ECOLOGICAL RISK ASSESSMENT FOR OPERABLE UNIT 1 OF THE SMURFIT-STONE/FRENCHTOWN MILL SITE LOCATED IN MISSOULA COUNTY, MONTANA

March 2017

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Document Revision History

Revision	Date	Change
01	03/09/17	Section 2.1; removal of permitting language and effluent containment language

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LIST OF ACRONYMS AND ABBREVIATIONS

95UCL	Upper 95 percent Confidence Limit
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Clark Fork River
COPEC	Contaminants of Potential Ecological Concern
CSM	Conceptual Site Model
DL	Detection Limit
EC20	Effective concentration at which 20% of the population is affected
ERA	Ecological Risk Assessment
FSP	Field Sampling Plan
HQ	Hazard Quotient
LOAEL	Lowest Observed Adverse Effect Level
LOEC	Lowest Observed Effect Concentration
MDEQ	Montana Department of Environmental Quality
MDL	Method Detection Limit
MFISH	Montana Fisheries Information System
MTNHP	Montana Natural Heritage Program
ND	Non-detect
NOAEL	No Observed Adverse Effect Level
NOEC	No-observed Effect Concentration
NPL	National Priorities List
NWPPC	Northwest Power Planning Council
OU	Operable Unit
PCDD	Polychlorinated dibenzodioxin
PCDF	Polychlorinated dibenzofuran
PRP	Potentially Responsible Party
QAPP	Quality Assurance Project Plan
RI	Remedial Investigation
RIWP	Remedial Investigation Work Plan
SI	Site Investigation
SOC	Species of Concern
SVOC	Semi-volatile Organic Compound
TCDD	2,3,7,8-tetrachlorodibenzodioxin
TEF	Toxicity Equivalence Factor
TEQ	TCDD Toxicity Equivalent value
TRV	Toxicity Reference Value
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WCT	Westslope Cutthroat Trout
WMW	Wilcoxon-Mann-Whitney

EXECUTIVE SUMMARY

This document is an Ecological Risk Assessment (ERA) for Operable Unit 1 (OU1) at the Smurfit-Stone/Frenchtown Mill site located in Missoula County, Montana.

Site Overview

A pulp and paper mill operated on the site from 1957 to 2010. Wood was chipped, and the chips were washed and digested to create a wood fiber pulp. Most of the pulp was used to produce un-bleached linerboard, but some was used to create white linerboard or sold as bleached pulp. OU1 encompasses about 1,200 acres of the site. This area has been and continues to be used largely for agricultural purposes, including grasslands for cattle grazing and cropland irrigated for alfalfa and grain crops. The main industrial area of the site is contained within OU2 and OU3, which will be evaluated separately.

The risk assessment for OU1 was performed in a series of steps, as follows.

Step 1: Identify Contaminants of Potential Ecological Concern (COPECs) that exist in OU1 soils, surface waters, and sediments.

This step was implemented by comparing the highest detected concentration of each contaminant in each medium to a conservative benchmark concentration for that medium. If the highest concentration did not exceed the benchmark, the contaminant was excluded as a COPEC unless it was considered to be a bioacummulative, in which case it was retained. This processes resulted in the identification of the following COPECs:

Surface Soil	Surface Water	Sediment
TEQ(a)	TEQ	TEQ
Aluminum		Arsenic
Arsenic		Copper
Chromium		Zinc
Copper		
Lead		
Manganese		
Selenium		
Vanadium		
Zinc		

(a) TEQ = Dioxin and dioxin-like compound Toxic Equivalency

Step 2. Refine the COPEC List

This step was implemented for each COPEC in each medium by performing a statistical test to compare the available site data to a relevant background data set. COPECs that were not higher than background were eliminated. This processes resulted in the exclusion of all COPECs except for copper and selenium in soil.

Step 3. Characterize Hazard to Ecological Receptors form Copper and Selenium in Soil

This step was implemented using different strategies for mobile and sessile receptors, as follows.

Step 3a. Mobile Receptors (Birds and Mammals)

For birds and mammals, hazard was characterized by computing the 95% upper confidence limit on the average concentration in OU1 soil and comparing that value to the receptor-specific no-observed effect concentration (NOEC) and the lowest-observed-effect concentration (LOEC) values:

Hazard Quotient (HQ) = 95% UCL / (LOEC or NOEC)

If the HQ value is below 1 based on the NOEC benchmark, it is believed that potential risks are minimal. If the HQ is above 1 based on the NOEC but is equal to or less than 1 based on the LOEC benchmark, it is considered possible that some adverse effects may occur in some individuals, but that the likelihood of a population level effect is likely to be low. If the HQ based on the LOEC exceeds 1, then adverse effects are potentially significant, with the magnitude of the hazard increasing as the HQ increases.

Step 3b: Sessile Receptors (Plants and Soil Invertebrates)

Because plants and soil invertebrates do not move around the site, hazard for this type of receptor was evaluated by computing LOEC-based and NOEC-based HQ values for every sample (rather than the 95% UCL of the samples), and evaluating the frequency and the magnitude of HQ values above 1. As above, if all or most NOEC-based HQs for individuals in a population of receptors are below 1, the hazard is considered to be minimal. Conversely, if many or all of the LOEC-based HQs are above 1, then unacceptable effects on the exposed population may occur, especially if the HQ values are large. If only a small portion of the exposed population has LOEC-based HQ values that exceed 1, some individuals may be impacted, but the hazard of population-level effects is low.

Results of this step are summarized below:

Receptor	Hazard from Copper	Hazard from Selenium
Birds	Minimal	Minimal
Mammals	Minimal	Low
Plants	Minimal	Low
Soil Invertebrates	Minimal	Minimal

Step 4: Identify Uncertainties

Most of the steps used to evaluate hazard are intentionally conservative. That is, confidence is high that things found to be pose minimal hazard are not of significant ecological concern. With regard to the low hazard that selenium may pose to mammals and plants, there are several sources of uncertainty that limit confidence, including:

- The benchmark values for selenium are uncertain and are more likely to be low than high, especially for plants. Consequently, the HQ values are more likely to be high than low.
- The Missoula Valley is known to have large phosphate formations which are associated with elevated levels of selenium. The state-wide background soil data may not have high enough resolution to properly represent local background conditions at the site. Indeed, the range of selenium in site soil (0.3-1.8 mg/kg) and background soil (0.2-1.6 mg/kg) are similar. Thus, confidence that selenium in OU1 surface soil is authentically or meaningfully higher than background is low.

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1.0 INTRODUCTION

1.1 Purpose of this Document

This document is an Ecological Risk Assessment (ERA) for Operable Unit 1 (OU1) at the Smurfit-Stone/Frenchtown Mill site located in Missoula County, Montana, hereafter referred to as the "OU1 site". The purpose of this document is to identify contaminants of potential ecological concern (COPECs) in OU1 soils, surface waters and sediments, to determine which of these COPECs are site-related, and to characterize the risks to ecological receptors from site-related COPECs. This information, along with other relevant site information, will be used by risk managers to make decisions on whether any additional investigations are required at OU1 to further characterize the nature and magnitude of risks to ecological receptors from site-related contaminants, and whether any actions may be needed to protect ecological receptors in OU1.

1.2 Overview of the Eight-Step Ecological Risk Assessment Process

The United States Environmental Protection Agency (USEPA) has developed specific methods and procedures for completing ecological risk assessments (USEPA 1992; 1997; 1998; 2001). Figure 1-1 shows the eight-step process that is recommended for ecological risk assessments completed at Superfund sites under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). The eight steps shown in Figure 1-1 are not intended to represent a linear sequence of mandatory tasks. Rather, some tasks may proceed in parallel, some tasks may be performed in a phased or iterative fashion, and some tasks may be judged to be unnecessary at certain sites.

1.3 Document Organization

In addition to this introduction, this report is organized into the following sections:

Section 2. This section presents the screening level problem formulation, including a site overview, the environmental setting, contaminants known or suspected to occur at the site, studies that provide data about contaminants in environmental media, fate and transport processes that may be occurring, types of ecological receptors likely to occur at the site, and exposure pathways that are likely to be complete.

Section 3. This section describes the process of identifying COPECs at the site.

Section 4. This section describes the process of refining the list of COPECs at the site.

Section 5. This section characterizes the ecological hazards from COPECs that were not eliminated in the refinement step.

Section 6. This section discusses uncertainties in the findings and conclusions of the ecological risk assessment.

Section 7. This section provides references for all documents referred to in the text.

All tables, figures, and appendices cited in the text are provided at the end of the report.

2.0 SCREENING LEVEL PROBLEM FORMULATION

Problem formulation is a systematic planning step that identifies the major concerns and issues considered in the ERA, and provides a description of the basic approach used to identify the potential risks that may exist (USEPA 1997). A screening level problem formulation represents Step 1 of the eight step ERA process (Figure 1-1) and results in a conceptual site model (CSM) that identifies sources of contaminant release to the environment, the fate and transport of contaminants in the environment, and exposure pathways of potential concern for ecological receptors.

Detailed information on site background and characteristics are included in the Remedial Investigation Work Plan (RIWP) (Newfields 2015). This report also provides a detailed discussion on the environmental setting for the Smurfit Stone/Frenchtown Mill site. Site information is also provided on USEPA's Superfund Page for the site[1]. Pertinent information from these sources is summarized briefly in the following subsections.

2.1 Site Overview

The Smurfit-Stone/Frenchtown Mill site is in Missoula County, Montana and is located 11 miles northwest of Missoula, Montana (Figure 2-1). The entire site encompasses approximately 3,150 acres.

Historically, a pulp and paper mill operated on site from 1957 to 2010. Wood was chipped, and the chips were washed and digested to create a wood fiber pulp. Beginning in 1990, pulp was also created from recycling old corrugated containers at a recycled fiber plant on site. Waste bark and wood (hog fuel) generated as part of the on-site chipping of logs was conveyed to a storage yard on site and burned in a boiler. Most of the pulp was used to produce un-bleached linerboard, but some of the total pulp produced from 1960-1999 was used to create white linerboard or sold as bleached pulp.

The core industrial footprint of the site includes the former mill, recycling plant, a wood chipping staging area, the hog fuel area, and various equipment storage areas. During the pulp and paper production, high usage of water and energy resulted in large amounts of waste generation like wastewater, solid waste (e.g., treatment sludges, boiler ash, wood processing residuals, lime kiln grits, inert materials, and general refuse) and air emissions. The paper making process at the site was designed to recover and recycle contaminants utilized in the

[1] Smurfit-Stone Mill Frenchtown, Missoula, MT webpage: https://cumulis.epa.gov/supercpad/cursites/csitinfo.cfm?id=0802850

washing and digesting processes. Stack emissions from recovery boilers, power boilers, and lime kilns were controlled and monitored. The mill included a wastewater treatment system that consisted of a clarifier and settling ponds (primary treatment), sludge dewatering plant, aeration basins (secondary treatment), polishing ponds, a color removal plant (tertiary treatment) and a series of unlined holding ponds used to store treated effluent prior to discharge. When holding ponds were at capacity, treated wastewater was moved to infiltration basins and infiltrated to groundwater. Effluent from the mill was discharged to the Clark Fork River (CFR) throughout the life of the mill when river flow and temperature conditions were within permit limits.

For assessment and management purposes, the USEPA, Montana Department of Environmental Quality (MDEQ) and the Respondents have agreed to divide the site into three operable units (OUs) based on historic use and the nature of the potential environmental concerns, as follows (Figure 2-2):

> **OU1** encompasses about 1,200 acres of the site. This area has been and continues to be used largely for agricultural purposes, including grasslands for cattle grazing and cropland irrigated for alfalfa and grain crops.
>
> **OU2** encompasses approximately 255 acres of the site and includes the former industrial area. This area includes the former buildings and process areas for the Mill.
>
> **OU3** encompasses approximately 1,700 acres of the site and includes areas of the site where solid and liquid wastes were treated and stored. This area includes the wastewater treatment system (settling ponds, aeration basins, polishing ponds, solid waste basins, spoils basins, holding ponds, and infiltration basins).

This ERA focuses on OU1. For the purposes of the remedial investigation (RI), OU1 was subdivided to support sampling needs as shown in Figure 2-2 to include 12 subareas. Nine of these (AG1-AG9) are used for farming, ranching, equipment storage, and production well fields (water supply), one is used as an office for a few employees of the current property owners (M2Green), and two are native forest located west of the CFR (WR1 and WR2). Portions of two subareas (AG8 and AG9) include floodplain upstream of the treated water holding ponds.

2.2 Environmental Setting

The Smurfit-Stone/Frenchtown Mill site is located within the northwestern portion of the Missoula Valley. The valley elevation ranges from approximately 3,000 to 3,200 feet above sea level, with surrounding mountain ranges, including the Sapphire Range to the east, the Bitterroot

Range to the south, the Rattlesnake Range to the north, and the Ninemile Divide to the west, rising to elevations ranging from 5,000 to 8,000 feet.

2.2.1 Aquatic Habitat

The Smurfit-Stone/Frenchtown Mill site is located in the CFR drainage (Figure 2-1). The CFR and Bitteroot Rivers drain the valley. The CFR flows westward through the valley and north along the site's western property boundary. Major tributaries upstream of the site include the Bitterroot River and the Blackfoot River. Numerous smaller tributaries also flow in to the CFR above the site including Rattlesnake Creek, Rock Creek, Little Blackfoot River, Flint Creek, O'Keefe Creek and Lavalle Creek. Of these, O'Keefe Creek and Lavalle Creek flow through the site (Figure 2-2). Because portions of these two Creeks flow through lands designated as OU1, they are included in this assessment. These Creeks may also be evaluated within the assessments conducted for the other OUs.

2.2.2 Terrestrial Habitat

As noted above, the OU1 site is primarily agricultural lands with several forested parcels. The agricultural land has primarily been used to cultivate crops for feeding livestock and providing grazing lands to cattle. The area included as OU1 is likely to provide suitable habitat for a wide variety of terrestrial invertebrates, plants, birds and mammals.

2.2.3 Animal Species within OU1

No site-specific aquatic or terrestrial surveys were located which provide information on the number and types of animal species present at the OU1 site.

The Montana Natural Heritage Program (MTNHP) provides information on Montana's species and habitats. A query of the MTNHP MapViewer[2] (queried January 2017) for the Smurfit-Stone/Frenchtown Mill site (Township 014N Range 21W) identified 36 invertebrate species, 20 fish species, 243 bird species, 3 amphibian species, 3 reptile species, and 30 mammal species that have been observed previously in the vicinity of the site (see Appendix A). Additionally, OU1 is located within the Clark Fork River-Grass Valley Important Bird Area where bald eagles have previously been observed (MTNHP 2016).

[2] http://mtnhp.org/mapviewer/

The online database for the Montana Fisheries Information System (MFISH) lists O'Keefe Creek as a Northwest Power Planning Council (NWPPC) Fishery and Wildlife Protected Area on the basis of Westslope Cutthroat Trout (WCT) presence and bald eagle nesting territory within 2.5 miles of O'Keefe Creek. However, the MFISH database indicates that no fish surveys have been conducted in either O'Keefe or Lavalle Creeks, and WCT abundance is listed as "rare" in O'Keefe based on professional judgment (MFISH 2016). No aquatic surveys were located which provide information on the numbers and types of aquatic invertebrate species present in O'Keefe or Lavalle Creeks. However, the attributes of these streams are similar to other coldwater streams in the northern plains of Montana, suggesting that benthic invertebrate populations are likely similar.

2.2.4 Sensitive Species that May Occur in the General Area of OU1

The U.S. Fish and Wildlife Service has identified six threatened, one proposed, and one candidate species that are likely to occur in Missoula County (see Table 2-1; USFWS 2016). A query of the MTNHP Species of Concern report[3] (queried January 2017) for the Smurfit-Stone/Frenchtown Mill site (Township 014N Range 21W) identified that the proposed wolverine and threatened bull trout included in Table 2-1 are known or expected to occur in the vicinity of the site.

2.3 Contaminants Known or Suspected to be Present at the Site

Mill operations (predominantly the pulping and bleaching processes) used or produced various hazardous contaminants on site, including semi-volatile organic compounds (SVOCs), heavy metals, and bleaching chemicals. The use of chlorine for the bleaching of pulp produces chlorinated organic compounds, including dioxins and furans. Site activities and waste disposal practices may have contaminated soil, sediment, surface water and groundwater. Studies that provide data on the actual occurrence of these types of contaminants in site media are described below.

2.3.1 Site Investigations

Numerous environmental studies and compliance monitoring events have been conducted at the site (Newfields 2015). The USEPA conducted a site investigation (SI) in 2011 to support evaluation of the site for possible National Priorities List (NPL) listing (USEPA 2012). This investigation was focused on the former wastewater treatment and storage area (currently

[3] http://mtnhp.org/SpeciesOfConcern/?AorP=a

designated as OU3), O'Keefe Creek, and the CFR. However, there are data quality concerns with regard to adherence to sampling guidance with the 2011 sampling event. In April 2014, the Potential Responsible Party (PRP) for the site commissioned the collection of environmental samples from areas that were not investigated by the USEPA in 2011. Follow-up sampling was conducted in accordance with the USEPA approved RIWP, associated Field Sampling Plan (FSP) and Quality Assurance Project Plan (QAPP) (Newfields 2015) in November and December 2015.

For this assessment, attention was focused on data collected from 2014 and 2015 because more recent data are likely to be more representative of current site conditions than older data.

2.3.2 Environmental Data

Available environmental data for the OU1 site include surface soil samples collected throughout OU1, and sediment and surface water samples collected from O'Keefe and Lavalle Creeks during the 2014 and 2015 site investigations (see Table 2-2). All of these data have been validated and are considered to be appropriate for use in this assessment.

Because polychlorinated dibenzodioxin (PCDD) and furan (PCDF) congeners all act by the same mechanism as 2,3,7,8-tetrachlorodibenzodioxin (TCDD), data for the PCDD and PCDF congeners was converted to a TCDD toxicity equivalent value (TEQ) by computing the sum across congeners of the product of congener-specific concentration and relative Toxicity Equivalence Factor (TEF):

$$TEQ = \sum (C_i \times TEF_i)$$

TEFs for mammals were based on USEPA (2010). TEFs for birds were based on van Den Berg et al. (1998). Three alternative values were computed, differing in the numeric concentration values assigned to non-detect (ND) congers evaluated using the method detection limit (MDL) as: ND = 0, ND = MDL/2, and ND = MDL. The calculated TEQ concentrations were considered ND if all of the individual congeners used in the calculation were reported as ND. If any individual congener was reported as detected, the calculated TEQ concentration was considered detected.

Excel files containing the data are provided in electronic format in Appendix B, and summary statistics are provided in Tables 2-3 to 2-5.

Data on concentrations in surface water for OU1 are limited to two samples, one collected in Lavalle Creek (SW9-LV) and one collected in O'Keefe Creek (SW10-OK). As shown in Figure 2-3, SW10-OK is located upstream of the mill site boundary. In the absence of additional data, this sample is included in the OU1 site dataset for surface water along with the co-located sediment sample (SE21-OK-SA).

2.4 Contaminant Fate and Transport Processes

Contaminants that may have been associated with historic mill operations may migrate in the environment by several processes:

- Wind transport of contaminated soil. Fine-grained soil particulates may be transported by air as a consequence either of wind erosion and/or human disturbances. In 2014, the USEPA identified the potential for the migration of dust from the wastewater treatment system ponds to OU1 (Newfields 2015). Transport of contaminants emitted to the air from boiler emissions can also result in direct deposition of contaminants in OU1 surface soils.

- Vaporization. Direct vaporization from soil can result in contaminants being transported as vapors in air. Such releases are generally rapidly dispersed by wind and are normally of low ecological concern.

- Runoff. Rain or snowmelt flowing over surface soils into area streams may result in contamination of both surface water and stream sediments. However, site data suggest that there is limited potential for runoff into O'Keefe and Lavalle Creeks (Newfields 2015).

- Leaching. Contaminants in soil may be dissolved by water (rain or snowmelt) and infiltrate into subsurface soils and downward into groundwater. Based on hydrogeology, the potential for subsurface soil migration is considered limited at this site (Newfields 2015).

- Tissue uptake. Plants can take up contaminants from the soil, and terrestrial vertebrates and invertebrates can ingest soil indirectly while feeding. Terrestrial fauna can also take up contaminants by ingesting terrestrial food items. Aquatic organisms experience similar uptake from contact with surface water or sediment and ingestion of aquatic food items.

2.5 Potential Exposure Pathways and Receptors of Concern

Based on the information presented above, Figure 2-4 presents the screening-level ecological CSM for the OU1 site. This figure identifies the main categories of ecological receptors that are likely to be present, and the most important exposure pathways for each.. This CSM is discussed in greater detail below.

Aquatic Receptors

The aquatic communities in O'Keefe and Lavalle Creeks are assumed to be made up of fish, benthic invertebrates, phytoplankton, zooplankton, and amphibians. Therefore, for the purposes of this ERA, sediment and surface water benchmarks that address the aquatic and benthic communities are used as measures of effect. Fish and benthic macroinvertebrate communities in O'Keefe and Lavalle Creeks may also serve as a food source for fish and other receptors. USEPA has established standard methods for the assessment of these groups, and it is considered likely that these groups can serve as an indicator for aquatic receptors in general.

For fish, the primary exposure route of concern is direct contact with surface water that is impacted by site releases. For benthic invertebrates, the primary route of concern is direct contact with surface water and sediment. Fish and aquatic macroinvertebrates may also be exposed to contaminants via ingestion of prey and sediment. However, exposures to fish and benthic invertebrates via ingestion are usually believed to be minor compared to risks from direct contact with surface water and sediment.

Terrestrial Plants and Soil Organisms

The structure and function of the terrestrial plant and invertebrate community are important because plants provides a significant portion of the energy, organic matter, and nutrient inputs for terrestrial systems as well as habitat and forage for wildlife. Terrestrial plants and soil organisms are good indicators of soil condition because they reside directly in the soil and are sessile or nearly sessile.

The primary exposure route for both terrestrial plants and soil organisms is direct contact with contaminated soils. For terrestrial plants, exposure may also occur due to deposition of dust on foliar (leaf) surfaces, but this pathway is believed to be minor compared to root exposures in surface soils.

Birds and Mammals

Birds and mammals may be exposed to site-related contaminants by ingestion of three types of environmental media: 1) ingestion of contaminants in or on prey items, 2) incidental ingestion of soil and/or sediment while feeding, grooming, or burrowing, and 3) ingestion of contaminated water. Direct contact (i.e., dermal exposure) of birds and mammals to soils is considered to be minimal because the skin of these animals is protected by feathers and fur. Inhalation exposure to airborne dusts or vapors in air are possible for all birds and mammals, but these exposures are considered to be minor in comparison to exposures from ingestion (USEPA, 2003), and meaningful toxicity information for wildlife is generally not available for use in the interpretation of such exposures.

2.6 Assessment and Measurement Endpoints

Assessment Endpoints

Assessment endpoints are explicit statements of the characteristics of the ecological system that are to be protected. Selection of appropriate assessment endpoints helps ensure that the risk assessment will evaluate the ecological attributes that are of primary importance to risk managers. In most cases, assessment endpoints focus on growth, survival and reproduction of exposed receptors, since these endpoints are indicative of the probability that an exposed receptor population will be healthy and self-sustaining.

Measurement Endpoints

Measurement endpoints represent quantifiable measures of exposure and/or effects. Ideally, selected measures of exposure and effect are directly related to the valued ecological components chosen as the assessment endpoints (USEPA 1992, 1997).

Conceptually, a wide range of different types of measurement endpoints may be useful in ecological risk assessments, including direct observations of population density and diversity, and direct tests of the effects of site media on growth, reproduction and/or survival in exposed receptors. At the OU1 site, no data are presently available to support these assessment endpoints, so the measurement endpoint selected for use is the concentration of contaminants measured in site media. These measured concentration values are compared to “benchmark” or “reference” concentration values (usually derived from non-site-specific toxicity studies) to draw inferences about the hazard of adverse effects in the exposed receptors.

3.0 IDENTIFICATION OF COPECs

3.1 Methodology

Figure 3-1 shows the approach used to evaluate the available environmental data from OU1 to identify COPECs for the evaluation of risks to ecological receptors from contaminated environmental media (soil, surface water, and sediment). This COPEC selection approach is intended to be conservative. That is, it is expected that some contaminants may be identified as COPECs that are actually of little or no concern, but that no contaminants of authentic concern will be overlooked.

The first step in the screening assessment for OU1 is to review available toxicity data to determine if an appropriate benchmark value is available for each contaminant. A benchmark is a concentration value in a medium that is expected to be without significant risk of adverse effects in ecological receptors exposed to that medium. Toxicity benchmark values for the protection of ecological receptors are available from numerous sources. Appendix C identifies the sources that were reviewed for this effort, and the hierarchy used to select the most relevant and appropriate values for each medium (soil, sediment, water) and each receptor class (birds, mammals, plants, soil invertebrates). The lowest value for each medium was used for COPEC screening. Values that were selected are consistent with ecological assessments conducted at other sites in USEPA Region 8.

If a contaminant was detected in 5% or more of the site samples, the maximum detected concentration is compared to the available benchmark. If the maximum detected concentration does not exceed the benchmark, the contaminant is judged to be of negligible concern and is excluded as a COPEC. If the maximum detected concentration exceeds the benchmark, the contaminant is retained for evaluation in the second step of the screen.

If a contaminant was detected in fewer than 5% of the site samples, then the detection limit is evaluated. If the detection limit is lower than the relevant benchmark, then it is very unlikely that the contaminant will pose a significant ecological risk and may be excluded as a COPEC. However, if the detection limit is above the benchmark, this is identified as a source of uncertainty.

For this assessment, contaminants detected in 5% or more of the site samples that are considered to be bioaccumulative are identified as COPECs without regard to whether the maximum value does or does not exceed the benchmark. This is because many benchmark values are derived in a way that may not adequately account for food web exposure of contaminants that tend to biomagnify in the food web. A contaminant was considered to be bioaccumulative in accordance with USEPA (1995).

If a contaminant lacks a benchmark value, then it is not possible to make a judgement whether the contaminant may or may not pose significant ecological risk. In order to judge whether this is a significant source of uncertainty that might require further evaluation or data collection, available information was reviewed to determine if the contaminant is likely to have been released from the site. If it does not appear that a release of the contaminant is likely, the contaminant is excluded from further consideration. If the data suggest that a release is likely to have occurred, then the lack of toxicity data for the contaminant is identified as a data gap and options for collecting information needed for assessing the potential risk from the contaminant are considered.

3.2 COPEC Results

Tables 3-1 to 3-3 present the application of the COPEC selection process described above. Contaminants that were identified as being bioaccumulative, or were detected in 5% or more of the available samples, and where the maximum detected concentrations exceeded a conservative benchmark value include the following:

Surface Soil	Surface Water	Sediment
TEQ(a)	TEQ	TEQ
Aluminum		Arsenic
Barium		Copper
Chromium		Zinc
Copper		
Lead		
Manganese		
Selenium		
Vanadium		
Zinc		

(a) TEQ = Dioxin and dioxin-like compound Toxic Equivalency

4.0 COPEC REFINEMENT

4.1 Refinement Methodology

Because the COPEC selection process is inherently conservative, it is sometimes useful to refine the COPEC list prior to further assessment efforts (USEPA 2001). One strategy for COPEC refinement that may be useful is a comparison of site data to an appropriate "background" data set. This is because USEPA does not require remedial action or further investigation of contaminants that are not elevated above background (non-site related) levels (USEPA 2002).

Accordingly, a statistical comparison of OU1 data to background data was performed for any contaminant that was identified as a COPEC in Section 3.2. If a COPEC is present in OU1 site media at concentrations that are not statistically higher than the level that would be expected for that contaminant based on background levels, then it may be concluded that the site-related contribution for that contaminant is sufficiently minor that further quantitative evaluation is not needed. If the contaminant is observed to be present at a level higher than would otherwise be expected based on background data, then it is appropriate to retain that contaminant for further assessment.

For the purposes of this assessment, USEPA's ProUCL Software (v 5.0) was used to compare available site data to available background data (USEPA 2013). This was done using the Wilcoxon-Mann-Whitney (WMW) two sample hypothesis test in ProUCL for the null hypothesis site >= background (Form 2) at a confidence coefficient of 95%. This form of the hypothesis guards against declaring the site is not higher than background when it actually is. If ProUCL concludes that the Form 2 null hypothesis cannot be rejected, the WMW two sample hypothesis test is conducted for the null hypothesis site = background at a confidence coefficient of 95%. The Gehan test was used when multiple detection limits are present as prompted by the ProUCL output based on the WMW test.

Background soil data considered in this assessment were collected and reported by the MDEQ for dioxins/furans and inorganics (Hydrometrics, 2011; 2013). Background data for sediment and surface water include data collected during RI sampling from areas un-impacted by site activities as well as data from select U.S. Geological Survey (USGS) monitoring stations (Table 4-1). Tables 4-2, 4-3, 4-4 present summary statistics for background concentrations in surface soil, surface water, and sediment, respectively.

4.2 COPEC Refinement Results

Data were adequate for performing statistical background comparisons for COPECs identified in the risk-based screen as being present in OU1 soil and sediment at maximum concentrations above relevant benchmarks. Appendix D includes the ProUCL output. The statistical comparisons between site and background soils indicated that copper and selenium are present in OU1 soils at concentrations significantly above background concentrations. No COPECs in OU1 sediment were found to be present at concentrations significantly above background.

For surface water, TEQ was identified as a COPEC because of its potential to bioaccumulate. As described in Section 2.3.2, TEQ concentrations were calculated following the TEF approach described in USEPA (2010). The available background surface water TEQ data consists of five samples, three detected concentrations and two non-detect concentrations. The calculated TEQ concentrations for those samples qualified as non-detect are higher than the concentrations for those samples qualified as detected when non-detects are evaluated as MDL/2 or at the MDL. Coupled with the relatively small dataset, the surface water TEQ data are considered inadequate for performing a meaningful statistical comparison between site TEQ and background TEQ. Although a statistical test comparing OU1 and background levels of TEQ cannot be conducted, it is apparent that distribution and range of site and background concentrations of TEQ are similar, as shown in Figure 4-1 and summarized below:

Analyte	**OU1 Surface Water (ug/L)**				**Background Surface Water (ug/L)**			
	N	DF(%)	Mean ± SD	Range	N	DF(%)	Mean ± SD	Range
Mammal TEQ (ND=1/2 MDL)	2	100	3.9E-07 ± 3.7E-08	3.6E-07 – 4.2E-07	5	60	3.3E-07 ± 1.7E-08	3.3E-07 – 3.6E-07

Based on this, only copper and selenium measured in OU1 surface soils were found to be present at concentrations that may be statistically higher than background. The following section presents a more detailed evaluation of risks from these two contaminants.

