic	0.852				**Shapiro Wilk GOF Test**		
83					5% Shapiro Wilk Critical Value	0.818				Detected Data appear Lognormal at 5% Significance Level		
84					Lilliefors Test Statistic	0.228				**Lilliefors GOF Test**		
85					5% Lilliefors Critical Value	0.283				Detected Data appear Lognormal at 5% Significance Level		
86	**Detected Data appear Lognormal at 5% Significance Level**											
87												
88	**Lognormal ROS Statistics Using Imputed Non-Detects**											
89					Mean in Original Scale	15.43				Mean in Log Scale		2.14
90					SD in Original Scale	15.42				SD in Log Scale		1.207
91					95% t UCL (assumes normality of ROS data)	22.73				95% Percentile Bootstrap UCL		22.21
92					95% BCA Bootstrap UCL	22.65				95% Bootstrap t UCL		24.25
93					95% H-UCL (Log ROS)	50.57						
94												
95	**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**											
96					KM Mean (logged)	2.388				KM Geo Mean		10.9
97					KM SD (logged)	0.892				95% Critical H Value (KM-Log)		2.618
98					KM Standard Error of Mean (logged)	0.255				95% H-UCL (KM -Log)		30.99
99					KM SD (logged)	0.892				95% Critical H Value (KM-Log)		2.618
100					KM Standard Error of Mean (logged)	0.255						
101												

	A	B	C	D	E	F	G	H	I	J	K	L
102						DL/2 Statistics						
103					DL/2 Normal					DL/2 Log-Transformed		
104					Mean in Original Scale	15.21				Mean in Log Scale		2.096
105					SD in Original Scale	15.6				SD in Log Scale		1.218
106					95% t UCL (Assumes normality)	22.59				95% H-Stat UCL		49.77
107					DL/2 is not a recommended method, provided for comparisons and historical reasons							
108												
109					Nonparametric Distribution Free UCL Statistics							
110					Detected Data appear Normal Distributed at 5% Significance Level							
111												
112					Suggested UCL to Use							
113					95% KM (t) UCL	23.42						
114												
115					Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.							
116					Recommendations are based upon data size, data distribution, and skewness.							
117					These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).							
118					However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.							
119												
120												
121	Arsenic											
122												
123					General Statistics							
124					Total Number of Observations	14				Number of Distinct Observations		13
125										Number of Missing Observations		0
126					Minimum	31				Mean		203.1
127					Maximum	430				Median		120
128					SD	143.8				Std. Error of Mean		38.44
129					Coefficient of Variation	0.708				Skewness		0.527
130												
131					Normal GOF Test							
132					Shapiro Wilk Test Statistic	0.854				Shapiro Wilk GOF Test		
133					5% Shapiro Wilk Critical Value	0.874				Data Not Normal at 5% Significance Level		
134					Lilliefors Test Statistic	0.266				Lilliefors GOF Test		
135					5% Lilliefors Critical Value	0.226				Data Not Normal at 5% Significance Level		
136					Data Not Normal at 5% Significance Level							
137												
138					Assuming Normal Distribution							
139					95% Normal UCL					95% UCLs (Adjusted for Skewness)		
140					95% Student's-t UCL	271.1				95% Adjusted-CLT UCL (Chen-1995)		272.1
141										95% Modified-t UCL (Johnson-1978)		272
142												
143					Gamma GOF Test							
144					A-D Test Statistic	0.641				Anderson-Darling Gamma GOF Test		
145					5% A-D Critical Value	0.746				Detected data appear Gamma Distributed at 5% Significance Level		
146					K-S Test Statistic	0.203				Kolmogorov-Smirnov Gamma GOF Test		
147					5% K-S Critical Value	0.232				Detected data appear Gamma Distributed at 5% Significance Level		
148					Detected data appear Gamma Distributed at 5% Significance Level							
149												

	A	B	C	D	E	F	G	H	I	J	K	L
150	**Gamma Statistics**											
151					k hat (MLE)	1.976				k star (bias corrected MLE)		1.6
152					Theta hat (MLE)	102.8				Theta star (bias corrected MLE)		126.9
153					nu hat (MLE)	55.32				nu star (bias corrected)		44.8
154					MLE Mean (bias corrected)	203.1				MLE Sd (bias corrected)		160.5
155										Approximate Chi Square Value (0.05)		30.44
156					Adjusted Level of Significance	0.0312				Adjusted Chi Square Value		28.88
157												
158	**Assuming Gamma Distribution**											
159			95% Approximate Gamma UCL (use when n>=50)			298.8				95% Adjusted Gamma UCL (use when n<50)		315
160												
161	**Lognormal GOF Test**											
162					Shapiro Wilk Test Statistic	0.916				**Shapiro Wilk Lognormal GOF Test**		
163					5% Shapiro Wilk Critical Value	0.874				Data appear Lognormal at 5% Significance Level		
164					Lilliefors Test Statistic	0.162				**Lilliefors Lognormal GOF Test**		
165					5% Lilliefors Critical Value	0.226				Data appear Lognormal at 5% Significance Level		
166	**Data appear Lognormal at 5% Significance Level**											
167												
168	**Lognormal Statistics**											
169					Minimum of Logged Data	3.434				Mean of logged Data		5.04
170					Maximum of Logged Data	6.064				SD of logged Data		0.809
171												
172	**Assuming Lognormal Distribution**											
173					95% H-UCL	374.9				90% Chebyshev (MVUE) UCL		351.7
174					95% Chebyshev (MVUE) UCL	416.7				97.5% Chebyshev (MVUE) UCL		507
175					99% Chebyshev (MVUE) UCL	684.3						
176												
177	**Nonparametric Distribution Free UCL Statistics**											
178	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
179												
180	**Nonparametric Distribution Free UCLs**											
181					95% CLT UCL	266.3				95% Jackknife UCL		271.1
182					95% Standard Bootstrap UCL	264.3				95% Bootstrap-t UCL		283.8
183					95% Hall's Bootstrap UCL	261.7				95% Percentile Bootstrap UCL		264.5
184					95% BCA Bootstrap UCL	273.4						
185					90% Chebyshev(Mean, Sd) UCL	318.4				95% Chebyshev(Mean, Sd) UCL		370.6
186					97.5% Chebyshev(Mean, Sd) UCL	443.1				99% Chebyshev(Mean, Sd) UCL		585.5
187												
188	**Suggested UCL to Use**											
189					95% Adjusted Gamma UCL	315						
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												

	A	B	C	D	E	F	G	H	I	J	K	L
196	Barium											
197												
198	General Statistics											
199					Total Number of Observations	14				Number of Distinct Observations		14
200					Number of Detects	11				Number of Non-Detects		3
201					Number of Distinct Detects	11				Number of Distinct Non-Detects		3
202					Minimum Detect	6.7				Minimum Non-Detect		4.9
203					Maximum Detect	270				Maximum Non-Detect		99
204					Variance Detects	5837				Percent Non-Detects		21.43%
205					Mean Detects	81.52				SD Detects		76.4
206					Median Detects	74				CV Detects		0.937
207					Skewness Detects	1.588				Kurtosis Detects		3.118
208					Mean of Logged Detects	3.931				SD of Logged Detects		1.125
209												
210	Normal GOF Test on Detects Only											
211					Shapiro Wilk Test Statistic	0.853	Shapiro Wilk GOF Test					
212					5% Shapiro Wilk Critical Value	0.85	Detected Data appear Normal at 5% Significance Level					
213					Lilliefors Test Statistic	0.168	Lilliefors GOF Test					
214					5% Lilliefors Critical Value	0.251	Detected Data appear Normal at 5% Significance Level					
215	Detected Data appear Normal at 5% Significance Level											
216												
217	Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs											
218					KM Mean	67.44				KM Standard Error of Mean		20.03
219					KM SD	70.87				95% KM (BCA) UCL		102.8
220					95% KM (t) UCL	102.9				95% KM (Percentile Bootstrap) UCL		99.96
221					95% KM (z) UCL	100.4				95% KM Bootstrap t UCL		115.9
222					90% KM Chebyshev UCL	127.5				95% KM Chebyshev UCL		154.7
223					97.5% KM Chebyshev UCL	192.5				99% KM Chebyshev UCL		266.7
224												
225	Gamma GOF Tests on Detected Observations Only											
226					A-D Test Statistic	0.2	Anderson-Darling GOF Test					
227					5% A-D Critical Value	0.748	Detected data appear Gamma Distributed at 5% Significance Level					
228					K-S Test Statistic	0.13	Kolmogorov-Smirnov GOF					
229					5% K-S Critical Value	0.261	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)	1.204				k star (bias corrected MLE)		0.937
234					Theta hat (MLE)	67.68				Theta star (bias corrected MLE)		87.04
235					nu hat (MLE)	26.5				nu star (bias corrected)		20.6
236					Mean (detects)	81.52						
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	0.01				Mean		65.93
245					Maximum	270				Median		42.15
246					SD	74.06				CV		1.123
247					k hat (MLE)	0.427				k star (bias corrected MLE)		0.383
248					Theta hat (MLE)	154.3				Theta star (bias corrected MLE)		172
249					nu hat (MLE)	11.96				nu star (bias corrected)		10.73

	A	B	C	D	E	F	G	H	I	J	K	L
250					Adjusted Level of Significance (β)	0.0312						
251					Approximate Chi Square Value (10.73, α)	4.405					Adjusted Chi Square Value (10.73, β)	3.881
252					95% Gamma Approximate UCL (use when n>=50)	160.6					95% Gamma Adjusted UCL (use when n<50)	182.3
253												
254					**Estimates of Gamma Parameters using KM Estimates**							
255					Mean (KM)	67.44					SD (KM)	70.87
256					Variance (KM)	5022					SE of Mean (KM)	20.03
257					k hat (KM)	0.906					k star (KM)	0.759
258					nu hat (KM)	25.36					nu star (KM)	21.26
259					theta hat (KM)	74.47					theta star (KM)	88.83
260					80% gamma percentile (KM)	110.5					90% gamma percentile (KM)	166.1
261					95% gamma percentile (KM)	222.9					99% gamma percentile (KM)	357.8
262												
263					**Gamma Kaplan-Meier (KM) Statistics**							
264					Approximate Chi Square Value (21.26, α)	11.78					Adjusted Chi Square Value (21.26, β)	10.86
265					95% Gamma Approximate KM-UCL (use when n>=50)	121.7					95% Gamma Adjusted KM-UCL (use when n<50)	132
266												
267					**Lognormal GOF Test on Detected Observations Only**							
268					Shapiro Wilk Test Statistic	0.956					**Shapiro Wilk GOF Test**	
269					5% Shapiro Wilk Critical Value	0.85					Detected Data appear Lognormal at 5% Significance Level	
270					Lilliefors Test Statistic	0.182					**Lilliefors GOF Test**	
271					5% Lilliefors Critical Value	0.251					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	66.33					Mean in Log Scale	3.528
276					SD in Original Scale	73.61					SD in Log Scale	1.324
277					95% t UCL (assumes normality of ROS data)	101.2					95% Percentile Bootstrap UCL	100.8
278					95% BCA Bootstrap UCL	107.4					95% Bootstrap t UCL	121.6
279					95% H-UCL (Log ROS)	280.7						
280												
281					**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**							
282					KM Mean (logged)	3.538					KM Geo Mean	34.4
283					KM SD (logged)	1.292					95% Critical H Value (KM-Log)	3.302
284					KM Standard Error of Mean (logged)	0.373					95% H-UCL (KM -Log)	258.9
285					KM SD (logged)	1.292					95% Critical H Value (KM-Log)	3.302
286					KM Standard Error of Mean (logged)	0.373						
287												
288					**DL/2 Statistics**							
289					**DL/2 Normal**						**DL/2 Log-Transformed**	
290					Mean in Original Scale	67.94					Mean in Log Scale	3.497
291					SD in Original Scale	73.02					SD in Log Scale	1.476
292					95% t UCL (Assumes normality)	102.5					95% H-Stat UCL	436.5
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	102.9						
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).							