5.0 RISK CHARACTERIZATION

5.1 Methodology

Risk characterization for COPECs that are retained after the COPEC refinement step was performed using the Hazard Quotient (HQ) approach. In this approach, the estimated exposure from the site is compared to a reference or benchmark concentration in order to draw inferences about hazard:

HQ = Exposure / Benchmark

Mobile Receptors

For ecological receptors that are mobile and move about the site, EPA recommends that the upper 95% confidence limit (95UCL) of the arithmetic mean of the contaminant concentrations be used to estimate exposure (USEPA 1992). This approach minimizes the probability of underestimating the level of hazard due to random variations in the available data set. The best method for computing a 95UCL depends on the nature of the data set. USEPA's ProUCL Software (v 5.0) calculates a range of alternative 95UCL values and recommends a value for use in risk assessment (USEPA 2013). Accordingly, all 95UCL values were derived from ProUCL.

HQ values were calculated for two types of toxicity benchmarks: No Observed Effect Concentration (NOEC) and Lowest Observed Effect Concentration (LOEC). If the HQ value is below 1 based on the NOEC benchmark, it is believed that potential risks are minimal. If the HQ is above 1 based on the NOEC but is equal to or less than 1 based on the LOEC benchmark, it is considered possible that some adverse effects may occur in some individuals, but that the likelihood of a population level effect is low. If the HQ based on the LOEC exceeds 1, then adverse effects are potentially significant, with the magnitude of the hazard increasing as the HQ increases.

For this assessment, LOEC-based benchmarks for wildlife were calculated based on the ratio between available dose-based wildlife no-observed adverse effect level (NOAEL)-based and lowest observed adverse effect level (LOAEL)-based Toxicity Reference Values (TRVs) obtained from other ecological risk assessments in Region 8 (Booz Allen Hamilton 2012):

$$\text{LOEC benchmark} = \text{NOEC benchmark} \times (TRV_{LOAEL} / TRV_{NOAEL})$$

Sessile Receptors

For sessile or nearly sessile receptors (plants, soil invertebrates), any given individual is exposed to the local concentration where that receptor exists, as opposed to being exposed to a site-wide average. For this reason, hazard for this type of receptor is best characterized as a distribution of HQ values, with each value representing one particular sampling location. Hazard is evaluated by considering the frequency and magnitude of the HQ values that exceed 1.0. As above, if most NOEC-based HQs for individuals in a population of receptors are below 1, it is very unlikely that unacceptable effects will occur in the exposed population. Conversely, if many or all of the LOEC-based HQs are above 1, then unacceptable effects on the exposed population may occur, especially if the HQ values are large. If only a small portion of the exposed population has LOEC-based HQ values that exceed 1, some individuals may be impacted, but population-level effects are less likely to occur. As the fraction of the population with LOEC-based HQ values above 1 increases, and as the magnitude of the exceedances increases, risk that a population-level effect will occur also increases.

For this evaluation, LOEC-based benchmarks for plants and soil invertebrates were not available. In the absence of these values, risks to plants and soil invertebrates were only evaluated based on the available NOEC-based benchmarks.

5.2 Results

Mobile Receptors (Birds, Mammals)

Table 5-1 shows the calculated NOEC-based and LOEC-based HQ values for birds and mammals exposed to copper and selenium in OU1 soil. For copper, all HQ values (both NOEC and LOEC-based) are below 1, indicating that hazard is minimal. For selenium, both HQ values are below 1 for birds, but for mammals both HQs slightly exceed 1. This indicates that risks to mammals from selenium may exist, but the hazard is likely to be low.

Sessile Receptors (Plants, Soil invertebrates)

Figure 5-1 shows the sample-specific NOEC-based and LOEC-based HQ values for plants and soil invertebrates exposed to copper in OU1 soil. NOEC-based values based on background soils are shown for comparison. As seen, all HQ values in site soils are below one, and the NOEC-based values in site soils are very similar to NOEC-HQ values in background soils. This indicates that copper in OU1 soils is likely to pose minimal risk to plants and soil invertebrates.

Figure 5-2 shows the sample-specific NOEC-based and LOEC-based HQ values for plants and soil invertebrates exposed to selenium in OU1 soil. NOEC-based values based on background soils are shown for comparison. For soil invertebrates (bottom panel), both NOEC- and LOEC-based HQ values in site soils are below one, indicating that selenium in OU1 soils is likely to pose minimal risk to soil invertebrates. For plants (upper panel), most NOEC-based HQ values for selenium are above 1, but the highest HQ values is relatively small (about 3). Assuming the LOEC is at least 3-times higher than the NOEC, this means that almost all LOEC-based HQ values for selenium are below 1. As discussed above, this pattern indicates that selenium in site soils may pose a hazard to plants, but the magnitude of the hazard is likely to be low.

Summary

Based on the risk assessment process described above, risks to ecological receptors are considered to be below a level of concern and/or not greater than background for all contaminants in all media except copper and selenium in OU1 soil. The level of hazard from these two COPECs is summarized below.

Receptor	Hazard from Copper	Hazard from Selenium
Birds	Minimal	Minimal
Mammals	Minimal	Low
Plants	Minimal	Low
Soil Invertebrates	Minimal	Minimal

6.0 UNCERTAINTY ASSESSMENT

Quantitative evaluation of exposures and risks to ecological receptors from environmental contamination is frequently limited by uncertainties in the representativeness of the environmental data and in the toxicological benchmarks used to identify and evaluate COPECs. The following sections discuss the most important sources of uncertainty in this assessment.

6.1 Representativeness of Environmental Data

As noted above, no COPECs were identified in surface water for O'Keefe and Lavalle Creeks. However, data from these two creeks are limited in number and in time (samples were all collected on one day). Consequently, there is some uncertainty as to whether a more extensive set of surface water data would have yielded a different finding. However, this is considered to be unlikely, since fate and transport processes that may cause movement of site-related contaminants into O'Keefe and Lavalle Creeks is considered to be limited (Newfield, 2015).

6.2 Uncertainties from Contaminants Not Evaluated

As described above, contaminants were screened only if a relevant benchmark was available. In the absence of an available benchmark, no conclusions can be drawn regarding if a contaminant without a benchmark should be identified as a COPEC. Additionally, contaminants detected at less than 5% were not identified as COPECs. In some cases, the average detection limit is higher than the available benchmark. This indicates that the detection limit for measuring that contaminant was not sensitive enough to determine if that contaminant was present at the site at concentrations below the benchmark. Such contaminants may contribute a small amount of added risk, but the contribution is expected to be small and this is not considered a significant source of uncertainty.

TEQ in surface water was identified as a COPEC because of its potential to bioaccumulate. A robust comparison of TEQ concentrations in O'Keefe and Lavalle Creeks to background surface water could not be conducted due to data limitations. However, as described in Section 4.2, observed concentrations were similar in water samples from site locations and background locations. Therefore, although it is unknown if TEQ is elevated in OU1 surface waters, any authentic elevation above background concentrations appears to be small and is therefore likely to be of minimal ecological concern.

6.3 Uncertainties in Benchmarks

The benchmarks used in this assessment generally do not account for the wide variety of differences between site media and the test systems used to establish the toxicity benchmarks. Laboratory tests generally do not account for site-specific factors that influence toxicity in site media (e.g., hardness in surface water, pH and total organic content in soil). Additionally, laboratory tests may not utilize test species that are likely to occur at the OU1 site.

For example, there is some question as to whether the plant benchmark of 0.52 mg/kg for selenium is appropriate to apply to plants in OU1. This benchmark value is based on toxicological studies of agricultural species, which are more sensitive to selenium than other plant species (USEPA 2007). In addition, the form of selenium and amount of sulfate in the soil are known to impact selenium effects on plant growth. The NOECs listed by USEPA (2007) were reported for tests using sandy soils with low sulfate and the most toxic form of selenium tested, which would also drive the NOEC down (USEPA 2007). The geometric mean of NOECs, reported by USEPA (2007) to be 0.52 mg/kg, is driven by a single study which reports growth effects for 20% of the population (EC20) at concentrations below the mean for three species. However in this same study, when species were tested in soils with high organic matter content, the EC20s were 1 mg/kg or greater. Given these considerations, it is considered likely that HQ values computed based on this benchmark are probably an overestimate of hazard to plants growing in OU1.

6.4 Uncertainties in Background Comparisons

Background data for surface soils for statistical comparisons were derived from a statewide dataset (Hydrometrics, 2013) which may not accurately represent the geochemistry of soils in the Missoula Valley. This region is known to have large phosphoria formations which are also associated with elevated levels of selenium (Sheldon 1957). In the Missoula Valley in particular, there are known areas of high phosphate concentrations that occur upstream of the site on the CFR (Pardee 1917). Natural geologic conditions are therefore a likely contributor to the selenium concentrations noted in OU1, and the state-wide background soil data may not have high enough resolution to properly represent local background conditions at the site.

Although the statistical tests comparing OU1 and background levels of copper and selenium indicated that OU1 levels appear to be higher, it is nevertheless apparent that distribution and range of site and background concentrations of these contaminants are actually rather similar, as shown below:

Analyte	OU1 Surface Soil (mg/kg)			Background Surface Soil (mg/kg)		
	N	Mean ± SD	Range	N	Mean ± SD	Range
Copper	96	19 ± 7.3	0.33 - 34	112	18 ± 10	3.8 – 71
Selenium	18	0.89 ± 0.49	0.28 – 1.8	112	0.38 ± 0.24	0.2 – 1.6

Mean and standard deviation were calculated with non-detects at ½ the method detection limit.

Thus, confidence that either copper or selenium in OU1 surface soil is authentically or meaningfully higher than background is low.

7.0 REFERENCES

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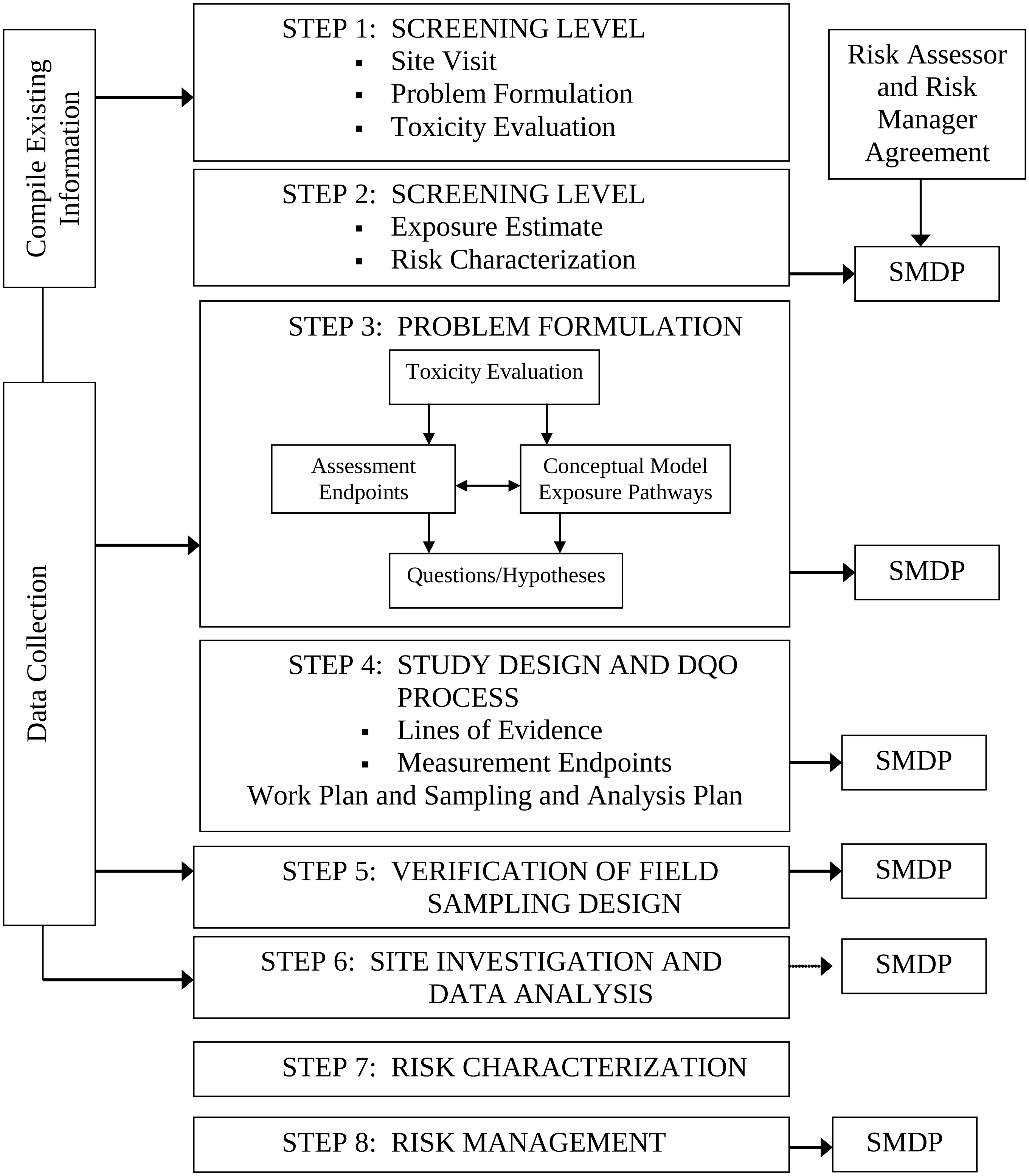
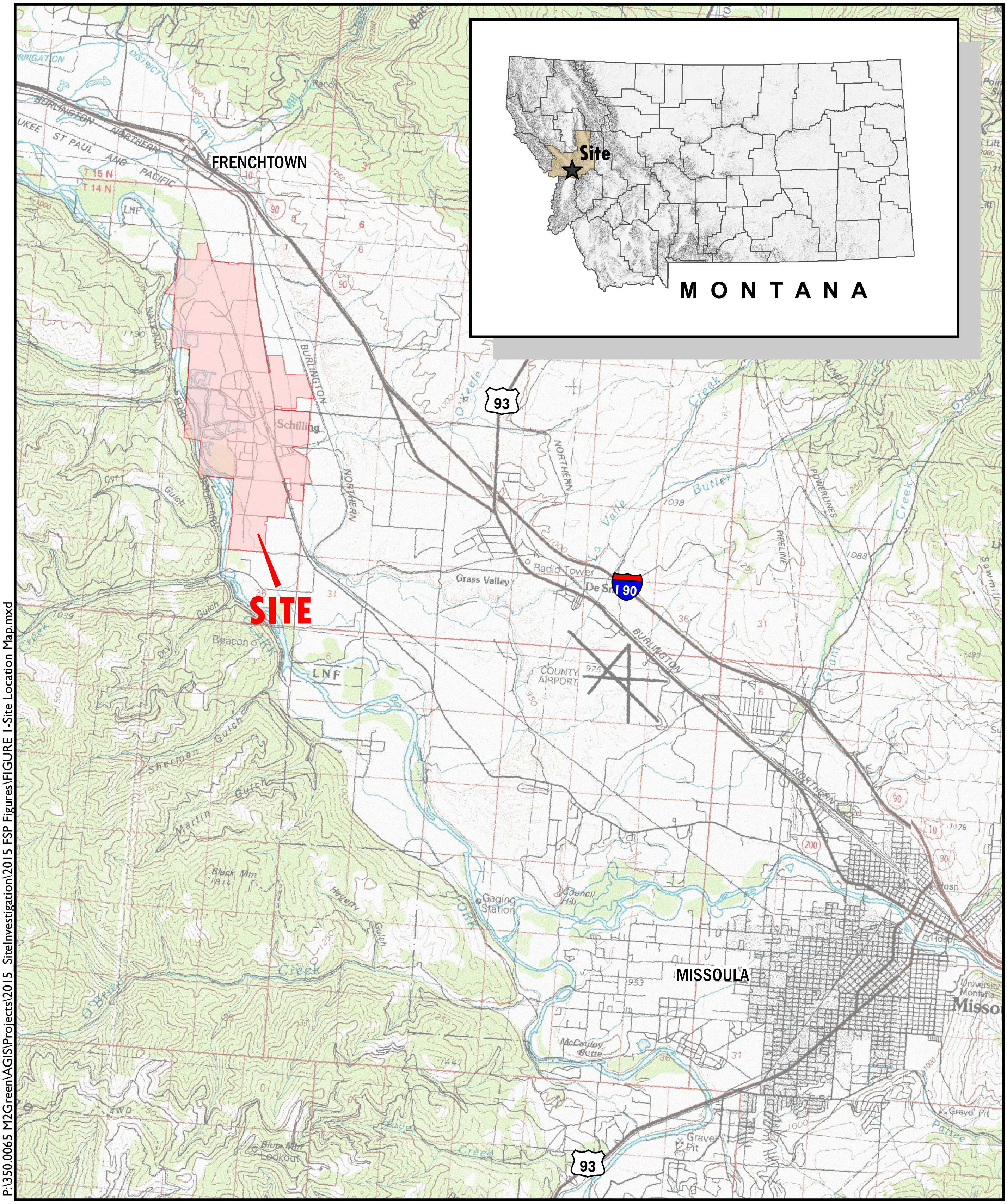
FIGURES

Figure 1-1. Eight Step Process for Ecological Risk Assessment at Superfund Sites



Source: USEPA 1997

SMDP = Scientific/Management Decision Point



Source: Montana USGS 100K Topographic Map

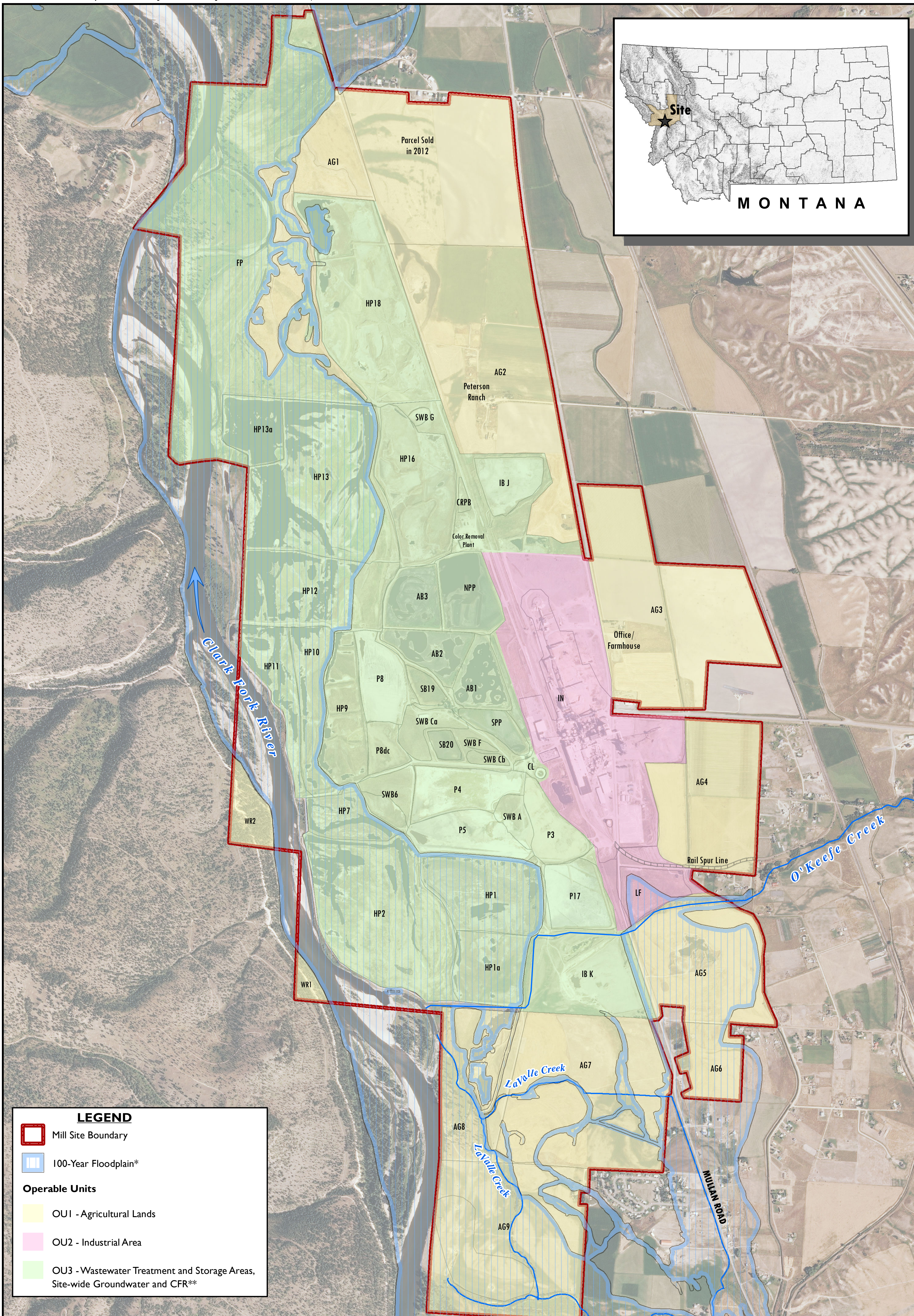
P:\350.0065 M2Green\AGIS\Projects\2015 SiteInvestigation\2015 FSP Figures\FIGURE 1-Site Location Map.mxd

0 Feet 10,000

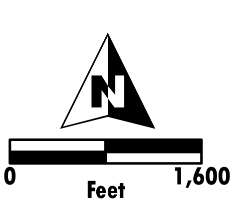
NewFields

Site Location Map
Former Frenchtown Mill Site
Missoula County, Montana
FIGURE 2-1

P:\350.0065 M2Green\AGIS\Projects\2015_SiteInvestigation\2015 RIWP Figures\FIGURE 2 - Site Plan and Operable Units.mxd Revised 10/8/2015



Aerial Photo Source: NAIP 2011



NewFields

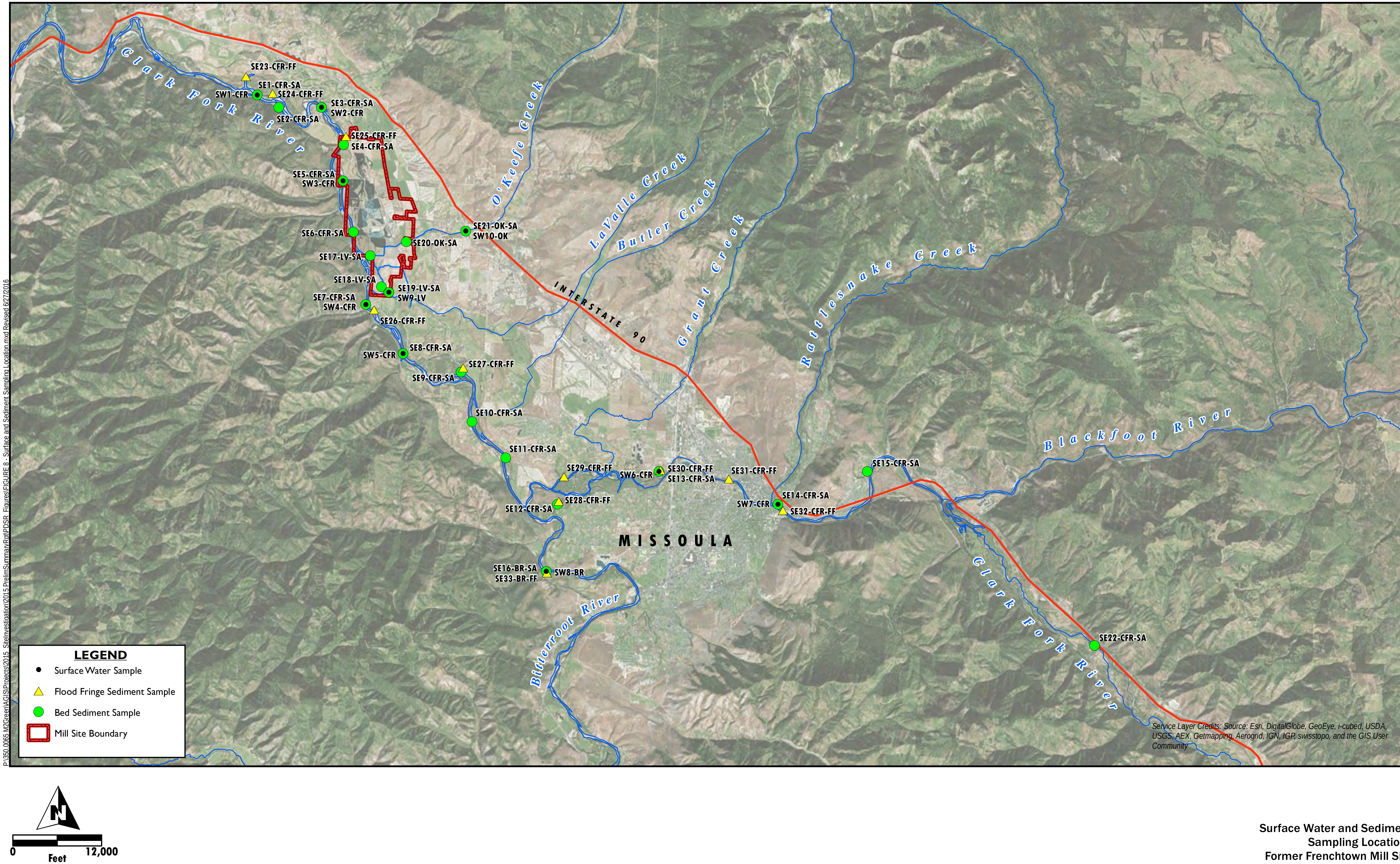
*Floodplain Source:
As defined by the Federal Emergency Management Agency (FEMA) 2013 Digital Flood Insurance Rate Map (DFIRM). (NFIP 2013)

**Where Contaminant of Potential Concern from the Site have come to be located in the CFR

Notes

AG - Agricultural Land
AB - Aeration Stabilization Basin
CFR - Clark Fork River
CRPB - Color Removal Plant Basin
CL - Clarifier
FP - Floodplain Area
HP - Holding or Storage Pond
IB - Rapid Infiltration Basin
LF - Land farm
IN - Industrial Area
NPP - North Polishing Pond
OU - Operable Unit
P - Settling Pond
SB - Spoils Basin
SPP - South Polishing Pond
SWB - Solid Waste Basin
WR - West of the Clark Fork River

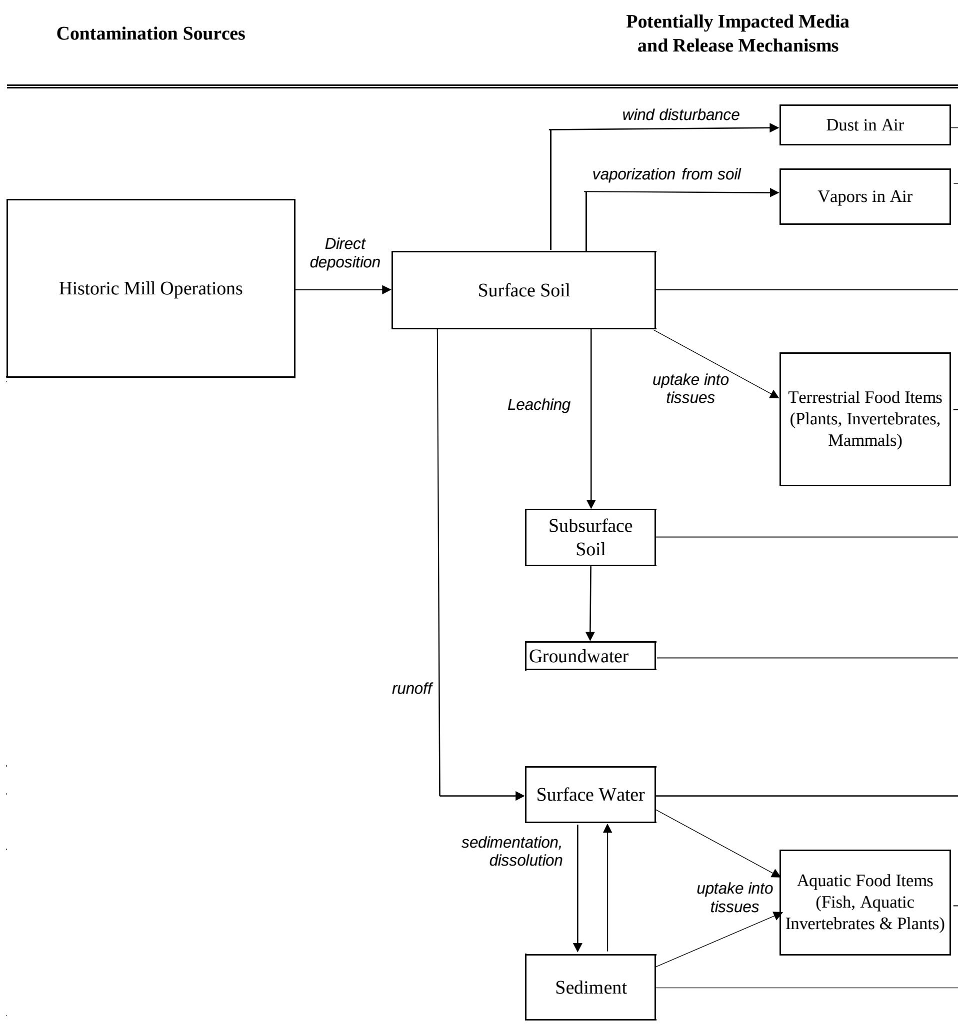
Site Plan and Operable Units
Former Frenchtown Mill Site
Missoula County, Montana
FIGURE 2-2



NewFields

Surface Water and Sediment
Sampling Locations
Former Frenchtown Mill Site
Missoula County, Montana
FIGURE 2-3

Figure 2-4. Conceptual Site Model for Ecological Exposure at OU1 - Agricultural Area Soils



Medium	Exposure Route	Aquatic Receptors [1]: Fish	Aquatic Receptors [1]: Benthic Organisms	Terrestrial Receptors: Plants	Terrestrial Receptors: Soil Invertebrates	Wildlife Receptors (Birds & Mammals)
Dust in Air	Inhalation			❍		❍
Vapors in Air	Inhalation					❍
Surface Soil	Ingestion				●	●
Surface Soil	Direct Contact			●		❍
Terrestrial Food Items	Ingestion					●
Subsurface Soil	Ingestion					
Subsurface Soil	Direct Contact					
Groundwater	Ingestion					
Surface Water	Ingestion					●
Surface Water	Direct Contact	●	●			❍
Aquatic Food Items	Ingestion	❍	❍			●
Sediment	Ingestion	❍	❍			●
Sediment	Direct Contact	❍	●			❍

LEGEND

●	Pathway is complete and might be significant.
❍	Pathway is complete, but is relatively minor.
	Pathway is not complete.