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

Cadmium

General Statistics

Total Number of Observations	14	Number of Distinct Observations	10
Number of Detects	8	Number of Non-Detects	6
Number of Distinct Detects	8	Number of Distinct Non-Detects	2
Minimum Detect	0.67	Minimum Non-Detect	0.49
Maximum Detect	65	Maximum Non-Detect	0.5
Variance Detects	505.5	Percent Non-Detects	42.86%
Mean Detects	9.373	SD Detects	22.48
Median Detects	1.45	CV Detects	2.399
Skewness Detects	2.826	Kurtosis Detects	7.988
Mean of Logged Detects	0.771	SD of Logged Detects	1.429

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.44	**Shapiro Wilk GOF Test**
5% Shapiro Wilk Critical Value	0.818	Detected Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.5	**Lilliefors GOF Test**
5% Lilliefors Critical Value	0.283	Detected Data Not Normal at 5% Significance Level

Detected Data Not Normal at 5% Significance Level

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

KM Mean	5.566	KM Standard Error of Mean	4.713
KM SD	16.49	95% KM (BCA) UCL	14.76
95% KM (t) UCL	13.91	95% KM (Percentile Bootstrap) UCL	14.67
95% KM (z) UCL	13.32	95% KM Bootstrap t UCL	164.8
90% KM Chebyshev UCL	19.7	95% KM Chebyshev UCL	26.11
97.5% KM Chebyshev UCL	35	99% KM Chebyshev UCL	52.46

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	1.81	**Anderson-Darling GOF Test**
5% A-D Critical Value	0.773	Detected Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.473	**Kolmogorov-Smirnov GOF**
5% K-S Critical Value	0.311	Detected Data Not Gamma Distributed at 5% Significance Level

Detected Data Not Gamma Distributed at 5% Significance Level

Gamma Statistics on Detected Data Only

k hat (MLE)	0.441	k star (bias corrected MLE)	0.359
Theta hat (MLE)	21.23	Theta star (bias corrected MLE)	26.09
nu hat (MLE)	7.064	nu star (bias corrected)	5.748
Mean (detects)	9.373		

Gamma ROS Statistics using Imputed Non-Detects

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

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)

For such situations, GROS method may yield incorrect values of UCLs and BTVs

This is especially true when the sample size is small.

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	0.01	Mean	5.36
Maximum	65	Median	0.79
SD	17.18	CV	3.206
k hat (MLE)	0.225	k star (bias corrected MLE)	0.224

	A	B	C	D	E	F	G	H	I	J	K	L
358					Theta hat (MLE)	23.83					Theta star (bias corrected MLE)	23.89
359					nu hat (MLE)	6.297					nu star (bias corrected)	6.281
360					Adjusted Level of Significance (β)	0.0312						
361					Approximate Chi Square Value (6.28, α)	1.785					Adjusted Chi Square Value (6.28, β)	1.487
362					95% Gamma Approximate UCL (use when n>=50)	18.86					95% Gamma Adjusted UCL (use when n<50)	22.65
363												
364					**Estimates of Gamma Parameters using KM Estimates**							
365					Mean (KM)	5.566					SD (KM)	16.49
366					Variance (KM)	272.1					SE of Mean (KM)	4.713
367					k hat (KM)	0.114					k star (KM)	0.137
368					nu hat (KM)	3.188					nu star (KM)	3.838
369					theta hat (KM)	48.88					theta star (KM)	40.6
370					80% gamma percentile (KM)	5.599					90% gamma percentile (KM)	16.26
371					95% gamma percentile (KM)	31.14					99% gamma percentile (KM)	75.15
372												
373					**Gamma Kaplan-Meier (KM) Statistics**							
374					Approximate Chi Square Value (3.84, α)	0.659					Adjusted Chi Square Value (3.84, β)	0.51
375					95% Gamma Approximate KM-UCL (use when n>=50)	32.42					95% Gamma Adjusted KM-UCL (use when n<50)	41.9
376												
377					**Lognormal GOF Test on Detected Observations Only**							
378					Shapiro Wilk Test Statistic	0.684					**Shapiro Wilk GOF Test**	
379					5% Shapiro Wilk Critical Value	0.818					Detected Data Not Lognormal at 5% Significance Level	
380					Lilliefors Test Statistic	0.37					**Lilliefors GOF Test**	
381					5% Lilliefors Critical Value	0.283					Detected Data Not Lognormal at 5% Significance Level	
382					**Detected Data Not Lognormal at 5% Significance Level**							
383												
384					**Lognormal ROS Statistics Using Imputed Non-Detects**							
385					Mean in Original Scale	5.395					Mean in Log Scale	-0.69
386					SD in Original Scale	17.17					SD in Log Scale	2.101
387					95% t UCL (assumes normality of ROS data)	13.52					95% Percentile Bootstrap UCL	14.54
388					95% BCA Bootstrap UCL	19.23					95% Bootstrap t UCL	133.4
389					95% H-UCL (Log ROS)	78.28						
390												
391					**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**							
392					KM Mean (logged)	0.135					KM Geo Mean	1.144
393					KM SD (logged)	1.249					95% Critical H Value (KM-Log)	3.224
394					KM Standard Error of Mean (logged)	0.357					95% H-UCL (KM -Log)	7.628
395					KM SD (logged)	1.249					95% Critical H Value (KM-Log)	3.224
396					KM Standard Error of Mean (logged)	0.357						
397												
398					**DL/2 Statistics**							
399					**DL/2 Normal**						**DL/2 Log-Transformed**	
400					Mean in Original Scale	5.462					Mean in Log Scale	-0.158
401					SD in Original Scale	17.15					SD in Log Scale	1.529
402					95% t UCL (Assumes normality)	13.58					95% H-Stat UCL	13.46
403					**DL/2 is not a recommended method, provided for comparisons and historical reasons**							
404												
405					**Nonparametric Distribution Free UCL Statistics**							
406					**Data do not follow a Discernible Distribution at 5% Significance Level**							
407												
408					**Suggested UCL to Use**							
409					95% KM (Chebyshev) UCL	26.11						
410												
411					Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.							

	A	B	C	D	E	F	G	H	I	J	K	L
412	Recommendations are based upon data size, data distribution, and skewness.											
413	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
414	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
415												
416	Chromium											
417												
418	General Statistics											
419					Total Number of Observations	14			Number of Distinct Observations			11
420					Number of Detects	10			Number of Non-Detects			4
421					Number of Distinct Detects	9			Number of Distinct Non-Detects			2
422					Minimum Detect	2.7			Minimum Non-Detect			2
423					Maximum Detect	30			Maximum Non-Detect			200
424					Variance Detects	62.79			Percent Non-Detects			28.57%
425					Mean Detects	13.61			SD Detects			7.924
426					Median Detects	13.5			CV Detects			0.582
427					Skewness Detects	0.773			Kurtosis Detects			0.922
428					Mean of Logged Detects	2.426			SD of Logged Detects			0.697
429												
430	Normal GOF Test on Detects Only											
431					Shapiro Wilk Test Statistic	0.956			Shapiro Wilk GOF Test			
432					5% Shapiro Wilk Critical Value	0.842			Detected Data appear Normal at 5% Significance Level			
433					Lilliefors Test Statistic	0.181			Lilliefors GOF Test			
434					5% Lilliefors Critical Value	0.262			Detected Data appear Normal at 5% Significance Level			
435	Detected Data appear Normal at 5% Significance Level											
436												
437	Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs											
438					KM Mean	10.93			KM Standard Error of Mean			2.4
439					KM SD	8.21			95% KM (BCA) UCL			14.95
440					95% KM (t) UCL	15.18			95% KM (Percentile Bootstrap) UCL			14.65
441					95% KM (z) UCL	14.88			95% KM Bootstrap t UCL			15.68
442					90% KM Chebyshev UCL	18.13			95% KM Chebyshev UCL			21.39
443					97.5% KM Chebyshev UCL	25.92			99% KM Chebyshev UCL			34.81
444												
445	Gamma GOF Tests on Detected Observations Only											
446					A-D Test Statistic	0.196			Anderson-Darling GOF Test			
447					5% A-D Critical Value	0.733			Detected data appear Gamma Distributed at 5% Significance Level			
448					K-S Test Statistic	0.149			Kolmogorov-Smirnov GOF			
449					5% K-S Critical Value	0.269			Detected data appear Gamma Distributed at 5% Significance Level			
450	Detected data appear Gamma Distributed at 5% Significance Level											
451												

	A	B	C	D	E	F	G	H	I	J	K	L
452	Gamma Statistics on Detected Data Only											
453					k hat (MLE)	2.861					k star (bias corrected MLE)	2.069
454					Theta hat (MLE)	4.757					Theta star (bias corrected MLE)	6.577
455					nu hat (MLE)	57.22					nu star (bias corrected)	41.39
456					Mean (detects)	13.61						
457												
458	Gamma ROS Statistics using Imputed Non-Detects											
459	GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs											
460	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)											
461	For such situations, GROS method may yield incorrect values of UCLs and BTVs											
462	This is especially true when the sample size is small.											
463	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates											
464					Minimum	0.01					Mean	10.45
465					Maximum	30					Median	9.164
466					SD	8.641					CV	0.827
467					k hat (MLE)	0.566					k star (bias corrected MLE)	0.492
468					Theta hat (MLE)	18.46					Theta star (bias corrected MLE)	21.23
469					nu hat (MLE)	15.84					nu star (bias corrected)	13.78
470					Adjusted Level of Significance (β)	0.0312						
471					Approximate Chi Square Value (13.78, α)	6.421					Adjusted Chi Square Value (13.78, β)	5.767
472					95% Gamma Approximate UCL (use when n>=50)	22.42					95% Gamma Adjusted UCL (use when n<50)	24.96
473												
474	Estimates of Gamma Parameters using KM Estimates											
475					Mean (KM)	10.93					SD (KM)	8.21
476					Variance (KM)	67.4					SE of Mean (KM)	2.4
477					k hat (KM)	1.773					k star (KM)	1.441
478					nu hat (KM)	49.64					nu star (KM)	40.33
479					theta hat (KM)	6.166					theta star (KM)	7.588
480					80% gamma percentile (KM)	16.99					90% gamma percentile (KM)	23
481					95% gamma percentile (KM)	28.86					99% gamma percentile (KM)	42.13
482												
483	Gamma Kaplan-Meier (KM) Statistics											
484					Approximate Chi Square Value (40.33, α)	26.78					Adjusted Chi Square Value (40.33, β)	25.32
485					95% Gamma Approximate KM-UCL (use when n>=50)	16.46					95% Gamma Adjusted KM-UCL (use when n<50)	17.41
486												
487	Lognormal GOF Test on Detected Observations Only											
488					Shapiro Wilk Test Statistic	0.946					Shapiro Wilk GOF Test	
489					5% Shapiro Wilk Critical Value	0.842					Detected Data appear Lognormal at 5% Significance Level	
490					Lilliefors Test Statistic	0.179					Lilliefors GOF Test	
491					5% Lilliefors Critical Value	0.262					Detected Data appear Lognormal at 5% Significance Level	
492	Detected Data appear Lognormal at 5% Significance Level											
493												
494	Lognormal ROS Statistics Using Imputed Non-Detects											
495					Mean in Original Scale	10.78					Mean in Log Scale	2.052
496					SD in Original Scale	8.181					SD in Log Scale	0.906
497					95% t UCL (assumes normality of ROS data)	14.65					95% Percentile Bootstrap UCL	14.82
498					95% BCA Bootstrap UCL	14.62					95% Bootstrap t UCL	15.68
499					95% H-UCL (Log ROS)	22.77						
500												

	A	B	C	D	E	F	G	H	I	J	K	L
501	**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**											
502					KM Mean (logged)	2.026					KM Geo Mean	7.584
503					KM SD (logged)	0.932					95% Critical H Value (KM-Log)	2.682
504					KM Standard Error of Mean (logged)	0.273					95% H-UCL (KM -Log)	23.43
505					KM SD (logged)	0.932					95% Critical H Value (KM-Log)	2.682
506					KM Standard Error of Mean (logged)	0.273						
507												
508	**DL/2 Statistics**											
509	**DL/2 Normal**						**DL/2 Log-Transformed**					
510					Mean in Original Scale	17.08					Mean in Log Scale	2.062
511					SD in Original Scale	25.32					SD in Log Scale	1.384
512					95% t UCL (Assumes normality)	29.06					95% H-Stat UCL	77.75
513	**DL/2 is not a recommended method, provided for comparisons and historical reasons**											
514												
515	**Nonparametric Distribution Free UCL Statistics**											
516	**Detected Data appear Normal Distributed at 5% Significance Level**											
517												
518	**Suggested UCL to Use**											
519					95% KM (t) UCL	15.18						
520												
521	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
522	Recommendations are based upon data size, data distribution, and skewness.											
523	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
524	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
525												
526												
527	Copper											
528												
529	**General Statistics**											
530					Total Number of Observations	14					Number of Distinct Observations	13
531											Number of Missing Observations	0
532					Minimum	880					Mean	7977
533					Maximum	24000					Median	5750
534					SD	7842					Std. Error of Mean	2096
535					Coefficient of Variation	0.983					Skewness	1.119
536												
537	**Normal GOF Test**											
538					Shapiro Wilk Test Statistic	0.821	**Shapiro Wilk GOF Test**					
539					5% Shapiro Wilk Critical Value	0.874	Data Not Normal at 5% Significance Level					
540					Lilliefors Test Statistic	0.218	**Lilliefors GOF Test**					
541					5% Lilliefors Critical Value	0.226	Data appear Normal at 5% Significance Level					
542	**Data appear Approximate Normal at 5% Significance Level**											
543												
544	**Assuming Normal Distribution**											
545	**95% Normal UCL**						**95% UCLs (Adjusted for Skewness)**					
546					95% Student's-t UCL	11689					95% Adjusted-CLT UCL (Chen-1995)	12094
547											95% Modified-t UCL (Johnson-1978)	11793
548												

	A	B	C	D	E	F	G	H	I	J	K	L
549						Gamma GOF Test						
550					A-D Test Statistic	0.439	Anderson-Darling Gamma GOF Test					
551					5% A-D Critical Value	0.759	Detected data appear Gamma Distributed at 5% Significance Level					
552					K-S Test Statistic	0.149	Kolmogorov-Smirnov Gamma GOF Test					
553					5% K-S Critical Value	0.235	Detected data appear Gamma Distributed at 5% Significance Level					
554					Detected data appear Gamma Distributed at 5% Significance Level							
555												
556						Gamma Statistics						
557					k hat (MLE)	1.065				k star (bias corrected MLE)		0.884
558					Theta hat (MLE)	7490				Theta star (bias corrected MLE)		9019
559					nu hat (MLE)	29.82				nu star (bias corrected)		24.77
560					MLE Mean (bias corrected)	7977				MLE Sd (bias corrected)		8482
561										Approximate Chi Square Value (0.05)		14.43
562					Adjusted Level of Significance	0.0312				Adjusted Chi Square Value		13.39
563												
564						Assuming Gamma Distribution						
565					95% Approximate Gamma UCL (use when n>=50))	13689				95% Adjusted Gamma UCL (use when n<50)		14750
566												
567						Lognormal GOF Test						
568					Shapiro Wilk Test Statistic	0.917	Shapiro Wilk Lognormal GOF Test					
569					5% Shapiro Wilk Critical Value	0.874	Data appear Lognormal at 5% Significance Level					
570					Lilliefors Test Statistic	0.15	Lilliefors Lognormal GOF Test					
571					5% Lilliefors Critical Value	0.226	Data appear Lognormal at 5% Significance Level					
572					Data appear Lognormal at 5% Significance Level							
573												
574						Lognormal Statistics						
575					Minimum of Logged Data	6.78				Mean of logged Data		8.446
576					Maximum of Logged Data	10.09				SD of logged Data		1.158
577												
578						Assuming Lognormal Distribution						
579					95% H-UCL	24353				90% Chebyshev (MVUE) UCL		17161
580					95% Chebyshev (MVUE) UCL	21093				97.5% Chebyshev (MVUE) UCL		26550
581					99% Chebyshev (MVUE) UCL	37270						
582												
583						Nonparametric Distribution Free UCL Statistics						
584						Data appear to follow a Discernible Distribution at 5% Significance Level						
585												
586						Nonparametric Distribution Free UCLs						
587					95% CLT UCL	11424				95% Jackknife UCL		11689
588					95% Standard Bootstrap UCL	11238				95% Bootstrap-t UCL		13232
589					95% Hall's Bootstrap UCL	11438				95% Percentile Bootstrap UCL		11334
590					95% BCA Bootstrap UCL	11699						
591					90% Chebyshev(Mean, Sd) UCL	14264				95% Chebyshev(Mean, Sd) UCL		17112
592					97.5% Chebyshev(Mean, Sd) UCL	21065				99% Chebyshev(Mean, Sd) UCL		28829
593												
594						Suggested UCL to Use						
595					95% Student's-t UCL	11689						
596												
597					When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test							
598					When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL							
599												

	A	B	C	D	E	F	G	H	I	J	K	L
600	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
601	Recommendations are based upon data size, data distribution, and skewness.											
602	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
603	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
604												
605												
606	**Lead**											
607												
608	**General Statistics**											
609					Total Number of Observations	14			Number of Distinct Observations			13
610									Number of Missing Observations			0
611					Minimum	18			Mean			243.9
612					Maximum	1200			Median			108.5
613					SD	325.9			Std. Error of Mean			87.11
614					Coefficient of Variation	1.336			Skewness			2.21
615												
616	**Normal GOF Test**											
617					Shapiro Wilk Test Statistic	0.72			**Shapiro Wilk GOF Test**			
618					5% Shapiro Wilk Critical Value	0.874			Data Not Normal at 5% Significance Level			
619					Lilliefors Test Statistic	0.244			**Lilliefors GOF Test**			
620					5% Lilliefors Critical Value	0.226			Data Not Normal at 5% Significance Level			
621	**Data Not Normal at 5% Significance Level**											
622												
623	**Assuming Normal Distribution**											
624					**95% Normal UCL**				**95% UCLs (Adjusted for Skewness)**			
625					95% Student's-t UCL	398.2			95% Adjusted-CLT UCL (Chen-1995)			442.2
626									95% Modified-t UCL (Johnson-1978)			406.8
627												
628	**Gamma GOF Test**											
629					A-D Test Statistic	0.584			**Anderson-Darling Gamma GOF Test**			
630					5% A-D Critical Value	0.771			Detected data appear Gamma Distributed at 5% Significance Level			
631					K-S Test Statistic	0.225			**Kolmogorov-Smirnov Gamma GOF Test**			
632					5% K-S Critical Value	0.238			Detected data appear Gamma Distributed at 5% Significance Level			
633	**Detected data appear Gamma Distributed at 5% Significance Level**											
634												
635	**Gamma Statistics**											
636					k hat (MLE)	0.747			k star (bias corrected MLE)			0.635
637					Theta hat (MLE)	326.3			Theta star (bias corrected MLE)			384.2
638					nu hat (MLE)	20.93			nu star (bias corrected)			17.78
639					MLE Mean (bias corrected)	243.9			MLE Sd (bias corrected)			306.1
640									Approximate Chi Square Value (0.05)			9.231
641					Adjusted Level of Significance	0.0312			Adjusted Chi Square Value			8.424
642												
643	**Assuming Gamma Distribution**											
644					95% Approximate Gamma UCL (use when n>=50)	469.8			95% Adjusted Gamma UCL (use when n<50)			514.8
645												
646	**Lognormal GOF Test**											
647					Shapiro Wilk Test Statistic	0.925			**Shapiro Wilk Lognormal GOF Test**			
648					5% Shapiro Wilk Critical Value	0.874			Data appear Lognormal at 5% Significance Level			
649					Lilliefors Test Statistic	0.188			**Lilliefors Lognormal GOF Test**			
650					5% Lilliefors Critical Value	0.226			Data appear Lognormal at 5% Significance Level			
651	**Data appear Lognormal at 5% Significance Level**											
652												
653	**Lognormal Statistics**											

	A	B	C	D	E	F	G	H	I	J	K	L
654					Minimum of Logged Data	2.89					Mean of logged Data	4.696
655					Maximum of Logged Data	7.09					SD of logged Data	1.361
656												
657					Assuming Lognormal Distribution							
658					95% H-UCL	1009					90% Chebyshev (MVUE) UCL	550.3
659					95% Chebyshev (MVUE) UCL	687.3					97.5% Chebyshev (MVUE) UCL	877.6
660					99% Chebyshev (MVUE) UCL	1251						
661												
662					Nonparametric Distribution Free UCL Statistics							
663					Data appear to follow a Discernible Distribution at 5% Significance Level							
664												
665					Nonparametric Distribution Free UCLs							
666					95% CLT UCL	387.2					95% Jackknife UCL	398.2
667					95% Standard Bootstrap UCL	385.3					95% Bootstrap-t UCL	545.7
668					95% Hall's Bootstrap UCL	976.3					95% Percentile Bootstrap UCL	391.7
669					95% BCA Bootstrap UCL	448.6						
670					90% Chebyshev(Mean, Sd) UCL	505.2					95% Chebyshev(Mean, Sd) UCL	623.6
671					97.5% Chebyshev(Mean, Sd) UCL	787.9					99% Chebyshev(Mean, Sd) UCL	1111
672												
673					Suggested UCL to Use							
674					95% Adjusted Gamma UCL	514.8						
675												
676					Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.							
677					Recommendations are based upon data size, data distribution, and skewness.							
678					These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).							
679					However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.							
680												
681												
682	Manganese											
683												
684					General Statistics							
685					Total Number of Observations	14					Number of Distinct Observations	12
686											Number of Missing Observations	0
687					Minimum	120					Mean	292.9
688					Maximum	700					Median	250
689					SD	166.3					Std. Error of Mean	44.46
690					Coefficient of Variation	0.568					Skewness	1.713
691												
692					Normal GOF Test							
693					Shapiro Wilk Test Statistic	0.78					Shapiro Wilk GOF Test	
694					5% Shapiro Wilk Critical Value	0.874					Data Not Normal at 5% Significance Level	
695					Lilliefors Test Statistic	0.293					Lilliefors GOF Test	
696					5% Lilliefors Critical Value	0.226					Data Not Normal at 5% Significance Level	
697					Data Not Normal at 5% Significance Level							
698												
699					Assuming Normal Distribution							
700					95% Normal UCL						95% UCLs (Adjusted for Skewness)	
701					95% Student's-t UCL	371.6					95% Adjusted-CLT UCL (Chen-1995)	387.7
702											95% Modified-t UCL (Johnson-1978)	375
703												