Notes:
[1] O'Keefe and Lavalle Creeks.

Figure 3-1. COPEC Selection Procedure

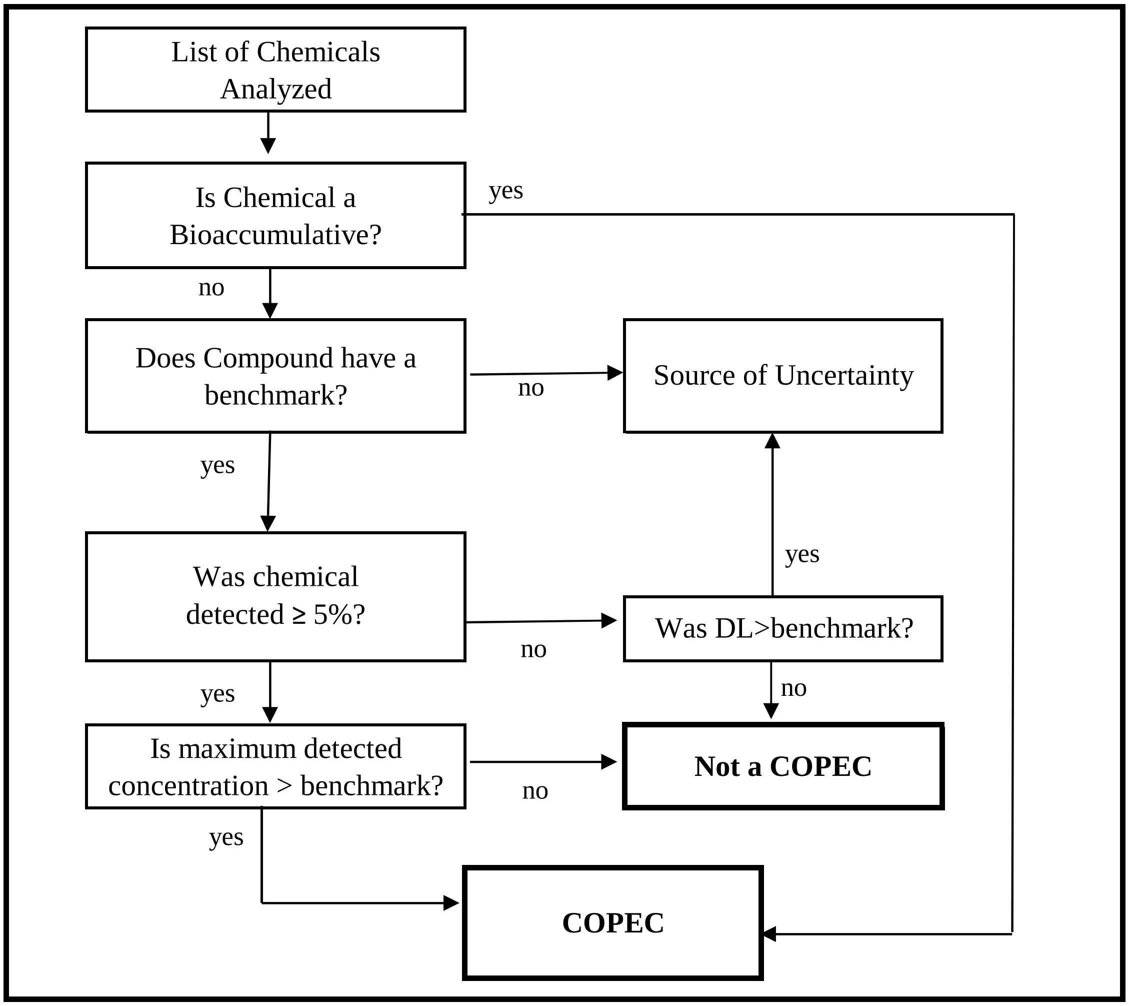


Figure 4-1. Site versus Background Surface Water TEQ (ND=MDL/2) Concentrations

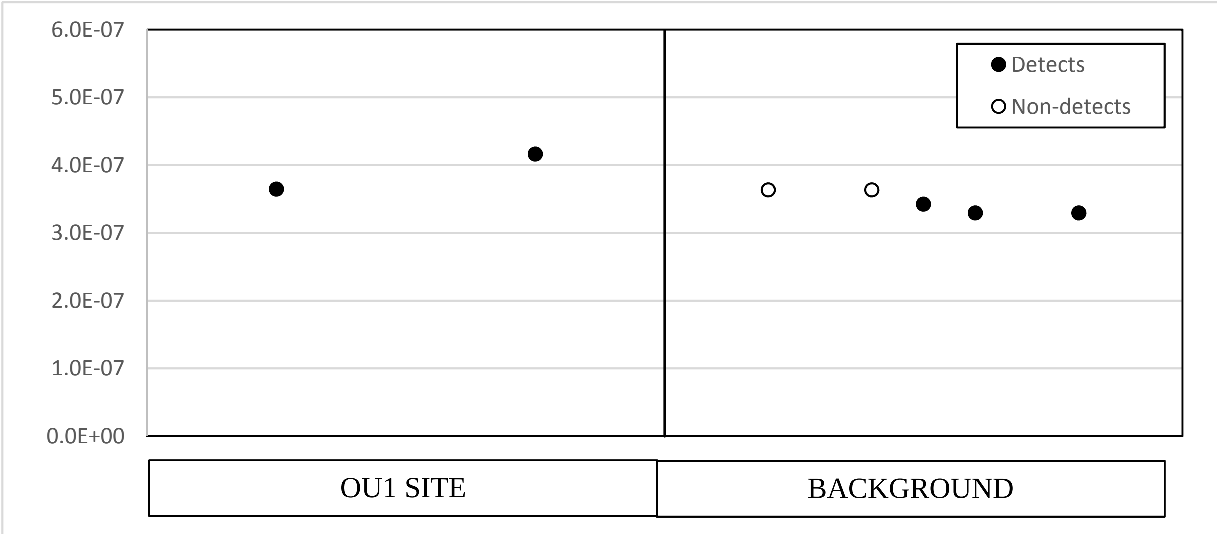
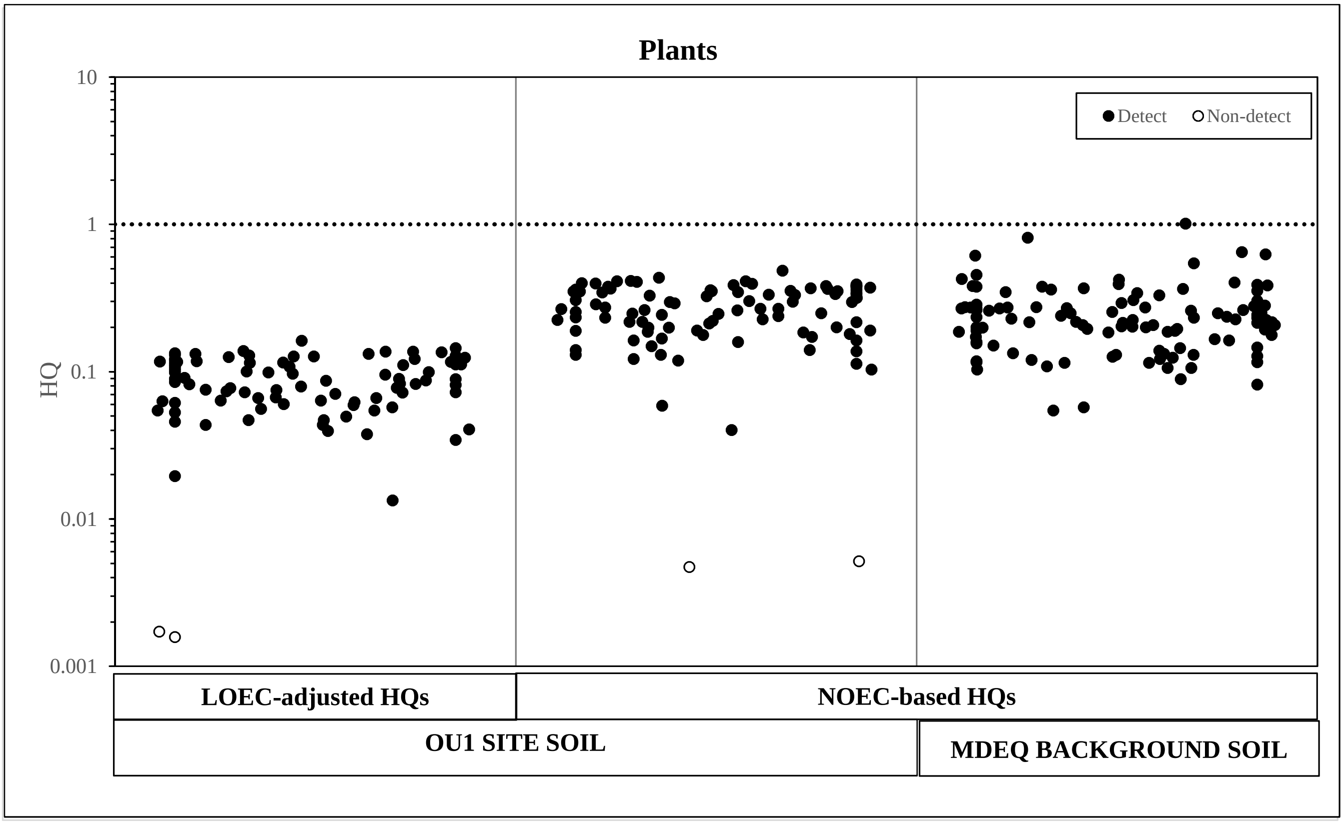


Figure 5-1. Hazard Quotients for Plants and Soil Invertebrates Exposed to Copper in OU1 Soils



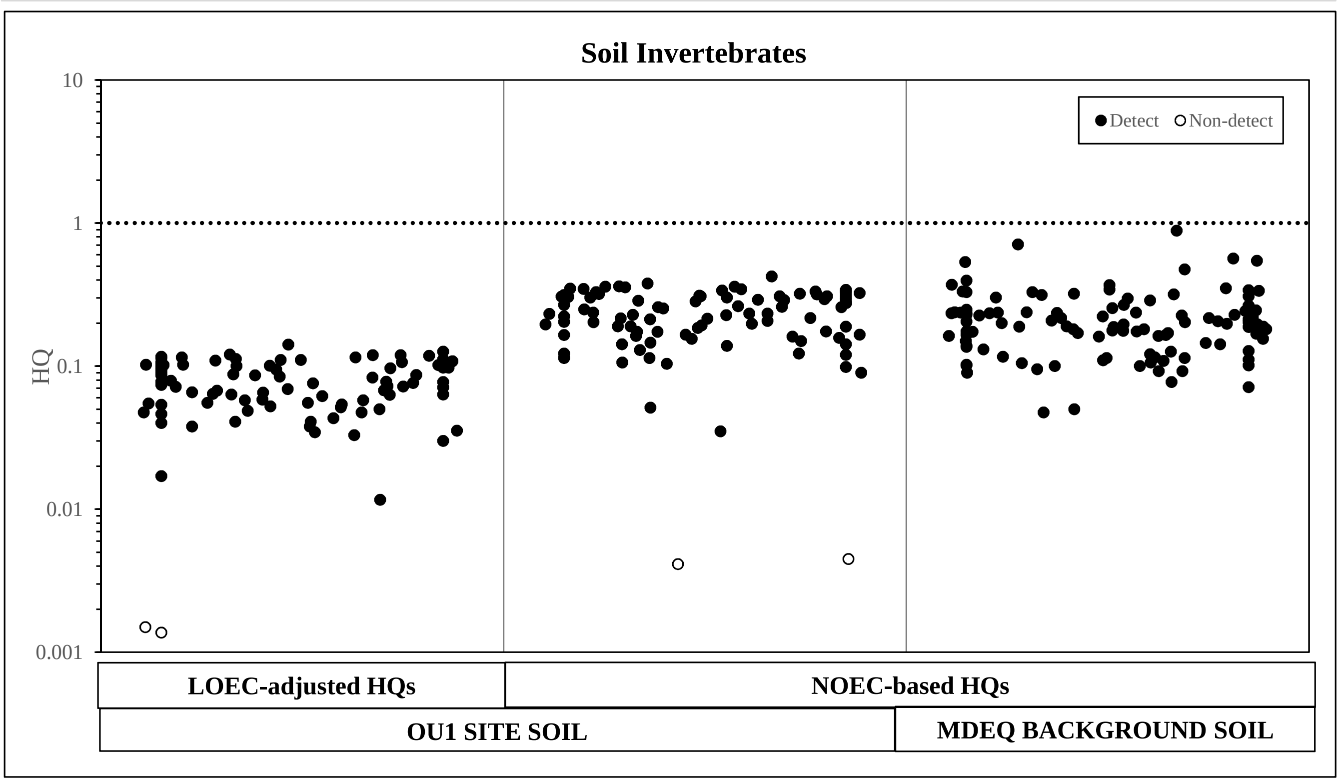
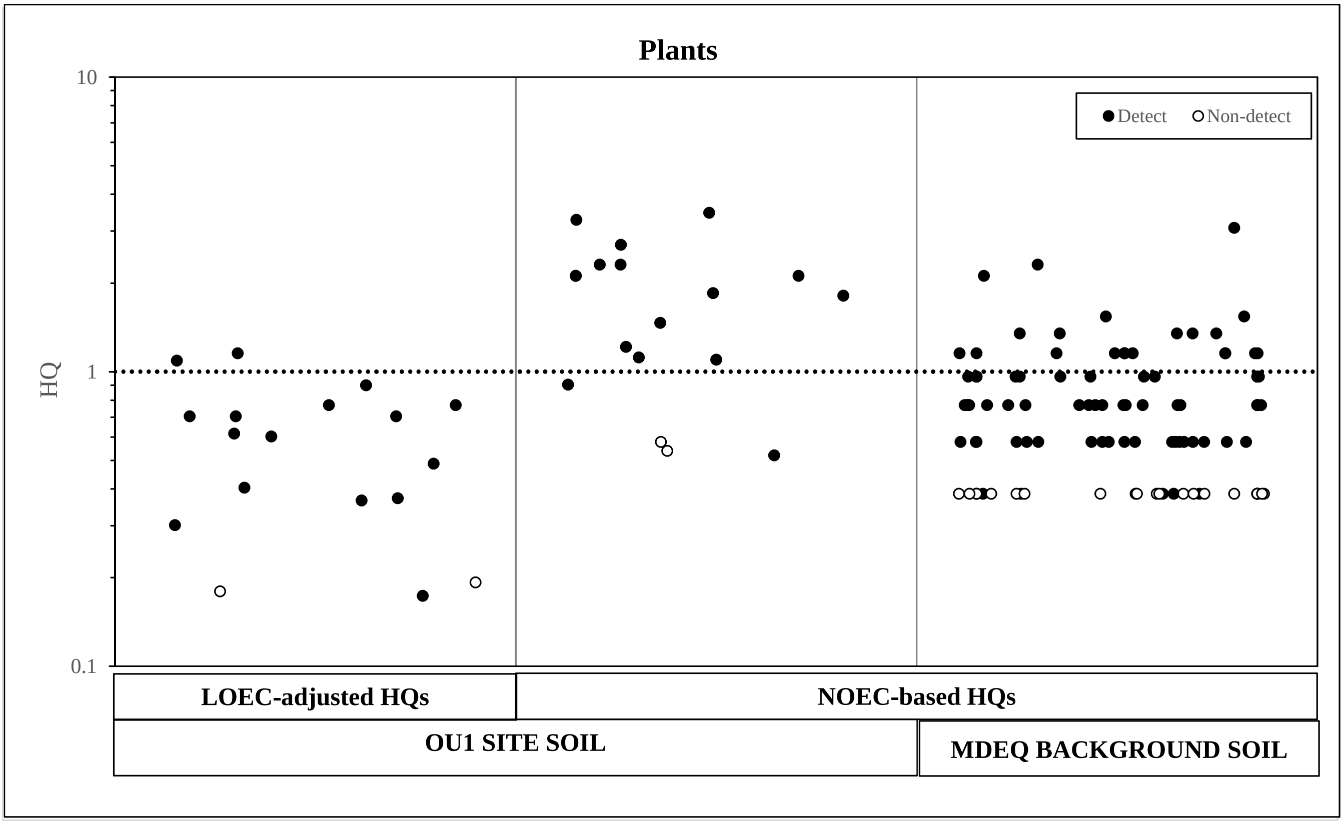
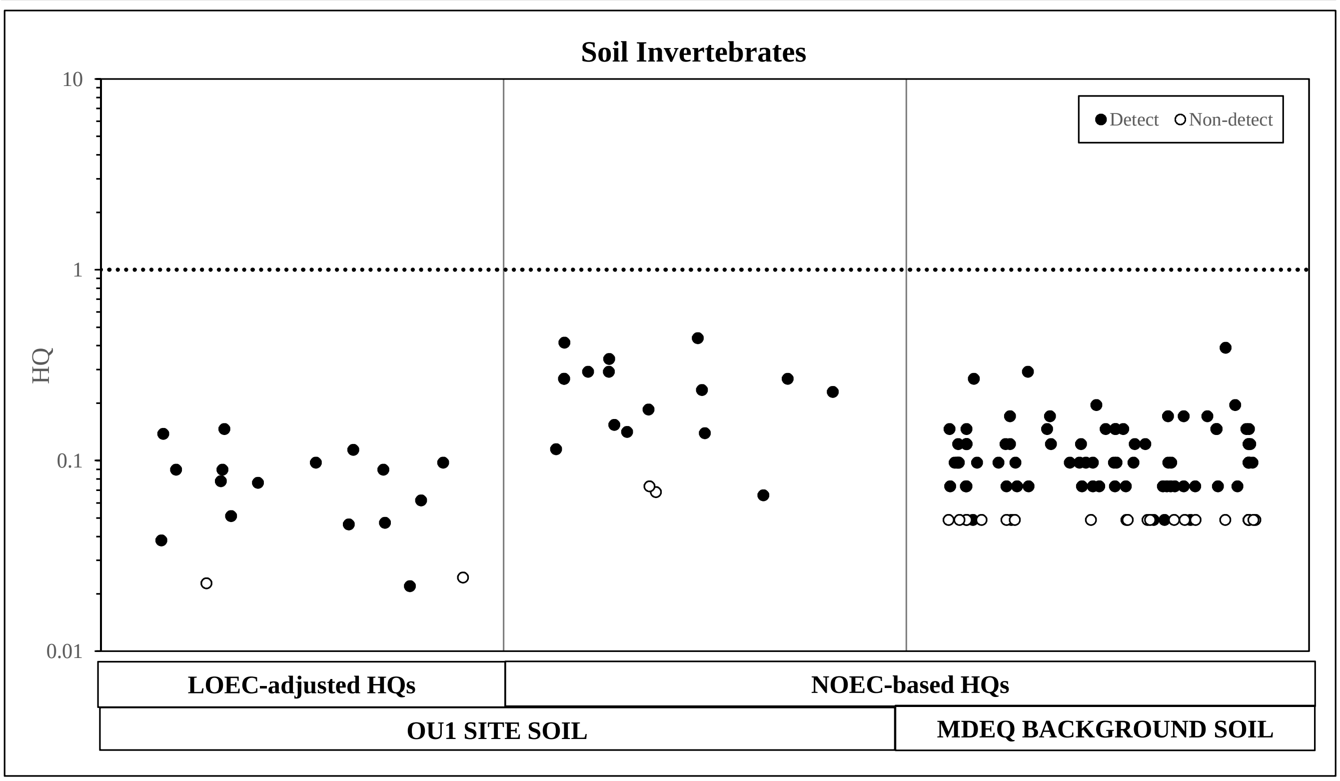


Figure 5-2. Hazard Quotients for Plants and Soil Invertebrates Exposed to Selenium in OU1 Soils





TABLES

Table 2-1. Endangered, Threatened, Proposed and Candidate Species in Missoula County, Montana

Scientific Name	Common Name	Status
Ursus arctos horribilis	Grizzly Bear	LT
Howellia aquatilis	Water Howellia	LT
Lynx canadensis	Canada Lynx	LT, CH
Salvelinus confluentus	Bull Trout	LT, CH
Coccyzus americanus	Yellow-billed cuckoo (western pop.)	LT
Calidris canutus rufa	Red Knot	LT
Gulo gulo luscus	Wolverine	P
Pinus albicaulis	Whitebark Pine	C

Source: U.S. Fish and Wildlife Service, Montana Field Office. November 25, 2016
(https://www.fws.gov/montanafieldoffice/Endangered_Species/Listed_Species/countylist.pdf)

Notes:
C = Candidate
LT = Listed Threatened
P = Proposed
CH = Designated Critical Habitat

Table 2-2. Data Summary

Media	Sample Date	Sample Description	Analysis
Soil	Apr-14	Surface (0-2.4 inches) soil samples were collected from 18 locations (n=18).	TAL metals, dioxins and furans.
	Nov-15	Surface soil samples were collected from 0-2 inch and 5-7 inch depth intervals at 39 locations (n=78).	TAL metals, PAHs, dioxins and furans.
Sediment	Nov-15	Sediment samples were collected from 0-0.34 feet at three locations in Lavalle Creek and two locations on O'Keefe Creek.	Aroclors, TAL metals, dioxins and furans.
Surface water	Nov-15	Two surface water samples were collected; one from Lavalle Creek and one from O'Keefe Creek.	Aroclors, total and dissolved TAL metals, SVOCs, dioxins and furans.

Table 2-3. OU1 Surface Soil Summary Statistics

Analysis	Analyte	Number of Samples	Number of Detected Samples	Detection Frequency (%)	Average Concentration[a] (mg/kg)	Standard Deviation	Maximum Detected Concentration (mg/kg)	Average MDL (mg/kg)
TEQ[b]	Avian TEQ (ND=0)	96	96	100	1.0E-07	2.1E-07	1.2E-06	--
	Avian TEQ (ND=1/2MDL)	96	96	100	1.5E-07	2.0E-07	1.2E-06	--
	Avian TEQ (ND=MDL)	96	96	100	2.0E-07	2.0E-07	1.3E-06	--
	Mammalian TEQ (ND=0)	96	96	100	1.7E-07	2.3E-07	1.2E-06	--
	Mammalian TEQ (ND=1/2MDL)	96	96	100	2.0E-07	2.3E-07	1.2E-06	--
	Mammalian TEQ (ND=MDL)	96	96	100	2.4E-07	2.2E-07	1.3E-06	--
Metals	Aluminum	96	96	100	1.3E+04	6.4E+03	3.1E+04	5.7E+00
	Antimony	18	14	78	1.3E-01	5.8E-02	2.4E-01	9.3E-02
	Arsenic	96	96	100	4.2E+00	1.5E+00	7.9E+00	1.3E-01
	Barium	96	96	100	2.0E+02	8.6E+01	4.3E+02	8.7E-02
	Beryllium	18	18	100	7.4E-01	3.5E-01	1.2E+00	8.4E-02
	Cadmium	96	91	95	1.5E-01	6.0E-02	2.8E-01	3.1E-02
	Calcium	18	18	100	1.8E+04	5.0E+04	2.2E+05	4.2E+01
	Chromium	96	91	95	1.0E+01	4.2E+00	1.9E+01	2.1E-01
	Cobalt	96	96	100	5.5E+00	2.2E+00	1.0E+01	2.5E-01
	Copper	96	94	98	1.9E+01	7.3E+00	3.4E+01	3.7E-01
	Iron	96	96	100	1.3E+04	4.9E+03	2.2E+04	2.8E+01
	Lead	96	96	100	1.0E+01	3.4E+00	2.1E+01	5.6E-02
	Magnesium	18	18	100	1.3E+04	2.6E+04	1.2E+05	1.5E+01
	Manganese	96	96	100	3.3E+02	1.4E+02	7.3E+02	2.3E-01
	Mercury	96	21	22	9.3E-03	1.3E-02	8.0E-02	8.0E-03
	Nickel	96	92	96	9.3E+00	4.0E+00	1.6E+01	1.5E-01
	Potassium	18	18	100	3.0E+03	1.2E+03	4.9E+03	8.3E+01
	Selenium	18	16	89	8.9E-01	4.9E-01	1.8E+00	3.0E-01
	Silver	96	0	0	7.4E-02	3.7E-02	--	1.5E-01
	Sodium	18	18	100	9.4E+01	4.0E+01	1.7E+02	2.9E+01
	Thallium	96	86	90	1.4E-01	5.7E-02	2.6E-01	3.8E-02
	Vanadium	96	96	100	1.4E+01	4.1E+00	2.2E+01	2.6E-01
	Zinc	96	96	100	5.3E+01	1.8E+01	9.1E+01	1.3E+00
SVOCs	Acenaphthene	78	0	0	2.3E-04	1.6E-05	--	4.5E-04
	Acenaphthylene	78	0	0	2.1E-04	1.5E-05	--	4.3E-04
	Anthracene	78	0	0	1.9E-04	1.3E-05	--	3.9E-04
	Benzo(a)anthracene	78	0	0	1.2E-04	7.9E-06	--	2.3E-04
	Benzo(a)pyrene	78	0	0	1.2E-04	8.8E-06	--	2.5E-04
	Benzo(b)fluoranthene	78	1	1	3.8E-04	1.4E-03	1.3E-02	4.4E-04
	Benzo(g,h,i)perylene	78	0	0	2.2E-04	1.5E-05	--	4.5E-04
	Benzo(k)fluoranthene	78	0	0	2.5E-04	1.7E-05	--	5.1E-04
	Chrysene	78	0	0	1.6E-04	1.1E-05	--	3.1E-04
	Dibenzo(a,h)anthracene	78	0	0	2.7E-04	1.9E-05	--	5.4E-04
	Fluoranthene	78	1	1	5.1E-04	3.2E-03	2.9E-02	2.8E-04
	Fluorene	78	0	0	2.0E-04	1.3E-05	--	3.9E-04
	Indeno(1,2,3-cd)pyrene	78	0	0	2.4E-04	1.7E-05	--	4.9E-04
	Naphthalene	78	0	0	2.3E-04	1.6E-05	--	4.7E-04
	Phenanthrene	78	1	1	3.3E-04	1.5E-03	1.4E-02	3.1E-04
	Pyrene	78	1	1	4.5E-04	2.7E-03	2.4E-02	3.0E-04

MDL = method detection limit; ND = non-detects; TEQ = Toxicity Equivalence

[a] Non-detects evaluated at 1/2 the MDL.

[b] TEQ values were calculated using TEFs for mammals from USEPA (2010) and using TEFs for birds from van Den Berg et al. (1998).