	A	B	C	D	E	F	G	H	I	J	K	L
704						Gamma GOF Test						
705					A-D Test Statistic	0.755	Anderson-Darling Gamma GOF Test					
706					5% A-D Critical Value	0.739	Data Not Gamma Distributed at 5% Significance Level					
707					K-S Test Statistic	0.247	Kolmogorov-Smirnov Gamma GOF Test					
708					5% K-S Critical Value	0.23	Data Not Gamma Distributed at 5% Significance Level					
709					Data Not Gamma Distributed at 5% Significance Level							
710												
711					Gamma Statistics							
712					k hat (MLE)	4.345			k star (bias corrected MLE)			3.461
713					Theta hat (MLE)	67.4			Theta star (bias corrected MLE)			84.6
714					nu hat (MLE)	121.7			nu star (bias corrected)			96.92
715					MLE Mean (bias corrected)	292.9			MLE Sd (bias corrected)			157.4
716									Approximate Chi Square Value (0.05)			75.21
717					Adjusted Level of Significance	0.0312			Adjusted Chi Square Value			72.68
718												
719					Assuming Gamma Distribution							
720					95% Approximate Gamma UCL (use when n>=50))	377.4			95% Adjusted Gamma UCL (use when n<50)			390.5
721												
722					Lognormal GOF Test							
723					Shapiro Wilk Test Statistic	0.925	Shapiro Wilk Lognormal GOF Test					
724					5% Shapiro Wilk Critical Value	0.874	Data appear Lognormal at 5% Significance Level					
725					Lilliefors Test Statistic	0.214	Lilliefors Lognormal GOF Test					
726					5% Lilliefors Critical Value	0.226	Data appear Lognormal at 5% Significance Level					
727					Data appear Lognormal at 5% Significance Level							
728												
729					Lognormal Statistics							
730					Minimum of Logged Data	4.787			Mean of logged Data			5.56
731					Maximum of Logged Data	6.551			SD of logged Data			0.487
732												
733					Assuming Lognormal Distribution							
734					95% H-UCL	383.6			90% Chebyshev (MVUE) UCL			406
735					95% Chebyshev (MVUE) UCL	458.6			97.5% Chebyshev (MVUE) UCL			531.6
736					99% Chebyshev (MVUE) UCL	674.9						
737												
738					Nonparametric Distribution Free UCL Statistics							
739					Data appear to follow a Discernible Distribution at 5% Significance Level							
740												
741					Nonparametric Distribution Free UCLs							
742					95% CLT UCL	366			95% Jackknife UCL			371.6
743					95% Standard Bootstrap UCL	363.7			95% Bootstrap-t UCL			466.1
744					95% Hall's Bootstrap UCL	838.1			95% Percentile Bootstrap UCL			371.4
745					95% BCA Bootstrap UCL	376.4						
746					90% Chebyshev(Mean, Sd) UCL	426.2			95% Chebyshev(Mean, Sd) UCL			486.6
747					97.5% Chebyshev(Mean, Sd) UCL	570.5			99% Chebyshev(Mean, Sd) UCL			735.2
748												
749					Suggested UCL to Use							
750					95% Student's-t UCL	371.6			or 95% Modified-t UCL			375
751					or 95% H-UCL	383.6						
752												
753					Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.							
754					Recommendations are based upon data size, data distribution, and skewness.							
755					These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).							
756					However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.							

	A	B	C	D	E	F	G	H	I	J	K	L
757												
758	ProUCL computes and outputs H-statistic based UCLs for historical reasons only.											
759	H-statistic often results in unstable (both high and low) values of UCL95 as shown in examples in the Technical Guide.											
760	It is therefore recommended to avoid the use of H-statistic based 95% UCLs.											
761	Use of nonparametric methods are preferred to compute UCL95 for skewed data sets which do not follow a gamma distribution.											
762												
763												
764	Mercury											
765												
766	General Statistics											
767					Total Number of Observations	14			Number of Distinct Observations			14
768									Number of Missing Observations			0
769					Minimum	0.17			Mean			2.554
770					Maximum	14			Median			0.825
771					SD	4.475			Std. Error of Mean			1.196
772					Coefficient of Variation	1.752			Skewness			2.264
773												
774	Normal GOF Test											
775					Shapiro Wilk Test Statistic	0.546			Shapiro Wilk GOF Test			
776					5% Shapiro Wilk Critical Value	0.874			Data Not Normal at 5% Significance Level			
777					Lilliefors Test Statistic	0.406			Lilliefors GOF Test			
778					5% Lilliefors Critical Value	0.226			Data Not Normal at 5% Significance Level			
779	Data Not Normal at 5% Significance Level											
780												
781	Assuming Normal Distribution											
782			95% Normal UCL						95% UCLs (Adjusted for Skewness)			
783					95% Student's-t UCL	4.672			95% Adjusted-CLT UCL (Chen-1995)			5.295
784									95% Modified-t UCL (Johnson-1978)			4.793
785												
786	Gamma GOF Test											
787					A-D Test Statistic	1.454			Anderson-Darling Gamma GOF Test			
788					5% A-D Critical Value	0.781			Data Not Gamma Distributed at 5% Significance Level			
789					K-S Test Statistic	0.267			Kolmogorov-Smirnov Gamma GOF Test			
790					5% K-S Critical Value	0.239			Data Not Gamma Distributed at 5% Significance Level			
791	Data Not Gamma Distributed at 5% Significance Level											
792												
793	Gamma Statistics											
794					k hat (MLE)	0.635			k star (bias corrected MLE)			0.546
795					Theta hat (MLE)	4.023			Theta star (bias corrected MLE)			4.674
796					nu hat (MLE)	17.78			nu star (bias corrected)			15.3
797					MLE Mean (bias corrected)	2.554			MLE Sd (bias corrected)			3.455
798									Approximate Chi Square Value (0.05)			7.471
799					Adjusted Level of Significance	0.0312			Adjusted Chi Square Value			6.757
800												
801	Assuming Gamma Distribution											
802					95% Approximate Gamma UCL (use when n>=50))	5.231			95% Adjusted Gamma UCL (use when n<50)			5.784
803												
804	Lognormal GOF Test											
805					Shapiro Wilk Test Statistic	0.886			Shapiro Wilk Lognormal GOF Test			
806					5% Shapiro Wilk Critical Value	0.874			Data appear Lognormal at 5% Significance Level			
807					Lilliefors Test Statistic	0.169			Lilliefors Lognormal GOF Test			
808					5% Lilliefors Critical Value	0.226			Data appear Lognormal at 5% Significance Level			
809	Data appear Lognormal at 5% Significance Level											
810												

	A	B	C	D	E	F	G	H	I	J	K	L
811						Lognormal Statistics						
812					Minimum of Logged Data	-1.772					Mean of logged Data	-0.0274
813					Maximum of Logged Data	2.639					SD of logged Data	1.302
814												
815						Assuming Lognormal Distribution						
816					95% H-UCL	7.529					90% Chebyshev (MVUE) UCL	4.457
817					95% Chebyshev (MVUE) UCL	5.543					97.5% Chebyshev (MVUE) UCL	7.05
818					99% Chebyshev (MVUE) UCL	10.01						
819												
820						Nonparametric Distribution Free UCL Statistics						
821						Data appear to follow a Discernible Distribution at 5% Significance Level						
822												
823						Nonparametric Distribution Free UCLs						
824					95% CLT UCL	4.522					95% Jackknife UCL	4.672
825					95% Standard Bootstrap UCL	4.45					95% Bootstrap-t UCL	16.85
826					95% Hall's Bootstrap UCL	16.89					95% Percentile Bootstrap UCL	4.759
827					95% BCA Bootstrap UCL	5.162						
828					90% Chebyshev(Mean, Sd) UCL	6.142					95% Chebyshev(Mean, Sd) UCL	7.768
829					97.5% Chebyshev(Mean, Sd) UCL	10.02					99% Chebyshev(Mean, Sd) UCL	14.45
830												
831						Suggested UCL to Use						
832					95% Chebyshev (Mean, Sd) UCL	7.768						
833												
834						Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.						
835						Recommendations are based upon data size, data distribution, and skewness.						
836						These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).						
837						However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.						
838												
839	Nickel											
840												
841						General Statistics						
842					Total Number of Observations	14					Number of Distinct Observations	10
843					Number of Detects	11					Number of Non-Detects	3
844					Number of Distinct Detects	9					Number of Distinct Non-Detects	1
845					Minimum Detect	3.1					Minimum Non-Detect	2
846					Maximum Detect	22					Maximum Non-Detect	2
847					Variance Detects	36.56					Percent Non-Detects	21.43%
848					Mean Detects	10.4					SD Detects	6.047
849					Median Detects	8.4					CV Detects	0.581
850					Skewness Detects	1.191					Kurtosis Detects	0.55
851					Mean of Logged Detects	2.198					SD of Logged Detects	0.564
852												
853						Normal GOF Test on Detects Only						
854					Shapiro Wilk Test Statistic	0.844					Shapiro Wilk GOF Test	
855					5% Shapiro Wilk Critical Value	0.85					Detected Data Not Normal at 5% Significance Level	
856					Lilliefors Test Statistic	0.241					Lilliefors GOF Test	
857					5% Lilliefors Critical Value	0.251					Detected Data appear Normal at 5% Significance Level	
858						Detected Data appear Approximate Normal at 5% Significance Level						
859												

	A	B	C	D	E	F	G	H	I	J	K	L
860	**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**											
861					KM Mean	8.6					KM Standard Error of Mean	1.728
862					KM SD	6.164					95% KM (BCA) UCL	11.54
863					95% KM (t) UCL	11.66					95% KM (Percentile Bootstrap) UCL	11.55
864					95% KM (z) UCL	11.44					95% KM Bootstrap t UCL	13.26
865					90% KM Chebyshev UCL	13.78					95% KM Chebyshev UCL	16.13
866					97.5% KM Chebyshev UCL	19.39					99% KM Chebyshev UCL	25.79
867												
868	**Gamma GOF Tests on Detected Observations Only**											
869					A-D Test Statistic	0.442	**Anderson-Darling GOF Test**					
870					5% A-D Critical Value	0.733	Detected data appear Gamma Distributed at 5% Significance Level					
871					K-S Test Statistic	0.189	**Kolmogorov-Smirnov GOF**					
872					5% K-S Critical Value	0.257	Detected data appear Gamma Distributed at 5% Significance Level					
873	**Detected data appear Gamma Distributed at 5% Significance Level**											
874												
875	**Gamma Statistics on Detected Data Only**											
876					k hat (MLE)	3.638					k star (bias corrected MLE)	2.706
877					Theta hat (MLE)	2.859					Theta star (bias corrected MLE)	3.843
878					nu hat (MLE)	80.03					nu star (bias corrected)	59.54
879					Mean (detects)	10.4						
880												
881	**Gamma ROS Statistics using Imputed Non-Detects**											
882	GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs											
883	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)											
884	For such situations, GROS method may yield incorrect values of UCLs and BTVs											
885	This is especially true when the sample size is small.											
886	For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates											
887					Minimum	0.01					Mean	8.243
888					Maximum	22					Median	7.15
889					SD	6.823					CV	0.828
890					k hat (MLE)	0.594					k star (bias corrected MLE)	0.514
891					Theta hat (MLE)	13.87					Theta star (bias corrected MLE)	16.02
892					nu hat (MLE)	16.64					nu star (bias corrected)	14.4
893					Adjusted Level of Significance (β)	0.0312						
894					Approximate Chi Square Value (14.40, α)	6.849					Adjusted Chi Square Value (14.40, β)	6.169
895					95% Gamma Approximate UCL (use when n>=50)	17.34					95% Gamma Adjusted UCL (use when n<50)	19.25
896												
897	**Estimates of Gamma Parameters using KM Estimates**											
898					Mean (KM)	8.6					SD (KM)	6.164
899					Variance (KM)	38					SE of Mean (KM)	1.728
900					k hat (KM)	1.946					k star (KM)	1.577
901					nu hat (KM)	54.5					nu star (KM)	44.16
902					theta hat (KM)	4.418					theta star (KM)	5.453
903					80% gamma percentile (KM)	13.23					90% gamma percentile (KM)	17.7
904					95% gamma percentile (KM)	22.03					99% gamma percentile (KM)	31.77
905												
906	**Gamma Kaplan-Meier (KM) Statistics**											
907					Approximate Chi Square Value (44.16, α)	29.92					Adjusted Chi Square Value (44.16, β)	28.37
908					95% Gamma Approximate KM-UCL (use when n>=50)	12.69					95% Gamma Adjusted KM-UCL (use when n<50)	13.39
909												

	A	B	C	D	E	F	G	H	I	J	K	L
910	**Lognormal GOF Test on Detected Observations Only**											
911					Shapiro Wilk Test Statistic	0.946	**Shapiro Wilk GOF Test**					
912					5% Shapiro Wilk Critical Value	0.85	Detected Data appear Lognormal at 5% Significance Level					
913					Lilliefors Test Statistic	0.153	**Lilliefors GOF Test**					
914					5% Lilliefors Critical Value	0.251	Detected Data appear Lognormal at 5% Significance Level					
915	**Detected Data appear Lognormal at 5% Significance Level**											
916												
917	**Lognormal ROS Statistics Using Imputed Non-Detects**											
918					Mean in Original Scale	8.69				Mean in Log Scale		1.912
919					SD in Original Scale	6.304				SD in Log Scale		0.761
920					95% t UCL (assumes normality of ROS data)	11.67				95% Percentile Bootstrap UCL		11.54
921					95% BCA Bootstrap UCL	11.51				95% Bootstrap t UCL		13.06
922					95% H-UCL (Log ROS)	15.06						
923												
924	**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**											
925					KM Mean (logged)	1.876				KM Geo Mean		6.525
926					KM SD (logged)	0.78				95% Critical H Value (KM-Log)		2.45
927					KM Standard Error of Mean (logged)	0.219				95% H-UCL (KM -Log)		15.03
928					KM SD (logged)	0.78				95% Critical H Value (KM-Log)		2.45
929					KM Standard Error of Mean (logged)	0.219						
930												
931	**DL/2 Statistics**											
932			**DL/2 Normal**				**DL/2 Log-Transformed**					
933					Mean in Original Scale	8.386				Mean in Log Scale		1.727
934					SD in Original Scale	6.644				SD in Log Scale		1.059
935					95% t UCL (Assumes normality)	11.53				95% H-Stat UCL		23.01
936	**DL/2 is not a recommended method, provided for comparisons and historical reasons**											
937												
938	**Nonparametric Distribution Free UCL Statistics**											
939	**Detected Data appear Approximate Normal Distributed at 5% Significance Level**											
940												
941	**Suggested UCL to Use**											
942					95% KM (t) UCL	11.66						
943												
944	When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test											
945	When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL											
946												
947	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
948	Recommendations are based upon data size, data distribution, and skewness.											
949	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
950	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
951												
952												
953	**Selenium0823**											
954												
955	**General Statistics**											
956					Total Number of Observations	14				Number of Distinct Observations		13
957										Number of Missing Observations		0
958					Minimum	8.3				Mean		35.24
959					Maximum	59				Median		32.5
960					SD	17.87				Std. Error of Mean		4.776
961					Coefficient of Variation	0.507				Skewness		-0.117
962												
963	**Normal GOF Test**											

	A	B	C	D	E	F	G	H	I	J	K	L
964					Shapiro Wilk Test Statistic	0.919	**Shapiro Wilk GOF Test**					
965					5% Shapiro Wilk Critical Value	0.874	Data appear Normal at 5% Significance Level					
966					Lilliefors Test Statistic	0.168	**Lilliefors GOF Test**					
967					5% Lilliefors Critical Value	0.226	Data appear Normal at 5% Significance Level					
968	**Data appear Normal at 5% Significance Level**											
969												
970	**Assuming Normal Distribution**											
971	**95% Normal UCL**						**95% UCLs (Adjusted for Skewness)**					
972					95% Student's-t UCL	43.69				95% Adjusted-CLT UCL (Chen-1995)		42.93
973										95% Modified-t UCL (Johnson-1978)		43.67
974												
975	**Gamma GOF Test**											
976					A-D Test Statistic	0.528	**Anderson-Darling Gamma GOF Test**					
977					5% A-D Critical Value	0.742	Detected data appear Gamma Distributed at 5% Significance Level					
978					K-S Test Statistic	0.17	**Kolmogorov-Smirnov Gamma GOF Test**					
979					5% K-S Critical Value	0.23	Detected data appear Gamma Distributed at 5% Significance Level					
980	**Detected data appear Gamma Distributed at 5% Significance Level**											
981												
982	**Gamma Statistics**											
983					k hat (MLE)	3.242				k star (bias corrected MLE)		2.595
984					Theta hat (MLE)	10.87				Theta star (bias corrected MLE)		13.58
985					nu hat (MLE)	90.78				nu star (bias corrected)		72.66
986					MLE Mean (bias corrected)	35.24				MLE Sd (bias corrected)		21.87
987										Approximate Chi Square Value (0.05)		54.03
988					Adjusted Level of Significance	0.0312				Adjusted Chi Square Value		51.91
989												
990	**Assuming Gamma Distribution**											
991			95% Approximate Gamma UCL (use when n>=50))			47.38				95% Adjusted Gamma UCL (use when n<50)		49.33
992												
993	**Lognormal GOF Test**											
994					Shapiro Wilk Test Statistic	0.888	**Shapiro Wilk Lognormal GOF Test**					
995					5% Shapiro Wilk Critical Value	0.874	Data appear Lognormal at 5% Significance Level					
996					Lilliefors Test Statistic	0.165	**Lilliefors Lognormal GOF Test**					
997					5% Lilliefors Critical Value	0.226	Data appear Lognormal at 5% Significance Level					
998	**Data appear Lognormal at 5% Significance Level**											
999												
1000	**Lognormal Statistics**											
1001					Minimum of Logged Data	2.116				Mean of logged Data		3.4
1002					Maximum of Logged Data	4.078				SD of logged Data		0.644
1003												
1004	**Assuming Lognormal Distribution**											
1005					95% H-UCL	55.31				90% Chebyshev (MVUE) UCL		55.76
1006					95% Chebyshev (MVUE) UCL	64.61				97.5% Chebyshev (MVUE) UCL		76.88
1007					99% Chebyshev (MVUE) UCL	101						
1008												
1009	**Nonparametric Distribution Free UCL Statistics**											
1010	**Data appear to follow a Discernible Distribution at 5% Significance Level**											
1011												

	A	B	C	D	E	F	G	H	I	J	K	L
1012					Nonparametric Distribution Free UCLs							
1013					95% CLT UCL	43.09				95% Jackknife UCL		43.69
1014					95% Standard Bootstrap UCL	42.94				95% Bootstrap-t UCL		43.69
1015					95% Hall's Bootstrap UCL	42.41				95% Percentile Bootstrap UCL		42.5
1016					95% BCA Bootstrap UCL	42.64						
1017					90% Chebyshev(Mean, Sd) UCL	49.56				95% Chebyshev(Mean, Sd) UCL		56.06
1018					97.5% Chebyshev(Mean, Sd) UCL	65.06				99% Chebyshev(Mean, Sd) UCL		82.76
1019												
1020					Suggested UCL to Use							
1021					95% Student's-t UCL	43.69						
1022												
1023					Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.							
1024					Recommendations are based upon data size, data distribution, and skewness.							
1025					These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).							
1026					However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.							
1027												
1028					Note: For highly negatively-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be							
1029					reliable. Chen's and Johnson's methods provide adjustments for positvely skewed data sets.							
1030												
1031	Silver											
1032												
1033					General Statistics							
1034					Total Number of Observations	14				Number of Distinct Observations		11
1035					Number of Detects	13				Number of Non-Detects		1
1036					Number of Distinct Detects	11				Number of Distinct Non-Detects		1
1037					Minimum Detect	2.5				Minimum Non-Detect		2.5
1038					Maximum Detect	14				Maximum Non-Detect		2.5
1039					Variance Detects	14.27				Percent Non-Detects		7.143%
1040					Mean Detects	7.454				SD Detects		3.777
1041					Median Detects	5.9				CV Detects		0.507
1042					Skewness Detects	0.268				Kurtosis Detects		-1.49
1043					Mean of Logged Detects	1.875				SD of Logged Detects		0.555
1044												
1045					Normal GOF Test on Detects Only							
1046					Shapiro Wilk Test Statistic	0.893				Shapiro Wilk GOF Test		
1047					5% Shapiro Wilk Critical Value	0.866				Detected Data appear Normal at 5% Significance Level		
1048					Lilliefors Test Statistic	0.203				Lilliefors GOF Test		
1049					5% Lilliefors Critical Value	0.234				Detected Data appear Normal at 5% Significance Level		
1050					Detected Data appear Normal at 5% Significance Level							
1051												
1052					Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs							
1053					KM Mean	7.1				KM Standard Error of Mean		1.036
1054					KM SD	3.723				95% KM (BCA) UCL		8.929
1055					95% KM (t) UCL	8.934				95% KM (Percentile Bootstrap) UCL		8.707
1056					95% KM (z) UCL	8.803				95% KM Bootstrap t UCL		9.096
1057					90% KM Chebyshev UCL	10.21				95% KM Chebyshev UCL		11.61
1058					97.5% KM Chebyshev UCL	13.57				99% KM Chebyshev UCL		17.4
1059												
1060					Gamma GOF Tests on Detected Observations Only							
1061					A-D Test Statistic	0.629				Anderson-Darling GOF Test		
1062					5% A-D Critical Value	0.737				Detected data appear Gamma Distributed at 5% Significance Level		
1063					K-S Test Statistic	0.236				Kolmogorov-Smirnov GOF		
1064					5% K-S Critical Value	0.238				Detected data appear Gamma Distributed at 5% Significance Level		
1065					Detected data appear Gamma Distributed at 5% Significance Level							

	A	B	C	D	E	F	G	H	I	J	K	L
1066												
1067						**Gamma Statistics on Detected Data Only**						
1068						k hat (MLE)	3.908				k star (bias corrected MLE)	3.057
1069						Theta hat (MLE)	1.907				Theta star (bias corrected MLE)	2.438
1070						nu hat (MLE)	101.6				nu star (bias corrected)	79.49
1071						Mean (detects)	7.454					
1072												
1073						**Gamma ROS Statistics using Imputed Non-Detects**						
1074						GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs						
1075						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)						
1076						For such situations, GROS method may yield incorrect values of UCLs and BTVs						
1077						This is especially true when the sample size is small.						
1078						For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates						
1079						Minimum	0.951				Mean	6.989
1080						Maximum	14				Median	5.6
1081						SD	4.024				CV	0.576
1082						k hat (MLE)	2.575				k star (bias corrected MLE)	2.071
1083						Theta hat (MLE)	2.714				Theta star (bias corrected MLE)	3.375
1084						nu hat (MLE)	72.1				nu star (bias corrected)	57.98
1085						Adjusted Level of Significance (β)	0.0312					
1086						Approximate Chi Square Value (57.98, α)	41.48				Adjusted Chi Square Value (57.98, β)	39.63
1087						95% Gamma Approximate UCL (use when n>=50)	9.771				95% Gamma Adjusted UCL (use when n<50)	10.23
1088												
1089						**Estimates of Gamma Parameters using KM Estimates**						
1090						Mean (KM)	7.1				SD (KM)	3.723
1091						Variance (KM)	13.86				SE of Mean (KM)	1.036
1092						k hat (KM)	3.638				k star (KM)	2.906
1093						nu hat (KM)	101.9				nu star (KM)	81.37
1094						theta hat (KM)	1.952				theta star (KM)	2.443
1095						80% gamma percentile (KM)	10.17				90% gamma percentile (KM)	12.68
1096						95% gamma percentile (KM)	15.04				99% gamma percentile (KM)	20.15
1097												
1098						**Gamma Kaplan-Meier (KM) Statistics**						
1099						Approximate Chi Square Value (81.37, α)	61.58				Adjusted Chi Square Value (81.37, β)	59.3
1100						95% Gamma Approximate KM-UCL (use when n>=50)	9.381				95% Gamma Adjusted KM-UCL (use when n<50)	9.742
1101												
1102						**Lognormal GOF Test on Detected Observations Only**						
1103						Shapiro Wilk Test Statistic	0.912				**Shapiro Wilk GOF Test**	
1104						5% Shapiro Wilk Critical Value	0.866				Detected Data appear Lognormal at 5% Significance Level	
1105						Lilliefors Test Statistic	0.235				**Lilliefors GOF Test**	
1106						5% Lilliefors Critical Value	0.234				Detected Data Not Lognormal at 5% Significance Level	
1107						**Detected Data appear Approximate Lognormal at 5% Significance Level**						
1108												
1109						**Lognormal ROS Statistics Using Imputed Non-Detects**						
1110						Mean in Original Scale	7.045				Mean in Log Scale	1.78
1111						SD in Original Scale	3.939				SD in Log Scale	0.641
1112						95% t UCL (assumes normality of ROS data)	8.909				95% Percentile Bootstrap UCL	8.707
1113						95% BCA Bootstrap UCL	8.781				95% Bootstrap t UCL	9.058
1114						95% H-UCL (Log ROS)	10.9					
1115												