Table 2-4. OU1 Surface Water Summary Statistics

Analysis	Analyte	Number of Samples	Number of Detected Samples	Detection Frequency (%)	Average Concentration[a] (ug/L)	Standard Deviation[a] (ug/L)	Maximum Detected Concentration (ug/L)	Average MDL (ug/L)
Aroclors	Aroclor-1016	2	0	0	2.3E-02	3.5E-04	--	4.6E-02
	Aroclor-1221	2	0	0	9.8E-03	3.5E-04	--	2.0E-02
	Aroclor-1232	2	0	0	1.8E-02	3.5E-04	--	3.7E-02
	Aroclor-1242	2	0	0	1.4E-02	0.0E+00	--	2.8E-02
	Aroclor-1248	2	0	0	6.3E-03	3.5E-04	--	1.3E-02
	Aroclor-1254	2	0	0	7.8E-03	3.5E-04	--	1.6E-02
	Aroclor-1260	2	0	0	7.3E-03	3.5E-04	--	1.5E-02
	Aroclor-1262	2	0	0	2.1E-02	3.5E-04	--	4.2E-02
	Aroclor-1268	2	0	0	1.1E-02	3.5E-04	--	2.3E-02
TEQ[b]	Avian TEQ (ND=0)	2	2	100	2.1E-08	2.2E-08	3.6E-08	--
	Avian TEQ (ND=1/2MDL)	2	2	100	4.4E-07	2.1E-08	4.6E-07	--
	Avian TEQ (ND=MDL)	2	2	100	8.6E-07	2.0E-08	8.8E-07	--
	Mammalian TEQ (ND=0)	2	2	100	6.6E-08	3.7E-08	9.2E-08	--
	Mammalian TEQ (ND=1/2MDL)	2	2	100	3.9E-07	3.7E-08	4.2E-07	--
	Mammalian TEQ (ND=MDL)	2	2	100	7.1E-07	3.6E-08	7.4E-07	--
Total Metals	Aluminum	2	2	100	8.0E+02	7.4E+02	1.3E+03	3.0E+00
	Arsenic	2	2	100	1.7E+00	7.1E-02	1.7E+00	1.1E-01
	Barium	2	2	100	2.6E+02	8.5E+00	2.6E+02	8.1E-02
	Cadmium	2	0	0	1.2E-02	0.0E+00	--	2.4E-02
	Chromium	2	1	50	6.4E-01	7.9E-01	1.2E+00	1.7E-01
	Cobalt	2	1	50	2.3E-01	2.4E-01	4.0E-01	1.3E-01
	Copper	2	0	0	1.1E-01	0.0E+00	--	2.1E-01
	Iron	2	2	100	6.4E+02	5.3E+02	1.0E+03	1.4E+01
	Lead	2	2	100	5.0E-01	2.2E-01	6.5E-01	4.6E-02
	Manganese	2	2	100	1.4E+01	8.9E+00	2.0E+01	2.4E-01
	Mercury	2	0	0	1.1E-02	0.0E+00	--	2.2E-02
	Nickel	2	0	0	8.0E-02	0.0E+00	--	1.6E-01
	Silver	2	0	0	7.5E-02	0.0E+00	--	1.5E-01
	Thallium	2	0	0	7.5E-03	0.0E+00	--	1.5E-02
	Vanadium	2	2	100	1.4E+00	2.1E-01	1.5E+00	2.8E-01
	Zinc	2	1	50	3.1E+00	2.7E+00	5.0E+00	2.4E+00
Dissolved Metals	Aluminum	2	1	50	2.2E+01	2.9E+01	4.2E+01	3.0E+00
	Arsenic	2	2	100	1.4E+00	7.1E-02	1.4E+00	1.1E-01
	Barium	2	2	100	2.3E+02	1.8E+01	2.4E+02	8.1E-02
	Cadmium	2	0	0	1.2E-02	0.0E+00	--	2.4E-02
	Calcium	2	2	100	4.1E+04	1.7E+04	5.2E+04	6.7E+01
	Chromium	2	0	0	8.5E-02	0.0E+00	--	1.7E-01
	Cobalt	2	1	50	4.9E-01	6.0E-01	9.2E-01	1.3E-01
	Copper	2	0	0	1.1E-01	0.0E+00	--	2.1E-01
	Iron	2	0	0	6.9E+00	0.0E+00	--	1.4E+01
	Lead	2	0	0	2.3E-02	0.0E+00	--	4.6E-02
	Magnesium	2	2	100	1.8E+04	6.2E+03	2.2E+04	2.0E+01
	Manganese	2	2	100	8.4E+00	3.1E+00	1.1E+01	2.4E-01
	Nickel	2	0	0	8.0E-02	0.0E+00	--	1.6E-01
	Potassium	2	0	0	6.3E+01	0.0E+00	--	1.3E+02
	Silver	2	0	0	7.5E-02	0.0E+00	--	1.5E-01
	Sodium	2	2	100	1.6E+04	1.0E+04	2.3E+04	3.3E+01
	Thallium	2	0	0	7.5E-03	0.0E+00	--	1.5E-02
	Vanadium	2	0	0	1.4E-01	0.0E+00	--	2.8E-01
	Zinc	2	0	0	1.2E+00	0.0E+00	--	2.4E+00
SVOCs	1,2,4-Trichlorobenzene	2	0	0	9.5E-01	0.0E+00	--	1.9E+00
	1,2-Dichlorobenzene	2	0	0	9.5E-01	0.0E+00	--	1.9E+00
	1,2-Diphenylhydrazine	2	0	0	1.3E+00	0.0E+00	--	2.5E+00
	1,3-Dichlorobenzene	2	0	0	8.3E-01	3.5E-02	--	1.7E+00
	1,4-Dichlorobenzene	2	0	0	9.5E-01	0.0E+00	--	1.9E+00
	1-Methylnaphthalene	2	0	0	1.1E+00	0.0E+00	--	2.1E+00
	2,4,5-Trichlorophenol	2	0	0	1.1E+00	0.0E+00	--	2.2E+00
	2,4,6-Trichlorophenol	2	0	0	1.1E+00	0.0E+00	--	2.2E+00
	2,4-Dichlorophenol	2	0	0	1.2E+00	0.0E+00	--	2.3E+00
	2,4-Dimethylphenol	2	0	0	3.4E+00	3.5E-02	--	6.9E+00
	2,4-Dinitrophenol	2	0	0	1.4E+00	0.0E+00	--	2.8E+00
	2,4-Dinitrotoluene	2	0	0	1.1E+00	3.5E-02	--	2.2E+00
	2,6-Dinitrotoluene	2	0	0	1.2E+00	0.0E+00	--	2.3E+00
	2-Chloronaphthalene	2	0	0	1.1E+00	3.5E-02	--	2.3E+00
	2-Chlorophenol	2	0	0	1.1E+00	0.0E+00	--	2.2E+00
	2-Methylnaphthalene	2	0	0	1.1E+00	0.0E+00	--	2.1E+00
	2-Nitroaniline	2	0	0	1.4E+00	0.0E+00	--	2.8E+00

Table 2-4. OU1 Surface Water Summary Statistics

Analysis	Analyte	Number of Samples	Number of Detected Samples	Detection Frequency (%)	Average Concentration[a] (ug/L)	Standard Deviation[a] (ug/L)	Maximum Detected Concentration (ug/L)	Average MDL (ug/L)
SVOCs	2-Nitrophenol	2	0	0	1.1E+00	3.5E-02	--	2.3E+00
	3,3`-Dichlorobenzidine	2	0	0	2.5E+00	3.5E-02	--	5.0E+00
	3-Nitroaniline	2	0	0	2.5E+00	3.5E-02	--	5.1E+00
	4,6-Dinitro-o-cresol	2	0	0	1.8E+00	3.5E-02	--	3.6E+00
	4-Bromophenyl phenyl ether	2	0	0	1.2E+00	0.0E+00	--	2.4E+00
	4-Chloro-3-methylphenol	2	0	0	8.0E-01	0.0E+00	--	1.6E+00
	4-Chlorophenyl phenyl ether	2	0	0	7.0E-01	0.0E+00	--	1.4E+00
	4-Nitroaniline	2	0	0	2.2E+00	0.0E+00	--	4.4E+00
	4-Nitrophenol	2	0	0	1.7E+00	0.0E+00	--	3.4E+00
	Acenaphthene	2	0	0	8.3E-01	3.5E-02	--	1.7E+00
	Acenaphthylene	2	0	0	1.1E+00	3.5E-02	--	2.3E+00
	Anthracene	2	0	0	1.3E+00	0.0E+00	--	2.5E+00
	Benzo(a)anthracene	2	0	0	2.6E+00	0.0E+00	--	5.1E+00
	Benzo(a)pyrene	2	0	0	1.2E+00	0.0E+00	--	2.4E+00
	Benzo(b)fluoranthene	2	0	0	1.3E+00	0.0E+00	--	2.5E+00
	Benzo(g,h,i)perylene	2	0	0	1.3E+00	0.0E+00	--	2.5E+00
	Benzo(k)fluoranthene	2	0	0	1.4E+00	0.0E+00	--	2.8E+00
	bis(2-chloroethoxy)methane	2	0	0	7.8E-01	3.5E-02	--	1.6E+00
	bis(2-chloroethyl)ether	2	0	0	1.2E+00	0.0E+00	--	2.3E+00
	Bis(2-chloroisopropyl)ether	2	0	0	1.2E+00	0.0E+00	--	2.3E+00
	Bis(2-ethylhexyl)phthalate	2	0	0	1.2E+00	0.0E+00	--	2.4E+00
	Butyl benzyl phthalate	2	0	0	9.5E-01	0.0E+00	--	1.9E+00
	Carbazole	2	0	0	1.4E+00	0.0E+00	--	2.7E+00
	Chrysene	2	0	0	1.2E+00	0.0E+00	--	2.3E+00
	Dibenzo(a,h)anthracene	2	0	0	9.0E-01	0.0E+00	--	1.8E+00
	Dibenzofuran	2	0	0	1.2E+00	0.0E+00	--	2.3E+00
	Dibutyl phthalate	2	0	0	1.2E+00	3.5E-02	--	2.5E+00
	Diethyl phthalate	2	0	0	1.3E+00	0.0E+00	--	2.5E+00
	Dimethyl phthalate	2	0	0	1.2E+00	3.5E-02	--	2.4E+00
	Di-n-octyl phthalate	2	0	0	8.5E-01	0.0E+00	--	1.7E+00
	Fluoranthene	2	0	0	1.3E+00	0.0E+00	--	2.5E+00
	Fluorene	2	0	0	1.2E+00	0.0E+00	--	2.4E+00
	Hexachlorobenzene	2	0	0	1.3E+00	0.0E+00	--	2.6E+00
	Hexachlorobutadiene	2	0	0	8.5E-01	0.0E+00	--	1.7E+00
	Hexachloroethane	2	0	0	8.5E-01	0.0E+00	--	1.7E+00
	Indeno(1,2,3-cd)pyrene	2	0	0	9.0E-01	0.0E+00	--	1.8E+00
	Isophorone	2	0	0	8.0E-01	0.0E+00	--	1.6E+00
	m & p-cresols	2	0	0	1.2E+00	0.0E+00	--	2.3E+00
	Naphthalene	2	0	0	1.0E+00	0.0E+00	--	2.0E+00
	Nitrobenzene	2	0	0	1.3E+00	0.0E+00	--	2.5E+00
	N-Nitrosodimethylamine	2	0	0	1.2E+00	0.0E+00	--	2.3E+00
	N-Nitrosodi-n-propylamine	2	0	0	1.2E+00	0.0E+00	--	2.3E+00
	N-Nitrosodiphenylamine	2	0	0	2.0E+00	3.5E-02	--	4.0E+00
	o-Cresol	2	0	0	1.0E+00	0.0E+00	--	2.0E+00
	p-Chloroaniline	2	0	0	1.8E+00	3.5E-02	--	3.7E+00
	Pentachlorophenol	2	0	0	1.1E+00	0.0E+00	--	2.2E+00
	Phenanthrene	2	0	0	1.3E+00	3.5E-02	--	2.6E+00
	Phenol	2	0	0	1.1E+00	3.5E-02	--	2.3E+00
	Pyrene	2	0	0	1.3E+00	0.0E+00	--	2.5E+00

MDL = method detection limit; ND = non-detects; TEQ = Toxicity Equivalence

[a]Non-detects evaluated at 1/2 the MDL.

[b]TEQ values were calculated using TEFs for mammals from USEPA (2010) and using TEFs for birds from van Den Berg et al. (1998).

Table 2-5. OU1 Sediment Summary Statistics

Analysis	Analyte	Number of Samples	Number of Detected Samples	Detection Frequency (%)	Average Concentration[a] (mg/kg)	Standard Deviation	Maximum Detected Concentration (mg/kg)	Average MDL (mg/kg)
Aroclors	Aroclor-1016	5	0	0	6.8E-03	3.0E-03	--	1.4E-02
	Aroclor-1221	5	0	0	1.6E-02	7.1E-03	--	3.2E-02
	Aroclor-1232	5	0	0	7.0E-03	3.2E-03	--	1.4E-02
	Aroclor-1242	5	0	0	1.8E-02	8.1E-03	--	3.6E-02
	Aroclor-1248	5	0	0	1.2E-02	5.2E-03	--	2.3E-02
	Aroclor-1254	5	0	0	4.4E-03	2.0E-03	--	8.8E-03
	Aroclor-1260	5	0	0	4.5E-03	2.0E-03	--	9.0E-03
	Aroclor-1262	5	0	0	5.9E-03	2.7E-03	--	1.2E-02
	Aroclor-1268	5	0	0	4.1E-03	1.8E-03	--	8.2E-03
TEQ[b]	Avian TEQ (ND=0)	5	5	100	8.9E-07	1.5E-06	3.6E-06	--
	Avian TEQ (ND=1/2MDL)	5	5	100	9.2E-07	1.5E-06	3.6E-06	--
	Avian TEQ (ND=MDL)	5	5	100	9.5E-07	1.5E-06	3.6E-06	--
	Mammalian TEQ (ND=0)	5	5	100	9.8E-07	1.2E-06	3.1E-06	--
	Mammalian TEQ (ND=1/2MDL)	5	5	100	1.0E-06	1.2E-06	3.1E-06	--
	Mammalian TEQ (ND=MDL)	5	5	100	1.0E-06	1.2E-06	3.1E-06	--
Metals	Aluminum	5	5	100	9.8E+03	3.2E+03	1.4E+04	7.8E+00
	Arsenic	5	5	100	7.4E+00	5.0E+00	1.3E+01	2.3E-01
	Barium	5	5	100	2.1E+02	7.9E+01	3.2E+02	1.5E-01
	Cadmium	5	2	40	2.0E-01	2.9E-01	6.8E-01	5.2E-02
	Chromium	5	5	100	1.1E+01	2.5E+00	1.4E+01	3.6E-01
	Cobalt	5	5	100	7.2E+00	3.8E+00	1.3E+01	4.6E-01
	Copper	5	5	100	4.6E+01	4.2E+01	1.2E+02	6.2E-01
	Iron	5	5	100	1.4E+04	6.4E+03	2.5E+04	4.7E+01
	Lead	5	5	100	1.7E+01	6.4E+00	2.3E+01	8.1E-02
	Manganese	5	5	100	2.6E+02	1.7E+02	4.8E+02	2.6E-01
	Mercury	5	1	20	3.6E-02	6.4E-02	1.5E-01	1.5E-02
	Nickel	5	5	100	1.0E+01	3.1E+00	1.5E+01	2.9E-01
	Silver	5	0	0	1.1E-01	4.7E-02	--	2.2E-01
	Thallium	5	0	0	4.1E-02	1.7E-02	--	8.1E-02
	Vanadium	5	5	100	1.6E+01	3.5E+00	2.1E+01	5.2E-01
	Zinc	5	5	100	9.7E+01	8.7E+01	2.5E+02	2.5E+00
SVOCs	1,2,4-Trichlorobenzene	5	0	0	6.4E-02	2.9E-02	--	1.3E-01
	1,2-Dichlorobenzene	5	0	0	2.5E-02	1.1E-02	--	5.0E-02
	1,2-Diphenylhydrazine	5	0	0	1.9E-01	8.7E-02	--	3.9E-01
	1,3-Dichlorobenzene	5	0	0	2.4E-02	1.1E-02	--	4.9E-02
	1,4-Dichlorobenzene	5	0	0	2.6E-02	1.2E-02	--	5.1E-02
	1-Methylnaphthalene	5	0	0	6.7E-02	3.0E-02	--	1.3E-01
	2,4,5-Trichlorophenol	5	0	0	4.6E-02	2.1E-02	--	9.2E-02
	2,4,6-Trichlorophenol	5	0	0	5.0E-02	2.3E-02	--	9.9E-02
	2,4-Dichlorophenol	5	0	0	7.3E-02	3.3E-02	--	1.5E-01
	2,4-Dimethylphenol	5	0	0	7.2E-02	3.3E-02	--	1.4E-01
	2,4-Dinitrophenol	5	0	0	1.9E-01	8.7E-02	--	3.9E-01
	2,4-Dinitrotoluene	5	0	0	1.9E-01	8.7E-02	--	3.9E-01
	2,6-Dinitrotoluene	5	0	0	3.3E-02	1.5E-02	--	6.6E-02
	2-Chloronaphthalene	5	0	0	6.0E-02	2.7E-02	--	1.2E-01
	2-Chlorophenol	5	0	0	9.0E-02	4.1E-02	--	1.8E-01
	2-Methylnaphthalene	5	0	0	6.9E-02	3.1E-02	--	1.4E-01
	2-Nitroaniline	5	0	0	4.2E-02	1.9E-02	--	8.4E-02
	2-Nitrophenol	5	0	0	6.6E-02	3.0E-02	--	1.3E-01
	3,3`-Dichlorobenzidine	5	0	0	5.4E-02	2.4E-02	--	1.1E-01
	3-Nitroaniline	5	0	0	3.9E-02	1.8E-02	--	7.9E-02
	4,6-Dinitro-o-cresol	5	0	0	7.7E-02	3.5E-02	--	1.5E-01
	4-Bromophenyl phenyl ether	5	0	0	4.1E-02	1.9E-02	--	8.2E-02
	4-Chloro-3-methylphenol	5	0	0	1.9E-01	8.7E-02	--	3.9E-01
	4-Chlorophenyl phenyl ether	5	0	0	4.4E-02	2.0E-02	--	8.9E-02
	4-Nitroaniline	5	0	0	3.4E-02	1.5E-02	--	6.8E-02
	4-Nitrophenol	5	0	0	4.1E-02	1.8E-02	--	8.1E-02
	Acenaphthene	5	0	0	4.5E-02	2.0E-02	--	8.9E-02
	Acenaphthylene	5	0	0	5.1E-02	2.3E-02	--	1.0E-01
	Anthracene	5	0	0	1.9E-01	8.7E-02	--	3.9E-01
	Benzo(a)anthracene	5	0	0	1.9E-01	8.7E-02	--	3.9E-01
	Benzo(a)pyrene	5	0	0	1.9E-01	8.7E-02	--	3.9E-01
	Benzo(b)fluoranthene	5	0	0	4.9E-02	2.2E-02	--	9.8E-02
	Benzo(g,h,i)perylene	5	0	0	4.7E-02	2.1E-02	--	9.4E-02
	Benzo(k)fluoranthene	5	0	0	4.9E-02	2.2E-02	--	9.9E-02
	bis(2-chloroethoxy)methane	5	0	0	7.5E-02	3.4E-02	--	1.5E-01
	bis(2-chloroethyl)ether	5	0	0	2.7E-02	1.2E-02	--	5.4E-02

Table 2-5. OU1 Sediment Summary Statistics

Analysis	Analyte	Number of Samples	Number of Detected Samples	Detection Frequency (%)	Average Concentration[a] (mg/kg)	Standard Deviation	Maximum Detected Concentration (mg/kg)	Average MDL (mg/kg)
SVOCs	Bis(2-chloroisopropyl)ether	5	0	0	8.9E-02	4.0E-02	--	1.8E-01
	Bis(2-ethylhexyl)phthalate	5	0	0	6.6E-02	3.0E-02	--	1.3E-01
	Butyl benzyl phthalate	5	0	0	1.9E-01	8.7E-02	--	3.9E-01
	Carbazole	5	0	0	1.9E-01	8.7E-02	--	3.9E-01
	Chrysene	5	0	0	5.2E-02	2.3E-02	--	1.0E-01
	Dibenzo(a,h)anthracene	5	0	0	1.9E-01	8.7E-02	--	3.9E-01
	Dibenzofuran	5	0	0	1.9E-01	8.7E-02	--	3.9E-01
	Dibutyl phthalate	5	0	0	5.4E-02	2.4E-02	--	1.1E-01
	Diethyl phthalate	5	0	0	1.9E-01	8.7E-02	--	3.9E-01
	Dimethyl phthalate	5	0	0	1.9E-01	8.7E-02	--	3.9E-01
	Di-n-octyl phthalate	5	0	0	1.9E-01	8.7E-02	--	3.9E-01
	Fluoranthene	5	0	0	1.9E-01	8.7E-02	--	3.9E-01
	Fluorene	5	0	0	1.9E-01	8.7E-02	--	3.9E-01
	Hexachlorobenzene	5	0	0	5.1E-02	2.3E-02	--	1.0E-01
	Hexachlorobutadiene	5	0	0	3.2E-02	1.5E-02	--	6.5E-02
	Hexachloroethane	5	0	0	2.5E-02	1.1E-02	--	4.9E-02
	Indeno(1,2,3-cd)pyrene	5	0	0	1.9E-01	8.7E-02	--	3.9E-01
	Isophorone	5	0	0	6.2E-02	2.8E-02	--	1.2E-01
	m & p-cresols	5	0	0	7.7E-02	3.5E-02	--	1.5E-01
	Naphthalene	5	0	0	7.2E-02	3.3E-02	--	1.4E-01
	Nitrobenzene	5	0	0	7.8E-02	3.5E-02	--	1.6E-01
	N-Nitrosodimethylamine	5	0	0	1.9E-01	8.7E-02	--	3.9E-01
	N-Nitrosodi-n-propylamine	5	0	0	5.3E-02	2.4E-02	--	1.1E-01
	N-Nitrosodiphenylamine	5	0	0	1.9E-01	8.7E-02	--	3.9E-01
	o-Cresol	5	0	0	8.4E-02	3.8E-02	--	1.7E-01
	p-Chloroaniline	5	0	0	5.9E-02	2.7E-02	--	1.2E-01
	Pentachlorophenol	5	0	0	1.9E-01	8.7E-02	--	3.9E-01
	Phenanthrene	5	0	0	5.5E-02	2.5E-02	--	1.1E-01
	Phenol	5	0	0	8.4E-02	3.8E-02	--	1.7E-01
	Pyrene	5	0	0	4.9E-02	2.2E-02	--	9.7E-02

MDL = method detection limit; ND = non-detects; TEQ = Toxicity Equivalence

[a]Non-detects evaluated at 1/2 the MDL.

[b]TEQ values were calculated using TEFs for mammals from USEPA (2010) and using TEFs for birds from van Den Berg et al. (1998).

Table 3-1. OU1 Surface Soil COPEC Screen

Analysis	Analyte	Detection Frequency (%)	Maximum Detected Concentration (mg/kg)	Average MDL (mg/kg)	Soil Benchmark (mg/kg)	COPEC SELECTION STEPS				OU1 SOIL COPECs		
						Does chemical have a benchmark?	Is chemical detected ≥5%?	Is Max Detect > benchmark?	Is MDL > benchmark?	COPEC	Not a COPEC	Source of Uncertainty
Dioxins/Furans	Avian TEQ ND=0	100%	1.2E-06	--	TEQ identified as a bioaacumulative and is retained as a COPEC.					X		
	Avian TEQ ND=1/2MDL	100%	1.2E-06	--						X		
	Avian TEQ ND=MDL	100%	1.3E-06	--						X		
	Mammalian TEQ ND=0	100%	1.2E-06	--						X		
	Mammalian TEQ ND=1/2MDL	100%	1.2E-06	--						X		
	Mammalian TEQ ND=MDL	100%	1.3E-06	--						X		
Metals	Aluminum	100%	3.1E+04	5.7E+00	5.0E+01	yes	yes	yes		X		
	Antimony	78%	2.4E-01	9.3E-02	2.7E-01	yes	yes	no			X	
	Arsenic	100%	7.9E+00	1.3E-01	1.0E+01	yes	yes	no			X	
	Barium	100%	4.3E+02	8.7E-02	3.3E+02	yes	yes	yes		X		
	Beryllium	100%	1.2E+00	8.4E-02	1.0E+01	yes	yes	no			X	
	Cadmium	95%	2.8E-01	3.1E-02	3.6E-01	yes	yes	no			X	
	Calcium	100%	2.2E+05	4.2E+01	NV	no	yes					X
	Chromium	95%	1.9E+01	2.1E-01	4.0E-01	yes	yes	yes		X		
	Cobalt	100%	1.0E+01	2.5E-01	1.3E+01	yes	yes	no			X	
	Copper	98%	3.4E+01	3.7E-01	2.8E+01	yes	yes	yes		X		
	Iron	100%	2.2E+04	2.8E+01	NV	no	yes					X
	Lead	100%	2.1E+01	5.6E-02	1.1E+01	yes	yes	yes		X		
	Magnesium	100%	1.2E+05	1.5E+01	NV	no	yes					X
	Manganese	100%	7.3E+02	2.3E-01	2.2E+02	yes	yes	yes		X		
	Mercury	22%	8.0E-02	8.0E-03	1.0E-01	yes	yes	no			X	
	Nickel	96%	1.6E+01	1.5E-01	3.0E+01	yes	yes	no			X	
	Potassium	100%	4.9E+03	8.3E+01	NV	no	yes					X
	Selenium	89%	1.8E+00	3.0E-01	5.2E-01	yes	yes	yes		X		
	Silver	0%	--	1.5E-01	2.0E+00	yes	no		no		X	
	Sodium	100%	1.7E+02	2.9E+01	NV	no	yes					X
	Thallium	90%	2.6E-01	3.8E-02	1.0E+00	yes	yes	no			X	
	Vanadium	100%	2.2E+01	2.6E-01	2.0E+00	yes	yes	yes		X		
	Zinc	100%	9.1E+01	1.3E+00	4.6E+01	yes	yes	yes		X		
Polycyclic Aromatic Hydrocarbons (PAHs)[a]	HMW PAHs	1%	6.8E-02	3.8E-03	1.1E+00	yes	no	no	no		X	
	LMW PAHs	1%	1.6E-02	2.4E-03	2.9E+01	yes	no	no	no		X	

TEQ = Toxicity equivalence; MDL = method detection limit; PAH = polyaromatic hydrocarbon; HMW = high-molecular weight; LMW = low molecular weight; NV = no value

Table 3-2. OU1 Surface Water COPEC Screen

Analysis	Analyte	Detection Frequency (%)	Maximum Detected Concentration (ug/L)	Average MDL (ug/L)	SW Benchmark (ug/L)	COPEC SELECTION STEPS: Does chemical have a benchmark?	Is chemical detected ≥5%?	Is Max Detect > benchmark?	Is MDL > benchmark?	OU1 SURFACE WATER COPECs: COPEC	Not a COPEC	Source of Uncertainty
Aroclors	Aroclor-1016	0%	--	4.6E-02	NV	no	no				X	
	Aroclor-1221	0%	--	2.0E-02	2.8E-01	yes	no		no		X	
	Aroclor-1232	0%	--	3.7E-02	5.8E-01	yes	no		no		X	
	Aroclor-1242	0%	--	2.8E-02	5.3E-02	yes	no		no		X	
	Aroclor-1248	0%	--	1.3E-02	8.1E-02	yes	no		no		X	
	Aroclor-1254	0%	--	1.6E-02	3.3E-02	yes	no		no		X	
	Aroclor-1260	0%	--	1.5E-02	9.4E+01	yes	no		no		X	
	Aroclor-1262	0%	--	4.2E-02	NV	no	no				X	
	Aroclor-1268	0%	--	2.3E-02	NV	no	no				X	
TEQ	Avian TEQ (ND=0)	100%	3.6E-08	--	TEQ is identified as a bioaccumulative and is retained as a COPEC.					X		
	Avian TEQ (ND=1/2MDL)	100%	4.6E-07	--						X		
	Avian TEQ (ND=MDL)	100%	8.8E-07	--						X		
	Mammalian TEQ (ND=0)	100%	9.2E-08	--						X		
	Mammalian TEQ (ND=1/2MDL)	100%	4.2E-07	--						X		
	Mammalian TEQ (ND=MDL)	100%	7.4E-07	--						X		
Dissolved Metals	Aluminum	50%	4.2E+01	3.0E+00	8.7E+01	yes	yes	no			X	
	Arsenic	100%	1.4E+00	1.1E-01	1.5E+02	yes	yes	no			X	
	Barium	100%	2.4E+02	8.1E-02	5.0E+03	yes	yes	no			X	
	Cadmium	0%	--	2.4E-02	2.5E-01	yes	no		no		X	
	Calcium	100%	5.2E+04	6.7E+01	1.2E+05	yes	yes	no			X	
	Chromium	0%	--	1.7E-01	1.1E+01	yes	no		no		X	
	Cobalt	50%	9.2E-01	1.3E-01	2.3E+01	yes	yes	no			X	
	Copper	0%	--	2.1E-01	9.0E+00	yes	no		no		X	
	Iron	0%	--	1.4E+01	1.0E+03	yes	no		no		X	
	Lead	0%	--	4.6E-02	2.5E+00	yes	no		no		X	
	Magnesium	100%	2.2E+04	2.0E+01	8.2E+04	yes	yes	no			X	
	Manganese	100%	1.1E+01	2.4E-01	1.2E+02	yes	yes	no			X	
	Nickel	0%	--	1.6E-01	5.2E+01	yes	no		no		X	
	Potassium	0%	--	1.3E+02	5.3E+04	yes	no		no		X	
	Silver	0%	--	1.5E-01	3.4E-01	yes	no		no		X	
	Sodium	100%	2.3E+04	3.3E+01	6.8E+05	yes	yes	no			X	
	Thallium	0%	--	1.5E-02	1.2E+01	yes	no		no		X	
	Vanadium	0%	--	2.8E-01	2.0E+01	yes	no		no		X	
	Zinc	0%	--	2.4E+00	1.2E+02	yes	no		no		X	
SVOCs	1,2,4-Trichlorobenzene	0%	--	1.9E+00	1.1E+02	yes	no		no		X	
	1,2-Dichlorobenzene	0%	--	1.9E+00	1.4E+01	yes	no		no		X	
	1,2-Diphenylhydrazine	0%	--	2.5E+00	2.7E+00	yes	no		no		X	
	1,3-Dichlorobenzene	0%	--	1.7E+00	7.1E+01	yes	no		no		X	
	1,4-Dichlorobenzene	0%	--	1.9E+00	1.5E+01	yes	no		no		X	
	1-Methylnaphthalene	0%	--	2.1E+00	2.1E+00	yes	no		no		X	
	2,4,5-Trichlorophenol	0%	--	2.2E+00	6.3E+01	yes	no		no		X	
	2,4,6-Trichlorophenol	0%	--	2.2E+00	4.9E+00	yes	no		no		X	
	2,4-Dichlorophenol	0%	--	2.3E+00	1.1E+01	yes	no		no		X	
	2,4-Dimethylphenol	0%	--	6.9E+00	1.5E+01	yes	no		no		X	
	2,4-Dinitrophenol	0%	--	2.8E+00	7.1E+01	yes	no		no		X	
	2,4-Dinitrotoluene	0%	--	2.2E+00	4.4E+01	yes	no		no		X	
	2,6-Dinitrotoluene	0%	--	2.3E+00	8.1E+01	yes	no		no		X	
	2-Chloronaphthalene	0%	--	2.3E+00	4.0E-01	yes	no		yes			X
	2-Chlorophenol	0%	--	2.2E+00	3.2E+01	yes	no		no		X	
	2-Methylnaphthalene	0%	--	2.1E+00	4.7E+00	yes	no		no		X	
	2-Nitroaniline	0%	--	2.8E+00	NV	no	no				X	
	2-Nitrophenol	0%	--	2.3E+00	7.3E+01	yes	no		no		X	
	3,3`-Dichlorobenzidine	0%	--	5.0E+00	4.5E+00	yes	no		yes			X
	3-Nitroaniline	0%	--	5.1E+00	NV	no	no				X	
	4,6-Dinitro-o-cresol	0%	--	3.6E+00	2.3E+01	yes	no		no		X	
	4-Bromophenyl phenyl ether	0%	--	2.4E+00	1.5E+00	yes	no		yes			X
	4-Chloro-3-methylphenol	0%	--	1.6E+00	7.4E+00	yes	no		no		X	
	4-Chlorophenyl phenyl ether	0%	--	1.4E+00	NV	no	no				X	
	4-Nitroaniline	0%	--	4.4E+00	NV	no	no				X	
	4-Nitrophenol	0%	--	3.4E+00	3.0E+02	yes	no		no		X	
	Acenaphthene	0%	--	1.7E+00	1.5E+01	yes	no		no		X	
	Acenaphthylene	0%	--	2.3E+00	1.3E+01	yes	no		no		X	
	Anthracene	0%	--	2.5E+00	7.3E-01	yes	no		yes			X
	Benzo(a)anthracene	0%	--	5.1E+00	2.7E-02	yes	no		yes			X
	Benzo(a)pyrene	0%	--	2.4E+00	1.4E-02	yes	no		yes			X
	Benzo(b)fluoranthene	0%	--	2.5E+00	2.6E+00	yes	no		no		X	
	Benzo(g,h,i)perylene	0%	--	2.5E+00	4.4E-01	yes	no		yes			X
	Benzo(k)fluoranthene	0%	--	2.8E+00	6.4E-01	yes	no		yes			X
	bis(2-chloroethoxy)methane	0%	--	1.6E+00	NV	no	no				X	
	bis(2-chloroethyl)ether	0%	--	2.3E+00	1.9E+03	yes	no		no		X	
	Bis(2-chloroisopropyl)ether	0%	--	2.3E+00	NV	no	no				X	
	Bis(2-ethylhexyl)phthalate	0%	--	2.4E+00	3.0E+00	yes	no		no		X	
	Butyl benzyl phthalate	0%	--	1.9E+00	1.9E+01	yes	no		no		X	
	Carbazole	0%	--	2.7E+00	NV	no	no				X	
	Chrysene	0%	--	2.3E+00	4.7E+00	yes	no		no		X	
	Dibenzo(a,h)anthracene	0%	--	1.8E+00	2.8E-01	yes	no		yes			X
	Dibenzofuran	0%	--	2.3E+00	3.7E+00	yes	no		no		X	
	Dibutyl phthalate	0%	--	2.5E+00	3.5E+01	yes	no		no		X	
	Diethyl phthalate	0%	--	2.5E+00	2.1E+02	yes	no		no		X	
	Dimethyl phthalate	0%	--	2.4E+00	3.0E+00	yes	no		no		X	
	Di-n-octyl phthalate	0%	--	1.7E+00	3.0E+00	yes	no		no		X	
	Fluoranthene	0%	--	2.5E+00	8.0E-01	yes	no		yes			X
	Fluorene	0%	--	2.4E+00	3.9E+00	yes	no		no		X	
	Hexachlorobenzene	0%	--	2.6E+00	3.7E+00	yes	no		no		X	
	Hexachlorobutadiene	0%	--	1.7E+00	1.0E+00	yes	no		yes			X
	Hexachloroethane	0%	--	1.7E+00	1.2E+01	yes	no		no		X	
	Indeno(1,2,3-cd)pyrene	0%	--	1.8E+00	2.8E-01	yes	no		yes			X
	Isophorone	0%	--	1.6E+00	1.2E+02	yes	no		no		X	
	m & p-cresols	0%	--	2.3E+00	7.4E+00	yes	no		no		X	
	Naphthalene	0%	--	2.0E+00	1.2E+01	yes	no		no		X	
	Nitrobenzene	0%	--	2.5E+00	3.8E+02	yes	no		no		X	
	N-Nitrosodimethylamine	0%	--	2.3E+00	NV	no	no				X	
	N-Nitrosodi-n-propylamine	0%	--	2.3E+00	NV	no	no				X	
	N-Nitrosodiphenylamine	0%	--	4.0E+00	2.1E+02	yes	no		no		X	
	o-Cresol	0%	--	2.0E+00	1.3E+01	yes	no		no		X	
	p-Chloroaniline	0%	--	3.7E+00	5.0E+01	yes	no		no		X	
	Pentachlorophenol	0%	--	2.2E+00	1.5E+01	yes	no		no		X	
	Phenanthrene	0%	--	2.6E+00	2.3E+00	yes	no		yes			X
	Phenol	0%	--	2.3E+00	1.6E+02	yes	no		no		X	
	Pyrene	0%	--	2.5E+00	4.6E+00	yes	no		no		X	