	A	B	C	D	E	F	G	H	I	J	K	L
1116	Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution											
1117					KM Mean (logged)	1.807					KM Geo Mean	6.091
1118					KM SD (logged)	0.57					95% Critical H Value (KM-Log)	2.128
1119					KM Standard Error of Mean (logged)	0.159					95% H-UCL (KM -Log)	10.03
1120					KM SD (logged)	0.57					95% Critical H Value (KM-Log)	2.128
1121					KM Standard Error of Mean (logged)	0.159						
1122												
1123	DL/2 Statistics											
1124	DL/2 Normal						DL/2 Log-Transformed					
1125					Mean in Original Scale	7.011					Mean in Log Scale	1.757
1126					SD in Original Scale	3.99					SD in Log Scale	0.692
1127					95% t UCL (Assumes normality)	8.899					95% H-Stat UCL	11.52
1128	DL/2 is not a recommended method, provided for comparisons and historical reasons											
1129												
1130	Nonparametric Distribution Free UCL Statistics											
1131	Detected Data appear Normal Distributed at 5% Significance Level											
1132												
1133	Suggested UCL to Use											
1134					95% KM (t) UCL	8.934						
1135												
1136	Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.											
1137	Recommendations are based upon data size, data distribution, and skewness.											
1138	These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).											
1139	However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.											
1140												
1141												
1142	Zinc											
1143												
1144	General Statistics											
1145					Total Number of Observations	14					Number of Distinct Observations	14
1146											Number of Missing Observations	0
1147					Minimum	55					Mean	1277
1148					Maximum	15000					Median	210
1149					SD	3953					Std. Error of Mean	1056
1150					Coefficient of Variation	3.095					Skewness	3.732
1151												
1152	Normal GOF Test											
1153					Shapiro Wilk Test Statistic	0.33	Shapiro Wilk GOF Test					
1154					5% Shapiro Wilk Critical Value	0.874	Data Not Normal at 5% Significance Level					
1155					Lilliefors Test Statistic	0.508	Lilliefors GOF Test					
1156					5% Lilliefors Critical Value	0.226	Data Not Normal at 5% Significance Level					
1157	Data Not Normal at 5% Significance Level											
1158												
1159	Assuming Normal Distribution											
1160	95% Normal UCL						95% UCLs (Adjusted for Skewness)					
1161					95% Student's-t UCL	3148					95% Adjusted-CLT UCL (Chen-1995)	4141
1162											95% Modified-t UCL (Johnson-1978)	3324
1163												
1164	Gamma GOF Test											
1165					A-D Test Statistic	2.54	Anderson-Darling Gamma GOF Test					
1166					5% A-D Critical Value	0.815	Data Not Gamma Distributed at 5% Significance Level					
1167					K-S Test Statistic	0.415	Kolmogorov-Smirnov Gamma GOF Test					
1168					5% K-S Critical Value	0.245	Data Not Gamma Distributed at 5% Significance Level					
1169	Data Not Gamma Distributed at 5% Significance Level											

	A	B	C	D	E	F	G	H	I	J	K	L
1170												
1171						Gamma Statistics						
1172					k hat (MLE)	0.386				k star (bias corrected MLE)		0.351
1173					Theta hat (MLE)	3312				Theta star (bias corrected MLE)		3643
1174					nu hat (MLE)	10.8				nu star (bias corrected)		9.818
1175					MLE Mean (bias corrected)	1277				MLE Sd (bias corrected)		2157
1176										Approximate Chi Square Value (0.05)		3.828
1177					Adjusted Level of Significance	0.0312				Adjusted Chi Square Value		3.347
1178												
1179						Assuming Gamma Distribution						
1180					95% Approximate Gamma UCL (use when n>=50))	3276				95% Adjusted Gamma UCL (use when n<50)		3747
1181												
1182						Lognormal GOF Test						
1183					Shapiro Wilk Test Statistic	0.795				Shapiro Wilk Lognormal GOF Test		
1184					5% Shapiro Wilk Critical Value	0.874				Data Not Lognormal at 5% Significance Level		
1185					Lilliefors Test Statistic	0.233				Lilliefors Lognormal GOF Test		
1186					5% Lilliefors Critical Value	0.226				Data Not Lognormal at 5% Significance Level		
1187						Data Not Lognormal at 5% Significance Level						
1188												
1189						Lognormal Statistics						
1190					Minimum of Logged Data	4.007				Mean of logged Data		5.436
1191					Maximum of Logged Data	9.616				SD of logged Data		1.44
1192												
1193						Assuming Lognormal Distribution						
1194					95% H-UCL	2701				90% Chebyshev (MVUE) UCL		1309
1195					95% Chebyshev (MVUE) UCL	1644				97.5% Chebyshev (MVUE) UCL		2108
1196					99% Chebyshev (MVUE) UCL	3021						
1197												
1198						Nonparametric Distribution Free UCL Statistics						
1199						Data do not follow a Discernible Distribution (0.05)						
1200												
1201						Nonparametric Distribution Free UCLs						
1202					95% CLT UCL	3015				95% Jackknife UCL		3148
1203					95% Standard Bootstrap UCL	2940				95% Bootstrap-t UCL		33015
1204					95% Hall's Bootstrap UCL	15944				95% Percentile Bootstrap UCL		3373
1205					95% BCA Bootstrap UCL	4408						
1206					90% Chebyshev(Mean, Sd) UCL	4446				95% Chebyshev(Mean, Sd) UCL		5882
1207					97.5% Chebyshev(Mean, Sd) UCL	7874				99% Chebyshev(Mean, Sd) UCL		11788
1208												
1209						Suggested UCL to Use						
1210					95% Chebyshev (Mean, Sd) UCL	5882						
1211												
1212						Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.						
1213						Recommendations are based upon data size, data distribution, and skewness.						
1214						These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).						
1215						However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.						
1216												

	A	B	C	D	E	F	G	H	I	J	K	L	M
1				General Statistics on Uncensored Data									
2		Date/Time of Computation		ProUCL 5.110/18/2019 10:50:15 AM									
3		User Selected Options											
4			From File	ProUCL Input_HCW.xls									
5			Full Precision	OFF									
6													
7	From File: ProUCL Input_HCW.xls												
8													
9	General Statistics for Censored Data Set (with NDs) using Kaplan Meier Method												
10													
11	Variable		NumObs	# Missing	Num Ds	NumNDs	% NDs	Min ND	Max ND	KM Mean	KM Var	KM SD	KM CV
12		Antimony	4	0	0	4	100.00%	4.8	5	N/A	N/A	N/A	N/A
13		Arsenic	4	0	3	1	25.00%	4.8	4.8	19.88	174.7	13.22	0.665
14		Barium	4	0	4	0	0.00%	N/A	N/A	55.25	911.6	30.19	0.546
15		Beryllium	4	0	1	3	75.00%	0.48	0.5	0.685	0.126	0.355	0.518
16		Cadmium	4	0	4	0	0.00%	N/A	N/A	0.708	0.0268	0.164	0.231
17		Chromium	4	0	4	0	0.00%	N/A	N/A	18.93	326.7	18.07	0.955
18		Copper	4	0	4	0	0.00%	N/A	N/A	1001	1138564	1067	1.066
19		Lead	4	0	4	0	0.00%	N/A	N/A	21.75	88.92	9.43	0.434
20		Manganese	4	0	4	0	0.00%	N/A	N/A	362.5	58958	242.8	0.67
21		Mercury	4	0	2	2	50.00%	0.093	0.1	0.304	0.115	0.339	1.115
22		Nickel	4	0	4	0	0.00%	N/A	N/A	19.7	316	17.78	0.902
23		Selenium	4	0	3	1	25.00%	4.8	4.8	8.325	8.017	2.831	0.34
24		Silver	4	0	0	4	100.00%	2.4	2.5	N/A	N/A	N/A	N/A
25		Thallium	4	0	0	4	100.00%	4.8	5	N/A	N/A	N/A	N/A
26		Zinc	4	0	4	0	0.00%	N/A	N/A	157	9036	95.06	0.605
27													
28	General Statistics for Raw Data Sets using Detected Data Only												
29													
30	Variable		NumObs	# Missing	Minimum	Maximum	Mean	Median	Var	SD	MAD/0.675	Skewness	CV
31		Antimony	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
32		Arsenic	3	0	8.7	34	24.9	32	197.8	14.07	2.965	-1.693	0.565
33		Barium	4	0	34	100	55.25	43.5	911.6	30.19	8.154	1.856	0.546
34		Beryllium	1	0	1.3	1.3	1.3	1.3	N/A	N/A	0	N/A	N/A
35		Cadmium	4	0	0.57	0.93	0.708	0.665	0.0268	0.164	0.119	1.09	0.231
36		Chromium	4	0	8.7	46	18.93	10.5	326.7	18.07	1.705	1.984	0.955
37		Copper	4	0	64	2200	1001	870	1138564	1067	1139	0.262	1.066
38		Lead	4	0	11	33	21.75	21.5	88.92	9.43	10.38	0.13	0.434
39		Manganese	4	0	120	690	362.5	320	58958	242.8	192.7	0.922	0.67
40		Mercury	2	0	0.14	0.89	0.515	0.515	0.281	0.53	0.556	N/A	1.03
41		Nickel	4	0	6.8	46	19.7	13	316	17.78	4.596	1.833	0.902
42		Selenium	3	0	6.5	12	9.5	10	7.75	2.784	2.965	-0.782	0.293
43		Silver	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
44		Thallium	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
45		Zinc	4	0	48	270	157	155	9036	95.06	105.3	0.103	0.605
46													

	A	B	C	D	E	F	G	H	I	J	K	L	M
47	Percentiles using all Detects (Ds) and Non-Detects (NDs)												
48													
49	Variable		NumObs	# Missing	10%ile	20%ile	25%ile(Q1)	50%ile(Q2)	75%ile(Q3)	80%ile	90%ile	95%ile	99%ile
50		Antimony	4	0	4.83	4.86	4.875	4.9	4.925	4.94	4.97	4.985	4.997
51		Arsenic	4	0	5.97	7.14	7.725	20.35	32.5	32.8	33.4	33.7	33.94
52		Barium	4	0	36.4	38.8	40	43.5	58.75	67	83.5	91.75	98.35
53		Beryllium	4	0	0.48	0.48	0.48	0.49	0.7	0.82	1.06	1.18	1.276
54		Cadmium	4	0	0.579	0.588	0.593	0.665	0.78	0.81	0.87	0.9	0.924
55		Chromium	4	0	9.09	9.48	9.675	10.5	19.75	25	35.5	40.75	44.95
56		Copper	4	0	86.8	109.6	121	870	1750	1840	2020	2110	2182
57		Lead	4	0	13.1	15.2	16.25	21.5	27	28.2	30.6	31.8	32.76
58		Manganese	4	0	162	204	225	320	457.5	504	597	643.5	680.7
59		Mercury	4	0	0.0951	0.0972	0.0983	0.12	0.328	0.44	0.665	0.778	0.868
60		Nickel	4	0	8.66	10.52	11.45	13	21.25	26.2	36.1	41.05	45.01
61		Selenium	4	0	5.31	5.82	6.075	8.25	10.5	10.8	11.4	11.7	11.94
62		Silver	4	0	2.43	2.46	2.475	2.5	2.5	2.5	2.5	2.5	2.5
63		Thallium	4	0	4.83	4.86	4.875	4.95	5	5	5	5	5
64		Zinc	4	0	69.6	91.2	102	155	210	222	246	258	267.6