TEQ = Toxicity equivalence; MDL = method detection limit; NV = no value

Table 3-3. OU1 Sediment COPEC Screen

Analysis	Analyte	Detection Frequency (%)	Maximum Detected Concentration (mg/kg)	Average MDL (mg/kg)	Sediment Benchmark (mg/kg)	COPEC SELECTION STEPS: Does chemical have a benchmark?	Is chemical detected ≥5%?	Is Max Detect > benchmark?	Is MDL > benchmark?	OU1 SEDIMENT COPECs: COPEC	Not a COPEC	Source of Uncertainty
Aroclors	Aroclor-1016	0%	--	1.4E-02	NV	no	no				X	
	Aroclor-1221	0%	--	3.2E-02	NV	no	no				X	
	Aroclor-1232	0%	--	1.4E-02	NV	no	no				X	
	Aroclor-1242	0%	--	3.6E-02	NV	no	no				X	
	Aroclor-1248	0%	--	2.3E-02	NV	no	no				X	
	Aroclor-1254	0%	--	8.8E-03	NV	no	no				X	
	Aroclor-1260	0%	--	9.0E-03	NV	no	no				X	
	Aroclor-1262	0%	--	1.2E-02	NV	no	no				X	
	Aroclor-1268	0%	--	8.2E-03	NV	no	no				X	
TEQ	Avian TEQ ND=0	100%	3E-06	--	TEQ is identified as a bioaccumulative and retained as a COPEC.					X		
	Avian TEQ ND=1/2MDL	100%	3E-06	--						X		
	Avian TEQ ND=MDL	100%	3E-06	--						X		
	Mammalian TEQ ND=0	100%	3E-06	--						X		
	Mammalian TEQ ND=1/2MDL	100%	3E-06	--						X		
	Mammalian TEQ ND=MDL	100%	3E-06	--						X		
Metals	Aluminum	100%	1.4E+04	7.8E+00	2.6E+04	yes	yes	no			X	
	Arsenic	100%	1.3E+01	2.3E-01	9.8E+00	yes	yes	yes		X		
	Barium	100%	3.2E+02	1.5E-01	NV	no	yes					X
	Cadmium	40%	6.8E-01	5.2E-02	9.9E-01	yes	yes	no			X	
	Chromium	100%	1.4E+01	3.6E-01	4.3E+01	yes	yes	no			X	
	Cobalt	100%	1.3E+01	4.6E-01	NV	no	yes					X
	Copper	100%	1.2E+02	6.2E-01	3.2E+01	yes	yes	yes		X		
	Iron	100%	2.5E+04	4.7E+01	1.9E+05	yes	yes	no			X	
	Lead	100%	2.3E+01	8.1E-02	3.6E+01	yes	yes	no			X	
	Manganese	100%	4.8E+02	2.6E-01	6.3E+02	yes	yes	no			X	
	Mercury	20%	1.5E-01	1.5E-02	1.8E-01	yes	yes	no			X	
	Nickel	100%	1.5E+01	2.9E-01	2.3E+01	yes	yes	no			X	
	Silver	0%	--	2.2E-01	1.0E+00	yes	no		no		X	
	Thallium	0%	--	8.1E-02	NV	no	no				X	
	Vanadium	100%	2.1E+01	5.2E-01	NV	no	yes					X
	Zinc	100%	2.5E+02	2.5E+00	1.2E+02	yes	yes	yes		X		
PAHs	HMW PAHs	0%	--	2.4E+00	1.9E-01	yes	no		yes			X
	LMW PAHs	0%	--	1.9E+00	7.6E-02	yes	no		yes			X
SVOCs	1,2,4-Trichlorobenzene	0%	--	1.3E-01	2.1E+00	yes	no		no		X	
	1,2-Dichlorobenzene	0%	--	5.0E-02	1.7E-02	yes	no		yes			X
	1,2-Diphenylhydrazine	0%	--	3.9E-01	NV	no	no				X	
	1,3-Dichlorobenzene	0%	--	4.9E-02	4.4E+00	yes	no		no		X	
	1,4-Dichlorobenzene	0%	--	5.1E-02	6.0E-01	yes	no		no		X	
	2,4,5-Trichlorophenol	0%	--	9.2E-02	NV	no	no				X	
	2,4,6-Trichlorophenol	0%	--	9.9E-02	2.1E-01	yes	no		no		X	
	2,4-Dichlorophenol	0%	--	1.5E-01	1.2E-01	yes	no		yes			X
	2,4-Dimethylphenol	0%	--	1.4E-01	2.9E-02	yes	no		yes			X
	2,4-Dinitrophenol	0%	--	3.9E-01	NV	no	no				X	
	2,4-Dinitrotoluene	0%	--	3.9E-01	4.2E-02	yes	no		yes			X
	2,6-Dinitrotoluene	0%	--	6.6E-02	NV	no	no				X	
	2-Chloronaphthalene	0%	--	1.2E-01	NV	no	no				X	
	2-Chlorophenol	0%	--	1.8E-01	3.1E-02	yes	no		yes			X
	2-Nitroaniline	0%	--	8.4E-02	NV	no	no				X	
	2-Nitrophenol	0%	--	1.3E-01	NV	no	no				X	
	3,3`-Dichlorobenzidine	0%	--	1.1E-01	1.3E-01	yes	no		no		X	
	3-Nitroaniline	0%	--	7.9E-02	NV	no	no				X	
	4,6-Dinitro-o-cresol	0%	--	1.5E-01	NV	no	no				X	
	4-Bromophenyl phenyl ether	0%	--	8.2E-02	1.2E+00	yes	no		no		X	
	4-Chloro-3-methylphenol	0%	--	3.9E-01	NV	no	no				X	
	4-Chlorophenyl phenyl ether	0%	--	8.9E-02	NV	no	no				X	
	4-Nitroaniline	0%	--	6.8E-02	NV	no	no				X	
	4-Nitrophenol	0%	--	8.1E-02	NV	no	no				X	
	bis(2-chloroethoxy)methane	0%	--	1.5E-01	NV	no	no				X	
	bis(2-chloroethyl)ether	0%	--	5.4E-02	NV	no	no				X	
SVOCs	Bis(2-chloroisopropyl)ether	0%	--	1.8E-01	NV	no	no				X	
	Bis(2-ethylhexyl)phthalate	0%	--	1.3E-01	1.8E-01	yes	no		no		X	
	Butyl benzyl phthalate	0%	--	3.9E-01	1.1E+01	yes	no		no		X	
	Carbazole	0%	--	3.9E-01	NV	no	no				X	
	Dibutyl phthalate	0%	--	1.1E-01	6.5E+00	yes	no		no		X	
	Diethyl phthalate	0%	--	3.9E-01	6.0E-01	yes	no		no		X	
	Dimethyl phthalate	0%	--	3.9E-01	NV	no	no				X	
	Di-n-octyl phthalate	0%	--	3.9E-01	NV	no	no				X	
	Hexachlorobenzene	0%	--	1.0E-01	2.0E-02	yes	no		yes			X
	Hexachlorobutadiene	0%	--	6.5E-02	NV	no	no				X	
	Hexachloroethane	0%	--	4.9E-02	1.0E+00	yes	no		no		X	
	Isophorone	0%	--	1.2E-01	NV	no	no				X	
	m & p-cresols	0%	--	1.5E-01	6.7E-01	yes	no		no		X	
	Nitrobenzene	0%	--	1.6E-01	NV	no	no				X	
	N-Nitrosodimethylamine	0%	--	3.9E-01	NV	no	no				X	
	N-Nitrosodi-n-propylamine	0%	--	1.1E-01	NV	no	no				X	
	N-Nitrosodiphenylamine	0%	--	3.9E-01	2.7E+00	yes	no		no		X	
	o-Cresol	0%	--	1.7E-01	NV	no	no				X	
	p-Chloroaniline	0%	--	1.2E-01	NV	no	no				X	
	Pentachlorophenol	0%	--	3.9E-01	5.0E-01	yes	no		no		X	
	Phenol	0%	--	1.7E-01	4.2E-01	yes	no		no		X	

TEQ = Toxicity equivalence; MDL = method detection limit; PAH = polyaromatic hydrocarbon; HMW = high-molecular weight; LMW = low molecular weight; NV = no value

Table 4-1. Background Locations

Source	Location ID	Media Type
Surface Water Background Locations		
USEPA[1]	SW4-CFR	SW
	SW5-CFR	SW
	SW6-CFR	SW
	SW7-CFR	SW
	SW8-BR	SW
USGS[2]	12340500	SW
	12334550	SW
	12331800	SW
Sediment Background Locations		
USEPA	SE7-CFR-SA	SE
	SE8-CFR-SA	SE
	SE9-CFR-SA	SE
	SE10-CFR-SA	SE
	SE11-CFR-SA	SE
	SE12-CFR-SA	SE
	SE13-CFR-SA	SE
	SE14-CFR-SA	SE
	SE15-CFR-SA	SE
	SE16-BR-SA	SE
	SE22-CFR-SA	SE
USGS	12340500	SE
	12334550	SE
	12331800	SE

Notes

[1]Data attributed to the USEPA source are those data collected at the site during RI sampling.

[2]USGS data are for surface water (2015-2016) and sediment (2013) (USGS 2016; Dodge et al. 2014).

Table 4-2. Background Surface Soil Summary Statistics

Analysis	Analyte	Number of Samples	Number of Detected Samples	Detection Frequency (%)	Average Concentration[a] (mg/kg)	Standard Deviation	Maximum Detected Concentration (mg/kg)	Average DL (mg/kg)
TEQ[b]	Avian TEQ (ND=0)	64	62	97	2.3E-07	3.1E-07	1.6E-06	--
	Avian TEQ (ND=1/2MDL)	64	62	97	9.5E-07	5.6E-07	2.1E-06	--
	Avian TEQ (ND=MDL)	64	62	97	1.7E-06	1.1E-06	3.5E-06	--
	Mammalian TEQ (ND=0)	64	62	97	1.8E-07	2.6E-07	1.6E-06	--
	Mammalian TEQ (ND=1/2MDL)	64	62	97	7.2E-07	4.6E-07	1.9E-06	--
	Mammalian TEQ (ND=MDL)	64	62	97	1.3E-06	8.7E-07	2.9E-06	--
Metals[c]	Aluminum	112	112	100	1.6E+04	5.8E+03	3.4E+04	--
	Antimony	112	89	79	2.0E-01	1.9E-01	1.2E+00	1.0E-01
	Arsenic	112	112	100	1.1E+01	1.2E+01	8.2E+01	--
	Barium	112	112	100	2.0E+02	1.1E+02	5.8E+02	--
	Beryllium	112	112	100	6.8E-01	2.5E-01	1.4E+00	--
	Cadmium	112	97	87	2.9E-01	2.0E-01	1.1E+00	1.0E-01
	Chromium	112	112	100	2.0E+01	1.2E+01	1.3E+02	--
	Chromium (III)	112	111	99	1.9E+01	1.2E+01	1.3E+02	5.0E+00
	Chromium (VI)	112	14	13	2.1E-01	1.9E-01	1.2E+00	2.9E-01
	Cobalt	112	112	100	7.3E+00	2.8E+00	1.6E+01	--
	Copper	112	112	100	1.8E+01	1.0E+01	7.1E+01	--
	Iron	112	112	100	1.8E+04	6.8E+03	5.9E+04	--
	Lead	112	112	100	1.5E+01	6.4E+00	3.7E+01	--
	Manganese	112	112	100	5.1E+02	3.7E+02	2.9E+03	--
	Mercury	112	1	1	2.5E-02	4.1E-03	6.8E-02	5.0E-02
	Nickel	112	112	100	1.7E+01	9.5E+00	8.2E+01	--
	Selenium	112	88	79	3.8E-01	2.4E-01	1.6E+00	2.0E-01
	Silver	112	30	27	1.1E-01	8.1E-02	5.0E-01	1.7E-01
	Thallium	112	112	100	2.5E-01	1.1E-01	8.4E-01	--
	Vanadium	112	112	100	3.1E+01	1.3E+01	9.2E+01	--
	Zinc	112	112	100	6.1E+01	2.3E+01	1.5E+02	--

DL = detection limit; ND = non-detects; TEQ = Toxicity Equivalence

[a] Non-detects evaluated at 1/2 the DL.

[b] TEQ values were calculated from data used in the Montana Dioxin Background Investigation Report (MDEQ, 2011).

[c] Metals data presented in this table are from Project Report: Background Concentrations of Inorganic Constituents in Montana Surface Soils (Hydrometrics, 2013).

Table 4-3. Background Surface Water Summary Statistics

Analysis	Analyte	Number of Samples	Number of Detected Samples	Detection Frequency (%)	Average Concentration[a] (ug/L)	Standard Deviation	Maximum Detected Concentration (ug/L)	Average MDL (ug/L)
Aroclors	Aroclor-1016	2	0	0	2.3E-02	0.0E+00	--	4.5E-02
	Aroclor-1221	2	1	50	7.5E-02	9.2E-02	1.4E-01	2.0E-02
	Aroclor-1232	2	0	0	1.8E-02	3.5E-04	--	3.7E-02
	Aroclor-1242	2	0	0	1.4E-02	0.0E+00	--	2.8E-02
	Aroclor-1248	2	0	0	6.0E-03	0.0E+00	--	1.2E-02
	Aroclor-1254	2	0	0	7.8E-03	3.5E-04	--	1.6E-02
	Aroclor-1260	2	0	0	7.5E-03	0.0E+00	--	1.5E-02
	Aroclor-1262	2	0	0	2.1E-02	0.0E+00	--	4.2E-02
	Aroclor-1268	2	0	0	1.2E-02	0.0E+00	--	2.3E-02
TEQ	Avian TEQ (ND=0)	5	3	60	6.4E-10	8.5E-10	2.1E-09	--
	Avian TEQ (ND=1/2MDL)	5	3	60	4.4E-07	2.2E-08	4.2E-07	--
	Avian TEQ (ND=MDL)	5	3	60	8.8E-07	4.5E-08	8.5E-07	--
	Mammalian TEQ (ND=0)	5	3	60	4.1E-09	7.3E-09	1.7E-08	--
	Mammalian TEQ (ND=1/2MDL)	5	3	60	3.5E-07	1.7E-08	3.4E-07	--
	Mammalian TEQ (ND=MDL)	5	3	60	6.9E-07	3.7E-08	6.7E-07	--
Total Metals	Aluminum	5	2	40	1.5E+01	1.8E+01	3.6E+01	3.0E+00
	Arsenic	41	41	100	6.9E+00	4.6E+00	2.0E+01	1.1E-01
	Barium	5	5	100	1.3E+02	7.4E+01	2.5E+02	8.1E-02
	Cadmium	41	28	68	7.8E-02	8.2E-02	3.9E-01	2.8E-02
	Chromium	5	0	0	8.5E-02	0.0E+00	--	1.7E-01
	Cobalt	5	0	0	6.5E-02	0.0E+00	--	1.3E-01
	Copper	41	39	95	1.4E+01	1.7E+01	8.3E+01	2.1E-01
	Iron	41	39	95	3.6E+02	3.7E+02	1.8E+03	1.4E+01
	Lead	41	39	95	2.1E+00	2.5E+00	1.2E+01	4.6E-02
	Manganese	41	41	100	4.8E+01	4.0E+01	1.9E+02	2.4E-01
	Mercury	5	0	0	1.1E-02	1.6E-10	--	2.2E-02
	Nickel	5	3	60	1.5E-01	6.6E-02	2.3E-01	1.6E-01
	Silver	5	0	0	7.5E-02	0.0E+00	--	1.5E-01
	Thallium	5	0	0	7.5E-03	0.0E+00	--	1.5E-02
	Vanadium	5	1	20	2.1E-01	1.7E-01	5.1E-01	2.8E-01
	Zinc	41	37	90	1.7E+01	1.7E+01	8.2E+01	2.4E+00
Dissolved Metals	Aluminum	5	0	0	1.5E+00	0.0E+00	--	3.0E+00
	Arsenic	41	39	95	5.5E+00	3.4E+00	1.3E+01	1.1E-01
	Barium	5	5	100	1.3E+02	7.8E+01	2.6E+02	8.1E-02
	Cadmium	41	14	34	2.4E-02	1.6E-02	8.3E-02	2.9E-02
	Calcium	41	41	100	3.7E+04	1.3E+04	7.2E+04	--
	Chromium	5	0	0	8.5E-02	0.0E+00	--	1.7E-01
	Cobalt	5	3	60	4.8E-01	4.0E-01	8.8E-01	1.3E-01
	Copper	41	38	93	3.4E+00	3.2E+00	1.8E+01	2.1E-01
	Iron	41	36	88	2.5E+01	5.5E+01	3.6E+02	1.4E+01
	Lead	41	30	73	1.6E-01	4.3E-01	2.8E+00	4.3E-02
	Magnesium	41	41	100	1.0E+04	3.1E+03	1.9E+04	--
	Manganese	41	41	100	9.5E+00	8.5E+00	4.9E+01	2.4E-01
	Nickel	5	0	0	8.0E-02	0.0E+00	--	1.6E-01
	Potassium	5	1	20	5.6E+02	1.1E+03	2.5E+03	1.3E+02
	Silver	5	0	0	7.5E-02	0.0E+00	--	1.5E-01
	Sodium	5	5	100	6.8E+03	3.7E+03	1.3E+04	3.3E+01
	Thallium	5	0	0	7.5E-03	0.0E+00	--	1.5E-02
	Vanadium	5	0	0	1.4E-01	0.0E+00	--	2.8E-01
	Zinc	41	23	56	2.8E+00	2.8E+00	1.7E+01	2.1E+00
SVOCs	1,2,4-Trichlorobenzene-SVOC	2	0	0	9.5E-01	0.0E+00	--	1.9E+00
	1,2-Dichlorobenzene-SVOC	2	0	0	9.5E-01	0.0E+00	--	1.9E+00
	1,2-Diphenylhydrazine	2	0	0	1.2E+00	3.5E-02	--	2.5E+00
	1,3-Dichlorobenzene-SVOC	2	0	0	8.3E-01	3.5E-02	--	1.7E+00
	1,4-Dichlorobenzene-SVOC	2	0	0	9.5E-01	0.0E+00	--	1.9E+00
	1-Methylnaphthalene	2	0	0	1.1E+00	0.0E+00	--	2.1E+00
	2,4,5-Trichlorophenol	2	0	0	1.1E+00	3.5E-02	--	2.2E+00
	2,4,6-Trichlorophenol	2	0	0	1.1E+00	0.0E+00	--	2.2E+00
	2,4-Dichlorophenol	2	0	0	1.2E+00	0.0E+00	--	2.3E+00
	2,4-Dimethylphenol	2	0	0	3.4E+00	7.1E-02	--	6.8E+00
	2,4-Dinitrophenol	2	0	0	1.4E+00	3.5E-02	--	2.8E+00
	2,4-Dinitrotoluene	2	0	0	1.1E+00	3.5E-02	--	2.2E+00
	2,6-Dinitrotoluene	2	0	0	1.2E+00	0.0E+00	--	2.3E+00
	2-Chloronaphthalene	2	0	0	1.1E+00	3.5E-02	--	2.3E+00
	2-Chlorophenol	2	0	0	1.1E+00	0.0E+00	--	2.2E+00
	2-Methylnaphthalene	2	0	0	1.1E+00	0.0E+00	--	2.1E+00
	2-Nitroaniline	2	0	0	1.4E+00	0.0E+00	--	2.8E+00

Table 4-3. Background Surface Water Summary Statistics

Analysis	Analyte	Number of Samples	Number of Detected Samples	Detection Frequency (%)	Average Concentration[a] (ug/L)	Standard Deviation	Maximum Detected Concentration (ug/L)	Average MDL (ug/L)
SVOCs	2-Nitrophenol	2	0	0	1.1E+00	3.5E-02	--	2.3E+00
	3,3`-Dichlorobenzidine	2	0	0	2.5E+00	3.5E-02	--	5.0E+00
	3-Nitroaniline	2	0	0	2.5E+00	3.5E-02	--	5.1E+00
	4,6-Dinitro-o-cresol	2	0	0	1.8E+00	3.5E-02	--	3.6E+00
	4-Bromophenyl phenyl ether	2	0	0	1.2E+00	0.0E+00	--	2.4E+00
	4-Chloro-3-methylphenol	2	0	0	8.0E-01	0.0E+00	--	1.6E+00
	4-Chlorophenyl phenyl ether	2	0	0	7.0E-01	0.0E+00	--	1.4E+00
	4-Nitroaniline	2	0	0	2.2E+00	3.5E-02	--	4.4E+00
	4-Nitrophenol	2	0	0	1.7E+00	0.0E+00	--	3.4E+00
	Acenaphthene	2	0	0	8.3E-01	3.5E-02	--	1.7E+00
	Acenaphthylene	2	0	0	1.1E+00	3.5E-02	--	2.3E+00
	Anthracene	2	0	0	1.2E+00	3.5E-02	--	2.5E+00
	Benzo(a)anthracene	2	0	0	2.5E+00	3.5E-02	--	5.1E+00
	Benzo(a)pyrene	2	0	0	1.2E+00	0.0E+00	--	2.4E+00
	Benzo(b)fluoranthene	2	0	0	1.3E+00	0.0E+00	--	2.5E+00
	Benzo(g,h,i)perylene	2	0	0	1.3E+00	0.0E+00	--	2.5E+00
	Benzo(k)fluoranthene	2	0	0	1.4E+00	0.0E+00	--	2.8E+00
	bis(2-chloroethoxy)methane	2	0	0	7.8E-01	3.5E-02	--	1.6E+00
	bis(2-chloroethyl)ether	2	0	0	1.2E+00	0.0E+00	--	2.3E+00
	Bis(2-chloroisopropyl)ether	2	0	0	1.1E+00	3.5E-02	--	2.3E+00
	Bis(2-ethylhexyl)phthalate	2	0	0	1.2E+00	3.5E-02	--	2.4E+00
	Butyl benzyl phthalate	2	0	0	9.5E-01	0.0E+00	--	1.9E+00
	Carbazole	2	0	0	1.3E+00	3.5E-02	--	2.7E+00
	Chrysene	2	0	0	1.2E+00	0.0E+00	--	2.3E+00
	Dibenzo(a,h)anthracene	2	0	0	9.0E-01	0.0E+00	--	1.8E+00
	Dibenzofuran	2	0	0	1.2E+00	0.0E+00	--	2.3E+00
	Dibutyl phthalate	2	0	0	1.2E+00	3.5E-02	--	2.5E+00
	Diethyl phthalate	2	0	0	1.2E+00	3.5E-02	--	2.5E+00
	Dimethyl phthalate	2	0	0	1.2E+00	3.5E-02	--	2.4E+00
	Di-n-octyl phthalate	2	0	0	8.5E-01	0.0E+00	--	1.7E+00
	Fluoranthene	2	0	0	1.3E+00	0.0E+00	--	2.5E+00
	Fluorene	2	0	0	1.2E+00	3.5E-02	--	2.4E+00
	Hexachlorobenzene	2	0	0	1.3E+00	0.0E+00	--	2.6E+00
	Hexachlorobutadiene-SVOC	2	0	0	8.5E-01	0.0E+00	--	1.7E+00
	Hexachloroethane	2	0	0	8.3E-01	3.5E-02	--	1.7E+00
	Indeno(1,2,3-cd)pyrene	2	0	0	9.0E-01	0.0E+00	--	1.8E+00
	Isophorone	2	0	0	8.0E-01	0.0E+00	--	1.6E+00
	m & p-cresols	2	0	0	1.1E+00	3.5E-02	--	2.3E+00
	Naphthalene-SVOC	2	0	0	1.0E+00	0.0E+00	--	2.0E+00
	Nitrobenzene	2	0	0	1.3E+00	0.0E+00	--	2.5E+00
	N-Nitrosodimethylamine	2	0	0	1.2E+00	0.0E+00	--	2.3E+00
	N-Nitrosodi-n-propylamine	2	0	0	1.2E+00	0.0E+00	--	2.3E+00
	N-Nitrosodiphenylamine	2	0	0	2.0E+00	3.5E-02	--	4.0E+00
	o-Cresol	2	0	0	1.0E+00	0.0E+00	--	2.0E+00
	p-Chloroaniline	2	0	0	1.8E+00	3.5E-02	--	3.7E+00
	Pentachlorophenol	2	0	0	1.1E+00	0.0E+00	--	2.2E+00
	Phenanthrene	2	0	0	1.3E+00	3.5E-02	--	2.6E+00
	Phenol	2	0	0	1.1E+00	3.5E-02	--	2.3E+00
	Pyrene	2	0	0	1.2E+00	3.5E-02	--	2.5E+00

MDL = method detection limit; ND = non-detects; TEQ = Toxicity Equivalence

[a]Non-detects evaluated at 1/2 the MDL

Table 4-4. Background Sediment Summary Statistics

Analysis	Analyte	Number of Samples	Number of Detected Samples	Detection Frequency (%)	Average Concentration[a] (mg/kg)	Standard Deviation	Maximum Detected Concentration (mg/kg)	Average MDL (mg/kg)
Aroclors	Aroclor-1016	2	0	0	5.7E-03	2.5E-03	--	1.1E-02
	Aroclor-1221	2	0	0	1.3E-02	6.0E-03	--	2.6E-02
	Aroclor-1232	2	0	0	5.9E-03	2.7E-03	--	1.2E-02
	Aroclor-1242	2	0	0	1.5E-02	6.8E-03	--	3.0E-02
	Aroclor-1248	2	0	0	9.7E-03	4.4E-03	--	1.9E-02
	Aroclor-1254	2	0	0	3.7E-03	1.7E-03	--	7.4E-03
	Aroclor-1260	2	0	0	3.8E-03	1.7E-03	--	7.5E-03
	Aroclor-1262	2	0	0	5.0E-03	2.3E-03	--	9.9E-03
	Aroclor-1268	2	0	0	3.4E-03	1.6E-03	--	6.8E-03
TEQ	Avian TEQ (ND=0)	11	11	100	3.1E-07	5.1E-07	1.5E-06	--
	Avian TEQ (ND=1/2MDL)	11	11	100	3.6E-07	5.0E-07	1.5E-06	--
	Avian TEQ (ND=MDL)	11	11	100	4.0E-07	4.9E-07	1.6E-06	--
	Mammalian TEQ (ND=0)	11	11	100	4.3E-07	4.5E-07	1.2E-06	--
	Mammalian TEQ (ND=1/2MDL)	11	11	100	4.6E-07	4.4E-07	1.3E-06	--
	Mammalian TEQ (ND=MDL)	11	11	100	4.9E-07	4.3E-07	1.3E-06	--
Metals	Aluminum	11	11	100	6.6E+03	2.6E+03	1.2E+04	7.0E+00
	Arsenic	20	20	100	1.2E+01	5.8E+00	2.1E+01	2.0E-01
	Barium	11	11	100	1.7E+02	7.7E+01	2.8E+02	1.3E-01
	Cadmium	20	19	95	1.1E+00	6.6E-01	2.4E+00	4.6E-02
	Chromium	20	20	100	1.1E+01	5.0E+00	2.2E+01	3.2E-01
	Cobalt	11	11	100	4.3E+00	1.4E+00	6.0E+00	4.1E-01
	Copper	20	20	100	1.4E+02	6.9E+01	2.3E+02	5.5E-01
	Iron	20	20	100	1.2E+04	4.1E+03	2.1E+04	4.1E+01
	Lead	20	20	100	2.5E+01	1.1E+01	4.2E+01	7.3E-02
	Manganese	20	20	100	5.9E+02	4.9E+02	1.8E+03	2.3E-01
	Mercury	11	10	91	1.9E-01	1.5E-01	4.6E-01	1.4E-02
	Nickel	20	20	100	7.5E+00	2.4E+00	1.0E+01	2.6E-01
	Silver	11	1	9	1.8E-01	2.7E-01	9.9E-01	2.0E-01
	Thallium	11	2	18	5.9E-02	4.8E-02	1.7E-01	7.3E-02
	Vanadium	11	11	100	1.5E+01	4.5E+00	2.0E+01	4.6E-01
	Zinc	20	20	100	3.1E+02	1.3E+02	4.8E+02	3.4E+00
SVOCs	1,2,4-Trichlorobenzene-SVOC	2	0	0	5.3E-02	2.4E-02	--	1.1E-01
	1,2-Dichlorobenzene-SVOC	2	0	0	2.1E-02	9.4E-03	--	4.2E-02
	1,2-Diphenylhydrazine	2	0	0	1.6E-01	7.3E-02	--	3.2E-01
	1,3-Dichlorobenzene-SVOC	2	0	0	2.0E-02	9.2E-03	--	4.1E-02
	1,4-Dichlorobenzene-SVOC	2	0	0	2.2E-02	9.7E-03	--	4.3E-02
	1-Methylnaphthalene	2	0	0	5.6E-02	2.5E-02	--	1.1E-01
	2,4,5-Trichlorophenol	2	0	0	3.9E-02	1.8E-02	--	7.7E-02
	2,4,6-Trichlorophenol	2	0	0	4.2E-02	1.9E-02	--	8.3E-02
	2,4-Dichlorophenol	2	0	0	6.1E-02	2.7E-02	--	1.2E-01
	2,4-Dimethylphenol	2	0	0	6.1E-02	2.8E-02	--	1.2E-01
	2,4-Dinitrophenol	2	0	0	1.6E-01	7.3E-02	--	3.2E-01
	2,4-Dinitrotoluene	2	0	0	1.6E-01	7.3E-02	--	3.2E-01
	2,6-Dinitrotoluene	2	0	0	2.8E-02	1.2E-02	--	5.5E-02
	2-Chloronaphthalene	2	0	0	5.1E-02	2.3E-02	--	1.0E-01
	2-Chlorophenol	2	0	0	7.5E-02	3.4E-02	--	1.5E-01
	2-Methylnaphthalene	2	0	0	5.8E-02	2.6E-02	--	1.2E-01
	2-Nitroaniline	2	0	0	3.5E-02	1.6E-02	--	7.0E-02
	2-Nitrophenol	2	0	0	5.5E-02	2.5E-02	--	1.1E-01
	3,3`-Dichlorobenzidine	2	0	0	4.5E-02	2.0E-02	--	9.0E-02
	3-Nitroaniline	2	0	0	3.3E-02	1.5E-02	--	6.6E-02
	4,6-Dinitro-o-cresol	2	0	0	6.4E-02	2.9E-02	--	1.3E-01
	4-Bromophenyl phenyl ether	2	0	0	3.4E-02	1.6E-02	--	6.9E-02
	4-Chloro-3-methylphenol	2	0	0	1.6E-01	7.3E-02	--	3.2E-01
	4-Chlorophenyl phenyl ether	2	0	0	3.7E-02	1.7E-02	--	7.4E-02
	4-Nitroaniline	2	0	0	2.8E-02	1.3E-02	--	5.7E-02
	4-Nitrophenol	2	0	0	3.4E-02	1.5E-02	--	6.8E-02
	Acenaphthene	2	0	0	3.7E-02	1.7E-02	--	7.5E-02
	Acenaphthylene	2	0	0	4.2E-02	1.9E-02	--	8.5E-02
	Anthracene	2	0	0	1.6E-01	7.3E-02	--	3.2E-01
	Benzo(a)anthracene	2	0	0	1.6E-01	7.3E-02	--	3.2E-01
	Benzo(a)pyrene	2	0	0	1.6E-01	7.3E-02	--	3.2E-01
	Benzo(b)fluoranthene	2	0	0	4.1E-02	1.9E-02	--	8.2E-02
	Benzo(g,h,i)perylene	2	0	0	3.9E-02	1.8E-02	--	7.9E-02
	Benzo(k)fluoranthene	2	0	0	4.1E-02	1.9E-02	--	8.3E-02
	bis(2-chloroethoxy)methane	2	0	0	6.3E-02	2.9E-02	--	1.3E-01
	bis(2-chloroethyl)ether	2	0	0	2.3E-02	1.0E-02	--	4.5E-02

Table 4-4. Background Sediment Summary Statistics

Analysis	Analyte	Number of Samples	Number of Detected Samples	Detection Frequency (%)	Average Concentration[a] (mg/kg)	Standard Deviation	Maximum Detected Concentration (mg/kg)	Average MDL (mg/kg)
SVOCs	Bis(2-chloroisopropyl)ether	2	0	0	7.5E-02	3.4E-02	--	1.5E-01
	Bis(2-ethylhexyl)phthalate	2	0	0	5.5E-02	2.5E-02	--	1.1E-01
	Butyl benzyl phthalate	2	0	0	1.6E-01	7.3E-02	--	3.2E-01
	Carbazole	2	0	0	1.6E-01	7.3E-02	--	3.2E-01
	Chrysene	2	0	0	4.3E-02	1.9E-02	--	8.7E-02
	Dibenzo(a,h)anthracene	2	0	0	1.6E-01	7.3E-02	--	3.2E-01
	Dibenzofuran	2	0	0	1.6E-01	7.3E-02	--	3.2E-01
	Dibutyl phthalate	2	0	0	4.5E-02	2.0E-02	--	9.0E-02
	Diethyl phthalate	2	0	0	1.6E-01	7.3E-02	--	3.2E-01
	Dimethyl phthalate	2	0	0	1.6E-01	7.3E-02	--	3.2E-01
	Di-n-octyl phthalate	2	0	0	1.6E-01	7.3E-02	--	3.2E-01
	Fluoranthene	2	0	0	1.6E-01	7.3E-02	--	3.2E-01
	Fluorene	2	0	0	1.6E-01	7.3E-02	--	3.2E-01
	Hexachlorobenzene	2	0	0	4.2E-02	1.9E-02	--	8.5E-02
	Hexachlorobutadiene-SVOC	2	0	0	2.7E-02	1.2E-02	--	5.4E-02
	Hexachloroethane	2	0	0	2.1E-02	9.3E-03	--	4.1E-02
	Indeno(1,2,3-cd)pyrene	2	0	0	1.6E-01	7.3E-02	--	3.2E-01
	Isophorone	2	0	0	5.2E-02	2.3E-02	--	1.0E-01
	m & p-cresols	2	0	0	6.4E-02	2.9E-02	--	1.3E-01
	Naphthalene-SVOC	2	0	0	6.1E-02	2.8E-02	--	1.2E-01
	Nitrobenzene	2	0	0	6.5E-02	2.9E-02	--	1.3E-01
	N-Nitrosodimethylamine	2	0	0	1.6E-01	7.3E-02	--	3.2E-01
	N-Nitrosodi-n-propylamine	2	0	0	4.4E-02	2.0E-02	--	8.8E-02
	N-Nitrosodiphenylamine	2	0	0	1.6E-01	7.3E-02	--	3.2E-01
	o-Cresol	2	0	0	7.0E-02	3.1E-02	--	1.4E-01
	p-Chloroaniline	2	0	0	5.0E-02	2.3E-02	--	9.9E-02
	Pentachlorophenol	2	0	0	1.6E-01	7.3E-02	--	3.2E-01
	Phenanthrene	2	0	0	4.6E-02	2.1E-02	--	9.2E-02
	Phenol	2	0	0	7.1E-02	3.2E-02	--	1.4E-01
	Pyrene	2	0	0	4.1E-02	1.8E-02	--	8.1E-02

MDL = method detection limit; ND = non-detects; TEQ = Toxicity Equivalence

[a]Non-detects evaluated at 1/2 the MDL

Table 5-1. Hazard Quotient Values for Birds and Mammals Exposed to Copper and Selenium in OU1 Soils

Contaminant	Soil EPC (mg/kg)	Benchmarks (mg/kg)				Hazard Quotients (HQs)			
		Birds (a)		Mammals (b)		Birds		Mammals	
		NOEC	LOEC	NOEC	LOEC	NOEC-based HQ	LOEC-based HQ	NOEC-based HQ	LOEC-based HQ
Copper	19.9	28	134	49	55	0.7	0.1	0.4	0.4
Selenium	1.098	1.2	1.2	0.63	0.95	0.9	0.9	**1.7**	**1.2**

Soil EPC = 95UCL calculated using ProUCL (see Appendix D).

(a) Based on the ratio of bird LOAEL/NOAEL TRVs (19.4/4.05 for copper; 0.29/0.29 for selenium) based on Booz Allen Hamilton (2012).

(b) Based on the ratio of mammal LOAEL/NOAEL TRVs (6.26/5.6 for copper; 0.215/0.143 for selenium) based on Booz Allen Hamilton (2012).

APPENDIX A

MTNHP Map Viewer Species Output

[*See Smurfit OU1 ERA Appendix A.xlsx*]

APPENDIX B

OU1 Data

[*See Smurfit OU1 ERA Appendix B.xlsx*]

APPENDIX C

Toxicity Benchmarks for Ecological Receptors

APPENDIX C
Toxicity Benchmarks for Ecological Receptors

Overview

The purpose of the screening level risk assessment is to identify COPECs based on comparison of site-related concentrations to appropriate benchmarks of toxicity. The benchmarks identified for this assessment are concentration-based (e.g., the concentration in soil, sediment, or surface water). Each benchmark is contaminant-specific, receptor-specific and is usually medium-specific.

For this SLERA, all toxicity benchmarks are based on values developed by various regulatory agencies and published in the literature. For this assessment, values were chosen to be consistent with other recent and/or ongoing regional ecological risk assessments. This appendix describes the various sources of benchmark values reviewed for this risk assessment, and identifies the hierarchy used to prioritize values when more than one value was available.

This appendix is organized into the following sections:

Aquatic Receptors

C-1 Benchmarks for Direct Contact with Surface Water
C-2 Benchmarks for Direct Contact with Sediment

Terrestrial Receptors

C-3 Benchmarks for Direct Contact with Surface Soils

Aquatic Receptors (Fish & Benthic Macroinvertebrates)

C-1 Benchmarks for Direct Contact with Surface Water

C-1a Aquatic Receptors

Toxicity values used in this risk assessment were chosen to be consistent with other recent regional ecological risk assessments. Toxicity values for the protection of aquatic life from contaminants in surface water are available from several sources. Each of these sources is described briefly below.

National Ambient Water Quality Criteria

The USEPA has established acute and chronic National Ambient Water Quality Criteria (NAWQC) values for surface waters for the protection of aquatic communities (USEPA 2002a). The Criteria Maximum Concentration (CMC) is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed briefly without resulting in an unacceptable effect. The Criterion Continuous Concentration (CCC) is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect on growth, reproduction, or survival. The NAWQC values are not species-specific, but are designed to protect 95% of the aquatic species for which toxicity data are available (USEPA 1985).

Great Lake Water Quality Initiative Tier II Values

The approach used for the derivation of Great Lake Water Quality Initiative (GLWQI) Tier II secondary acute values (SAVs) and secondary chronic values (SCVs) is similar to that used to derive NAWQC. USEPA (1995) describes how to calculate the GLWQI Tier II values. Data and detailed methods and are described in Appendix B of Suter and Tsao (1996). In brief, a secondary acute value is derived by taking the lowest genus mean acute value (GMAV) and dividing it by the Final Acute Value Factor (FAVF). The FAVF is based on the number of studies and types of species used to derive the FAV. Once an SAV is calculated, the geometric mean of each of the secondary acute-chronic ratios (SACR) is found. The SCV is calculated by dividing the SAV by the SACR.

USEPA Region 4 Screening Values

Screening level freshwater benchmarks are also available from USEPA Region 4 (USEPA, 2002b). The Region 4 acute and chronic screening values are equal to the lowest effect level (LEL) divided by 10 to protect for sensitive species. If no chronic LEL is available, the chronic screening value is equal to the lowest acute median lethal concentration (LC50) or median effective concentration (EC50) divided by 10.

USEPA Region 5 Ecological Screening Levels

The USEPA Region 5 has derived ecological screening levels (ESLs) for RCRA Appendix IX Hazardous Constituents in soil, surface water, sediment, and air (USEPA 2003). The surface water ESL is based on either an aquatic benchmark, which is protective of direct contact exposures, or a wildlife receptor-specific benchmark, which is protective of ingestion exposures in the mink and belted kingfisher.

Canadian Water Quality Guidelines

The Canadian Council of Ministers of the Environment (CCME) have established water quality guidelines (WQG) for the protection of aquatic life in Canadian waters (CCME, 1991, 2001). The protocol for deriving water quality guidelines is similar to the NAWQC procedure. Protocol details are available on the CCME WQG website. In brief, the guideline is equal to the most sensitive lowest observed effect level (LOEL) from a chronic exposure study divided by a safety factor of 10. If a chronic LOEL is not available, the WQG is equal to the acute LC50 divided by the acute/chronic ratio (ACR). The CCME WQG is designed to be protective of "100% of the aquatic life species, 100% of the time".

Oak Ridge National Laboratory Lowest Chronic Values and EC20 Values

Oak Ridge National Laboratory (ORNL) has compiled summary tables of the lowest chronic values (LCVs) in surface water for fish, daphnids, non-daphnid invertebrates, aquatic plants, and aquatic populations (Suter and Tsao, 1996). In some instances, the LCVs were extrapolated from LC50 and EC50 data using fish and daphnid-specific equations. ORNL also summarized EC20 data for fish, daphnids, sensitive species, and aquatic populations. The EC20s are based on a level of biological effect; they are benchmarks derived by using mathematical models to evaluate a dose-response relationship, such as a concentration estimated to correspond to a 20% reduction in fish production (Suter and Tsao, 1996).

Office of Solid Waste and Emergency Response (OSWER) Ecotox Thresholds

The OSWER Ecotox Thresholds (ETs) were presented in a USEPA ECO Update Bulletin (USEPA, 1996). The bulletin provided an overview of the development and use of ecological benchmarks for surface water and sediment. For surface water, the ET is based on either the chronic NAWQC or the GLWQI Tier II value.

The OSWER ETs were excluded because they are based on primary sources (NAWQC, GLWQI Tier II) that had been previously reviewed. For the remaining sources, selection of the surface water toxicity benchmarks for aquatic receptors was based on the following hierarchy:

- National Ambient Water Quality Criteria (NAWQC)
- Great Lake Water Quality Initiative (GLWQI) Tier II Values
- USEPA Region 4 Screening Values
- USEPA Region 5 ESLs
- Canadian Water Quality Guidelines
- Oak Ridge National Laboratory (ORNL) LCVs and EC20s

NAWQCs were selected preferentially over other benchmark sources because these surface water quality criteria are derived using a well-documented derivation approach which incorporates toxicity data from multiple studies, receptors, and endpoints that has undergone extensive review and approval by EPA. GLWQI Tier II values were selected next in the hierarchy because toxicity values are derived using a derivation procedure that is similar to NAWQC, but allows for derivation of toxicity benchmarks for data sets that are too limited to meet NAWQC requirements. USEPA Region 4 screening values, the Canadian WQG, the ORNL LCVs and EC20s, and USEPA Region ESLs are last in the hierarchy because they are often based on extremely limited data sets (i.e., only 1 or 2 studies), and these toxicity benchmarks tend to incorporate safety factor adjustments to account for limitations in the underlying data sets. USEPA Region 4 screening values and USEPA Region 5 ESLs were selected in preference over the Canadian WQG and the ORNL values because they have undergone Regional EPA review.

The surface water benchmark values from these sources are shown in Table C-1, along with the values selected for use in the risk assessment.

The water quality values for Se of 20 ug/L (EPA 2002b) and 5 ug/L (EPA 2002a) for acute and chronic exposures, respectively are considered uncertain for use in this risk assessment. Since the issuance of these criterion values, considerable data have demonstrated that diet is the primary pathway of selenium exposure to aquatic life, and traditional methods for predicting toxicity on the basis of exposure to dissolved concentrations in water are not appropriate for selenium (EPA 2004; Chapman et al. 2009).

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C-2 Benchmarks for Direct Contact with Sediment

Toxicity values for the protection of benthic macroinvertebrates from contaminants in freshwater sediment are available from several sources. Each of these sources is described briefly below.

Consensus-Based Sediment Quality Guidelines

MacDonald et al. (2000) issued consensus-based sediment quality guidelines (SQGs) for 28 chemicals of concern, in an effort to focus on agreement among the various sediment quality guidelines. For each chemical of concern, a threshold effect concentration (TEC) and a probable effect concentration (PEC) were identified based on available sediment toxicity literature. The consensus-based TECs were calculated by determining the geometric mean of all threshold effect values from the literature. The consensus-based PECs were calculated by determining the geometric mean of all probable effect values from the literature. A summary of the types of sediment effect concentrations included in the TEC and PEC calculations is provided in MacDonald et al. (2000).

The predictive reliability of these values was also evaluated. The predictive ability analyses were focused on the ability of each SQG when applied alone to classify samples as either toxic or non-toxic. Sediment toxicity should be observed only rarely below the TEC and should be frequently observed above the PEC. Individual TECs were considered reliable if more than 75% of the sediment samples were correctly predicted to be non-toxic. Similarly, the individual PEC was considered reliable if greater than 75% of the sediment samples were correctly predicted to be toxic. The SQGs were considered to be reliable only if a minimum of 20 samples were included in the predictive ability evaluation (MacDonald et al. 2000).

Because field collected sediments contain a mixture of chemicals, a second analysis was completed to investigate whether the toxicity of a sediment could be predicted based on the average of the PEC ratios for the sediment, using only the PEC values that were found to be reliable. It was found that 92% of sediment samples with a mean PEC quotient > 1.0 were toxic to one or more species of aquatic organisms. The mean PEC quotient was found to be highly correlated with incidence of toxicity ($R^2 = 0.98$) (MacDonald et al. 2000).

ARCS Sediment Effect Concentrations

As part of the Assessment and Remediation of Contaminated Sediment (ARCS) Project, Ingersoll et al. (1996) compiled freshwater sediment toxicity data from nine different sites in the United States and identified a series of sediment effect concentrations (SECs) for metals in sediment. The SECs are defined as the concentrations of individual contaminants in sediment below which toxicity is rarely observed and above which toxicity is frequently observed. The database was compiled to classify toxicity data for Great Lakes sediment samples and is segregated into “effect” data and “no effect” data.

Ingersoll et al. (1996) derived five different SECs; effect range low (ERL), effect range median (ERM), threshold effect level (TEL), probable effect level (PEL) and no effect concentration (NEC). The derivation of each of these SECs is presented below:

- effect range low (ERL) = 10^{th} percentile of adverse effect data
- effect range median (ERM) = 50^{th} percentile (median) of adverse effect data
- no effect range median (NERM) = 50^{th} percentile (median) of no effect data
- no effect range high (NERH) = 85^{th} percentile of no effect data
- threshold effect level (TEL) = geometric mean of ERL and NERM
- probable effect level (PEL) = geometric mean of ERM and NERH
- no effect concentration (NEC) = maximum of no effect data

The ERL is defined as the concentration below which adverse effects are unlikely to occur. The ERM is defined as the concentration of a chemical above which effects are frequently or always observed or predicted among most species. The NEC is the maximum concentration of a chemical in sediment that does not significantly adversely affect the particular response when compared to the control.

USEPA Region 5 Ecological Screening Levels

The USEPA Region 5 Ecological Screening Levels (ESLs) for sediment were developed based on available federal freshwater sediment criteria and state-promulgated sediment quality guidelines (USEPA 2003). If no freshwater guidelines were available, marine criteria were used. For those chemicals for which no guidelines were available, an interim ESL was developed using the equilibrium partitioning approach. These interim guidelines were developed for both nonpolar and polar organic constituents. The equilibrium partitioning method is generally only applied to nonpolar organics, however, it was assumed to be a satisfactory method for organics for use on a screening level approach (USEPA 2003). The ESL was derived from the lowest federal, state or interim water quality guideline and assumes a total organic carbon content of 1%.

NOAA Sediment Effect Concentrations

The National Oceanic and Atmospheric Administration (NOAA) compiled sediment data from studies performed in both freshwater and saltwater (originally presented in NOS OMA Technical Memo 52, Long and Morgan 1990).The NOAA ERL and ERM were developed using the same procedures as outlined for the ARCS Project (Ingersoll et al. 1996). The NOAA ERL is defined as the concentration of a chemical in sediment below which adverse effects are rarely observed or predicted among sensitive species. The NOAA ERM is representative of concentrations above which effects frequently occur. The original data set used by Long and Morgan (1990) has since been supplemented with additional saltwater data, therefore these additional marine reports are not applicable (ie: Long et al. 1995).

USEPA Region 4 Screening Levels

The USEPA Region 4 Screening Levels are derived from three different sediment effects data sets including NOAA freshwater and marine data from Long and Morgan (1990), additional NOAA marine data from Long et al. (1995), and Florida State Department of Environmental Protection marine data from MacDonald et al. (1996). The sediment effect level is based on the reported ERL from each study. In instances when the USEPA Contract Laboratory Program (CLP) practical quantitation limit (PQL) is above the effect level, the screening value is equal to the CLP PQL (USEPA 2002).

CCME Sediment Quality Guidelines

The Canadian Council of Ministers of the Environment (CCME) derived sediment quality guidelines to support protection and management strategies for freshwater, estuarine, and marine ecosystems (CCME 1995). Guideline derivation protocols are detailed in CCME (1995) and are similar to the procedures described previously for the ARCS Project (Ingersoll et al. 1996). Separate guidelines were derived for freshwater and marine sediments (CCME 2001). The freshwater interim sediment quality guideline (ISQG) was equal to the TEL and is representative of the concentration below which adverse effects are not anticipated for aquatic life associated with bed sediments (CCME 1995). A PEL was also calculated to establish concentrations above which adverse effects are likely to occur.

Ontario Sediment Effect Levels

Persaud et al. (1993) derived sediment effect levels for the protection of aquatic organisms in Ontario, Canada. Three types of sediment quality guidelines were developed; a No Effect Level (NEL; no toxic effects), a Low Effect Level (LEL; tolerable by benthic species), and a Severe Effect Level (SEL; detrimental to most benthic species). A summary and review of the available approaches to sediment guideline development and the protocol for the derivation of the Ontario values is described in detail in Persaud et al. (1993). Briefly, the NEL is obtained through a chemical equilibrium approach using water quality standards. Because the equilibrium partitioning approach is only predictive for nonpolar organics, a No Effect Level is not derived for metals and polar organics. The LEL and SEL are based on the 5^{th} and 95^{th} percentiles of all effects data for bulk sediment analysis, respectively. For non-polar organics these concentrations were normalized for total organic carbon.

U.S. EPA Region 3 Screening Benchmarks

The Region 3 screening benchmarks were derived based on the following hierarchy:

- Preference was given to benchmarks based on chronic direct exposure, non-lethal endpoint studies designed to be protective of sensitive species.

- Values derived by statistical or consensus-based evaluation of multiple studies were given first priority.
- Equilibrium partitioning values were selected for contaminants with 2.0 < log Kow< 6.0 if empirical values based on multiple studies were not available.
- Absent consensus or equilibrium partitioning values, single study toxicity values were selected.

Marine values were used for freshwater only if a suitable freshwater value was not available.

Of these sources, the following are excluded from use in this risk assessment due to inadequate documentation of derivation methodology, use of site-specific assumptions, use of marine or estuarine sediments, use of inappropriate receptors, or errors in benchmark derivation.

USEPA Region 5 Screening Levels
USEPA Region 4 Screening Levels
CCME Sediment Quality Guidelines (ISQG/PEL)
Ontario Sediment Effect Levels (Low/Severe)
ORNL EqP Guidelines

Of the remaining sources, a benchmark selection hierarchy is established as follows:

Consensus-based TEC (MacDonald et al., 2000)
ARCs TEL (Ingersoll et al., 1996)
NOAA ERL (Long and Morgan, 1990)
U.S. EPA Region 3 Screening Benchmarks

The consensus-based SQGs presented in MacDonald et al. (2000) were selected as the first preference in the hierarchy because they utilized a derivation procedure that incorporated toxicity data from numerous sources. ARCs TEL (Ingersoll et al. 1996) and NOAA ERL (Long and Morgan 1990) rank after the consensus-based SQGs because they are derived from toxicity data from a limited number of studies (i.e., only 1-2 studies). The ARCs TELs and NOAA ERLs were both developed using similar derivation procedures. ARCs TELs were selected in preference to NOAA ERLs because the ARCs data set included only freshwater studies, while the NOAA data set included both freshwater and saltwater studies. A summary of all selected sediment toxicity benchmarks is shown in Table C-2.

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Terrestrial Receptors

C-3 Benchmarks for Direct Contact with Surface Soils

Toxicity values for the protection of terrestrial plants, soil invertebrates and wildlife from contaminants in surface soils are available from several sources. Each of these sources is described briefly below.

Ecological Soil Screening Levels (Eco-SSLs). Eco-SSLs are concentrations of contaminants in soils that are protective of ecological receptors that commonly come into contact with soil or ingest biota that live in or on soil. The Eco-SSLs are screening values that can be used routinely to identify those contaminants of potential concern (COPCs) in soils requiring further evaluation in a baseline ecological risk assessment (ERA). Eco-SSLs are derived separately for four groups of ecological receptors, plants, soil invertebrates, birds and mammals. As such, these values are presumed to provide adequate protection of terrestrial ecosystems. The lower of the values for plants and soil invertebrates is used preferentially as the soil screening benchmark.

The Eco-SSL derivation process represents a three year collaborative effort of a multi-stakeholder workgroup consisting of federal, state, consulting, industry and academic participants led by the USEPA, Office of Emergency and Remedial Response (OERR) (USEPA, 2002b). The USEPA issued the final guidance for Eco-SSLs and interim final Eco-SSL values for several contaminants in 2003.

Oak Ridge National Laboratory Plants/Soil Organisms/Microbes

Oak Ridge National Laboratory (ORNL) reviewed data on the toxicity of contaminants in soil on a wide range of plants, soil organisms, and microbes, and determined the lowest observed effect concentration (LOEC) (Efroymson et al. 1997a,b). The LOEC is defined as the lowest applied concentration of the chemical causing a greater than 20% reduction in the measured response. In some cases, the LOEC is the lowest concentration tested or the only concentration reported (EC50 or ED50 data). The LOECs for a series of different plants and soil organisms are rank ordered and a value selected that approximated the 10th percentile. When a benchmark is based on a lethality endpoint, the benchmark value is divided by 5 to approximate an effects concentration for growth and reproduction. The factor is selected based on the author’s judgement (Efroymson et al. 1997a,b). The benchmark values are then rounded to one significant figure.

Dutch Target and Intervention Values

The Dutch Target and Intervention Values are derived from available data on ecotoxicological effects of contaminants in soil to terrestrial species and soil microbial processes (Swartjes 1999). The Target Values for soil are related to negligible risk for soil ecosystems (95% protection). The Intervention Values are defined as the hazardous concentration for 50% of the soil ecosystem population and are not protective of sensitive species. The Dutch benchmarks are developed by reviewing available literature to determine the lowest no observed effect concentration (NOEC). When there is a LOEC but no NOEC, the NOEC is estimated from the LOEC according to the effect level observed at the LOEC, as follows:

LOEC Effect Range	NOEC
10% - 20%	LOEC / 2
20% - 50%	LOEC / 3
50% - 80%	LOEC / 10

The ecotoxicological data are selected according to the criteria established in Crommenentujin et al. (1994) and are normalized for soil characteristics such as organic matter and clay content. If not enough data is available for terrestrial species and microbial processes, aquatic data (adjusted by an uncertainty factor of 10) are used to derive the benchmark values (Swartjes 1999).

CCME Soil Quality Guidelines

The Canadian Council of Ministers of the Environment (CCME) established effects-based environmental soil quality guidelines (SQG_E) designed to be clean-up goals to protect ecological receptors from direct contact and ingestion exposures to soil-based contaminants. From the available soil toxicity literature, CCME compiled an adverse effect data set and a no effect data set. Several SQG_Es are calculated based on land use types (agricultural-A, residential/parkland-R/P, commercial/industrial-C/I). Based on the amount of toxicity data available, different derivation methods are used to calculate the land use SQG_E. Each of these methods are detailed in CCME (1999) and described briefly below.

<u>Weight-of Evidence Method</u>
A, R/P Land Uses = threshold effects concentration (TEC), 25th percentile of effect and no effect data sets divided by an uncertainty factor
C/I Land Use = effects concentration low (ECL), 25th percentile of effect data set

<u>Lowest-Observed-Effect Concentration (LOEC) Method</u>
A, R/P Land Uses = lowest available LOEC divided by an uncertainty factor
C/I Land Use = geometric mean of available LOEC data

<u>Median Effects Method</u>
A, R/P Land Uses = lowest available EC50 or LC50 divided by an uncertainty factor

C/I Land Use = no guideline calculated

In addition to calculating an SQG_E, CCME also derived SQGs for human health (SQG_{HH}). The final soil guideline is the minimum of the SQG_E and the SQG_{HH}.

USEPA Region 4 Ecological Screening Levels

The USEPA Region 4 compiled soil toxicity screening benchmarks from several sources including ORNL (Efroymson et al. 1997a,b), CCME (CCME 1997), and Dutch values (Crommenentujin et al. 1994). From these sources, screening levels are selected based on contaminant levels associated with ecological effects (USEPA 2002b). These screening values do not take into account area or regional background levels.

USEPA Region 5 Ecological Screening Levels

The USEPA Region 5 reviewed and evaluated soil quality criteria from international, federal, and state sources (USEPA 1999). A default soil ecological screening level (ESL) is selected based on the lowest receptor-specific ESL for terrestrial (plant/soil organisms) and wildlife receptors found during a review of existing toxicological information. The ESL is derived from the concentration which resulted in no observed adverse effects (NOAEL) for chronic exposure of the target species. When a chronic value is not available, the most relevant toxicological result is adjusted by division with uncertainty factors as appropriate to approximate the chronic NOAEL for the selected receptor (USEPA 1999).

Because the CCME final SQGs do not make a distinction between ecological and human health benchmarks, they are not included as a benchmark source. The Region 4 benchmarks are also excluded because they are based on primary sources that had been previously reviewed. For the remaining sources, selection of the surficial soil toxicity benchmarks for terrestrial receptors is based on the following hierarchy:

Eco-SSLs
ORNL benchmarks
Region 5 ESLs

Benchmarks for soil microbes were not included for the purposes of performing screening level risk calculations (see Attachment 1-2 of the Eco-SSL guidance document for additional information on the exclusion of microbes). The soil benchmark values for all chemicals analyzed in surface soils are shown in Table C-3.