ATTACHMENT H-4

ECOLOGICAL RISK MODEL RESULTS

Table H4-1
Step Screening Level Risk Estimate, EA 1 Surface Soil

												Blacktailed Jackrabbit	Horned Lark	Coyote
										FIRavg	kg/kg BW-d	0.048	0.214	0.032
										ps	fraction	0.02	0.029	0.028
										diet - pl?	fraction	1	0.1	0.025
										diet - si?	fraction	0	0.9	0.025
		Soil Concentration	Bioaccumulation Factors			Toxicity Reference Values (TRV)				diet - sm?	fraction	0	0	0.95
										SUF		1	1	1
		MDC	BAFsp	BAFsi	BAFsm	TRVlow-m	TRVlow-b	TRVhigh-m	TRVhigh-b					
COPEC	CAS	mg/kg	unitless			mg/kgBW-d						*Low (NOAEL)*	*Low (NOAEL)*	*Low (NOAEL)*
Metals														
Antimony	7440-36-0	7.2	0.035	1.000	0.050	0.059	NA	0.59	NA			0.3	no TRV-qual	0.4
Arsenic	7440-38-2	250	1.103	0.048	0.003	1.04	2.24	1.66	4.5			13.0	4.4	0.5
Cadmium	7440-43-9	6.8	0.260	5.590	0.103	0.77	1.47	2.64	2.4			0.1	5.0	0.1
Copper	7440-50-8	22,000	0.005	1.530	0.000	5.6	4.1	15.5	12.1			4.6	1,615	8.4
Lead	7439-92-1	140	0.030	0.310	0.069	4.7	1.63	8.9	3.26			0.1	5.7	0.1
Manganese	7439-96-5	2,400	0.234	0.037	0.060	51.5	179	71	376.6			0.6	0.2	0.1
Mercury	7439-97-6	2.7	0.235	1.690	0.190	1	0.45	5.1	0.9			0.0	2.0	0.0
Nickel	7440-02-0	14	0.056	1	0.191	1.7	6.71	3.4	18.6			0.0	0.4	0.1
Selenium	7782-49-2	77	0.798	0.291	0.102	0.143	0.29	0.215	0.37			21.2	21	2.6
Silver	7440-22-4	20	0.037	15.340	0.500	6.02	2.02	60.2	20.2			0.0	29.3	0.1
Zinc	7440-66-6	1,800	0.085	0.555	0.074	75.4	66.1	81.1	79.3			0.1	3.1	0.1

Notes

Highlighting indicates HQ>1 based on the EPC (95% UCL of the mean or MDC)
CAS = Chemical Abstracts Service
COPEC = chemical of potential ecological concern
diet-pl? = fraction of plants in diet
diet-si? = fraction of invertebrates in diet (generally modeled as earthworms)
diet-sm? = fraction of small mammals (and birds) in diet
FIRavg= average food intake rate for endpoint
LOAEL = Risk at High TRV based on Lowest Observed Adverse Effect Level
MDC= Maximum Detected Concentration
mg/kg = milligram per kilogram
NOAEL = Risk at Low TRV based on No Observed Adverse Effect Level
ps = incidental soil ingestion as fraction of total food intake
SUF= site use factor
TRV = toxicity reference value
UCL = EPC based on 95%UCL of the mean

Table H4-2
Step 2 Screening Level Risk Estimate, EA 2 Surface Soil

												Blacktailed Jackrabbit	Horned Lark	Coyote
										FIRavg	kg/kg BW-d	0.048	0.214	0.032
										ps	fraction	0.02	0.029	0.028
										diet - pl?	fraction	1	0.1	0.025
										diet - si?	fraction	0	0.9	0.025
		Soil Concentration	Bioaccumulation Factors			Toxicity Reference Values (TRV)				diet - sm?	fraction	0	0	0.95
										SUF		1	1	1
		MDC	BAFsp	BAFsi	BAFsm	TRVlow-m	TRVlow-b	TRVhigh-m	TRVhigh-b					
COPEC	**CAS**	**mg/kg**	**unitless**			**mg/kgBW-d**						***Low (NOAEL)***	***Low (NOAEL)***	***Low (NOAEL)***
Metals														
Antimony	7440-36-0	42	0.031	1.000	0.050	0.059	NA	0.59	NA			1.8	no TRV-qual	2.3
Arsenic	7440-38-2	450	1.103	0.040	0.003	1.04	2.24	1.66	4.5			23.3	7.5	0.8
Cadmium	7440-43-9	65	0.093	3.519	0.031	0.77	1.47	2.64	2.4			0.5	30.3	0.4
Chromium	7440-47-3	31	0.083	3.160	0.093	2.4	2.66	9.6	5			0.1	7.2	0.1
Copper	7440-50-8	24,000	0.004	1.530	0.000	5.6	4.1	15.5	12.1			5.0	1,762	9.1
Lead	7439-92-1	1,200	0.012	0.205	0.021	4.7	1.63	8.9	3.26			0.4	33.8	0.4
Manganese	7439-96-5	700	0.234	0.055	0.060	51.5	179	71	376.6			0.2	0.1	0.0
Mercury	7439-97-6	14	0.111	1.690	0.190	1	0.45	5.1	0.9			0.1	10.4	0.1
Nickel	7440-02-0	22	0.050	1	0.150	1.7	6.71	3.4	18.6			0.0	0.7	0.1
Selenium	7782-49-2	59	0.777	0.312	0.127	0.143	0.29	0.215	0.37			15.8	17	2.3
Silver	7440-22-4	14	0.037	15.340	0.500	6.02	2.02	60.2	20.2			0.0	20.5	0.1
Zinc	7440-66-6	15,000	0.033	0.134	0.010	75.4	66.1	81.1	79.3			0.5	7.4	0.3

Notes

Highlighting indicates HQ>1 based on the EPC (95% UCL of the mean or MDC)
CAS = Chemical Abstracts Service
COPEC = chemical of potential ecological concern
diet-pl? = fraction of plants in diet
diet-si? = fraction of invertebrates in diet (generally modeled as earthworms)
diet-sm? = fraction of small mammals (and birds) in diet
FIRavg= average food intake rate for endpoint
LOAEL = Risk at High TRV based on Lowest Observed Adverse Effect Level
MDC= Maximum Detected Concentration
mg/kg = milligram per kilogram
NOAEL = Risk at Low TRV based on No Observed Adverse Effect Level
ps = incidental soil ingestion as fraction of total food intake
SUF= site use factor
TRV = toxicity reference value
UCL = EPC based on 95%UCL of the mean
SRL = soil remediation level

Table H4-3
Step 3A Site-Specific Risk Estimate and Preliminary Soil Remediation Level, EA 1 Surface Soil

												Blacktailed Jackrabbit		Horned Lark		Coyote	
										FIRavg	kg/kg BW-d	0.048		0.214		0.032	
										ps	fraction	0.02		0.029		0.028	
										diet - pl?	fraction	1		0.1		0.025	
										diet - si?	fraction	0		0.9		0.025	
		Soil Concentration	**Bioaccumulation Factors**			**Toxicity Reference Values (TRV)**				diet - sm?	fraction	0		0		0.95	
										SUF		0.161		1		0.0016	
		95%UCL	**BAFsp**	**BAFsi**	**BAFsm**	**TRVlow-m**	**TRVlow-b**	**TRVhigh-m**	**TRVhigh-b**	Background Eval							
COPEC	**CAS**	**mg/kg**	**unitless**			**mg/kgBW-d**				***Bkgrd mg/kg***	***UCL <Bkgrd***	***Low (NOAEL)***	***High (LOAEL)***	***Low (NOAEL)***	***High (LOAEL)***	***Low (NOAEL)***	***High (LOAEL)***
Metals																	
Antimony	7440-36-0	5.34	0.036	1.000	0.050	0.059	NA	0.59	NA	<5.0	NA	0.0	0.0	no TRV-qual	no TRV-qual	0.0	0.0
Arsenic	7440-38-2	143.2	0.038	0.056	0.003	1.04	2.24	1.66	4.5	26.4	No	0.1	0.0	1	0.6	0.0	0.0
Cadmium	7440-43-9	1.8	0.476	7.341	0.209	0.77	1.47	2.64	2.4	3.98	**Yes**	0.0	0.0	2	1	0.0	0.0
Copper	7440-50-8	5077	0.011	0.515	0.001	5.6	4.1	15.5	12.1	384.3	No	0.2	0.1	131	44	0.0	0.0
Lead	7439-92-1	50.63	0.047	0.377	0.121	4.7	1.63	8.9	3.26	64.42	**Yes**	0.0	0.0	2	0.9	0.0	0.0
Manganese	7439-96-5	842.2	0.079	0.052	0.021	51.5	179	71	376.6	1769	**Yes**	0.0	0.0	0.1	0.0	0.0	0.0
Mercury	7439-97-6	1.34	0.323	1.690	0.054	1	0.45	5.1	0.9	0.159	No	0.0	0.0	1	0.5	0.0	0.0
Nickel	7440-02-0	4.52	0.074	1	0.349	1.7	6.71	3.4	18.6	8.35	**Yes**	0.0	0.0	0.1	0.0	0.0	0.0
Selenium	7782-49-2	40.33	0.746	0.346	0.183	0.143	0.29	0.215	0.37	7.29	No	2	1	12	10	0.0	0.0
Silver	7440-22-4	7.84	0.014	2.045	0.004	6.02	2.02	60.2	20.2	<2.5	NA	0.0	0.0	2	0.2	0.0	0.0
Zinc	7440-66-6	416.6	0.162	1.485	0.289	75.4	66.1	81.1	79.3	201.1	No	0.0	0.0	2	2	0.0	0.0

Notes

Highlighting indicates HQ>1 based on the EPC (95% UCL of the mean or MDC)

bkgrd = background level higher than preliminary Soil Remediation Level

CAS = Chemical Abstracts Service

COPEC = chemical of potential ecological concern

diet-pl? = fraction of plants in diet

diet-si? = fraction of invertebrates in diet (generally modeled as earthworms)

diet-sm? = fraction of small mammals (and birds) in diet

FIRavg= average food intake rate for endpoint

LOAEL = Risk at High TRV based on Lowest Observed Adverse Effect Level

MDC= Maximum Detected Concentration

mg/kg = milligram per kilogram

NOAEL = Risk at Low TRV based on No Observed Adverse Effect Level

ps = incidental soil ingestion as fraction of total food intake

SUF= site use factor

TRV = toxicity reference value

UCL = EPC based on 95%UCL of the mean

Table H4-4
Step 3A Site-Specific Risk Estimate and Preliminary Soil Remediation Level, EA 2 Surface Soil