References:

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Table C-1. Surface Water Toxicity Benchmarks

Analyte Type	Analyte	NAWQC - Chronic (ug/L)		GLWQI Tier II SCV (ug/L)	USEPA R4 - Chronic (ug/L)	USEPA R5 (ug/L)	Other (ug/L)		**Surface Water Chronic Benchmark (ug/L)**
Inorganics	Aluminum	87		--	87	--	75	EC20 Sensitive Species	87
	Arsenic	150		--	190	148	5	CCME WQG	150
	Barium	5,000	a	4	--	220	--		5,000
	Cadmium	0.25	b	--	1.13	--	--		0.25
	Calcium	--		--	116,000	--	116,000	LCV Daphnids	116,000
	Chromium III	74	b	--	207	--	--		74
	Chromium VI	11	b	--	11	--	--		11
	Cobalt	--		23	--	24	--		23
	Copper	9	b	--	11.8	1.58	--		9
	Iron	1,000		--	1,000	--	300	CCME WQG	1,000
	Lead	2.5	b	--	3.18	1.17	--		2.5
	Magnesium	--		--	82,000	--	82,000	LCV Daphnids	82,000
	Manganese	--		120	--	--	--		120
	Mercury	0.65		1.3	0.012	0.0013	--		0.65
	Nickel	52	b	--	158	28.9	--		52
	Potassium	--		--	53,000	--	53,000	LCV Daphnids	53,000
	Silver	0.3	a	0.36	0.012	0.12	--		0.3
	Sodium	--		--	680,000	--	680,000	LCV Daphnids	680,000
	Thallium	--		12	4	10	--		12
	Vanadium	--		20	--	12	--		20
	Zinc	118	b	--	106	65.7	--		118
Aroclors	Aroclor-1016	--		--	--	--	--		no benchmark
	Aroclor-1221	--		0.28	--	--	60	LCV Fish	0.3
	Aroclor-1232	--		0.58	--	--	124	LCV Fish	0.58
	Aroclor-1242	--		0.053	--	--	2.9	EC20 Fish	0.05
	Aroclor-1248	--		0.081	--	--	0.4	EC20 Fish	0.08
	Aroclor-1254	--		0.033	--	--	0.1	LCV Aquatic Plants	0.03
	Aroclor-1260	--		94	--	--	1.3	LCV Fish	94
	Aroclor-1262	--		--	--	--	--		no benchmark
	Aroclor-1268	--		--	--	--	--		no benchmark
SVOCs	1,2,4-Trichlorobenzene	--		110	130	30	24	CCME WQG	110
	1,2-Dichlorobenzene	--		14	23	14	1	CCME WQG	14
	1,2-Diphenylhydrazine	3		--	1	--	--	--	3

1,3-Dichlorobenzene	--	71	22	38	150	CCME WQG	71
1,4-Dichlorobenzene	--	15	9	9	26	CCME WQG	15
1-Methylnaphthalene	--	2	2	--	500	EC20 Fish	2
2,4,5-Trichlorophenol	63	--	2	--	--	--	63
2,4,6-Trichlorophenol	--	--	5	5	--	--	5
2,4-Dichlorophenol	--	--	11	11	--	--	11
2,4-Dimethylphenol	--	--	15	100	--	--	15
2,4-Dinitrophenol	--	--	71	19	--	--	71
2,4-Dinitrotoluene	--	--	44	44	--	--	44
2,6-Dinitrotoluene	--	--	81	81	--	--	81
2-Chloronaphthalene	--	--	--	0.4	--	--	0.4
2-Chlorophenol	--	--	32	24	--	--	32
2-Methylnaphthalene	--	--	5	330	--	--	5
2-Nitroaniline	--	--	--	--	--	--	no benchmark
2-Nitrophenol	--	--	73	--	--	--	73
3,3`-Dichlorobenzidine	--	--	5	5	--	--	5
3-Nitroaniline	--	--	--	--	--	--	no benchmark
4,6-Dinitro-o-cresol	--	--	--	23	--	--	23
4-Bromophenyl phenyl ether	--	2	2	2	--	--	2
4-Chloro-3-methylphenol	--	--	7.4	35	--	--	7.4
4-Chlorophenyl phenyl ether	--	--	--	--	--	--	no benchmark
4-Nitroaniline	--	--	--	--	--	--	no benchmark
4-Nitrophenol	--	300	58	60	464	EC20 Fish	300
Acenaphthene	--	--	15	38	6	CCME WQG	15
Acenaphthylene	--	--	13	4840	--	--	13
Anthracene	--	0.73	0	0.04	0.01	CCME WQG	0.73
Benzo(a)anthracene	--	0.03	5	0.03	0.02	CCME WQG	0.03
Benzo(a)pyrene	--	0.01	0	0.01	0.02	CCME WQG	0.01
Benzo(b)fluoranthene	--	--	3	9	--	--	3
Benzo(g,h,i)perylene	--	--	0.44	8	--	--	0.44
Benzo(k)fluoranthene	--	--	0.64	--	--	--	0.6
bis(2-chloroethoxy)methane	--	--	--	--	--	--	no benchmark
bis(2-chloroethyl)ether	--	--	--	1900	--	--	1,900
Bis(2-chloroisopropyl)ether	--	--	--	--	--	--	no benchmark
Bis(2-ethylhexyl)phthalate	--	3	3.0	0.3	16	CCME WQG	3
Butyl benzyl phthalate	--	19	23	23	--	--	19

	Carbazole	--	--	--	--	--	--	no benchmark
	Chrysene	--	--	5	--	--	--	5
	Dibenzo(a,h)anthracene	--	--	0	--	--	--	0
	Dibenzofuran	--	4	4	4	1000	LCV Daphnids	4
	Dibutyl phthalate	--	35	19	10	19	CCME WQG	35
	Diethyl phthalate	--	210	220	110	85600	LCV Aquatic Plants	210
	Dimethyl phthalate	3	--	1100	--	--	--	3
	Di-n-octyl phthalate	3	--	--	30	100	EC20 Fish	3
	Fluoranthene	--	--	1	2	0.04	CCME WQG	1
	Fluorene	--	4	19	19	3	CCME WQG	4
	Hexachlorobenzene	4	--	--	0.0003	--	--	4
	Hexachlorobutadiene	--	--	1.0	0.05	1.3	CCME WQG	1.0
	Hexachloroethane	--	12	12	8	--	--	12
	Indeno(1,2,3-cd)pyrene	--	--	0	4	--	--	0
	Isophorone	117	--	920	920	--	--	117
	m & p-cresols	--	--	7.4	35	--	--	7.4
	Naphthalene	--	12	21	13	1.1	CCME WQG	12
	Nitrobenzene	--	--	380	220	--	--	380
	N-Nitrosodimethylamine	--	--	--	--	--	--	no benchmark
	N-Nitrosodi-n-propylamine	--	--	--	--	--	--	no benchmark
	N-Nitrosodiphenylamine	--	210	25	--	332	LCV Fish	210
	o-Cresol	--	13	67	67	470	EC20 Fish	13
	p-Chloroaniline	50	--	19	232	--	--	50
	Pentachlorophenol	15	--	15	4	0.5	CCME WQG	15
	Phenanthrene	--	--	2	4	0.4	CCME WQG	2
	Phenol	--	--	160	180	4	CCME WQG	160
	Pyrene	--	--	5	0.3	0.03	CCME WQG	4.6

(a) Only acute NAWQC available; chronic NAWQC is equal to acute / 10.

(b) Metal toxicity is hardness-dependent; values shown are calculated based on a hardness of 100 mg/L.

NAWQC = National Ambient Water Quality Criteria

GLQWI = Great Lakes Water Quality Initiative

SAV/SCV = Secondary Acute/Chronic Value

CCME = Canadian Council of Ministers of the Environment

WQG = Water Quality Guidelines

LCV = Lowest Chronic Value

EC20 = Effect Concentration Causing Less Than 20% Reduction

Table C-2. Sediment Toxicity Benchmarks

Analyte	Analyte	Threshold Effect Concentrations (TEC)[1]				
		Consensus-Based TEC (mg/kg) [a]	ARCS TEL (mg/kg) [b]	Other (mg/kg)		Sediment Screening Benchmark (mg/kg)
Metals	Aluminum	--	25,519	--		25,519
	Arsenic	9.8	11	--		9.8
	Barium	--	--	--		no benchmark
	Cadmium	0.99	0.58	--		0.99
	Chromium	43	36	--		43
	Cobalt	--	--	--		no benchmark
	Copper	32	28	--		32
	Iron	--	188,400	--		188,400
	Lead	36	37	--		36
	Manganese	--	631	--		631
	Mercury	0.18	--	--		0.18
	Nickel	23	20	--		23
	Silver	--	--	1.0	NOAA ERL [c]	1
	Thallium	--	--	--		no benchmark
	Vanadium	--	--	--		no benchmark
	Zinc	121	98	--		121
PAHs	HMW PAHs	--	0.19	--		0.19
	LMW PAHs	--	0.08	--		0.08
Aroclors	Aroclor-1016	--	--	--		no benchmark
	Aroclor-1221	--	--	--		no benchmark
	Aroclor-1232	--	--	--		no benchmark
	Aroclor-1242	--	--	--		no benchmark
	Aroclor-1248	--	--	--		no benchmark
	Aroclor-1254	--	--	--		no benchmark
	Aroclor-1260	--	--	--		no benchmark
	Aroclor-1262	--	--	--		no benchmark
	Aroclor-1268	--	--	--		no benchmark
SVOCs	1,2,4-Trichlorobenzene	--	--	2.1	USEPA Region 3 [d]	2
	1,2-Dichlorobenzene	--	--	0.02	USEPA Region 3	0.02
	1,2-Diphenylhydrazine	--	--	--		no benchmark
	1,3-Dichlorobenzene	--	--	4.4	USEPA Region 3	4

	1,4-Dichlorobenzene	--	--	0.6	USEPA Region 3	0.6
	2,4,5-Trichlorophenol	--	--	--		no benchmark
	2,4,6-Trichlorophenol	--	--	0.21	USEPA Region 3	0.21
	2,4-Dichlorophenol	--	--	0.12	USEPA Region 3	0.12
	2,4-Dimethylphenol	--	--	0.03	USEPA Region 3	0.03
	2,4-Dinitrophenol	--	--	--		no benchmark
	2,4-Dinitrotoluene	--	--	0.04	USEPA Region 3	0.04
	2,6-Dinitrotoluene	--	--	--		no benchmark
	2-Chloronaphthalene	--	--	--		no benchmark
	2-Chlorophenol	--	--	0.03	USEPA Region 3	0.03
	2-Nitroaniline	--	--	--		no benchmark
	2-Nitrophenol	--	--	--		no benchmark
	3,3`-Dichlorobenzidine	--	--	0.13	USEPA Region 3	0.13
	3-Nitroaniline	--	--	--		no benchmark
	4,6-Dinitro-o-cresol	--	--	--		no benchmark
	4-Bromophenyl phenyl ether	--	--	1.2	USEPA Region 3	1.2
	4-Chloro-3-methylphenol	--	--	--		no benchmark
	4-Chlorophenyl phenyl ether	--	--	--		no benchmark
	4-Nitroaniline	--	--	--		no benchmark
	4-Nitrophenol	--	--	--		no benchmark
	bis(2-chloroethoxy)methane	--	--	--		no benchmark
	bis(2-chloroethyl)ether	--	--	--		no benchmark
	Bis(2-chloroisopropyl)ether	--	--	--		no benchmark
	Bis(2-ethylhexyl)phthalate	--	--	0.18	USEPA Region 3	0.18
	Butyl benzyl phthalate	--	--	10.9	USEPA Region 3	11
	Carbazole	--	--	--		no benchmark
	Dibutyl phthalate	--	--	6.5	USEPA Region 3	6.5
	Diethyl phthalate	--	--	0.6	USEPA Region 3	0.6
	Dimethyl phthalate	--	--	--		no benchmark
	Di-n-octyl phthalate	--	--	--		no benchmark
	Hexachlorobenzene	--	--	0.02	USEPA Region 3	0.02
	Hexachlorobutadiene	--	--	--		no benchmark
	Hexachloroethane	--	--	1.0	USEPA Region 3	1.0
	Isophorone	--	--	--		no benchmark
	m & p-cresols	--	--	--		no benchmark

	Nitrobenzene	--	--	--		no benchmark
	N-Nitrosodimethylamine	--	--	--		no benchmark
	N-Nitrosodi-n-propylamine	--	--	--		no benchmark
	N-Nitrosodiphenylamine	--	--	2.7	USEPA Region 3	2.7
	o-Cresol	--	--	--		no benchmark
	p-Chloroaniline	--	--	--		no benchmark
	Pentachlorophenol	--	--	0.50	USEPA Region 3	0.5
	Phenol	--	--	0.42	USEPA Region 3	0.42

Notes:

1 The TEC encompasses several types of sediment quality guidelines including the Lowest Effect Level (LEL), the Threshold Effect Level (TEL), the Effect Range Low (ERL), the TEL for Hyalella azetca in 28 day tests (TEL-HA28), and the Minimum Effect Threshold (MET).

Sources Hierarchy:

a MacDonald et al. (2000); consensus-based threshold effect concentration (TEC) and probable effect concentration (PEC).

b Ingersoll, et al. (1996); Threshold Effect Level (TEL) and Probable Effect Level (PEL) for total extraction of sediment (BT) samples from *Hyalella azteca* 28-day (HA28) tests.

c Long and Morgan (1990); NOAA Effect Range Low (ERL) and Effect Range Median (ERM).

d U.S. EPA Region 3. 2009. Ecological Risk Assessment. Freshwater Screening Benchmarks. http://www.epa.gov/reg3hscd/risk/eco/btag/sbv/fw/screenbench.htm

Table C-3. Soil Toxicity Benchmarks

Analyte	Plants		Soil Invertebrates		Birds	Mammals	Benchmark
	EcoSSL	ORNL	EcoSSL	ORNL	EcoSSL	EcoSSL	
Aluminum		50					50
Antimony		5	78			0.27	0.27
Arsenic	18	10		60	43	46	10
Barium		500	330			2000	330
Beryllium		10	40			21	10
Cadmium	32	4	140	20	0.77	0.36	0.36
Chromium (III)		1		0.4	26	34	0.4
Chromium (VI)						130	130
Cobalt	13	20			120	230	13
Copper	70	100	80	50	28	49	28
Lead	120	50	1700	500	11	56	11
Manganese	220	500	450		4300	4000	220
Mercury		0.3		0.1			0.1
Nickel	38	30	280	200	210	130	30
Selenium	0.52	1	4.1	70	1.2	0.63	0.52
Silver	560	2			4.2	14	2
Thallium		1					1
Vanadium		2			7.8	280	2
Zinc	160	50	120	200	46	79	46
HMW PAHs			18			1.1	1.1
LMW PAHs			29			100	29

All values shown are in units of mg/kg.

EcoSSL = Ecological Soil Screening Level; ORNL = Oak Ridge National Laboratory
HMW = high molecular weight; LMW = low molecular weight

APPENDIX D

ProUCL Output

OU1 SOIL VERSUS BACKGROUND SOIL

Wilcoxon-Mann-Whitney Sample 1 vs Sample 2 Comparison Test for Data Sets with Non-Detects

Full Precision	**OFF**
Confidence Coefficient	**95%**
Selected Null Hypothesis	**Sample 1 Mean/Median >= Sample 2 Mean/Median (Form 2)**
Alternative Hypothesis	**Sample 1 Mean/Median < Sample 2 Mean/Median**

ALUMINUM

Sample 1 Data: SiteAl
Sample 2 Data: BkgAl

Raw Statistics

	Sample 1	Sample 2
Number of Valid Data	96	112
Number of Non-Detects	0	0
Number of Detect Data	96	112
Minimum Non-Detect	N/A	N/A
Maximum Non-Detect	N/A	N/A
Percent Non-detects	0.00%	0.00%
Minimum Detect	1190	4150
Maximum Detect	30700	33700
Mean of Detects	12686	15522
Median of Detects	12150	15000
SD of Detects	6388	5758

Wilcoxon-Mann-Whitney (WMW) Test

H0: Mean/Median of Sample 1 >= Mean/Median of Sample 2

Sample 1 Rank Sum W-Stat	8675
Standardized WMW U-Stat	-3.137
Mean (U)	5376
SD(U) - Adj ties	432.7
Approximate U-Stat Critical Value (0.05)	-1.645
P-Value (Adjusted for Ties)	8.53E-04

Conclusion with Alpha = 0.05
Reject H0, Conclude Sample 1 < Sample 2
P-Value < alpha (0.05)

BARIUM

Sample 1 Data: SiteBa
Sample 2 Data: BkgBa

Raw Statistics

	Sample 1	Sample 2
Number of Valid Data	96	112
Number of Non-Detects	0	0
Number of Detect Data	96	112
Minimum Non-Detect	N/A	N/A
Maximum Non-Detect	N/A	N/A
Percent Non-detects	0.00%	0.00%
Minimum Detect	21.4	32
Maximum Detect	425	575
Mean of Detects	196.2	195.8
Median of Detects	193.5	171.5
SD of Detects	85.59	105.8

Wilcoxon-Mann-Whitney (WMW) Test

H0: Mean/Median of Sample 1 >= Mean/Median of Sample 2

Sample 1 Rank Sum W-Stat	10414
Standardized WMW U-Stat	0.88
Mean (U)	5376
SD(U) - Adj ties	432.7
Approximate U-Stat Critical Value (0.05)	-1.645
P-Value (Adjusted for Ties)	0.811

Conclusion with Alpha = 0.05
Do Not Reject H0, Conclude Sample 1 >= Sample 2
P-Value >= alpha (0.05)

H0: Mean/Median of Sample 1 = Mean/Median of Sample 2

Sample 1 Rank Sum W-Stat	10414
WMW U-Stat	5758
Standardized WMW U-Stat	0.882
Mean (U)	5376
SD(U) - Adj ties	432.7
Lower Approximate U-Stat Critical Value (0.025)	-1.96
Upper Approximate U-Stat Critical Value (0.975)	1.96
P-Value (Adjusted for Ties)	0.378

Conclusion with Alpha = 0.05
Do Not Reject H0, Conclude Sample 1 = Sample 2
P-Value >= alpha (0.05)

CHROMIUM

Sample 1 Data: SiteCr
Sample 2 Data: BkgCr

Raw Statistics

	Sample 1	Sample 2
Number of Valid Data	96	112
Number of Non-Detects	5	0
Number of Detect Data	91	112
Minimum Non-Detect	0.16	N/A
Maximum Non-Detect	0.21	N/A
Percent Non-detects	5.21%	0.00%
Minimum Detect	1.2	3.2
Maximum Detect	18.5	130
Mean of Detects	10.84	19.6
Median of Detects	10.7	18.05
SD of Detects	3.562	12.22

Wilcoxon-Mann-Whitney (WMW) Test

H0: Mean/Median of Sample 1 >= Mean/Median of Sample 2

Sample 1 Rank Sum W-Stat	5991
Standardized WMW U-Stat	-9.341
Mean (U)	5376
SD(U) - Adj ties	432.7
Approximate U-Stat Critical Value (0.05)	-1.645
P-Value (Adjusted for Ties)	4.77E-21

Conclusion with Alpha = 0.05
Reject H0, Conclude Sample 1 < Sample 2
P-Value < alpha (0.05)

COPPER
Sample 1 Data: SiteCu
Sample 2 Data: BkgCu

Raw Statistics

	Sample 1	Sample 2
Number of Valid Data	96	112
Number of Non-Detects	2	0
Number of Detect Data	94	112
Minimum Non-Detect	0.33	N/A
Maximum Non-Detect	0.36	N/A
Percent Non-detects	2.08%	0.00%
Minimum Detect	2.8	3.8
Maximum Detect	33.9	70.7
Mean of Detects	19.08	17.62
Median of Detects	18.85	15.75
SD of Detects	6.801	10.1

Wilcoxon-Mann-Whitney (WMW) Test

H0: Mean/Median of Sample 1 >= Mean/Median of Sample 2

Sample 1 Rank Sum W-Stat	10991
Standardized WMW U-Stat	2.214
Mean (U)	5376
SD(U) - Adj ties	432.7
Approximate U-Stat Critical Value (0.05)	-1.645
P-Value (Adjusted for Ties)	0.987

Conclusion with Alpha = 0.05
Do Not Reject H0, Conclude Sample 1 >= Sample 2
P-Value >= alpha (0.05)

H0: Mean/Median of Sample 1 = Mean/Median of Sample 2

Sample 1 Rank Sum W-Stat	10991
WMW U-Stat	6335
Standardized WMW U-Stat	2.215
Mean (U)	5376
SD(U) - Adj ties	432.7
Lower Approximate U-Stat Critical Value (0.025)	-1.96
Upper Approximate U-Stat Critical Value (0.975)	1.96
P-Value (Adjusted for Ties)	0.0268

Conclusion with Alpha = 0.05
Reject H0, Conclude Sample 1 <> Sample 2
P-Value < alpha (0.05)

LEAD

Sample 1 Data: SitePb
Sample 2 Data: BkgPb

Raw Statistics

	Sample 1	Sample 2
Number of Valid Data	96	112
Number of Non-Detects	0	0
Number of Detect Data	96	112
Minimum Non-Detect	N/A	N/A
Maximum Non-Detect	N/A	N/A
Percent Non-detects	0.00%	0.00%
Minimum Detect	2.6	3
Maximum Detect	20.5	36.9
Mean of Detects	10.2	15.28
Median of Detects	10.45	14.5
SD of Detects	3.386	6.374

Wilcoxon-Mann-Whitney (WMW) Test

H0: Mean/Median of Sample 1 >= Mean/Median of Sample 2

Sample 1 Rank Sum W-Stat	7415
Standardized WMW U-Stat	-6.05
Mean (U)	5376
SD(U) - Adj ties	432.7
Approximate U-Stat Critical Value (0.05)	-1.645
P-Value (Adjusted for Ties)	7.22E-10

Conclusion with Alpha = 0.05
Reject H0, Conclude Sample 1 < Sample 2
P-Value < alpha (0.05)

MANGANESE

Sample 1 Data: SiteMn
Sample 2 Data: BkgMn

Raw Statistics

	Sample 1	Sample 2
Number of Valid Data	96	112
Number of Non-Detects	0	0
Number of Detect Data	96	112
Minimum Non-Detect	N/A	N/A
Maximum Non-Detect	N/A	N/A
Percent Non-detects	0.00%	0.00%
Minimum Detect	91.7	74
Maximum Detect	726	2920
Mean of Detects	329.6	508.4
Median of Detects	318.5	425
SD of Detects	144.4	369.2

Wilcoxon-Mann-Whitney (WMW) Test

H0: Mean/Median of Sample 1 >= Mean/Median of Sample 2

Sample 1 Rank Sum W-Stat	7998
Standardized WMW U-Stat	-4.702
Mean (U)	5376
SD(U) - Adj ties	432.7
Approximate U-Stat Critical Value (0.05)	-1.645
P-Value (Adjusted for Ties)	1.29E-06

Conclusion with Alpha = 0.05
Reject H0, Conclude Sample 1 < Sample 2
P-Value < alpha (0.05)

SELENIUM
Sample 1 Data: SiteSe
Sample 2 Data: BkgSe

Raw Statistics

	Sample 1	Sample 2
Number of Valid Data	18	112
Number of Non-Detects	2	24
Number of Detect Data	16	88
Minimum Non-Detect	0.28	0.2
Maximum Non-Detect	0.3	0.2
Percent Non-detects	11.11%	21.43%
Minimum Detect	0.27	0.2
Maximum Detect	1.8	1.6
Mean of Detects	0.986	0.46
Median of Detects	1.03	0.4
SD of Detects	0.43	0.218

WMW test is meant for a Single Detection Limit Case
Use of Gehan or T-W test is suggested when multiple detection limits are present
All observations <= 0.3 (Max DL) are ranked the same

Wilcoxon-Mann-Whitney (WMW) Test

H0: Mean/Median of Sample 1 >= Mean/Median of Sample 2

Sample 1 Rank Sum W-Stat	1817
Standardized WMW U-Stat	4.487
Mean (U)	1008
SD(U) - Adj ties	147.7
Approximate U-Stat Critical Value (0.05)	-1.645
P-Value (Adjusted for Ties)	1

Conclusion with Alpha = 0.05
Do Not Reject H0, Conclude Sample 1 >= Sample 2
P-Value >= alpha (0.05)

Sample 1 vs Sample 2 Gehan Test

H0: Mean of Sample 1 >= Mean of background

Gehan z Test Value	4.192
Critical z (0.05)	-1.645
P-Value	1

Conclusion with Alpha = 0.05
Do Not Reject H0, Conclude Sample 1 >= Sample 2
P-Value >= alpha (0.05)

Sample 1 vs Sample 2 Gehan Test

H0: Mean of Sample 1 = Mean of background

Gehan z Test Value	4.192
Lower Critical z (0.025)	-1.96
Upper Critical z (0.975)	1.96
P-Value	2.77E-05

Conclusion with Alpha = 0.05
Reject H0, Conclude Sample 1 <> Sample 2
P-Value < alpha (0.05)

VANADIUM
Sample 1 Data: SiteV
Sample 2 Data: BkgV

Raw Statistics

	Sample 1	Sample 2
Number of Valid Data	96	112
Number of Non-Detects	0	0
Number of Detect Data	96	112
Minimum Non-Detect	N/A	N/A
Maximum Non-Detect	N/A	N/A
Percent Non-detects	0.00%	0.00%
Minimum Detect	3.9	6.7
Maximum Detect	21.9	92.2
Mean of Detects	13.59	30.94
Median of Detects	13.55	29.6
SD of Detects	4.147	13.48

Wilcoxon-Mann-Whitney (WMW) Test

H0: Mean/Median of Sample 1 >= Mean/Median of Sample 2

Sample 1 Rank Sum W-Stat	5339
Standardized WMW U-Stat	-10.85
Mean (U)	5376
SD(U) - Adj ties	432.7
Approximate U-Stat Critical Value (0.05)	-1.645
P-Value (Adjusted for Ties)	1.04E-27

Conclusion with Alpha = 0.05
Reject H0, Conclude Sample 1 < Sample 2
P-Value < alpha (0.05)

ZINC
Sample 1 Data: SiteZn
Sample 2 Data: BkgZn

Raw Statistics

	Sample 1	Sample 2
Number of Valid Data	96	112
Number of Non-Detects	0	0
Number of Detect Data	96	112
Minimum Non-Detect	N/A	N/A
Maximum Non-Detect	N/A	N/A
Percent Non-detects	0.00%	0.00%
Minimum Detect	10.6	16
Maximum Detect	90.6	147
Mean of Detects	53.49	60.51
Median of Detects	54.45	56.5
SD of Detects	17.83	23.26

Wilcoxon-Mann-Whitney (WMW) Test

H0: Mean/Median of Sample 1 >= Mean/Median of Sample 2

Sample 1 Rank Sum W-Stat	9259
Standardized WMW U-Stat	-1.788
Mean (U)	5376
SD(U) - Adj ties	432.7
Approximate U-Stat Critical Value (0.05)	-1.645
P-Value (Adjusted for Ties)	0.0369

Conclusion with Alpha = 0.05
Reject H0, Conclude Sample 1 < Sample 2
P-Value < alpha (0.05)

TEQ MAMMAL ND=0

Sample 1 Data: SiteMammalND0
Sample 2 Data: BkgMammalND0

Raw Statistics

	Sample 1	Sample 2
Number of Valid Data	96	64
Number of Non-Detects	0	2
Number of Detect Data	96	62
Minimum Non-Detect	N/A	0
Maximum Non-Detect	N/A	0
Percent Non-detects	0.00%	3.13%
Minimum Detect	5.53E-09	7.20E-10
Maximum Detect	1.23E-06	1.56E-06
Mean of Detects	1.67E-07	1.81E-07
Median of Detects	6.60E-08	8.14E-08
SD of Detects	2.28E-07	2.67E-07

Wilcoxon-Mann-Whitney (WMW) Test

H0: Mean/Median of Sample 1 >= Mean/Median of Sample 2

Sample 1 Rank Sum W-Stat	7640
Standardized WMW U-Stat	-0.308
Mean (U)	3072
SD(U) - Adj ties	287.1
Approximate U-Stat Critical Value (0.05)	-1.645
P-Value (Adjusted for Ties)	0.379

Conclusion with Alpha = 0.05
Do Not Reject H0, Conclude Sample 1 >= Sample 2
P-Value >= alpha (0.05)

Wilcoxon-Mann-Whitney (WMW) Test

H0: Mean/Median of Sample 1 = Mean/Median of Sample 2

Sample 1 Rank Sum W-Stat	7640
WMW U-Stat	2984
Standardized WMW U-Stat	-0.307
Mean (U)	3072
SD(U) - Adj ties	287.1
Lower Approximate U-Stat Critical Value (0.025)	-1.96
Upper Approximate U-Stat Critical Value (0.975)	1.96
P-Value (Adjusted for Ties)	0.759

Conclusion with Alpha = 0.05
Do Not Reject H0, Conclude Sample 1 = Sample 2
P-Value >= alpha (0.05)

TEQ AVIAN ND=0

Sample 1 Data: SiteBirdND0
Sample 2 Data: BkgBirdND0

Raw Statistics

	Sample 1	Sample 2
Number of Valid Data	96	64
Number of Non-Detects	0	2
Number of Detect Data	96	62
Minimum Non-Detect	N/A	0
Maximum Non-Detect	N/A	0
Percent Non-detects	0.00%	3.13%
Minimum Detect	6.98E-10	2.40E-10
Maximum Detect	1.22E-06	1.65E-06
Mean of Detects	1.03E-07	2.41E-07
Median of Detects	2.03E-08	1.42E-07
SD of Detects	2.08E-07	3.15E-07

Wilcoxon-Mann-Whitney (WMW) Test

H0: Mean/Median of Sample 1 >= Mean/Median of Sample 2

Sample 1 Rank Sum W-Stat	6838
Standardized WMW U-Stat	-3.102
Mean (U)	3072
SD(U) - Adj ties	287.1
Approximate U-Stat Critical Value (0.05)	-1.645
P-Value (Adjusted for Ties)	9.62E-04

Conclusion with Alpha = 0.05
Reject H0, Conclude Sample 1 < Sample 2
P-Value < alpha (0.05)

TEQ MAMMAL ND=1/2 MDL (SITE); 1/2 RL (BKGD)

Sample 1 Data: SiteMammalNDhalfMDL
Sample 2 Data: BkgMammalNDhalfRL

Raw Statistics

	Sample 1	Sample 2
Number of Valid Data	96	64
Number of Non-Detects	0	2
Number of Detect Data	96	62
Minimum Non-Detect	N/A	1.03E-06
Maximum Non-Detect	N/A	1.10E-06
Percent Non-detects	0.00%	3.13%
Minimum Detect	3.78E-08	1.32E-07
Maximum Detect	1.24E-06	1.85E-06
Mean of Detects	2.02E-07	7.05E-07
Median of Detects	1.02E-07	6.11E-07
SD of Detects	2.25E-07	4.65E-07

WMW test is meant for a Single Detection Limit Case
Use of Gehan or T-W test is suggested when multiple detection limits are present
All observations <= 1.0986E-6 (Max DL) are ranked the same

Wilcoxon-Mann-Whitney (WMW) Test

H0: Mean/Median of Sample 1 >= Mean/Median of Sample 2

Sample 1 Rank Sum W-Stat	6803
Standardized WMW U-Stat	-5.493
Mean (U)	3072
SD(U) - Adj ties	287.1
Approximate U-Stat Critical Value (0.05)	-1.645
P-Value (Adjusted for Ties)	1.97E-08