												Blacktailed Jackrabbit		Horned Lark		Coyote	
										FIRavg	kg/kg BW-d	0.048		0.214		0.032	
										ps	fraction	0.02		0.029		0.028	
										diet - pl?	fraction	1		0.1		0.025	
										diet - si?	fraction	0		0.9		0.025	
		Soil Concentration	Bioaccumulation Factors			Toxicity Reference Values (TRV)				diet - sm?	fraction	0		0		0.95	
										SUF		0.053		1		0.0005	
		95%UCL	BAFsp	BAFsi	BAFsm	TRVlow-m	TRVlow-b	TRVhigh-m	TRVhigh-b	Background Eval							
COPEC	**CAS**	**mg/kg**	**unitless**			**mg/kgBW-d**				***mg/kg***	***UCL <Bkgrd***	***Low (NOAEL)***	***High (LOAEL)***	***Low (NOAEL)***	***High (LOAEL)***	***Low (NOAEL)***	***High (LOAEL)***
Metals																	
Antimony	7440-36-0	23.42	0.032	1.000	0.050	0.059	NA	0.59	NA	<5.0	NA	0.1	0.0	no TRV-qual	no TRV-qual	0.0	0.0
Arsenic	7440-38-2	315	0.038	0.045	0.003	1.04	2.24	1.66	4.5	26.4	No	0.0	0.0	2	1	0.0	0.0
Cadmium	7440-43-9	26.11	0.141	4.243	0.051	0.77	1.47	2.64	2.4	3.98	No	0.0	0.0	15	9	0.0	0.0
Chromium	7440-47-3	15.18	0.041	0.306	0.113	2.4	2.66	9.6	5	11.18	No	0.0	0.0	0.4	0.2	0.0	0.0
Copper	7440-50-8	11,689	0.007	0.515	0.0004	5.6	4.1	15.5	12.1	384.3	No	0.1	0.1	301	102	0.0	0.0
Lead	7439-92-1	514.8	0.017	0.241	0.033	4.7	1.63	8.9	3.26	64.42	No	0.0	0.0	12	6	0.0	0.0
Manganese	7439-96-5	371.6	0.079	0.068	0.021	51.5	179	71	376.6	1,769	**Yes**	0.0	0.0	0.0	0.0	0.0	0.0
Mercury	7439-97-6	7.77	0.145	1.690	0.054	1	0.45	5.1	0.9	0.159	No	0.0	0.0	6	3	0.0	0.0
Nickel	7440-02-0	11.66	0.058	1	0.210	1.7	6.71	3.4	18.6	8.35	No	0.0	0.0	0.3	0.1	0.0	0.0
Selenium	7782-49-2	43.69	0.753	0.338	0.168	0.143	0.29	0.215	0.37	7.29	No	0.6	0.4	13	10	0.0	0.0
Silver	7440-22-4	8.93	0.014	2.045	0.004	6.02	2.02	60.2	20.2	<2.5	NA	0.0	0.0	2	0.2	0.0	0.0
Zinc	7440-66-6	5,882	0.050	0.251	0.025	75.4	66.1	81.1	79.3	201.1	No	0.0	0.0	5	4	0.0	0.0

Notes

Highlighting indicates HQ>1 based on the EPC (95% UCL of the mean or MDC)

bkgrd = background level higher than preliminary Soil Remediation Level

CAS = Chemical Abstracts Service

COPEC = chemical of potential ecological concern

diet-pl? = fraction of plants in diet

diet-si? = fraction of invertebrates in diet (generally modeled as earthworms)

diet-sm? = fraction of small mammals (and birds) in diet

FIRavg= average food intake rate for endpoint

LOAEL = Risk at High TRV based on Lowest Observed Adverse Effect Level

MDC= Maximum Detected Concentration

mg/kg = milligram per kilogram

NOAEL = Risk at Low TRV based on No Observed Adverse Effect Level

ps = incidental soil ingestion as fraction of total food intake

SUF= site use factor

TRV = toxicity reference value

UCL = EPC based on 95%UCL of the mean

APPENDIX I

BIOAVAILABILITY DATA

Appendix I : Review of Literature Values for Bioavailability of Arsenic

Summary of As *In Vivo* Studies

	Reference		Test Animal		Site		Name of Test Material	As Total (mg/kg)	As reported within		Updated Value used in the Review	Values for mining related studies only
									Ref Study	EPA 2010		
References included in 2006 selection of RBA distribution that was used in the Bisbee/Ajo HHRA												
A	Freeman et al. 1993	A.1	Rabbit	Anaconda Co. Smelter Site	Montana		soil	3,900	0.48		0.48	0.48
B	Freeman et al. 1995	B.1	Monkey	Anaconda Co. Smelter Site	Montana		soil (residential)	410	0.20		0.20	0.20
		B.2					house dust	170	0.28		0.28	
C	Casteel et al. 1997	C.1	Swine	Kennecott NPL Site, Salt Lake City,	Bingham Creek		tailings (channel)	149	0.37	0.39	0.39	0.39
		C.2		Silver Bow Creek/Butte Area NPL	Butte		soil	234	0.10	0.09	0.09	0.09
		C.3		Milltown Reservoir Sediments NPL	Clark Fork		tailings (GK)	181	0.49	0.51	0.51	0.51
		C.4		California Gulch NPL Site, Leadville, Colorado	Leadville		soil (Fe-Mn lead oxide)	110	0.28	0.57	0.57	0.57
		C.5					slag (AV)	1,050	0.07	0.13	0.13	0.13
		C.6					slag (AV)	1,050	0.15	0.18	0.18	0.18
		C.7					soil (residential)	203	-0.08	0.08	0.08	0.08
		C.8		Midvale Slag NPL Site, Midvale, Utah	Midvale		slag	591	0.18	0.23	0.23	0.23
		C.9		New Jersey Zinc NPL Site, Palmerton, Pennsylvania	Palmerton		soil (location 2)	110	0.39	0.49	0.49	
		C.10					soil (location 4)	134	0.52	0.61	0.61	
		C.11		Murray Smelter Superfund Site	Murray Smelter		slag	695	0.51	0.55	0.55	0.55
		C.12					soil	310	0.34	0.33	0.33	0.33
		C.13		Smuggler Mountain NPL Site, Aspen, Colorado	Aspen Berm		Composite of samples collected from the Racquet Club property (including a parking lot and a vacant lot)	67	0.62	1.00	Rejected by EPA as invalid	
		C.14			Aspen Residential		Composite of samples collected from residential properties within the study area	17	0.98	1.28		
D	Rodriguez and Basta 1999	D.1	Swine	Mining / Smelter Site	Oklahoma		Sample 1 - calcine/soil	11,300	0.03		0.03	0.03
		D.2					Sample 2 - calcine/soil	17,500	0.03		0.03	0.03
		D.3					Sample 3 - calcine/soil	13,500	0.08		0.08	0.08
		D.4					Sample 4- calcine/soil	11,500	0.22		0.22	0.22
		D.5					Sample 5 - calcine/soil	6,250	0.30		0.30	0.30
		D.6					Sample 8 - iron slag	1,180	0.29		0.29	0.29
		D.7					Sample 9 - iron slag	5,020	0.30		0.30	0.30
		D.8					Sample 10 - iron slag	4,650	0.16		0.16	0.16
		D.9					Sample 6 - iron slag	405	bdl		bdl	
		D.10					Sample 7 - iron slag	450	bdl		bdl	
		D.11					Sample 11 - other soil/slag	331	0.06		0.06	0.06
		D.12					Sample 12 - other soil/slag	233	0.43		0.43	0.43
		D.13					Sample 13 - other soil/slag	799	0.29		0.29	0.29
		D.14					Sample 14 - other soil/slag	1,460	0.19		0.19	0.19
		D.15					Sample 15 - other soil/slag	401	0.37		0.37	0.37
E	Roberts et al. 2002	E.1	Monkey		Florida		Electrical substation	312	0.15		0.15	
		E.2					Pesticide site #1	743	0.11		0.11	
		E.3					Wood treatment Site	101	0.16		0.16	
		E.4					Pesticide Site #2	329	0.17		0.17	
		E.5					Cattle dip site	189	0.25		0.25	

Summary of As *In Vivo* Studies

	Reference		Test Animal		Site	Name of Test Material	As Total (mg/kg)	As reported within		Updated Value used in the Review	Values for mining related studies only
								Ref Study	EPA 2010		
Additional Studies											
F	Casteel et al. 2001	F.1	Swine	Vasquez Boulevard and I-70 NPL Site, Denver, Colorado	Colorado TM1	residential soil	312	0.35	0.40	0.4	
		F.2			Colorado TM2	residential soil	983	0.45	0.42	0.42	
		F.3			Colorado TM3	residential soil	390	0.36	0.37	0.37	
		F.4			Colorado TM4	residential soil	813	0.21	0.24	0.24	
		F.5			Colorado TM5	residential soil	368	0.18	0.21	0.21	
		F.6			Colorado TM6	Clean soil spiked with pesticide	516	0.23	0.24	0.24	
G	Casteel et al. 2002	G.1	Swine	Wells G & H Superfund Site, Woburn,	Aberjona River TM1	Sediment	676	0.37	0.38	0.38	
		G.1			Aberjona River TM2	Sediment	313	0.51	0.52	0.52	
H	Casteel et al. 2003	H.1	Swine	Silver Bow Creek/Butte Area NPL Site, Butte, Montana	Butte TM1	soil	234	0.17	0.18	0.18	0.18
		H.2			Butte TM2	soil	367	0.22	0.24	0.24	0.24
I	Casteel et al. 2005	I.1	Swine	Palestine Tx Coal gasification plant and foundary	Texas	soil	47	0.15		0.15	
J	Juhasz et a. 2007(b)	J.1	Swine	Australia	Australia - 10	railway corridor soils	257	0.11		0.11	
		J.2			Australia - 16	railway corridor soils	751	0.23		0.23	
		J.3			Australia - 18	railway corridor soils	91	0.75		0.75	
		J.4			Australia - 2	railway corridor soils	267	0.67		0.67	
		J.5			Australia - 24	dip site soils	713	0.33		0.33	
		J.6			Australia - 27	dip site soils	228	0.50		0.50	
		J.7			Australia - 33	mine site soils	807	0.41		0.41	0.41
		J.8			Australia - 34	mine site soils	577	0.07		0.07	0.07
		J.9			Australia - 4	railway corridor soils	42	0.42		0.42	
		J.10			Australia - 44	gossan soils	190	0.16		0.16	
		J.11			Australia - 45	gossan soils	88	0.12		0.12	
		J.12			Australia - 5	railway corridor soils	1,114	0.20		0.20	
K	Roberts et al. 2007	K.1	Monkey	California		mine tailings	300	0.19		0.19	0.19
		K.2		California Gulch NPL Site, Leadville, Colorado	Leadville, CO	smelter composite soil	394	0.18		0.18	0.18
		K.3				residential soil	1,230	0.17		0.17	0.17
		K.4				smelter soil	1,492	0.05		0.05	0.05
		K.5		Florida		Cattle dip site	189	0.31		0.31	
		K.6				chemical plant soil	268	0.07		0.07	
		K.7		Hawaii		volcanic soil	724	0.05		0.05	
		K.8		Montana		smelter soil	650	0.13		0.13	0.13
		K.9		New York		orchard soil	125	0.15		0.15	
		K.10				pesticide facility 3	339	0.19		0.19	
		K.11				pesticide facility 2	546	0.28		0.28	
		K.12				pesticide facility 1	1,000	0.20		0.20	
		K.13		Washington		orchard soil	301	0.24		0.24	
		K.14		Western Iron		slag or soil?	1,412	0.13		0.13	

Summary of As *In Vivo* Studies

Reference		Test Animal		Site	Name of Test Material	As Total (mg/kg)	As reported within		Updated Value used in the Review	Values for mining related studies only
							Ref Study	EPA 2010		
L EPA 2010	L.1	Swine	-- (Study sponsored by American Chemistry Council)	ACC Utility Pole Soil	Soil affected by chromated copper arsenate (CCA)-treated wood utility poles from a test plot in Conley, Georgia (soil was affected by being adjacent to the poles for over ten years)	320	0.47	0.47	0.47	
	L.2			ACC Dis-lodgeable Arsenic	Dis-lodgeable material obtained from the surface of chromated copper arsenate (CCA)-treated wood (boards from in-service residential decks, aged outdoors for one to three years)	3,500	0.26	0.26	Not a soil	
	L.3		Jasper County, Missouri Superfund Site	Jasper County High Lead Mill	Soil composite collected from an on-site location	16	3.27	3.27	Rejected by EPA as invalid	
	L.4		El Paso/Dona Ana County Metals Survey site	El Paso TM1	Soil sample collected approximately 1.5 miles east of	74	0.44	0.44	0.44	
	L.5			El Paso TM2		73	0.37	0.37	0.37	
Percentile Values								99th	0.69	0.56
								95th	0.56	0.52
								90th	0.50	0.46
								50th	0.23	0.20

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