Conclusion with Alpha = 0.05
Reject H0, Conclude Sample 1 < Sample 2
P-Value < alpha (0.05)

Sample 1 vs Sample 2 Gehan Test

H0: Mean of Sample 1 >= Mean of background

Gehan z Test Value	-7.946
Critical z (0.05)	-1.645
P-Value	9.64E-16

Conclusion with Alpha = 0.05
Reject H0, Conclude Sample 1 < Sample 2
P-Value < alpha (0.05)

TEQ AVIAN ND=1/2 MDL (SITE); 1/2 RL (BKGD)
Sample 1 Data: SiteBirdNDhalfMDL
Sample 2 Data: BkgBirdNDhalfRL

Raw Statistics

	Sample 1	Sample 2
Number of Valid Data	96	64
Number of Non-Detects	0	2
Number of Detect Data	96	62
Minimum Non-Detect	N/A	1.39E-06
Maximum Non-Detect	N/A	1.48E-06
Percent Non-detects	0.00%	3.13%
Minimum Detect	4.25E-08	2.09E-07
Maximum Detect	1.24E-06	2.13E-06
Mean of Detects	1.52E-07	9.39E-07
Median of Detects	7.36E-08	7.53E-07
SD of Detects	2.03E-07	5.66E-07

WMW test is meant for a Single Detection Limit Case
Use of Gehan or T-W test is suggested when multiple detection limits are present
All observations <= 1.4787E-6 (Max DL) are ranked the same

Wilcoxon-Mann-Whitney (WMW) Test

H0: Mean/Median of Sample 1 >= Mean/Median of Sample 2
All observations are identical in at least one group
No analysis will be performed

Sample 1 vs Sample 2 Gehan Test

H0: Mean of Sample 1 >= Mean of background

Gehan z Test Value	-9.456
Critical z (0.05)	-1.645
P-Value	1.59E-21

Conclusion with Alpha = 0.05
Reject H0, Conclude Sample 1 < Sample 2
P-Value < alpha (0.05)

TEQ MAMMAL ND=MDL (SITE); RL (BKGD)

Sample 1 Data: SiteMammalNDMDL
Sample 2 Data: BkgMammalNDRL

Raw Statistics

	Sample 1	Sample 2
Number of Valid Data	96	64
Number of Non-Detects	0	2
Number of Detect Data	96	62
Minimum Non-Detect	N/A	2.05E-06
Maximum Non-Detect	N/A	2.20E-06
Percent Non-detects	0.00%	3.13%
Minimum Detect	7.00E-08	2.24E-07
Maximum Detect	1.25E-06	2.94E-06
Mean of Detects	2.38E-07	1.23E-06
Median of Detects	1.37E-07	1.08E-06
SD of Detects	2.23E-07	8.73E-07

WMW test is meant for a Single Detection Limit Case
Use of Gehan or T-W test is suggested when multiple detection limits are present
All observations <= 2.1971E-6 (Max DL) are ranked the same

Wilcoxon-Mann-Whitney (WMW) Test

H0: Mean/Median of Sample 1 >= Mean/Median of Sample 2
All observations are identical in at least one group
No analysis will be performed

Sample 1 vs Sample 2 Gehan Test

H0: Mean of Sample 1 >= Mean of background

Gehan z Test Value	-8.677
Critical z (0.05)	-1.645
P-Value	2.03E-18

Conclusion with Alpha = 0.05
Reject H0, Conclude Sample 1 < Sample 2
P-Value < alpha (0.05)

<u>TEQ AVIAN ND=MDL (SITE); RL (BKGD)</u>

Sample 1 Data: SiteBirdNDMDL
Sample 2 Data: BkgBirdNDRL

Raw Statistics

	Sample 1	Sample 2
Number of Valid Data	96	64
Number of Non-Detects	0	2
Number of Detect Data	96	62
Minimum Non-Detect	N/A	2.77E-06
Maximum Non-Detect	N/A	2.96E-06
Percent Non-detects	0.00%	3.13%
Minimum Detect	8.43E-08	2.89E-07
Maximum Detect	1.25E-06	3.50E-06
Mean of Detects	2.01E-07	1.64E-06
Median of Detects	1.26E-07	1.47E-06
SD of Detects	1.99E-07	1.13E-06

WMW test is meant for a Single Detection Limit Case
Use of Gehan or T-W test is suggested when multiple detection limits are present
All observations <= 2.9573E-6 (Max DL) are ranked the same

Wilcoxon-Mann-Whitney (WMW) Test

H0: Mean/Median of Sample 1 >= Mean/Median of Sample 2
All observations are identical in at least one group
No analysis will be performed

Sample 1 vs Sample 2 Gehan Test

H0: Mean of Sample 1 >= Mean of background

Gehan z Test Value	-9.821
Critical z (0.05)	-1.645
P-Value	4.59E-23

Conclusion with Alpha = 0.05
Reject H0, Conclude Sample 1 < Sample 2
P-Value < alpha (0.05)

OU1 SEDIMENT VERSUS BACKGROUND SEDIMENT

Wilcoxon-Mann-Whitney Sample 1 vs Sample 2 Comparison Test for Data Sets with Non-Detects

User Selected Options	
From File	**ProUCL_IN_OU1_Sed.xls**
Full Precision	**OFF**
Confidence Coefficient	**95%**
Selected Null Hypothesis	**Sample 1 Mean/Median >= Sample 2 Mean/Median (Form 2)**
Alternative Hypothesis	**Sample 1 Mean/Median < Sample 2 Mean/Median**

<u>ARSENIC</u>

Sample 1 Data: SiteAs
Sample 2 Data: BGAs

Raw Statistics

	Sample 1	Sample 2
Number of Valid Data	6	20
Number of Non-Detects	0	0
Number of Detect Data	6	20
Minimum Non-Detect	N/A	N/A
Maximum Non-Detect	N/A	N/A
Percent Non-detects	0.00%	0.00%
Minimum Detect	2.7	1.2
Maximum Detect	13.4	21.43
Mean of Detects	6.983	12.32
Median of Detects	4.8	13.11
SD of Detects	4.588	5.799

Wilcoxon-Mann-Whitney (WMW) Test

H0: Mean/Median of Sample 1 >= Mean/Median of Sample 2

Sample 1 Rank Sum W-Stat	49.5
WMW U-Stat	28.5
Mean (U)	60
SD(U) - Adj ties	16.43
WMW U-Stat Critical Value (0.05)	33
Standardized WMW U-Stat	-1.948
Approximate P-Value	0.0257

Conclusion with Alpha = 0.05
Reject H0, Conclude Sample 1 < Sample 2

COPPER

Sample 1 Data: SiteCu
Sample 2 Data: BGCu

Raw Statistics

	Sample 1	Sample 2
Number of Valid Data	6	20
Number of Non-Detects	0	0
Number of Detect Data	6	20
Minimum Non-Detect	N/A	N/A
Maximum Non-Detect	N/A	N/A
Percent Non-detects	0.00%	0.00%
Minimum Detect	14.4	6.6
Maximum Detect	118	234.3
Mean of Detects	45.53	137.9
Median of Detects	35.25	146.5
SD of Detects	37.34	69.49

Wilcoxon-Mann-Whitney (WMW) Test

H0: Mean/Median of Sample 1 >= Mean/Median of Sample 2

Sample 1 Rank Sum W-Stat	38
WMW U-Stat	17
Mean (U)	60
SD(U) - Adj ties	16.43
WMW U-Stat Critical Value (0.05)	33
Standardized WMW U-Stat	-2.647
Approximate P-Value	0.00406

Conclusion with Alpha = 0.05
Reject H0, Conclude Sample 1 < Sample 2

ZINC

Sample 1 Data: SiteZn

Sample 2 Data: BGZn

Raw Statistics

	Sample 1	Sample 2
Number of Valid Data	6	20
Number of Non-Detects	0	0
Number of Detect Data	6	20
Minimum Non-Detect	N/A	N/A
Maximum Non-Detect	N/A	N/A
Percent Non-detects	0.00%	0.00%
Minimum Detect	41.9	24
Maximum Detect	248	478.6
Mean of Detects	97.73	305.5
Median of Detects	76.2	336.4
SD of Detects	77.63	132.7

Wilcoxon-Mann-Whitney (WMW) Test

H0: Mean/Median of Sample 1 >= Mean/Median of Sample 2

Sample 1 Rank Sum W-Stat	35
WMW U-Stat	14
Mean (U)	60
SD(U) - Adj ties	16.43
WMW U-Stat Critical Value (0.05)	33
Standardized WMW U-Stat	-2.83
Approximate P-Value	0.00233

Conclusion with Alpha = 0.05

Reject H0, Conclude Sample 1 < Sample 2

TEQ MAMMAL ND=0

Sample 1 Data: SiteMammalND0
Sample 2 Data: BkgMammalND0

Raw Statistics

	Sample 1	Sample 2
Number of Valid Data	5	11
Number of Non-Detects	0	0
Number of Detect Data	5	11
Minimum Non-Detect	N/A	N/A
Maximum Non-Detect	N/A	N/A
Percent Non-detects	0.00%	0.00%
Minimum Detect	2.46E-07	5.14E-08
Maximum Detect	3.08E-06	1.24E-06
Mean of Detects	9.83E-07	4.31E-07
Median of Detects	5.11E-07	3.00E-07
SD of Detects	1.18E-06	4.47E-07

Wilcoxon-Mann-Whitney (WMW) Test

H0: Mean/Median of Sample 1 >= Mean/Median of Sample 2

Sample 1 Rank Sum W-Stat	55
WMW U-Stat	40
Mean (U)	27.5
SD(U) - Adj ties	8.827
WMW U-Stat Critical Value (0.05)	13
Standardized WMW U-Stat	1.359
Approximate P-Value	0.913

Conclusion with Alpha = 0.05
Do Not Reject H0, Conclude Sample 1 >= Sample 2

H0: Mean/Median of Sample 1 = Mean/Median of Sample 2

Sample 1 Rank Sum W-Stat	55
WMW U-Stat	40
Mean (U)	27.5
SD(U) - Adj ties	8.827
Lower U-Stat Critical Value (0.025)	10
Upper U-Stat Critical Value (0.975)	45
Standardized WMW U-Stat	1.359
Approximate P-Value	0.174

Conclusion with Alpha = 0.05
Do Not Reject H0, Conclude Sample 1 = Sample 2

TEQ AVIAN ND=0

Sample 1 Data: SiteBirdND0
Sample 2 Data: BkgBirdND0

Raw Statistics

	Sample 1	Sample 2
Number of Valid Data	5	11
Number of Non-Detects	0	0
Number of Detect Data	5	11
Minimum Non-Detect	N/A	N/A
Maximum Non-Detect	N/A	N/A
Percent Non-detects	0.00%	0.00%
Minimum Detect	8.84E-08	1.76E-08
Maximum Detect	3.60E-06	1.52E-06
Mean of Detects	8.88E-07	3.14E-07
Median of Detects	2.85E-07	7.21E-08
SD of Detects	1.52E-06	5.10E-07

Wilcoxon-Mann-Whitney (WMW) Test

H0: Mean/Median of Sample 1 >= Mean/Median of Sample 2

Sample 1 Rank Sum W-Stat	55
WMW U-Stat	40
Mean (U)	27.5
SD(U) - Adj ties	8.827
WMW U-Stat Critical Value (0.05)	13
Standardized WMW U-Stat	1.359
Approximate P-Value	0.913

Conclusion with Alpha = 0.05
Do Not Reject H0, Conclude Sample 1 >= Sample 2

H0: Mean/Median of Sample 1 = Mean/Median of Sample 2

Sample 1 Rank Sum W-Stat	55
WMW U-Stat	40
Mean (U)	27.5
SD(U) - Adj ties	8.827
Lower U-Stat Critical Value (0.025)	10
Upper U-Stat Critical Value (0.975)	45
Standardized WMW U-Stat	1.359
Approximate P-Value	0.174

Conclusion with Alpha = 0.05
Do Not Reject H0, Conclude Sample 1 = Sample 2

TEQ MAMMAL ND=1/2 MDL (SITE); 1/2 RL (BKGD)

Sample 1 Data: SiteMammalNDhalfMDL
Sample 2 Data: BkgMammalNDhalfMDL

Raw Statistics

	Sample 1	Sample 2
Number of Valid Data	5	11
Number of Non-Detects	0	0
Number of Detect Data	5	11
Minimum Non-Detect	N/A	N/A
Maximum Non-Detect	N/A	N/A
Percent Non-detects	0.00%	0.00%
Minimum Detect	2.75E-07	8.35E-08
Maximum Detect	3.09E-06	1.26E-06
Mean of Detects	1.01E-06	4.62E-07
Median of Detects	5.38E-07	3.37E-07
SD of Detects	1.17E-06	4.41E-07

Wilcoxon-Mann-Whitney (WMW) Test

H0: Mean/Median of Sample 1 >= Mean/Median of Sample 2

Sample 1 Rank Sum W-Stat	55
WMW U-Stat	40
Mean (U)	27.5
SD(U) - Adj ties	8.827
WMW U-Stat Critical Value (0.05)	13
Standardized WMW U-Stat	1.359
Approximate P-Value	0.913

Conclusion with Alpha = 0.05
Do Not Reject H0, Conclude Sample 1 >= Sample 2

H0: Mean/Median of Sample 1 = Mean/Median of Sample 2

Sample 1 Rank Sum W-Stat	55
WMW U-Stat	40
Mean (U)	27.5
SD(U) - Adj ties	8.827
Lower U-Stat Critical Value (0.025)	10
Upper U-Stat Critical Value (0.975)	45
Standardized WMW U-Stat	1.359
Approximate P-Value	0.174

Conclusion with Alpha = 0.05
Do Not Reject H0, Conclude Sample 1 = Sample 2

TEQ AVIAN ND=1/2 MDL (SITE); 1/2 RL (BKGD)

Sample 1 Data: SiteBirdNDhalfMDL
Sample 2 Data: BkgBirdNDhalfMDL

Raw Statistics

	Sample 1	Sample 2
Number of Valid Data	5	11
Number of Non-Detects	0	0
Number of Detect Data	5	11
Minimum Non-Detect	N/A	N/A
Maximum Non-Detect	N/A	N/A
Percent Non-detects	0.00%	0.00%
Minimum Detect	1.29E-07	5.93E-08
Maximum Detect	3.61E-06	1.55E-06
Mean of Detects	9.20E-07	3.58E-07
Median of Detects	3.22E-07	1.27E-07
SD of Detects	1.50E-06	5.00E-07

Wilcoxon-Mann-Whitney (WMW) Test

H0: Mean/Median of Sample 1 >= Mean/Median of Sample 2

Sample 1 Rank Sum W-Stat	55
WMW U-Stat	40
Mean (U)	27.5
SD(U) - Adj ties	8.827
WMW U-Stat Critical Value (0.05)	13
Standardized WMW U-Stat	1.359
Approximate P-Value	0.913

Conclusion with Alpha = 0.05

Do Not Reject H0, Conclude Sample 1 >= Sample 2

H0: Mean/Median of Sample 1 = Mean/Median of Sample 2

Sample 1 Rank Sum W-Stat	55
WMW U-Stat	40
Mean (U)	27.5
SD(U) - Adj ties	8.827
Lower U-Stat Critical Value (0.025)	10
Upper U-Stat Critical Value (0.975)	45
Standardized WMW U-Stat	1.359
Approximate P-Value	0.174

Conclusion with Alpha = 0.05

Do Not Reject H0, Conclude Sample 1 = Sample 2

TEQ MAMMAL ND=MDL (SITE); RL (BKGD)
Sample 1 Data: SiteMammalNDMDL
Sample 2 Data: BkgMammalNDMDL

Raw Statistics

	Sample 1	Sample 2
Number of Valid Data	5	11
Number of Non-Detects	0	0
Number of Detect Data	5	11
Minimum Non-Detect	N/A	N/A
Maximum Non-Detect	N/A	N/A
Percent Non-detects	0.00%	0.00%
Minimum Detect	3.04E-07	1.16E-07
Maximum Detect	3.09E-06	1.28E-06
Mean of Detects	1.03E-06	4.93E-07
Median of Detects	5.64E-07	3.73E-07
SD of Detects	1.16E-06	4.34E-07

Wilcoxon-Mann-Whitney (WMW) Test

H0: Mean/Median of Sample 1 >= Mean/Median of Sample 2

Sample 1 Rank Sum W-Stat	54
WMW U-Stat	39
Mean (U)	27.5
SD(U) - Adj ties	8.827
WMW U-Stat Critical Value (0.05)	13
Standardized WMW U-Stat	1.246
Approximate P-Value	0.894

Conclusion with Alpha = 0.05
Do Not Reject H0, Conclude Sample 1 >= Sample 2

H0: Mean/Median of Sample 1 = Mean/Median of Sample 2

Sample 1 Rank Sum W-Stat	54
WMW U-Stat	39
Mean (U)	27.5
SD(U) - Adj ties	8.827
Lower U-Stat Critical Value (0.025)	10
Upper U-Stat Critical Value (0.975)	45
Standardized WMW U-Stat	1.246
Approximate P-Value	0.213

Conclusion with Alpha = 0.05
Do Not Reject H0, Conclude Sample 1 = Sample 2

TEQ AVIAN ND=MDL (SITE); RL (BKGD)
Sample 1 Data: SiteBirdNDMDL
Sample 2 Data: BkgBirdNDMDL

Raw Statistics

	Sample 1	Sample 2
Number of Valid Data	5	11
Number of Non-Detects	0	0
Number of Detect Data	5	11
Minimum Non-Detect	N/A	N/A
Maximum Non-Detect	N/A	N/A
Percent Non-detects	0.00%	0.00%
Minimum Detect	1.69E-07	1.01E-07
Maximum Detect	3.61E-06	1.57E-06
Mean of Detects	9.52E-07	4.02E-07
Median of Detects	3.58E-07	1.82E-07
SD of Detects	1.49E-06	4.90E-07

Wilcoxon-Mann-Whitney (WMW) Test

H0: Mean/Median of Sample 1 >= Mean/Median of Sample 2

Sample 1 Rank Sum W-Stat	54
WMW U-Stat	39
Mean (U)	27.5
SD(U) - Adj ties	8.827
WMW U-Stat Critical Value (0.05)	13
Standardized WMW U-Stat	1.246
Approximate P-Value	0.894

Conclusion with Alpha = 0.05
Do Not Reject H0, Conclude Sample 1 >= Sample 2

H0: Mean/Median of Sample 1 = Mean/Median of Sample 2

Sample 1 Rank Sum W-Stat	54
WMW U-Stat	39
Mean (U)	27.5
SD(U) - Adj ties	8.827
Lower U-Stat Critical Value (0.025)	10
Upper U-Stat Critical Value (0.975)	45
Standardized WMW U-Stat	1.246
Approximate P-Value	0.213

Conclusion with Alpha = 0.05
Do Not Reject H0, Conclude Sample 1 = Sample 2

ProUCL Input for Copper and Selenium

SiteCu	D_SiteCu	SiteSe	D_SiteSe
9.1	1	0.57	1
12	1	0.63	1
9.8	1	0.58	1
21.4	1	0.28	0
18.3	1	1.2	1
22.1	1	1.8	1
17.3	1	1.1	1
18.7	1	1.2	1
22.7	1	1.7	1
19	1	1.4	1
16.3	1	1.1	1
16.2	1	0.96	1
8.5	1	0.47	1
4.1	1	0.27	1
18.6	1	0.76	1
33.9	1	1.1	1
13.2	1	0.3	0
28.7	1	0.94	1
24.7	1		
23.4	1		
23.5	1		
26.3	1		
24.9	1		
20	1		
20.7	1		
20.7	1		
7.9	1		
20.8	1		
17.8	1		
16.6	1		
17.2	1		
13.9	1		
24.4	1		
25.2	1		
22.9	1		
24.1	1		
26	1		
7.2	1		
25.2	1		
25.4	1		
26.8	1		
24.5	1		
23.3	1		
24.4	1		
18.2	1		
25.7	1		
27.7	1		
26.6	1		
14.8	1		
25.6	1		
23.2	1		
24.6	1		
13	1		
14	1		
30.3	1		
28.4	1		
26.6	1		
27	1		
24	1		
15.8	1		
24.2	1		
26.3	1		
24.6	1		
27.3	1		
28.9	1		
18.7	1		
21	1		
20.3	1		
17	1		
11.4	1		
15.2	1		
15.7	1		
11.1	1		
11.7	1		
15.1	1		
11.4	1		
12.9	1		
13.9	1		
0.36	0		
13.3	1		
8.3	1		
15.2	1		
9.6	1		
9.8	1		
13.3	1		
17.4	1		
27.6	1		
27.9	1		
28.7	1		
0.33	0		
12.4	1		
10.4	1		
9.1	1		
12.6	1		
2.8	1		
15.4	1		

ProUCL Output for Copper and Selenium in OU1 Soil

UCL Statistics for Data Sets with Non-Detects

User Selected Options	
From File	ProUCL_IN_OU1 Soil_v2.xls
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

COPPER

General Statistics			
Total Number of Observations	96	Number of Distinct Observations	82
Number of Detects	94	Number of Non-Detects	2
Number of Distinct Detects	80	Number of Distinct Non-Detects	2
Minimum Detect	2.8	Minimum Non-Detect	0.33
Maximum Detect	33.9	Maximum Non-Detect	0.36
Variance Detects	46.25	Percent Non-Detects	2.08%
Mean Detects	19.08	SD Detects	6.801
Median Detects	18.85	CV Detects	0.356
Skewness Detects	-0.212	Kurtosis Detects	-0.845
Mean of Logged Detects	2.867	SD of Logged Detects	0.443

Normal GOF Test on Detects Only		
Shapiro Wilk Test Statistic	0.959	Normal GOF Test on Detected Observations Only
5% Shapiro Wilk P Value	0.0238	Detected Data Not Normal at 5% Significance Level
Lilliefors Test Statistic	0.111	Lilliefors GOF Test
5% Lilliefors Critical Value	0.0914	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			
Mean	18.69	Standard Error of Mean	0.74
SD	7.209	95% KM (BCA) UCL	19.86
95% KM (t) UCL	19.92	95% KM (Percentile Bootstrap) UCL	19.84
95% KM (z) UCL	19.91	95% KM Bootstrap t UCL	19.92
90% KM Chebyshev UCL	20.91	95% KM Chebyshev UCL	21.92
97.5% KM Chebyshev UCL	23.31	99% KM Chebyshev UCL	26.05

Gamma GOF Tests on Detected Observations Only		
A-D Test Statistic	1.617	Anderson-Darling GOF Test
5% A-D Critical Value	0.754	Detected Data Not Gamma Distributed at 5% Significance Level
K-S Test Statistic	0.123	Kolmogrov-Smirnoff GOF
5% K-S Critical Value	0.0924	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)	6.307	k star (bias corrected MLE)	6.113
Theta hat (MLE)	3.025	Theta star (bias corrected MLE)	3.122
nu hat (MLE)	1186	nu star (bias corrected)	1149
MLE Mean (bias corrected)	19.08	MLE Sd (bias corrected)	7.718

Gamma Kaplan-Meier (KM) Statistics			
k hat (KM)	6.722	nu hat (KM)	1291
Approximate Chi Square Value (N/A, α)	1208	Adjusted Chi Square Value (N/A, β)	1207
95% Gamma Approximate KM-UCL (use when n>=50)	19.97	95% Gamma Adjusted KM-UCL (use when n<50)	19.99

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 detected data is small such as < 0.1
For such situations, GROS method tends to yield inflated values of UCLs and BTVs
For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	2.8	Mean	18.83
Maximum	33.9	Median	18.7
SD	6.953	CV	0.369
k hat (MLE)	5.874	k star (bias corrected MLE)	5.697
Theta hat (MLE)	3.205	Theta star (bias corrected MLE)	3.305
nu hat (MLE)	1128	nu star (bias corrected)	1094
MLE Mean (bias corrected)	18.83	MLE Sd (bias corrected)	7.888
		Adjusted Level of Significance (β)	0.0475
Approximate Chi Square Value (N/A, α)	1018	Adjusted Chi Square Value (N/A, β)	1017
95% Gamma Approximate UCL (use when n>=50)	20.23	95% Gamma Adjusted UCL (use when n<50)	20.25

Lognormal GOF Test on Detected Observations Only		
Lilliefors Test Statistic	0.122	Lilliefors GOF Test
5% Lilliefors Critical Value	0.0914	Detected Data Not Lognormal at 5% Significance Level
Detected Data Not Lognormal at 5% Significance Level		

Lognormal ROS Statistics Using Imputed Non-Detects			
Mean in Original Scale	18.81	Mean in Log Scale	2.845
SD in Original Scale	6.981	SD in Log Scale	0.464
95% t UCL (assumes normality of ROS data)	20	95% Percentile Bootstrap UCL	19.94
95% BCA Bootstrap UCL	19.94	95% Bootstrap t UCL	19.95
95% H-UCL (Log ROS)	20.91		

DL/2 Statistics			
DL/2 Normal		DL/2 Log-Transformed	
Mean in Original Scale	18.69	Mean in Log Scale	2.771
SD in Original Scale	7.256	SD in Log Scale	0.796
95% t UCL (Assumes normality)	19.92	95% H-Stat UCL	25.96

DL/2 is not a recommended method, provided for comparisons and historical reasons

Nonparametric Distribution Free UCL Statistics
Data do not follow a Discernible Distribution at 5% Significance Level

Suggested UCL to Use
95% KM (BCA) UCL **19.86**

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

SELENIUM

General Statistics

Total Number of Observations	18	Number of Distinct Observations	15
Number of Detects	16	Number of Non-Detects	2
Number of Distinct Detects	13	Number of Distinct Non-Detects	2
Minimum Detect	0.27	Minimum Non-Detect	0.28
Maximum Detect	1.8	Maximum Non-Detect	0.3
Variance Detects	0.185	Percent Non-Detects	11.11%
Mean Detects	0.986	SD Detects	0.43
Median Detects	1.03	CV Detects	0.436
Skewness Detects	0.284	Kurtosis Detects	-0.376
Mean of Logged Detects	-0.119	SD of Logged Detects	0.503

Normal GOF Test on Detects Only

Shapiro Wilk Test Statistic	0.966	Shapiro Wilk GOF Test	
5% Shapiro Wilk Critical Value	0.887	Detected Data appear Normal at 5% Significance Level	
Lilliefors Test Statistic	0.122	Lilliefors GOF Test	
5% Lilliefors Critical Value	0.222	Detected Data appear Normal at 5% Significance Level	

Detected Data appear Normal at 5% Significance Level

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

Mean	0.907	Standard Error of Mean	0.11
SD	0.452	95% KM (BCA) UCL	1.103
95% KM (t) UCL	1.098	95% KM (Percentile Bootstrap) UCL	1.084
95% KM (z) UCL	1.088	95% KM Bootstrap t UCL	1.101
90% KM Chebyshev UCL	1.237	95% KM Chebyshev UCL	1.387
97.5% KM Chebyshev UCL	1.594	99% KM Chebyshev UCL	2.002

Gamma GOF Tests on Detected Observations Only

A-D Test Statistic	0.285	Anderson-Darling GOF Test	
5% A-D Critical Value	0.741	Detected data appear Gamma Distributed at 5% Significance Level	
K-S Test Statistic	0.154	Kolmogrov-Smirnoff GOF	
5% K-S Critical Value	0.216	Detected data appear Gamma Distributed at 5% Significance Level	

Detected data appear Gamma Distributed at 5% Significance Level

Gamma Statistics on Detected Data Only

k hat (MLE)	4.913	k star (bias corrected MLE)	4.033
Theta hat (MLE)	0.201	Theta star (bias corrected MLE)	0.245
nu hat (MLE)	157.2	nu star (bias corrected)	129.1
MLE Mean (bias corrected)	0.986	MLE Sd (bias corrected)	0.491

Gamma Kaplan-Meier (KM) Statistics

k hat (KM)	4.017	nu hat (KM)	144.6
Approximate Chi Square Value (144.60, α)	117.8	Adjusted Chi Square Value (144.60, β)	115.5
95% Gamma Approximate KM-UCL (use when n>=50)	1.113	95% Gamma Adjusted KM-UCL (use when n<50)	1.135

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 detected data is small such as < 0.1
For such situations, GROS method tends to yield inflated values of UCLs and BTVs
For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

Minimum	0.27	Mean	0.911
Maximum	1.8	Median	0.95
SD	0.46	CV	0.505
k hat (MLE)	3.634	k star (bias corrected MLE)	3.065
Theta hat (MLE)	0.251	Theta star (bias corrected MLE)	0.297
nu hat (MLE)	130.8	nu star (bias corrected)	110.3
MLE Mean (bias corrected)	0.911	MLE Sd (bias corrected)	0.52
		Adjusted Level of Significance (β)	0.0357
Approximate Chi Square Value (110.35, α)	87.1	Adjusted Chi Square Value (110.35, β)	85.12
95% Gamma Approximate UCL (use when n>=50)	1.154	95% Gamma Adjusted UCL (use when n<50)	1.181

Lognormal GOF Test on Detected Observations Only

Shapiro Wilk Test Statistic	0.942	Shapiro Wilk GOF Test	
5% Shapiro Wilk Critical Value	0.887	Detected Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.17	Lilliefors GOF Test	
5% Lilliefors Critical Value	0.222	Detected Data appear Lognormal at 5% Significance Level	

Detected Data appear Lognormal at 5% Significance Level

Lognormal ROS Statistics Using Imputed Non-Detects

Mean in Original Scale	0.915	Mean in Log Scale	-0.225
SD in Original Scale	0.454	SD in Log Scale	0.564
95% t UCL (assumes normality of ROS data)	1.101	95% Percentile Bootstrap UCL	1.094
95% BCA Bootstrap UCL	1.08	95% Bootstrap t UCL	1.113
95% H-UCL (Log ROS)	1.246		

UCLs using Lognormal Distribution and KM Estimates when Detected data are Lognormally Distributed

KM Mean (logged)	-0.251	95% H-UCL (KM -Log)	1.256
KM SD (logged)	0.592	95% Critical H Value (KM-Log)	2.116
KM Standard Error of Mean (logged)	0.144		

DL/2 Statistics

DL/2 Normal		DL/2 Log-Transformed	
Mean in Original Scale	0.893	Mean in Log Scale	-0.32
SD in Original Scale	0.487	SD in Log Scale	0.753
95% t UCL (Assumes normality)	1.092	95% H-Stat UCL	1.468

DL/2 is not a recommended method, provided for comparisons and historical reasons

Nonparametric Distribution Free UCL Statistics
Detected Data appear Normal Distributed at 5% Significance Level

Suggested UCL to Use

95% KM (t) UCL	**1.098**	**95% KM (Percentile Bootstrap) UCL**	**1.084**

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.